SATYAM SIR

ZERO 2 HERO PHYSICS

LEVELUP YOUR PHYSICS

for

IIT JEE & NEET

VOLUME 01

ZERO
2
HERO PHYSICS

VOLUME 01

for

School Exams

State Engineering Entrance

NEET Medical Entrance Exam

IIT JEE Mains & Advanced Exams

AP & International Physics Olympiad Exams

1st Edition (Feb 2024)

Disclaimer

In spite of many efforts taken to present this book without errors, still some errors might be possible. In various places some of the Answer Keys or Solutions might not be present. The author doesn't take any responsibility for such errors in any form. We request you to kindly give error information to author at satyamquestapps@gmail.com , so that he will rectify those mistakes in his next edition of his book.

Author’s Message

Physics is a subject to understand nature. How it works? There are certain laws that applies to nature that we study in physics in terms of conceptual theory. Then we apply these theories in day-to-day life or its applications in form of numerical. It is the toughest subject for those who tend to mug up this subject. A subject requires an IQ. However, an IQ is a subjective prospect. To measure, it has numerous parameters. It grows, as we tend to understand the subject. The intension is to create this book to present physics subject as in a most systematic approach to learn in depth knowledge and develop a good problem solving skill. All the chapters presented in this book starts with an adaptive topic wise question bank, that personally I have made especially for other teacher to use in their class. However, it is not limited to do so. These problems are given in order of difficulty level. Further, the chapter gives a plenty of unsolved questions exercise questions to practice, plus last year asked JEE Mains and Advanced Questions along with NCERT questions. This book also contains selected BOARD level problems in every chapter, which gives a good boost in your school and board exams. I hope you would enjoy this journey of learning. Though an enormous of hard work and efforts have been to make this book as error free as possible still I expect feedbacks and content mistakes (if any), so to remove in the next upcoming editions.

Enjoy learning Physics!

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Ex- FIITJEE, AAKASH, ALLEN TEACHER

ACKNOWLEDGMENTS

I am thankful to my family members for the support provided throughout this project. Especial thanks to Kasibhatla Suryanarayana Sir, my colleague who helped in proofread this book. I am thankful to my few close friends for helping me editing this book with their great efforts. I am also thankful to all my coaching institute friends for helping me out with several solutions and removing ambiguous questions. I also give credit to some of the writers and publications whose help been taken to produce this book. I also helpful to my college friends for the final proofread of this book. I am grateful for all the efforts you all people made to make my dream true.

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Basic Math

Chapter Summary

Quadratic Equations:

For a quadratic equation, $ax^2 + bx + c = 0$

Roots of the Quadratic equation are:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Arithmetic Progression:

(i) n^{th} term of arithmetic progression

$$a_n = a_0 + (n-1)d$$

a_0 = First term,

n = Number of terms,

d = Common difference

= $(a_1 - a_0)$ or $(a_2 - a_1)$ or $(a_3 - a_2)$

(ii) Sum of arithmetic progression

$$S_n = \frac{n}{2}\left[2a_0 + (n-1)d\right] = \frac{n}{2}\left[a_0 + a_n\right]$$

a_n = last term

Geometric Progression:

Here a = first term, r = common ratio

(i) Sum of 'n' terms of G.P.

$$S_n = \frac{a(1-r^n)}{1-r} \text{ if } r < 1$$

$$S_n = \frac{a(r^n - 1)}{r-1} \text{ if } r > 1$$

(ii) Sum of infinite terms of G.P.

$$S_\infty = \frac{a}{1-r} \quad \text{if } r < 1$$

$$S_\infty = \frac{a}{r-1} \quad \text{if } r > 1$$

Common Formulae of Algebra

(i) $(a + b)^2 = a^2 + b^2 + 2ab$

(ii) $(a - b)^2 = a^2 + b^2 - 2ab$

(iii) $(a + b + c)^2 = a^2 + b^2 + c^2 + 2ab + 2bc + 2ca$

(iv) $(a + b)(a - b) = a^2 - b^2$

(v) $(a + b)^3 = a^3 + b^3 + 3ab(a + b)$

(vi) $(a - b)^3 = a^3 - b^3 - 3ab(a - b)$

(vii) $(a + b)^2 - (a - b)^2 = 4ab$

(viii) $(a + b)^2 + (a - b)^2 = 2(a^2 + b^2)$

(ix) $a^3 - b^3 = (a - b)(a^2 + b^2 + ab)$

(x) $a^3 + b^3 = (a + b)(a^2 + b^2 - ab)$

Trigonometry Angle:

$$\text{Angle } (\theta) = \frac{\text{Arc Length}}{\text{Radius}} = \frac{L}{r}$$

(formula true for radian only)

Trigonometry Ratio:

$$\sin\theta = \frac{\text{Perpendicular}}{\text{Hypotenuse}} = \frac{p}{h} = \frac{opp.side}{hypotaneous}$$

$$\cos\theta = \frac{\text{Base}}{\text{Hypotenuse}} = \frac{b}{h} = \frac{adj.side}{hypotaneous}$$

$$\tan\theta = \frac{\text{Perpendicular}}{\text{Base}} = \frac{p}{b} = \frac{opp.side}{adj.side}$$

$$\text{cosec}\,\theta = \frac{1}{\sin\theta} = \frac{h}{p} = \frac{hypotaneous}{opp.side}$$

$$\sec\theta = \frac{1}{\cos\theta} = \frac{h}{b} = \frac{hypotaneous}{adj.side}$$

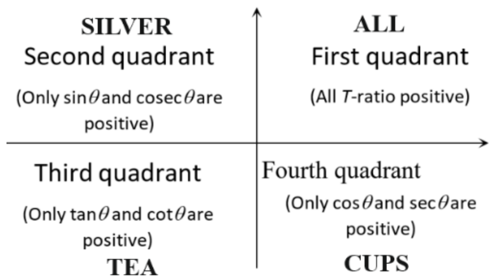
$$\cot\theta = \frac{1}{\tan\theta} = \frac{b}{p} = \frac{adj.\text{side}}{opp.side}$$

Value of Trigonometric ratio of standard angles

Angle	0°	30°	45°	60°	90°	180°
sinθ	0	1/2	1/√2	√3/2	1	0
cosθ	1	√3/2	1/√2	1/2	0	– 1
tanθ	0	1/√3	1	√3	ND	0

Angle	37°	53°	15°	75°
sinθ	3/5	4/5	$\frac{\sqrt{3}-1}{2\sqrt{2}}$	$\frac{\sqrt{3}+1}{2\sqrt{2}}$
cosθ	4/5	3/5	$\frac{\sqrt{3}+1}{2\sqrt{2}}$	$\frac{\sqrt{3}-1}{2\sqrt{2}}$
tanθ	3/4	4/3	1	√3

Trigonometry values of Larger Angles



$\sin(180° - \theta) = \sin\theta$	$\sin(360° - \theta) = -\sin\theta$
$\cos(180° - \theta) = -\cos\theta$	$\cos(360° - \theta) = \cos\theta$

tan(180° – θ)= -tanθ	tan(360° – θ)= -tanθ
sin(180° + θ)= -sinθ cos(180° + θ)= -cosθ tan(180° + θ)= tanθ	sin(360n° + θ)= sinθ cos(360n° + θ)= cosθ tan(360n° + θ)= tanθ

Trigonometrical Identities

(i) $\sin^2\theta+\cos^2\theta=1$

(ii) $\sec^2\theta-\tan^2\theta=1$

(iii) $\text{cosec}^2\theta-\cot^2\theta=1$

Trigonometry Formulae

$$\sin(A+B)=\sin A\cos B+\cos A\sin B$$

$$\sin(A-B)=\sin A\cos B-\cos A\sin B$$

$$\cos(A+B)=\cos A\cos B-\sin A\sin B$$

$$\cos(A-B)=\cos A\cos B+\sin A\sin B$$

$$\tan(A+B)=\frac{\tan A+\tan B}{1-\tan A\tan B}$$

$$\tan(A-B)=\frac{\tan A-\tan B}{1+\tan A\tan B}$$

$$\sin 2\theta=2\sin\theta\cos\theta$$

$$\cos 2\theta=\cos^2\theta-\sin^2\theta$$
$$=2\cos^2\theta-1$$
$$=1-2\sin^2\theta$$

$$\tan 2\theta=\frac{2\tan\theta}{1-\tan^2\theta}$$

Logarithm

If $a^x=N$ then $\log_a N=x$

Conversion of natural log into common log:

$$\log_e x=\ln x=2.3026\log_{10} x$$

Important formulae of logarithm:

(i) $\log_a(mn)=\log_a m+\log_a n$

(ii) $\log_a\left(\frac{m}{n}\right)=\log_a m-\log_a n$

(iii) $\log_a m^n=n\log_a m$

Differential Calculus

The differential coefficient or derivative of variable *y* with respect to variable *x* is defined as the instantaneous rate of change of *y w.r.t. x.*

It is denoted by $\frac{dy}{dx}$=f `(x)=y `

Fundamental formulae of differentiation:

$y=x^n$	$\frac{dy}{dx}=nx^{n-1}$
$y=k\,x$	$\frac{dy}{dx}=k\frac{dx}{dx}=k$
$y=k$	$\frac{dy}{dx}=0$
$y=\frac{1}{x}$	$\frac{dy}{dx}=-\frac{1}{x^2}$
$y=\sqrt{x}$	$\frac{dy}{dx}=\frac{1}{2\sqrt{x}}$
$y=\ln x$	$\frac{dy}{dx}=\frac{1}{x}$
$y=\log_a x$	$\frac{dy}{dx}=\frac{1}{x}\log_a e$
$y=e^x$	$\frac{dy}{dx}=e^x$
$y=a^x$	$\frac{dy}{dx}=a^x\log_e a$

$y=\sin x$	$\frac{dy}{dx}=\cos x$
$y=\cos x$	$\frac{dy}{dx}=-\sin x$
$y=\tan x$	$\frac{dy}{dx}=\sec^2 x$
$y=\cos ec\,x$	$\frac{dy}{dx}=-\cot x\,\text{cosec}\,x$
$y=\sec x$	$\frac{dy}{dx}=\sec x\tan x$
$y=\cot x$	$\frac{dy}{dx}=-\text{cosec}^2 x$

Integral Calculus

The process of integration is just the reverse of differentiation.

The symbol ∫ is used to denote integration.

Fundamental formulae of integration

$y = x^n$	$\int x^n dx = \frac{x^{n+1}}{n+1} + c$
$y = k$	$\int k dx = kx + c$
$y = 1$	$\int dx = x + c$
$y = \frac{1}{x}$	$\int \frac{1}{x} dx = \ln x + c$
$y = e^x$	$\int e^x dx = e^x + c$
$y = a^x$	$\int a^x dx = \frac{a^x}{\log_e a} + c$

$y = \sin x$	$\int \sin x\, dx = -\cos x$
$y = \cos x$	$\int \cos x\, dx = \sin x$
$y = \sec^2 x$	$\int \sec^2 x\, dx = \tan x$
$y = \sec x \tan x$	$\int \sec x \tan x\, dx = \sec x$
$y = \text{cosec}^2 x$	$\int \text{cosec}^2 x\, dx = -\cot x$
$y = \text{cosec}\, x \cot x$	$\int \text{cosec}\, x \cot x\, dx = -\text{cosec}\, x$

Formulae for Area and Volume

1. Area of square = (side)^2
2. Area of rectangle = length × breadth
3. Area of triangle $= \frac{1}{2} \times \text{base} \times \text{height}$
4. Area enclosed by a circle $= \pi r^2$
5. Surface area of sphere $= 4\pi r^2$
6. Surface area of cube $= 6L^2$
7. Surface area of cuboid
   $= 2[L \times b + b \times h + h \times L]$
8. Area of curved surface of cylinder $= 2\pi rl$
9. Volume of cube $= L^3$
10. Volume of cuboid $= L \times b \times h$
11. Volume of sphere $= \frac{4}{3}\pi r^3$
12. Volume of cylinder $= \pi r^2 l$
13. Volume of cone $= \frac{1}{2}\pi r^2 h$

Vectors

Definition:
The physical quantities which have Magnitude and Direction, and which can be added according to the vector
Mathematical rule, are called vector quantities.

Examples:
Force, linear momentum, electric field, magnetic field etc.

Unit vector:
A vector with magnitude of unity is called unit vector. Unit vector in the direction of a is

$$a = \frac{\vec{a}}{|\vec{a}|}$$

Representation of Vectors:
There are two methods for representation of vectors.

(a) Graphical method.
(b) Mathematical method.

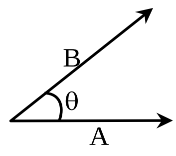
(a) Graphical method:
The length of the arrow shows the magnitude and head of the arrow shows the direction.

(b) Mathematical Representation:
If a_x is a component of any vector in x-direction, a_y is a component in y-direction and a_z is component in z-direction then

$$\vec{a} = a_x\hat{i} + a_y\hat{j} + a_z\hat{k}$$

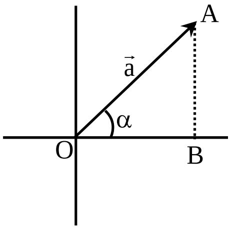
where a_x, a_y, a_z may be the co-ordinates of point a

Vector Addition
Magnitude of Resultant of two vectors is given by



$$R = |\vec{a} + \vec{b}| = \sqrt{(a^2 + b^2 + 2ab\cos\theta)}$$

Resolution of Vector
See the figure below. Vector $\vec{a}$ is in x–y plane and it makes the angle θ with the x–axis.



$\vec{a} = a_x\hat{i} + a_y\hat{j}$

$a_x = |\vec{a}|\cos\alpha, a_y = |\vec{a}|\sin\alpha$

$\vec{a} = |\vec{a}|\cos\alpha\,\hat{i} + |\vec{a}|\sin\alpha\; j$

Multiplication of two Vectors:

Two types of multiplication

(a) Scalar (or dot) product of two vectors.

(b) Vector (or cross) product of two vectors

Dot Product

The scalar or dot product of two vectors **a** and **b** denoted

by **a**. **b** (read as **a** dot **b**) it's defined as

$$\vec{a}.\vec{b} = |\vec{a}||\vec{b}|\cos\theta$$

where, a = |**a**| ; b = |**b**| & θ is the angle between **a** and **b**

Angle Between two vectors

$$\cos\theta = \left(\frac{\vec{a}.\vec{b}}{ab\cos\theta}\right)$$

Cross Product

If $\vec{A}$ & $\vec{B}$ are two vectors, then their vector product written as $\vec{A} \times \vec{B}$ is a vector $\vec{C}$ defined by

$$\vec{C} = \vec{A}\times\vec{B} = AB\sin\theta\, n$$

where, $\hat{n}$ is the unit vector whose direction is perpendicular to the plane containing the two vectors, in accordance with right hand screw rule.

Kindly note:

$$\hat{i}\,x\,\hat{i} = 0 \qquad \hat{i}\,x\,j = k \qquad j\,x\,\hat{i} = -k$$

$$j\,x\,j = 0 \quad \& \quad j\,x\,k = \hat{i}\,, \quad k\,x\,j = -\hat{i}$$

$$k\,x\,k = 0 \qquad k\,x\,\hat{i} = j \qquad \hat{i}\,x k = -j$$

If **a** = $a_1\hat{i} + a_2\hat{j} + a_3\hat{k}$, **b** = $b_1\hat{i} + b_2\hat{j} + b_3\hat{k}$

$$\mathbf{a}\times\mathbf{b} = \begin{vmatrix} \hat{i} & \hat{j} & \hat{k} \\ a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \end{vmatrix}$$

a × **b** = $(a_2b_3 - a_3b_2)\hat{i} - (a_1b_3 - a_3b_1)\hat{j} + (a_1b_2 - a_2b_1)\hat{k}$

Units and Measurements

Physical Quantities:

The quantities by means of which we describe the laws of physics are called physical quantities.

These are of two types:

(a) Fundamental quantities

(b) Derived quantities

(a) Fundamental quantities:

The quantities, which do not depend upon other physical quantities, are called fundamental quantities and all other quantities may be expressed in terms of the fundamental quantity. There are of seven fundamental quantities in SI system:

(i) Mass

(ii) Length

(iii) Time

(iv) Temperature

(v) Electric current

(vi) Luminous intensity

(vii) Amount of substance

These quantities are also called base quantities.

(b) Derived quantities:

The quantities which are derived with the help of fundamental quantities is called derived quantities as

$$\text{Speed} = \frac{Distance}{Time} = \frac{Length}{Time}$$

Here we know that length and time are the fundamental quantities.

System of Units Used:

These are of Four types –

(i) C.G.S – (Centimetres – Gram – Second) system.

(ii) M.K.S. – (Metre – Kilogram – Second) system

(iii) F.P.S. – (Foot – Pound – Second) system

(iv) S.I. – (System – international) system

Following table will show the difference between all the systems.

Quantity	C.G.S.	M.K.S.	F.P.S.	S.I.(Symb.)
Mass	gm	kg	pound	kg
Length	cm	m	foot	metre
Time	second	sec	sec	second
Temperature	kelvin	kelvin		kelvin (K)
Electric Current		ampere		ampere(A)
Luminous Intensity				candela (cd)
Amount of substance				mole(mol)

Dimensions

Dimensions of a physical quantity are the powers to which the fundamental units of mass, length, time etc. must be raised in order to represent that physical quantity.

Dimensional formula = [Ma Lb Tc Qd]

where a, b, c, d

are the dimensions of M, L, T, Q respectively.

Error Analysis

Consider a physical quantity measured by x_1, x_2, x_3, x_4,. are the measured values and Δx_1, Δx_2, Δx_3, Δx_4,..are their respective errors.

$$x_{true} = x_{mean} = \frac{x_1 + x_2 + x_3 + x_4 + ...}{n}$$

$$\Delta x = | x_{measured} - x_{true} |$$

Therefore, the **mean error** is given by

$$\Delta x_{mean} = \frac{|\Delta x_1| + |\Delta x_2| + |\Delta x_3| + |\Delta x_4| + ...}{n}$$

Therefore, the **relative error** is given by

$$\text{Relative Error} = \frac{\Delta x_{mean}}{x_{mean}}$$

Therefore, the **percentage error** is given by

$$\text{Percentage Error} = \frac{\Delta x_{mean}}{x_{mean}} x100\%$$

Operations in Error

(a) When two quantities are **added or subtracted** the absolute error in the find is the sum of the absolute error in the quantities.

Let error in x is $\pm \Delta x$, and error in y is $\pm \Delta y$, then the error in x + y or x – y is $\pm (\Delta x + \Delta y)$.

The errors are added.

(b) When two quantities any **multiplied or divided,** the fractional error in the result is the sum of the fractional error in the quantities to be multiplied or to be divided.

Let say errors in x, y are respectively $\pm \Delta x$, $\pm \Delta y$. Then error in a quantity f (defined as)

$$f = xy$$

$$\frac{\Delta f}{f} = \left|\frac{\Delta x}{x}\right| + \left|\frac{\Delta y}{y}\right|$$

The fraction errors add. The error in f is $\pm \Delta f$.

(c) If the same quantity x is to the **power** n times (i.e. x^n), then the fractional error in x^n is **n times** the fractional error in x,

$$\text{i.e.} \quad \pm n \frac{\Delta x}{x}$$

Rules for Finding No. of Significant Figures

a) Every non – zero digits are significant figures.
E.g., 454.76 has 5 (five) significant figures.

b) All zeroes which lie between two non – zero digits are also significant figures.
E.g., 703.004 has 6 (six) significant figures.

c) All zeros after decimal but before a non – zero digit is not considered a significant figure.
E.g., 0.00465 has only 3 (three) significant figures.

d) All zeros which are at the right side of decimal and also at the right side of a non – zero digits are considered as significant figures.
E.g., 0.64000 has 5 (five)significant figures

e) When the given number does not contain a decimal point, then the final zeroes are ambiguous and they are not considered as significant figures.
E.g., 75000 has two (2) significant figures. But when the number which is obtained on the basis of actual (real) measurement, then all zeroes which are to the right of the last non zero digit are also considered as significant figures.
E.g., 8070 has four (4) significant figures.

f) When a decimal is present at the end of a whole number, then all zeros which are at the right end just before the decimal are considered as significant figures.
E.g., 13300. Has five (5) significant figures.

g) When the number contains both an integral part as well as a decimal part, then all zeros in the number are considered as significant figures.
E.g., 34.40 has four (4) significant figures.

Rounding Off

(a) If the number lying to the right of cut off digit is less than 5, then the cut off digit is retained as such. However, if it is more than 5, then the cut off digit is increased by 1.
For example, x = 6.24 is rounded off to 6.2 (two significant digits) and x = 5.328 is rounded off to 5.33 (three significant digits).

(b) If the digit to be dropped is 5 followed by digits other than zero, then the preceding digit is increased by 1.
For example, x = 14.252 is rounded off to x = 14.3 to three significant digits.

(c) If the digit to be dropped is simply 5 or 5 followed by zeroes, then the preceding digit is left unchanged if it is an even number.
For example, x = 6.250 or x = 6.25 becomes x = 6.2 after rounding off to two significant digits.

(d) If the digit to be dropped is 5 or 5 followed by zeroes, then the preceding digit is raised by one if it is an odd number.
For example, x = 6.350 or 6.35 becomes x = 6.4 after rounding off to two significant digits

Algebraic Operations with Significant Figures

(a) Addition and subtraction: Suppose in the measured values to be added or subtracted, the least number of significant digits after the decimal is n. Then, in the sum or difference also, the number of significant digits after the decimal should be n.
Example: 420.42 + 420.4 + 0.402 = 441.222 ≈ **441.2**

(b) Multiplication or division: Suppose in the measured values to be multiplied or divided, the least number of significant digits is n; then, in the product or quotient, the number of significant digits should also be n.
Example 01: 1.2 x 36.72 = 44.064 ≈ **44**
Example 02: 1100/10.2 = 107.8431373 ≈ **108**

Important Notes:

1. Additional / Subtraction shortcut

$$\boxed{Least\ Decimal}$$

2. Multiplication / Division shortcut

$$\boxed{Least\ S.F}$$

3. Rounding off Shortcut
Even no $\rightarrow$ same
Odd no $\rightarrow$ next

Vernier Calliper

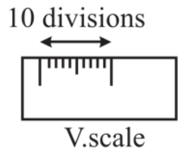
It is a measuring device with a linear scale attached to it, to measure length or diameter of an object up to a precision of 0.1 mm or more.

Least count

$$\boxed{Least\ count = 1\ MSD - 1VSD}$$

where, 1MSD means 1 main scale division value and 1 VSD means 1 vernier scale division value

Calculation of Least Count



9 MSD = 10 VSD

$$1\,VSD = \frac{9}{10}MSD$$

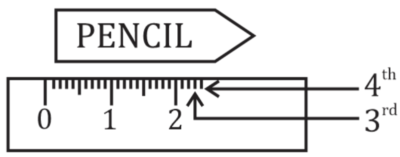
= 0.9 mm

$$\boxed{LC = 1\ mm - 0.9\ mm = 0.1\ mm}$$

So, in general,
If n division of VS coincides with (n – 1) division of main scale, Therefore
n VSD = (n –1) MSD

$$\boxed{1\,VSD = \left(\frac{n-1}{n}\right)MSD}$$

Let's take the measurement of a pencil,

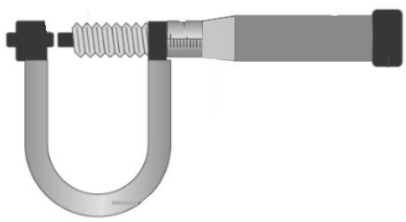


Actual Value is between 2.3 cm to 2.4 cm
Formula to calculate True Value:

*
True Reading = MSR + (L.C) VSR
↓
Actual value

Screw Gauge

It is a measuring device with a circular scale attached to it, to measure length or diameter of an object up to a precision of 0.01 mm or more.



$$LC = \frac{pitch}{\text{No. of division on circular scale}}$$

$$True\ Reading = MSR + (LC)(CSR)$$

If pitch is 1 mm, and n = 100, then

$$LC = \frac{1mm}{100} = 0.01mm$$

Beginner **Quadratic Equations**

1. Find the roots of the following quadratic equations
(i) $x^2 - 3x - 10 = 0$
(ii) $2x^2 + x - 6 = 0$

2. The roots of quadratic equation $5x^2 - 4x + 5 = 0$ are
(a) Real & Equal
(b) Real & Unequal
(c) Not real
(d) Non-real and equal

3. Find the roots of $4x^2 + 3x + 5 = 0$

4. Solve the following quadratic equation for x:
$4\sqrt{3}x^2 + 5x - 2\sqrt{3} = 0$

5. Solve the following for x:
$\sqrt{2}x^2 + 7x + 5\sqrt{2} = 0$

Expert **Quadratic Equations**

6. Find two numbers whose sum is 27 and product is 182.

7. Solve for x: $36x^2 - 12ax + (a^2 - b^2) = 0$

8. Find the value(s) of k so that the quadratic equation $x^2 - 4kx + k = 0$ has equal roots.

9. Solve the quadratic equation $2x^2 + ax - a^2 = 0$

10. Solve for x: $\sqrt{2x+9} + x = 13$

11. Solve for x: $\sqrt{6x+7} - (2x-7) = 0$

Beginner **Arithmetic Progression**

12. Which of the following are in APs? If they form an AP, find the common difference d and write three more terms.
(i) 2, 4, 8, 16, …….
(ii) 2, $\frac{5}{2}$, 3, $\frac{7}{2}$, …….
(iii) – 1.2, –3.2, –5.2, –7.2, ……
(iv) –10, –6, –2, 2, …..
(v) 3, 3 + $\sqrt{2}$, 3 + $2\sqrt{2}$, 3 + $3\sqrt{2}$, …….

13. Choose the correct choice in the following and justify:
(i) 30th term of the AP: 10, 7, 4, …, is
(a) 97 (b) 77
(c) –77 (d) –87

14. 11th term of the AP: $-3, \frac{-1}{2}, 2, ...,$ is
(a) 28 (b) 22
(c) –38 (d) –48

15. Which term of the AP: 3, 8, 13, 18, …, is 78?

16. Find the sums given below:
(i) $7 + 10\frac{1}{2} + 14 + ... + 84$
(ii) 34 + 32 + 30 + … + 10
(iii) –5 + (–8) + (–11) + …..+ (–230)

Expert **Arithmetic Progression**

17. Which term of the AP: 121, 117, 113, ……, is its first negative terms?

18. The sum of the third term and the seventh term of an AP is 6 and their product is 8. Find the sum of first sixteen terms of the AP?

Beginner **Geometric Progression**

19. Find the sum of 7 terms of the G.P. 3, 6, 12, …

20. Find the sum of 10 terms of the G.P. 1, 1/2, ¼, 1/8 …

21. Find the sum of the series 2 + 6 + 18 + … + 4374.

22. Find the sum to infinity of the G.P.
$-\frac{5}{4}, \frac{5}{16}, -\frac{5}{64}, ...$

23. The first term of a G.P. is 2 and the sum to infinity is 6. Find the common ratio.

Expert **Geometric Progression**

24. Find the 5th term of the progression
$1, \frac{(\sqrt{2}-1)}{2\sqrt{3}}, \left(\frac{3-2\sqrt{2}}{12}\right), \left(\frac{5\sqrt{2}-7}{24\sqrt{3}}\right), ...$

25. How many terms of the geometric series 1 + 4 + 16 + 64 + … will make the sum 5461?

26. The sum of an infinite G.P. is 57 and the sum of their cubes is 9747, Find the G.P.

Beginner — Angles

27. Convert the following angles from degrees to radians
(a) 0° (b) 30°
(c) 45° (d) 60°
(e) 90° (f) 120°
(g) 150° (h) 180°
(i) 210° (j) 240°

28. The minute hand of a clock is 10 cm long. How far does the tip of the hand move in 20 minutes?
(a) $\frac{10\pi}{3}$ (b) $\frac{20\pi}{3}$
(c) $\frac{30\pi}{3}$ (d) $\frac{40\pi}{3}$

29. The radius of the circle whose arc of length 15 cm makes an angle of 3/4 radian at the centre is
(a) 10 cm (b) 20 cm
(c) $11\frac{1}{4}$ cm (d) $22\frac{1}{2}$ cm

30. Find the length of an arc of a circle of radius 5 cm subtending a central angle measuring 15°.

31. Find in degrees the angle subtended at the center of a circle of diameter 50 cm by an arc of length 11 cm.

32. In a circle of diameter 40 cm the length of a chord is 20 cm. Find the length of minor arc corresponding to the chord.

33. A rail road curve is to be laid out on a circle. What radius should be used if the track is to change direction by 25° in a distance of 40 meters?

Expert — Angles

34. The circular wire of radius 7 cm is cut and bend again into an arc of radius 12 cm. The angle subtended by an arc at the centre of the circle is:
(a) 50° (b) 210°
(c) 100° (d) 60°

35. Which of the following relation is correct?
(a) sin 1° > sin 1 (b) sin 1 > sin 1°
(c) sin 1 = sin 1° (d) $\frac{\pi}{180}$ sin 1 = sin 1°

36. A horse is tied to a post by a rope, if the horse moves along a circular path always keeping the rope tight and describe 88 metres when it has traced out 72° at the center, find the length of the rope.

37. A circular wire of radius 3 cm is cut and bent so as to lie along the circumference of a hoop whose radius is 48 cm. Find in degrees the angle which is subtended at the centre of the hoop.

Beginner — Trigonometry Ratio

38. If $\tan\theta = +\frac{1}{\sqrt{5}}$ and θ lies in the 1st quadrant, then cos θ is
(a) $\frac{1}{\sqrt{6}}$ (b) $-\frac{1}{\sqrt{6}}$
(c) $\frac{\sqrt{5}}{\sqrt{6}}$ (d) $-\frac{\sqrt{5}}{\sqrt{6}}$

39. If $\tan\theta = \frac{20}{21}$, cos θ will be
(a) $\pm\frac{20}{41}$ (b) $\pm\frac{1}{21}$
(c) $\pm\frac{21}{29}$ (d) $\pm\frac{20}{21}$

40. If sin θ = 1/2, Find the value of $(3\cos\theta - 4\cos^3\theta)$

41. If cos θ = 3/5, find the value of (5cosec θ – 4 tanθ)/(sec θ + cot θ)

42. If 3 tan θ = 4, Evaluate (3sin θ + 2 cos θ)/(3sin θ – 2cos θ)

43. If 5 cot θ = 3, find the value of (5 sin θ – 3 cosθ)/(4 sin θ + 3 cos θ)

44. If √3 tan Φ = 3 sin Φ, then find the value of $\sin^2\Phi - \cos^2\Phi$

45. If sin x = a/ $\sqrt{a^2+b^2}$, then the value of cot x is
(a) a/b (b) b/a
(c) a/b + 1 (d) b/a + 1

46. If 4 sin θ = 3 cos θ then $\frac{\sec^2\theta}{4\left[1-\tan^2\theta\right]}$ equals to
(a) $\frac{25}{16}$ (b) $\frac{25}{28}$
(c) $\frac{1}{4}$ (d) 1

Expert — Trigonometry Ratio

47. If 5 tan θ = 4 then $\frac{5\sin\theta - 3\cos\theta}{5\sin\theta + 2\cos\theta}$ equal to

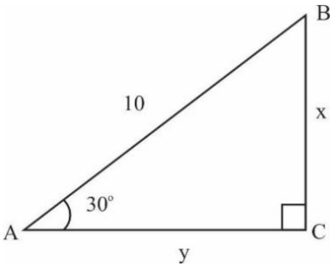
(a) 0 (b) 1
(c) 1/6 (d) 6

48. In triangle ABC, right angled at B if sin A = 1/2, find the value of
(a) sin C cos A – cos C sin A
(b) cos A cos C + sin A sin C

49. If θ is an acute angle and $\frac{\sin\theta+1}{\sin\theta-1}=\frac{\sqrt{3}+2}{\sqrt{3}-2}$, find θ.

Beginner **Trigonometry Angles**

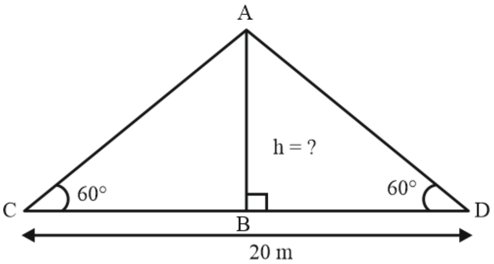
50. Find the exact values of x and y.



51. An isosceles triangle has base angle of 30° and base 10√3 cm long. The height of this triangle is
(a) 4 cm (b) 5 cm
(c) 5 √3 (d) 4 √3

52. An isosceles triangle has base angle of 45° and base 20 cm long. The height of this triangle is
(a) 5 cm (b) 10 cm
(b) 20 cm (d) 40 cm

53. Find the height of the triangle.



54. Evaluate the following:
(i) sin 60° cos 30° + sin 30° cos 60°
(ii) 2 $\tan^2 45° + \cos^2 30° - \sin^2 60°$
(iii) $\frac{\cos 45°}{\sec 30°+\cos ec 30°}$
(iv) $\frac{\sin 30°+\tan 45°-\cos ec 60°}{\sec 30°+\cos 60°+\cot 45°}$
(v) $\frac{5\cos^2 60°+4\sec^2 30°-\tan^2 45°}{\sin^2 30°+\cos^2 30°}$

55. Choose the correct option and justify your choice:
(i) $\frac{2\tan 30°}{1+\tan^2 30°}=$
(a) sin 60° (b) cos 60°
(c) tam 60° (d) sin 30°

56. Choose the correct option.
(ii) $\frac{1-\tan^2 45°}{1+\tan^2 45°}=$
(a) tan 90° (b) 1
(c) sin 45° (d) 0

57. Find the values of
(a) cos (–60°) (b) tan 210°
(c) sin 300° (d) cos (–120°)
(e) sin (–1485°)

58. Sin 75° =
(a) $\frac{2-\sqrt{3}}{2}$ (b) $\frac{\sqrt{3}+1}{2\sqrt{2}}$
(c) $-\frac{\sqrt{3}-1}{2\sqrt{2}}$ (d) $\frac{\sqrt{3}-1}{2\sqrt{2}}$

59. The value of cos 15° – sin 15° equal to
(a) $\frac{1}{\sqrt{2}}$ (b) $\frac{1}{2}$
(c) $\frac{-1}{\sqrt{2}}$ (d) Zero

60. If sin x = $-\frac{24}{25}$, then the value of tan x is
(a) $\frac{24}{25}$ (b) $\frac{-24}{7}$
(c) $\frac{25}{24}$ (d) None of these

61. The value of sin 600° cos 330° + cos 120° sin 150° is
(a) –1 (b) 1
(c) $\frac{1}{\sqrt{2}}$ (d) $\frac{\sqrt{3}}{2}$

62. If tan θ = $\frac{-4}{3}$, then sin θ

(a) $\frac{-4}{5}$ but not $\frac{4}{5}$

(b) $-\frac{4}{5}$ or $\frac{4}{5}$

(c) $\frac{4}{5}$ but not $-\frac{4}{5}$

(d) None of these

63. If sin θ = $\frac{24}{25}$ and θ lies in the second quadrant, then sec θ + tan θ equal to

(a) – 3 (b) – 5
(c) –7 (d) – 9

64. The value of tan(–945°) is

(a) –1 (b) – 2
(c) – 3 (d) – 4

65. tan 75° – cot 75°

(a) $2\sqrt{3}$ (b) $2 + \sqrt{3}$
(c) $2 - \sqrt{3}$ (d) None

66. The value of cos 105° + sin 105° is

(a) $\frac{1}{2}$ (b) 1
(c) $\sqrt{2}$ (d) $\frac{1}{\sqrt{2}}$

Expert **Trigonometry Angles**

67. Find theta in the following: 0 < θ < 90°

(a) $2\sin^2\theta = 3/2$
(b) $3\tan^2\theta + 2 = 3$
(c) $\cos^2\theta - 1/4 = 1/2$

68. $\frac{\cot^2 15° - 1}{\cot^2 15° + 1} =$

(a) $\frac{1}{2}$ (b) $\frac{\sqrt{3}}{2}$
(c) $\frac{3\sqrt{3}}{4}$ (d) $\sqrt{3}$

69. $\sin 15^o + \cos 105^o =$

(a) 0
(b) 2 sin 15°
(c) cos 15° + sin 15°
(d) sin15° – cos 15°

70. cos 15° =

(a) $\sqrt{\frac{1+\cos 30°}{2}}$ (b) $\sqrt{\frac{1-\cos 30°}{2}}$
(c) $\pm\sqrt{\frac{1+\cos 30°}{2}}$ (d) $\pm\sqrt{\frac{1-\cos 30°}{2}}$

Beginner **Trigonometry Formula**

71. $(\sec^2\theta - 1)(\text{cosec}^2\theta - 1) =$

(a) 0
(b) 1
(c) $\sec\theta\,\text{cosec}\,\theta$
(d) $\sin^2\theta - \cos^2\theta$

72. If $\sin\theta - \cos\theta = 1$, then $\sin\theta\cos\theta =$

(a) 0 (b) 1
(c) 2 (d) ½

73. If $\sin\theta = e^x$ then cos θ equals

(a) $1+ e^{2x}$ (b) $1- e^{2x}$
(c) $\sqrt{1-e^{2x}}$ (d) $\frac{(e^x - e^{-x})}{(e^x + e^{-x})}$

74. If $\tan A = -\frac{1}{2}$ and $\tan B = -\frac{1}{3}$, then A + B =

(a) $\frac{\pi}{4}$ (b) $\frac{3\pi}{4}$
(c) $\frac{5\pi}{4}$ (d) None

Expert **Trigonometry Formula**

75. If sin x + cos x = $\frac{1}{5}$, then tan 2x is

(a) $\frac{25}{17}$ (b) $\frac{7}{25}$
(c) $\frac{25}{7}$ (d) $\frac{24}{7}$

76. If $x = \sec\theta + \tan\theta$, then $x + \frac{1}{x} =$

(a) 1 (b) $2\sec\theta$
(c) 2 (d) $2\tan\theta$

77. If $\sec\theta + \tan\theta = p$, then $\tan\theta$ is equal to

(a) $\frac{2p}{p^2-1}$ (b) $\frac{p^2-1}{2p}$
(c) $\frac{p^2+1}{2p}$ (d) $\frac{2p}{p^2+1}$

78. $\sqrt{\frac{1-\sin\theta}{1+\sin\theta}}$ Equals

(a) 0 (b) 1

(c) $\sec\theta - \tan\theta$ (d) $\sec\theta.\tan\theta$

79. $\dfrac{\sin\theta}{1-\cot\theta}+\dfrac{\cos\theta}{1-\tan\theta}$ equals to

(a) 0 (b) 1
(c) cos θ – sin θ (d) cos θ + sin θ

80. If tan(A + B) = p and tan(A – B) = q then the value of tan 2A =

(a) $\dfrac{p+q}{p-q}$ (b) $\dfrac{p-q}{1+pq}$
(c) $\dfrac{1+pq}{1-p}$ (d) $\dfrac{p+q}{1-pq}$

81. If $\sin\alpha = \dfrac{-3}{5}$ where $\pi < \alpha < \dfrac{3\pi}{2}$, then $\cos\dfrac{\alpha}{2}$ equal to

(a) $\dfrac{1}{\sqrt{10}}$ (b) $-\dfrac{1}{\sqrt{10}}$
(c) $\dfrac{3}{\sqrt{10}}$ (d) $\dfrac{-3}{\sqrt{10}}$

82. If 90° < A < 180° and $\sin A = \dfrac{4}{5}$ then $\tan\dfrac{A}{2}$ is equal to

(a) $\dfrac{1}{2}$ (b) $\dfrac{3}{5}$
(c) $\dfrac{3}{2}$ (d) 2

83. $\sin(\pi+\theta)\sin(\pi-\theta)\text{cosec}^2\theta =$

(a) 1 (b) –1
(c) sin θ (d) – sin θ

84. If $\cos P = \frac{1}{7}$ and $\cos Q = \dfrac{13}{14}$ where P and Q both are acute angles. Then the value of P – Q is

(a) 30° (b) 60°
(c) 45° (d) 75°

85. If $\sin A = \dfrac{1}{\sqrt{10}}$ and $\sin B = \dfrac{1}{\sqrt{5}}$ where A and B are positive acute angles, then $A+B=$

(a) π (b) $\dfrac{\pi}{2}$
(c) $\dfrac{\pi}{3}$ (d) $\dfrac{\pi}{4}$

86. $\sin\left(\dfrac{\pi}{10}\right)\sin\left(\dfrac{3\pi}{10}\right) =$

(a) 1/2 (b) –1/2
(c) 1/4 (d) 1

87. If $3\sin\alpha = 5\sin\beta$, then $\dfrac{\tan\dfrac{\alpha+\beta}{2}}{\tan\dfrac{\alpha-\beta}{2}} =$

(a) 1 (b) 2
(c) 3 (d) 4

88. If $\cos\alpha + \cos\beta = 0 = \sin\alpha + \sin\beta$, then $\cos 2\alpha + \cos 2\beta =$

(a) $-2\sin(\alpha+\beta)$ (b) $-2\cos(\alpha+\beta)$
(c) $2\sin(\alpha+\beta)$ (d) $2\cos(\alpha+\beta)$

Beginner **Differentiation**

89. Find f'(x). Given: f(x) = $6x^3 - 9x + 4$

90. Find f'(x). Given: f(x) = $\sqrt{x} + 8\sqrt[3]{x} - 2\sqrt[4]{x}$

91. Find f'(x). Given:

f(x) = $10\sqrt[5]{x^3} - \sqrt{x^7} + 6\sqrt[3]{x^8} - 3$

92. Find g'(x). Given: g(x) = $\dfrac{4x^3 - 7x + 8}{x}$

93. For each function obtain the derivative.

(a) y = $12x^5 + 3x^4 + 7x^3 + x^2 - 9x + 6$
(b) y = $\dfrac{\cos x}{x}$
(c) y = $\dfrac{x}{\cos x}$
(d) y = $\sin(5x^3 + 2x)$
(e) y = $\ln \sin 5x^3$
(f) y = $\ln(4e^{3x})$
(g) y = e^{3x-2}
(h) y = cosec 3x
(i) y = $e^{\sqrt{2x+17}}$
(j) y = $4xe^{-5x}$
(k) y = $x^2 \sin 2x$
(l) y = $e^x \ln(5x^3 + x^2)$
(m) y = $\dfrac{x^2}{\ln\left(1-4x^2\right)}$

94. Differentiate with respect to x:

(a) $y = \dfrac{(1-x)^2}{x^2}$

(b) $y=\sqrt{\frac{1+x}{1-x}}$

(c) $y=\sin\left(\frac{1+x^2}{1-x^2}\right)$

(d) $y=\frac{\tan x+\cot x}{\tan x-\cot x}$

(e) If $y=e^{\sqrt{x}}$

(f) $y=\sqrt{\frac{1+e^x}{1-e^x}}$

95. $\frac{d}{dx}\left(\frac{1}{\sqrt{x}}\right)=$

(a) $\frac{1}{2\sqrt{x^3}}$ (b) $\frac{1}{\sqrt{x^3}}$

(c) $\frac{-1}{2\sqrt{x^3}}$ (d) None

96. $\frac{d}{dx}\left[\frac{3x+4}{4x+5}\right]=$

(a) $\frac{-1}{(4x+5)^2}$ (b) $\frac{1}{(4x+5)^2}$

(c) $\frac{-1}{(4x-5)^2}$ (d) None

Expert — Differentiation

97. Differentiate with respect to x:

(a) $y=\sin\left(\sqrt{\sin x+\cos x}\right)$

(b) If $y=\log\frac{1+\sqrt{x}}{1-\sqrt{x}}$

98. $\frac{d}{dx}\left[\log\left\{e^x\left(\frac{x-2}{x+2}\right)^{3/4}\right\}\right]$ equals to

(a) 1 (b) $\frac{x^2+1}{x^2-4}$

(c) $\frac{x^2-1}{x^2-4}$ (d) $e^x\frac{x^2-1}{x^2-4}$

Beginner — Implicit Differentiation

99. Find $\frac{dy}{dx}$ for $x^2 + y^3 = 3$

100. Find $\frac{dy}{dx}$ for $x^2 + y^2 = 2$

101. Find $\frac{dy}{dx}$ for $2y^3 + 4x^2 - y = x^6$

102. Find $\frac{dy}{dx}$ for $7y^2 + \sin(3x) = 12 - y^4$

103. Find $\frac{dy}{dx}$ for $e^x - \sin(y) = x$

104. Find y' for xy = 1

105. Find y′ for each of the following.

(a) $x^3y^5 + 3x = 8y^3 + 1$

(b) $x^2 \tan(y) + y^{10} \sec(x) = 2x$

(c) $e^{2x + 3y} = x^2 - 1n(xy^3)$

Expert — Implicit Differentiation

106. If $x=\exp\left\{\tan^{-1}\left(\frac{y-x^2}{x^2}\right)\right\}$ then $\frac{dy}{dx}$ equals

(a) $2x\left[1+\tan(\log x)\right]+x\sec^2(\log x)$

(b) $x\left[1+\tan(\log x)\right]+\sec^2(\log x)$

(c) $2x\left[1+\tan(\log x)\right]+x^2\sec^2(\log x)$

(d) $2x\left[1+\tan(\log x)\right]+\sec^2(\log x)$

Beginner — Application of Differentiation

107. The radius of a circle is increasing at the rate of 0.7 cm/s. What is the rate of increase of its circumference?

108. The sides of an equilateral triangle are changing length at the rate of 0.2 cm/s. At what rate is the area changing when the sides are 4.0 cm?

109. What is the rate of change of the surface area of a sphere when the radius of the sphere is 3 cm and the radius is increasing at 6 cm/s?

110. The radius of an air bubble is increasing at the rate of $\frac{1}{2}cm/\sec$. Determine the rate of increase in its volume when the radius is 1 cm.

111. A spherical ball of ice is melting at a rate of 10 cm^3/s. Find the rate of change of the radius when the ball has a radius of 5.0 cm.

112. A metal ring is being heated so that at any instant of time t in second, its area is given by

$A=3t^2+\frac{t}{3}+2$

What will be the rate of increase of area at t = 10 sec?

113. Find the slope of the tangent line to $g(x)=\frac{16}{x}-4\sqrt{x}$ at x = 4.

114. Find the slope of the tangent line to $f(x)=7x^4+8x^{-6}+2x$ at x = –1.

115. Find the angle of tangent drawn to the curve y = $3x^2$ – 7x + 5 at the point (1, 1) with the x-axis.

116. If the surface area of a spherical balloon is increasing at the rate of 900 cm^2/sec. then the rate of change of radius of balloon at instant when radius is 15 cm [in cm/sec]

(a) $\frac{22}{7}$ (b) 22

(c) $\frac{7}{22}$ (d) None of these

Expert **Application of Differentiation**

117. The volume of a sphere is given by $V=\frac{4}{3}\pi R^3$ where R is the radius of the sphere. The rate of change of volume with respect to R and the change in volume of the sphere as the radius is increased from 20.0 cm to 20.1 cm respectively are (Assume that the rate does not appreciably change between R = 20.0 cm to R = 20.1 cm)

(a) $4\pi R^2$, 160π cm^3 (b) $4\pi R^2$, 1600π cm^3

(c) $4\pi R^2$, 16π cm^3 (d) None of these

118. At the point (1, b) on the curve y = $2x^3$, the gradient of the curve is increasing K times as fast as x. Then K =

(a) 6 (b) 12

(c) 18 (d) 24

119. The rate of change of the surface area of a sphere of radius r when the radius is increasing at the rate of 2cm/sec is proportional to

(a) $\frac{l}{r}$ (b) $\frac{l}{r^2}$

(c) r (d) r^2

Beginner **Indefinite Integration**

120. Evaluate the indefinite integral.

$\int(6x^5-18x^2+7)dx$

121. Evaluate the indefinite integral.

$\int(40x^3+12x^2-9x+14)dx$

122. $\int(12t^7-t^2-t+3)dt$

123. $\int(10w^4+9w^3+7w)dw$

124. $\int(z^6+4z^4-z^2)dz$

125. Find the indefinite integral of a function: (Use the basic indefinite integral formulas and rules)

(a) $\int\left(3x^2-6x+3\right)dx$

(b) $\int\left(8x^3-x^2+5x-1\right)dx$

(c) $\int\left(x^5+\frac{1}{4}x^4+\frac{1}{3}x^3\right)dx$

(d) $\int\left(-\frac{x^4}{2}-\frac{x^3}{3}-\frac{x^2}{6}\right)dx$

(e) $\int\left(2x-6\right)^3dx$

(f) $\int\left(\left(\sqrt{x}-5\right)^2-x\right)^2dx$

(g) $\int\left(x^{10}-x^8+x^6-x^4\right)dx$

(h) $\int\left(x^{-5}+x^{-3}+x^{-1}\right)dx$

(i) $\int\left(\frac{16}{x^5}-\frac{9}{x^4}+\frac{4}{x^3}\right)dx$

126. $\int\frac{3x^3-2\sqrt{x}}{x}dx=$

(a) $x^3-\sqrt{x}+c$ (b) $x^3+\sqrt{x}+c$

(c) $x^3-2\sqrt{x}+c$ (d) $x^3-4\sqrt{x}+c$

127. $\int\left(2\sin x+\frac{1}{x}\right)dx$ is equal to

(a) $-2\cos x+\log x+C$

(b) $2\cos x+\log x+C$

(c) $-2\sin x-\frac{1}{x^2}+C$

(d) $-2\cos x+\frac{1}{x^2}+C$

128. $\int \frac{(1+x)^3}{\sqrt{x}} dx$ equals

(a) $\frac{2}{7}x^{7/2}+\frac{6}{5}x^{5/2}+2x^{3/2}+2x^{1/2}+c$

(b) $\frac{2}{5}x^{7/2}+2x^{5/2}+6x^{3/2}+2x^{1/2}+c$

(c) $\frac{2}{7}x^{7/2}-\frac{6}{5}x^{5/2}+2x^{3/2}-2x^{1/2}+c$

(d) None of these

129. $\int (\sec x+\tan x)^2 dx=$

(a) $2(\sec x+\tan x)-x+c$

(b) $\frac{1}{3}(\sec x+\tan x)^3+c$

(c) $\sec x(\sec x+\tan x)+c$

(d) $2(\sec x+\tan x)+c$

130. $\int \frac{\sin x+\cos x}{\sqrt{1+\sin 2x}}dx=$

(a) $\sin x+c$ (b) $\cos x+c$

(c) $x+c$ (d) x^2+c

131. $\int \frac{1+\cos^2 x}{\sin^2 x}dx=$

(a) $-\cot x-2x+c$

(b) $-2\cot x-2x+c$

(c) $-2\cot x-x+c$

(d) $-2\cot x+x+c$

Expert **Indefinite Integration**

132. (a) $\int\left(\sqrt{x}+\sqrt[5]{x}+\sqrt[9]{x}\right)dx$

(b) $\int\left(\sqrt[5]{x^7}-\sqrt[4]{x^8}+\sqrt[3]{x^9}\right)dx$

(c) $\int\left(\frac{1}{\sqrt[3]{3x^8}}-\frac{1}{\sqrt[7]{3x^5}}\right)dx$

(d) $\int\left(\frac{\sqrt[3]{4x}}{6}+\sqrt{\frac{1}{x^4}}\right)dx$

(e) $\int\left(\sqrt{x^5}-\sqrt[5]{x^2}\right)dx$

(f) $\int\left(\sqrt[3]{x\sqrt{x}}+\sqrt[6]{x^5\sqrt{x^4}}\right)dx$

(g) $\int\sqrt{x\sqrt{x^3\sqrt{x^5\sqrt{x^7}}}}\,dx$

(h) $\int\left(1-3x+x^3\right)\sqrt[3]{x}dx$

(i) $\int\left(\sqrt[7]{\frac{1}{x^5}}+\frac{\sqrt[6]{x\sqrt{x^{-9}}}}{\sqrt{9x\sqrt{x^{10}}}}\right)dx$

Beginner **Substitution Method**

133. $\int 90x^2\sin\left(2+6x^3\right)dx$

134. $\int \sec(1-z)\tan(1-z)dz$

135. $\int \tan x dx$

136. $\int\left(7y-2y^3\right)e^{y^4-7y^2}dy$

137. $\int \frac{4w+3}{4w^2+6w-1}dw$

138. $\int(8x-12)\left(4x^2-12x\right)^4 dx$

139. $\int 3t^{-4}\left(2+4t^{-3}\right)^{-7}dt$

140. $\int(3-4w)\left(4w^2-6w+7\right)^{10}dw$

141. $\int(3\text{cosec}^2 x+2\sin 3x)\,dx=$

(a) $3\cot x+\frac{2}{3}\cos 3x+c$

(b) $-\left(3\cot x+\frac{2}{3}\cos 3x\right)+c$

(c) $3\cot x-\frac{2}{3}\cos 3x+c$

(d) None of these

142. The value of $\int \frac{1}{(x-5)^2}dx$ is

(a) $\frac{1}{x-5}+c$ (b) $-\frac{1}{x-5}+c$

(c) $\frac{2}{(x-5)^3}+c$ (d) $-2(x-5)^3+c$

143. The value of $\int \frac{x^3}{\sqrt{1+x^4}}dx$ is

(a) $(1+x^4)^{1/2}+c$

(b) $-(1+x^4)^{1/2}+c$

(c) $\frac{1}{2}(1+x^4)^{1/2}+c$

(d) $-\frac{1}{2}(1+x^4)^{1/2}+c$

144. $\int x\cos x^2\,dx$ is equal to

(a) $-\frac{1}{2}\sin^2 x + C$

(b) $\frac{1}{2}\sin^2 x + C$

(c) $-\frac{1}{2}\sin x^2 + C$

(d) $\frac{1}{2}\sin x^2 + C$

145. $\int \sin^2 x\cos x\,dx$ is equal to

(a) $\frac{\cos^2 x}{2}$ (b) $\frac{\sin^2 x}{3}$

(c) $\frac{\sin^3 x}{3}$ (d) $-\frac{\cos^2 x}{2}$

146. $\int \frac{(1+\log x)^2}{x}dx =$

(a) $(1+\log x)^3 + c$

(b) $3(1+\log x)^3 + c$

(c) $\frac{1}{3}(1+\log x)^3 + c$

(d) None of these

147. $\int xe^{x^2}dx =$

(a) $-\frac{e^{x^2}}{2} + C$ (b) $\frac{e^{x^2}}{2} + C$

(c) $\frac{e^x}{2} + C$ (d) $-\frac{e^x}{2} + C$

148. $\int e^{\cos^2 x}\sin 2x\,dx =$

(a) $e^{\cos^2 x} + c$ (b) $-e^{\cos^2 x} + c$

(c) $\frac{1}{2}e^{\cos^2 x} + c$ (d) None of these

Expert **Substitution Method**

149. $\int \frac{4w+3}{4w^2+6w-1}dw$

150. $\int\left(\cos(3t)-t^2\right)\left(\sin(3t)-t^3\right)^5 dt$

151. Find the indefinite integral of a function :
(Use the substitution method for indefinite integrals)

(a) $\int\sqrt{5+2x}dx$

(b) $\int x\left(3x^2-4\right)^5 dx$

(c) $\int \frac{1n^2 x}{x}dx$

(d) $\int \frac{3}{\sqrt{(5-2x)^3}}dx$

(e) $\int \frac{1}{x^2}\cos\frac{1}{x}dx$

(f) $\int \frac{5}{\sqrt[3]{1-6x}}dx$

Beginner **Definite Integration**

152. $\int_1^4 (\frac{8}{\sqrt{t}} - 12\sqrt{t^3})dt$

153. $\int_1^{-1}(3x+4)dx$

(a) $\frac{145}{2}$ (b) -8

(c) 0 (d) 9

154. $\int_{-5}^{-2}(7e^y + \frac{2}{y})dy$

155. $\int_0^{\pi}(\sec(z)\tan(z)-1)dz$

156. $\int_1^e \frac{1}{x}dx$ is equal to

(a) ∞ (b) 0

(c) 1 (d) log (1 + e)

157. $\int_0^{\pi/4}\tan^2 x dx =$

(a) $1-\frac{\pi}{4}$ (b) $1+\frac{\pi}{4}$

(c) $\frac{\pi}{4}-1$ (d) $a=\frac{3}{4}, b=\frac{3}{2}$

158. $\int_0^{2\pi}(\sin x + \cos x)dx =$

(a) 0 (b) 2

(c) – 2 (d) 1

159. $\int_1^3 (x-1)(x-2)(x-3)dx =$

(a) 3 (b) 2

(c) 1 (d) 0

160. $\int_2^4 (3x-2)^2 dx$ equals

(a) 102 (b) 104

(c) 100 (d) 98

Expert **Definite Integration**

161. $\int_2^1 (\frac{2y^3-6y^2}{y^2})dy$

162. $\int_{\pi}^{5\pi} [\sin(\theta)-\cos(\theta)]d\theta$

(a) $-\frac{1}{2}$ (b) 1

(c) 0 (d) $\frac{1}{2}$

163. $\int_0^{\pi/2} \sqrt{1+\sin 2x}\, dx$ equals

(a) 1

(b) 1/2

(c) 2

(d) None of these

Beginner Definite Integration with Subs. Method

164. $\int_0^1 x^2\left(1+2x^3\right)^5 dx$

165. $\int_{-1}^0 y\left(2y^2-3\right)^5 dy$

166. $\int_1^2 e^{1-x}dx$

167. $\int_1^2 \frac{1}{x}dx$

168. $\int_1^2 \frac{1}{x^3}e^{4x^{-2}}dx$

169. $\int_0^{\pi/2} \frac{\sin x}{1+\cos x}dx$

170. $\int_{-2}^0 2t^2\sqrt{1-4t^3}dt$

Expert Definite Integration with Subs. Method

171. $\int_0^{\pi/2} \cos^2\theta d\theta$

Beginner **Addition and Subtraction**

172. $\vec{A}=2\hat{i}+j$, $\vec{B}=3j-k$ and $\vec{C}=6\hat{i}-2k$.

Value of $\vec{A}-2\vec{B}+3\vec{C}$ would be

(a) $20\hat{i}+5j+4k$ (b) $20\hat{i}-5j-4k$

(c) $4\hat{i}+5j+20k$ (d) $5\hat{i}+4j+10k$

173. A body is at rest under the action of three forces, two of which are $\vec{F_1}=4\hat{i}, \vec{F_2}=6j$, the third force is

(a) $4\hat{i}+6j$ (b) $4\hat{i}-6j$

(c) $-4\hat{i}+6j$ (d) $-4\hat{i}-6j$

174. Magnitude of vector which comes on addition of two vectors, $6\hat{i}+7j$ and $3\hat{i}+4j$ is

(a) $\sqrt{136}$ (b) $\sqrt{13.2}$

(c) $\sqrt{202}$ (d) $\sqrt{160}$

175. The resultant of two vectors A and B is perpendicular to the vector A and its magnitude is equal to half the magnitude of vector B. The angle between A and B is

(a) 120° (b) 150°

(c)135° (d) None

176. Which of the following sets of forces cannot have a vector sum of zero?

(a) 5, 5 and 5 N (b) 5, 5 and 10 N

(c) 5, 10 and 10 N (d) 5, 10 and 20 N

177. The maximum and minimum resultant of two forces are in ratio 5 : 3, then the ratio of the forces is

(a) 10 : 6 (b) 3 : 5

(c) 4 : 1 (d) 5 : 3

178. Find the maximum and minimum magnitude of the resultant of two forces 16 N and 4 N.

179. If $\vec{P}=6\hat{i}+8j$ and $\vec{Q}=4\hat{i}-3j$ then calculate the following:

(a) $|\vec{P}|$ (b) $|\vec{Q}|$

(c) $|\vec{P}+\vec{Q}|$ (d) $|\vec{P}-\vec{Q}|$

180. If $\vec{a}+\vec{b}=\vec{c}$ and a + b = c. What is the angle between $\vec{a}$ and $\vec{b}$.

Expert **Addition and Subtraction**

181. The magnitude of vector $\vec{A},\vec{B}$ and $\vec{C}$ are respectively 12, 5 and 13 units and $\vec{A}+\vec{B}=\vec{C}$ then the angle between $\vec{A}$ and $\vec{B}$ is

(a) 0 (b) π

(c) π/2 (d) π/4

182. Maximum and minimum magnitudes of the resultant of two vectors of magnitudes P and Q are in the ratio 3:1. Which of the following relations is true?

(a) P = 2Q (b) P = Q
(c) PQ = 1 (d) None

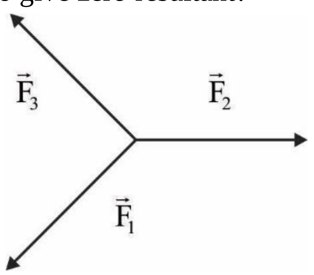
183. The three vectors
$\vec{A} = 3\hat{i} - 2j + k, \vec{B} = \hat{i} - 3j + 5k$ and
$\vec{C} = 2\hat{i} + j - 4k$ form
(a) An equilateral triangle
(b) Isosceles triangle
(c) A right angled triangle
(d) No triangle

184. Two vectors $\vec{A}$ and $\vec{B}$ lie in a plane, another vector $\vec{C}$ lies outside this plane, then the resultant of these three vectors i.e., $\vec{A}+\vec{B}+\vec{C}$
(a) Can be zero
(b) Cannot be zero
(c) Lies in the plane containing $\vec{A}+\vec{B}$
(d) Lies in the plane containing $\vec{C}$

185. If the resultant of the two forces has a magnitude smaller than the magnitude of larger force, the two forces must be
(a) Different both in magnitude and direction
(b) Mutually perpendicular to one another
(c)Possess extremely small magnitude
(d) Point in opposite directions

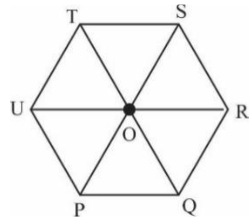
186. Let the angle between two non zero vectors $\vec{A}$ and $\vec{B}$ be 120° and resultant be $\vec{C}$
(a) $\vec{C}$ must be equal to $|\vec{A}-\vec{B}|$
(b) $\vec{C}$ must be less than $|\vec{A}-\vec{B}|$
(c) $\vec{C}$ must be greater than $|\vec{A}-\vec{B}|$
(d) $\vec{C}$ may be equal to $|\vec{A}-\vec{B}|$

187. How many minimum numbers of coplanar vectors having different magnitudes can be added to give zero resultant?



(a) 2 (b) 3
(c) 4 (d) 5

188. Figure shows regular hexagon PQRSTU. Find the value of $\overrightarrow{PQ}+\overrightarrow{PR}+\overrightarrow{PS}+\overrightarrow{PT}+\overrightarrow{PU}$



(a) $\overrightarrow{PO}$ (b) $2\overrightarrow{PO}$
(c) $4\overrightarrow{PO}$ (d) $6\overrightarrow{PO}$

189. Find the angle between the vectors $\vec{A}$ and $\vec{B}$ if $|\vec{A}+\vec{B}| = |\vec{A}-\vec{B}|$

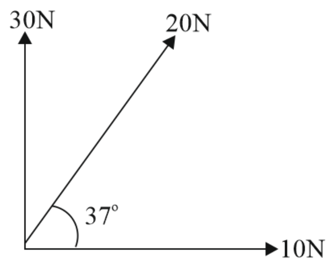
190. The algebraic sum of modulus of two vectors acting at a point is 20 N. The resultant of these two vectors is perpendicular to the smaller vector and has magnitude of 10 N. If the smaller vector is of magnitude b, then the value of b is
(a) 5 N (b) 20 N
(c) 7.5 N (d) none

Beginner **Resolution of a Vector**

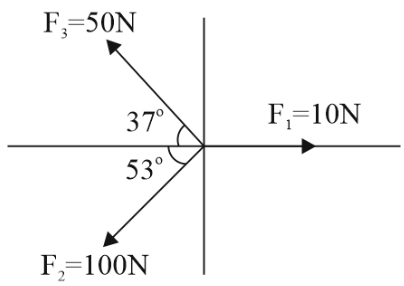
191. A force of 5 N acts on a particle along a direction making an angle of 60° with vertical. Its vertical component will be
(a) 10 N (b) 3 N
(c) 4 N (d) 2.5 N

192. A force of 24 N acts on a particle along a direction making an angle of 37° with horizontal. Its vertical component be
(a) 10 N (b) 3 N
(c) 4 N (d) None

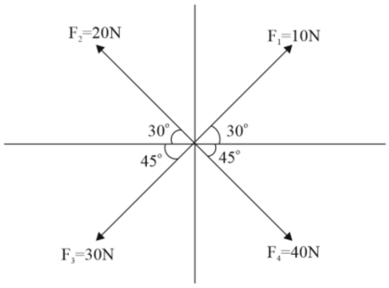
193. Find the result force in rector from.



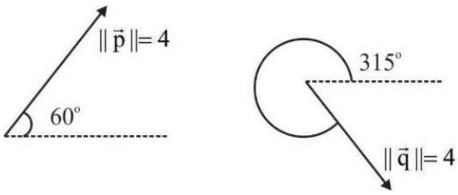
194. Find the resultant force in rector from.



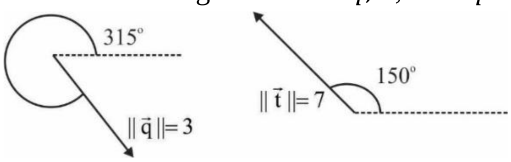
195. Find the resultant vector.



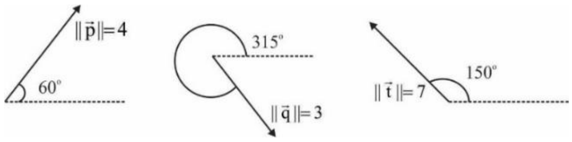
196. Given the following vectors for $\vec{p}, \vec{q}$, Find $\vec{p}+\vec{q}$



197. Given the following vectors for $\vec{q}, \vec{t}$, Find $\vec{q}+\vec{t}$



198. Given the following vectors for $\vec{p}, \vec{q}, \vec{t}$, Find $\vec{p}+\vec{q}+\vec{t}$



Beginner Magnitude & Direction of a Vector

199. If $\vec{A}=4\hat{i}-3j$ and $\vec{B}=6\hat{i}+8j$ then magnitude and direction of $\vec{A}+\vec{B}$ will be

(a) $5, \tan^{-1}\left(\frac{3}{4}\right)$

(b) $5\sqrt{5}, \tan^{-1}\left(\frac{1}{2}\right)$

(c) $10, \tan^{-1}(5)$

(d) $25, \tan^{-1}\left(\frac{3}{4}\right)$

200. Calculate the magnitude and direction of vector u given by its components as u = < - 7 $\sqrt{3}$, 7>

201. Calculate the magnitude and direction of vector v given by its components as v = < - 5, - 5 $\sqrt{3}$ >

202. Calculate and compare the magnitude and direction of the vector u and 3 u with u given by u = < 4 , 1 >

203. Find the magnitude of the vector $\overrightarrow{PQ}$ whose initial point *P* is at (1, 1) and end point is at Q is at (5, 3).

204. Find the direction of the vector $\overrightarrow{PQ}$ whose initial point *P* is at (2,3) and end point is Q is at (5,8).

205. Find the magnitude and direction of the vector with initial point *P*(-8, 1) and terminal point *Q*(-2, -5).

206. Find the magnitude and direction of following vectors:

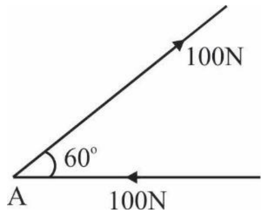
(a) $\vec{A}=\left(\frac{1}{\sqrt{2}}\hat{i}+\frac{1}{\sqrt{2}}j\right)$ (b) $\vec{A}=2\vec{i}+3\vec{j}$

(c) $\vec{A}=5\hat{i}-12j$ (d) $\vec{A}=4\hat{i}-6j$

(e) $\vec{A}=4\hat{i}+6j$ (f) $\vec{A}=-4\hat{i}-6j$

Expert Magnitude & Direction of a Vector

207. In the below figure two numerically equal forces are acting at a point A. Find the magnitude of the resultant forces.



Beginner Unit Vector

208. If a unit vector is represented by $0.5\hat{i}+0.8j+ck$, then the value of 'c' is

(a) 1 (b) $\sqrt{0.11}$

(c) $\sqrt{0.01}$ (d) $\sqrt{0.39}$

209. Unit vector parallel to the resultant of vectors $\vec{A}=4\hat{i}-3j$ and $\vec{B}=8\hat{i}+8j$ will be

(a) $\frac{24\hat{i}+5j}{13}$ (b) $\frac{12\hat{i}+5j}{13}$

(c) $\frac{6\hat{i}+5j}{13}$ (d) None of these

210. The unit vector along $\hat{i}+j$ is

(a) k (b) $\hat{i}+j$

(c) $\frac{\hat{i}+j}{\sqrt{2}}$ (d) $\frac{\hat{i}+j}{2}$

211. Find the vector of magnitude 3 units which is parallel to $= 4\hat{\imath} + 3\hat{\jmath}$.

(a) $2/5\left(4\hat{i}+3j\right)$ (b) $3/5\left(5\hat{i}+3j\right)$

(c) $7/5\left(4\hat{i}+3j\right)$ (d) $3/5\left(4\hat{i}+3j\right)$

212. The unit vector parallel to the resultant of the vectors $\vec{A}=4\hat{i}+3j+6k$ and $\vec{B}=-\hat{i}+3j-8k$ is

(a) $\frac{1}{7}\left(3\hat{i}+6j-2k\right)$

(b) $\frac{1}{7}\left(3\hat{i}+6j+2k\right)$

(c) $\frac{1}{49}\left(3\hat{i}+6j-2k\right)$

(d) $\frac{1}{49}\left(3\hat{i}-6j+2k\right)$

213. If $A=3\hat{i}+4j$ and $B=7\hat{i}+24j$ the vector having the same magnitude as B and parallel to A is

(a) $5\hat{i}+20j$ (b) $15\hat{i}+10j$

(c) $20\hat{i}+15j$ (d) $15\hat{i}+20j$

214. If $\bar{a}=3\hat{i}+4j$ and $\bar{b}=7\hat{i}+24j$ the vector having the same magnitude as B parallel to A is

(a) $15\hat{i}+20j$ (b) $20\hat{i}-15j$

(c) $6\hat{i}+8j$ (d) $10\hat{i}+8j$

Expert **Unit Vector**

215. If the sum of two-unit vectors is a unit vector, then magnitude of difference is

(a) $\sqrt{2}$ (b) $\sqrt{3}$

(c) $1/\sqrt{2}$ (d) $\sqrt{5}$

Beginner **Dot Product**

216. A force $\vec{F}=\left(5\hat{i}+3j\right)$ Newton is applied over a particle which displaces it from its origin to the point $\vec{r}=\left(2\hat{i}-1j\right)$ meters. The work done on the particle is (Given $W=\vec{F}\cdot\vec{r}$)

(a) – 7 J (b) +13 J

(c) +7 J (d) +11 J

217. A particle moves with a velocity $6\hat{i}-4j+3k\,m/s$ under the influence of a constant force $\vec{F}=20\hat{i}+15j-5k$ N. The instantaneous power applied to the particle is (Given $P=\vec{F}\cdot\vec{v}$)

(a) 35 J/s (b) 45 J/s

(c) 25 J/s (d) 195 J/s

218. The angle between the vectors $\hat{i}+j$ and $j+k$ is

(a) 30° (b) 45°

(c) 60° (d) 90°

219. The angle between the two vectors $\vec{A}=5\hat{i}+5j$ and $\vec{B}=5\hat{i}-5j$ will be

(a) Zero (b) 45°

(c) 90° (d) 180°

220. The angle between two vectors given by $6\bar{i}+6\bar{j}-3\bar{k}$ and $7\bar{i}+4\bar{j}+4\bar{k}$ is

(a) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$ (b) $\cos^{-1}\left(\frac{5}{\sqrt{3}}\right)$

(c) $\sin^{-1}\left(\frac{2}{\sqrt{3}}\right)$ (d) $\sin^{-1}\left(\frac{\sqrt{5}}{3}\right)$

221. Given vector $\vec{A}=2\hat{i}+3j$, the angle between $\vec{A}$ and y-axis is

(a) $\tan^{-1}3/2$ (b) $\tan^{-1}2/3$

(c) $\sin^{-1}2/3$ (d) $\cos^{-1}2/3$

222. The angle made by the vector $A=\hat{i}+j$ with x-

axis is

(a) 90° (b) 45°

(c) 22.5° (d) 30°

223. The vector $\vec{P}=a\hat{i}+aj+3k$ and $\vec{Q}=a\hat{i}-2j-k$ are perpendicular to each other. The positive value of a is

(a) 3 (b) 4
(c) 9 (d) 13

224. $\vec{A} = 5\hat{i} + 7j - 3k$ and $\vec{B} = 2\hat{i} + 2j - ck$ are perpendicular vectors, then value of c is
(a) -2 (b) 8
(c) -7 (d) -8

225. The vectors $2\hat{\imath} + 3\hat{\jmath} - 4\hat{k}$ and $a\hat{\imath} + b\hat{\jmath} + c\hat{k}$ are perpendicular if
(a) a = 3, b = 3, c = -4
(b) a = 4, b = 4, c = 5
(c) a = 2, b = 4, c = -6
(d) None of these

226. Find the angle between $\vec{F} = 2\hat{i} - 4j$ and $\vec{F} = 4\hat{i} + 2j$

Expert — **Dot Product**

227. If $\vec{P} \cdot \vec{Q} = PQ$ then angle between $\vec{P}$ and $\vec{Q}$ is
(a) 0° (b) 30°
(c) 45° (d) 60°

228. If for two vectors $\vec{A}$ and $\vec{B}$, sum $(\vec{A} + \vec{B})$ is perpendicular to the difference $(\vec{A} - \vec{B})$. The ratio of their magnitude is
(a) 1 (b) 2
(c) 3 (d) None of these

229. The magnitude of vector product is $\sqrt{3}$ times the magnitude of scalar product, then angle between the two vectors is
(a) π/2 (b) π/6
(c) π/3 (d) π/4

230. Find the value(s) of x for which the angle between the vectors $\vec{a} = x\hat{i} - 3j - k$ and $\vec{b} = 2x\hat{i} + xj - k$ is obtuse.

Beginner — **Cross Product**

231. The torque of the force $\vec{F} = (2\hat{i} - 3j + 4k)N$ acting at the point $\vec{r} = (3\hat{i} + 2j + 3k)$ m about the origin be (Given T=r x F)
(a) $6\hat{i} - 6j + 12k$ (b) $17\hat{i} - 6j - 13k$
(c) $-6\hat{i} + 6j - 12k$ (d $-17\hat{i} + 6j + 13k$

232. $\hat{i} \times (j \times k)$ is
(a) $\hat{i} + j + k$ (b) $\hat{i} + j + k$
(c) Zero vector (d) Unit vector

233. If $\vec{A} = 3\hat{i} + j + 2k$ and $\vec{B} = 2\hat{i} - 2j + 4k$, then value of $|\vec{A} \times \vec{B}|$ will be
(a) $8\sqrt{2}$ (b) $8\sqrt{3}$
(c) $8\sqrt{5}$ (d) $5\sqrt{8}$

234. The sine of the angle between the two vectors 3i + 2j - k and 12i + 5j - 5k is
(a) $\frac{\sqrt{115}}{\sqrt{14}\sqrt{194}}$ (b) $\frac{\sqrt{151}}{\sqrt{14}\sqrt{190}}$
(c) $\frac{\sqrt{161}}{\sqrt{14}\sqrt{196}}$ (d) None

235. If $\vec{A} = 3\hat{i} + j + 2k$ and $\vec{B} = 2\hat{i} - 2j + 4k$ then value of $|\vec{A} \times \vec{B}|$ will be

236. If $\vec{A} = 4\hat{i} - 3j$ and $\vec{B} = 6\hat{i} + 8j$ then magnitude and direction of $\vec{A} \times \vec{B}$ will be?

237. If two vectors $2\hat{i} + 3j - k$ and $-4\hat{i} - 6j - \lambda k$ are parallel to each other then value of λ will be?

Expert — **Cross Product**

238. The area of the parallelogram represented by the vectors $\vec{A} = 2\hat{i} + 3j$ and $\vec{B} = \hat{i} + 4j$ is
(a) 14 units (b)7.5 units
(c)10 units (d) 5 units

239. Which of the following expression is/are equal to zero
(a) $\vec{A} \times \vec{A}$ (b) $\vec{A}.\vec{A} \times \vec{B}$
(c) $\vec{B} \times [\vec{A} \times (\vec{A} \times \vec{B})]$ (d) $\hat{i} \times (j \times k)$

Beginner — **Direction Cosine**

240. Vector $\vec{A}$ makes equal angles with x, y and z axes. Value of its components (in terms of magnitude of $\vec{A}$) will be
(a) $\frac{A}{\sqrt{3}}$ (b) $\frac{A}{\sqrt{2}}$

(c) $\sqrt{3}A$ (d) $\frac{\sqrt{3}}{A}$

241. If $\vec{A}=2\hat{i}+4j-5k$ the direction of cosines of the vector $\vec{A}$ are

(a) $\frac{2}{\sqrt{45}},\frac{4}{\sqrt{45}}$ and $\frac{-5}{\sqrt{45}}$

(b) $\frac{1}{\sqrt{45}},\frac{2}{\sqrt{45}}$ and $\frac{3}{\sqrt{45}}$

(c) $\frac{4}{\sqrt{45}},0$ and $\frac{4}{\sqrt{45}}$

(d) $\frac{3}{\sqrt{45}},\frac{2}{\sqrt{45}}$ and $\frac{5}{\sqrt{45}}$

Expert **Direction Cosine**

242. A triangle is formed by joining the points (1, 0, 0), (0, 1, 0) and (0, 0, 1). Find the direction cosines of the medians.

243. In an upcoming episode of a crime drama, a swarm of special-effect insects bothers one of the investigators after the discovery of a murder victim in a drainage ditch. The animator uses position vectors to track the positions of the virtual pests with respect to an origin at the investigator's head. One such insect is located at a point 33 cm in front, 52 cm to the left, and 18 cm below the tip of the investigator's nose. What are the directional cosines for this insect?

244. Determine the position vector for a small plane at the moment it is 2.5 km east, 8.8 km south, and 4.1 km above its home airport. Use a coordinate system where the x-direction corresponds to east, the y-direction to north, and the z-direction to the zenith. Then determine the directional cosines used by the air-traffic control personnel to identify the plane's location.

Beginner **Dimension Analysis**

245. Find the dimension of the following physical quantities:

(a) Force
(b) Charge
(c) Impulse
(d) Latent Heat
(e) Universal Gas Constant
(f) Resistance
(g) Magnetic Field
(h) Electric Flux

246. The SI unit of surface tension is

(a) Dyne/cm (b) Newton/cm
(c) Newton/meter (d) Newton-meter

247. The SI unit of universal gas constant (R) is

(a) Watt K^{-1} mol^{-1}
(b) Newton K^{-1} mol^{-1}
(c) Joule K^{-1} mol^{-1}
(d) Erg K^{-1} mol^{-1}

248. The unit of permittivity of free space ε_0 is

(a) Coulomb/Newton-meter

(b) $\frac{Newton-metre^2}{Columb^2}$

(c) $\frac{Columb^2}{(Newton-metre)^2}$

(d) $\frac{Columb^2}{Newton-metre^2}$

249. What are the units of $\frac{1}{4\pi\varepsilon_0}$

(a) $C^2N^{-1}m^{-2}$ (b) Nm^2C^{-2}
(c) Nm^2C^2 (d) Unitless

250. The physical quantities not having same dimensions are

(a) Speed and $(\mu_0\varepsilon_0)^{-\frac{1}{2}}$
(b) Torque and work
(c) Momentum and Planck's constant
(d) Stress and Young's modules

251. The dimensional formula of relative density is

(a) ML^{-3} (b) LT^{-1}
(c) MLT^{-2} (d) Dimensionless

252. Pressure gradient has the same dimension as that of

(a) Velocity gradient
(b) Potential gradient
(c) Energy gradient
(d) None of these

253. Which of the following groups have different dimensions?

(a) Potential difference, EMF, voltage
(b) Pressure, stress, young's modulus
(c) Heat, energy, work-done
(d) Dipole moment, electric flux, electric field

254. Which of the following quantities is dimensionless?
(a) Gravitational constant
(b) Planck's constant
(c) Power of a convex lens
(d) None

255. Identify the pair whose dimensions are equal
(a) torque and work
(b) stress and energy
(c) force and stress
(d) force and work

256. Dimension of $\frac{1}{\mu_0\varepsilon_0}$, where symbols have their usual meaning are
(a) $\left[L^{-1}T\right]$ (b) $\left[L^{-2}T^{2}\right]$
(c) L^2T^{-2} (d) LT^{-1}

257. The physical quantities not having same dimensions are
(a) torque and work
(b) momentum and plank's constant
(c) stress and young's modulus
(d) speed and $\left(\mu_0\varepsilon_0\right)^{-\frac{1}{2}}$

258. Which one of the following represents the correct dimensions of the coefficient of viscosity?
(a) $ML^{-1}T^{-1}$ (b) MLT^{-1}
(c) $ML^{-1}T^{-2}$ (d) $ML^{-2}T^{-2}$

259. Out of the following pair, which one does NOT have identical dimensions?
(a) impulse and momentum
(b) angular momentum and Plank's constant
(c) work and torque
(d) moment of inertia and moment of a force
(towards north-west)

260. Linear momentum is given by:
$\vec{\rho} = At^2 + Bt + C$, Find out the dimension of A, B & C.

261. In $S = a + bt + ct^2$. S is measured in meters and t in seconds. The unit of c is
(a) None
(b) m
(c) ms^{-1}
(d) ms^{-2}

262. The velocity υ of water waves may depend on their wavelength λ density of water ρ and the acceleration due to gravity g. Find relation between these quantities by the method of dimension?

263. Find out the dimension of a, b, where v is velocity, t = time, Equation is v=a + bt

264. Power $\left(p\right) = \frac{\alpha}{\beta} e^{\frac{-2\alpha}{nRQ}}$, where α is distance, *n* is no. of moles, R is universal gas constant, Q = Temperature. Find out the dimension of β.

265. The velocity v(in cm/sec) of a particle is given in terms of time t (in sec) by the relation $v = at + \frac{b}{t+c}$; the dimensions of a, b and c are
(a) a = L^2, b = T, c = LT^2
(b) a = LT^2, b = LT, c = L
(c) a = LT^{-2}, b = L, c = T
(d) a = L, b = LT, c = T^2

266. The equation of state of some gases can be expressed as $\left(P + \frac{a}{V^2}\right) = \frac{R\theta}{V}$; where P is the pressure, V the volume, θ the absolute temperature and a and b are constants. The dimensional formula of a is
(a) $\left[ML^5T^{-2}\right]$ (b) $\left[M^{-1}L^5T^{-2}\right]$
(c) $\left[ML^{-1}T^{-2}\right]$ (d) $\left[ML^{-5}T^{-2}\right]$

267. The dimensions of $\frac{a}{b}$ in the equation $p = \frac{a - t^2}{bx}$ where P is pressure, x is distance and t is time, are
(a) $[MT^{-2}]$ (b) $\left[M^2LT^{-3}\right]$
(c) $\left[ML^3T^{-1}\right]$ (d) $\left[LT^{-3}\right]$

268. The air bubble formed by explosion inside water perform oscillations with time period T which depends on pressure (*p*), density (*d*) and on energy due to explosion (E). Establish relation between T, *p*, *E* and *d*.

269. The velocity of a sound v depends on its young's modulus (Y) density (τ). Obtain a relationship between v, τ, Y.

270. A dimensionally consistent relation for the volume V of a liquid of coefficient of viscosity η flowing per second through a tube of radius r and length l and having a pressure difference p across its ends, is

(a) $V=\frac{\pi pr^4}{8\eta l}$ (b) $V=\frac{\pi\eta l}{8pr^4}$

(c) $V=\frac{8p\eta l}{\pi pr^4}$ (d) $V=\frac{\pi p\eta}{8lr^4}$

271. A force *F* is given by $F=at+bt^2$, where t is time. What are the dimensions of a and b?

272. A gas bubble, from an explosion under water, oscillates with a period T proportional to $p^a d^b E^c$ where 'p' is the static pressure, 'd' is the density of water and 'E' is the total energy explosion. Find the values of a, b, c.

Expert	**Dimension Analysis**

273. If the dimensions of length are expressed as $G^x c^y h$ where G, c and h are the universal gravitational constant, speed of light and Planck's constant respectively, then

(a) $x=\frac{1}{2}, y=\frac{1}{2}$ (b) $x=\frac{1}{2}, z=\frac{1}{2}$

(c) $y=\frac{1}{2}, z=\frac{3}{2}$ (d) $x=-\frac{3}{2}, z=\frac{1}{2}$

274. If the constant of gravitation (G) , Planck's constant (h) and the velocity of light (c) be chosen as fundamental units. The dimension of the radius of gyration is

(a) $h^{1/2}c^{-3/2}G^{1/2}$ (b) $h^{1/2}c^{3/2}G^{1/2}$

(c) $h^{1/2}c^{-3/2}G^{-1/2}$ (d) $h^{-1/2}c^{-3/2}G^{1/2}$

275. If force (F), length (L) and time (T) are assumed to be fundamental units, then the dimensional formula of the mass will be

(a) FL–1T2 (b) $FL^{-1}T^{-2}$

(c) $FL^{-1}T^{-1}$ (d) FL^2T^2

276. Density of a liquid in CGS system is 0.625. What is its magnitude in SI SYSTEM?

(a) 0.625 (b) 0.0625

(c) 0.00625 (d) 625

277. A calorie is a unit of heat or energy and it equals about 4.2 J where 1J = 1 kg $m^2\ s^{-2}$. Suppose we employ a system of units in which the unit of mass equals α kg, the unit of length equals β m, the unit of time is γ s. Show that a calorie has a magnitude 4.2 $\alpha^{-1}\ \beta^{-2}\ \gamma^2$ in terms of the new units.

278. A book with many printing errors contains four different formulas for the displacement y of a particle undergoing a certain periodic motion:

$y = asin(\frac{2\pi t}{T})$

$y = a\ sin\ vt$

$y = (a\sqrt{2})(sin\frac{2\pi t}{T} + cos\frac{2\pi t}{T})$

a = maximum displacement of the particle, v = speed of the particle. T = time-period of motion). Rule out the wrong formulas on dimensional grounds.

279. To find the distance d over which a signal can be seen clearly in foggy conditions, the railways –engineer uses dimensions and assume that the distance depends on the mass density ρ of the fog, intensity (power/area) S of the light from the signal and its frequency f. The engineer finds d is proportional to $S^{1/n}$.the value of n is

280. Some time it is convenient to construct a system of units so that all quantities can be expressed in terms of only one physical quantity. In one such system, dimensions of different quantities are given in terms of a quantity X as follows. [position] = [X^α]; [speed] = [X^β]; [acceleration] = [X^p]; [linear momentum] = [X^q]; [force] = [X^r]. Then

(a) α +p = 2β (b) p+q - r = β

(c) p – q + r = α (d) p + q + r =β

281. The angle of 1'(minute of arc) in radian is nearly equal to

(a) 2.91×10^{-4} rad (b) 4.85×10^{-4} rad

(c) 4.80×10^{-6} rad (d) 1.75×10^{-2} rad

282. A physical quantity of the dimensions of length that can be formed out of c, G and $\frac{e^2}{4\pi\varepsilon_0}$ is [c is velocity of light, G is universal constant of gravitation and e is charge]

(a) $\frac{1}{c^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

(b) $c^2\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$

(c) $\frac{1}{c^2}\left[\frac{e^2}{G4\pi\varepsilon_0}\right]^{1/2}$

(d) $\frac{1}{c}G\frac{e^2}{4\pi\varepsilon_0}$

Beginner **Error Analysis**

283. The value of a particular length is 4.283. Three instruments A, B & C measure readings: 4.1 cm, 4.24 cm & 4.093 cm. Arrange these readings in increasing order of Accuracy & Precision.

284. The length of rod in an experiment is measured as: 2.48 cm, 2.46 cm, 4.49 cm, 2.49 cm & 2.46 cm. Find out

(a) Average Length

(b) Absolute error in each experiment

(c) Mean Absolute error

(d) % Error

285. The period of oscillation of a simple pendulum in the experiment is recorded as 2.63 s, 2.56 s, 2.42 s, 2.71 s and 2.80 s respectively. The average absolute error is

(a) 0.1 s (b) 0.11 s

(c) 0.01 s (d) 1.0 s

286. A physical quantity X is connected from $X=\frac{ab^2}{c}$. Calculate the percentage error in X, when % error in a, b, c are 4%, 2%, and 3% respectively.

287. According to Joule's law of heating, heat produced H = I^2Rt, where I is current, R is resistance and it is time. If the errors in the measurement of I, R and t are 3%, 4% and 6% respectively then error in the measurement of H is

(a) ±17% (b) ±16%

(c) ±19% (d) ±25%

288. A physical quantity A is related to four observables a, b, c and d as follows, $A=\frac{a^2b^3}{c\sqrt{d}}$, the percentage errors of measurement in a, b, c and d are 1%,3%,2% and 2% respectively. What is the percentage error in the quantity A?

(a) 12% (b) 7%

(c) 5% (d) 14%

289. The percentage errors in the measurement of mass and speed are 2% and 3% respectively. How much will be the maximum error in the estimation of the kinetic energy obtained by measuring mass and speed?

(a) 11% (b) 8%

(c) 5% (d) 1%

290. Error in the measurement of radius of a sphere is 1%. The error in the calculated value of its volume is

(a) 1% (b) 3%

(c) 5% (d) 7%

291. If L = 2.331 cm, B = 2.1 cm, then L+B =

(a) 4.431 cm (b) 4.43 cm

(c) 4.4 cm (d) 4 cm

292. Find the relative error in Z, if $Z=\frac{A^4B^{1/3}}{CD^{3/2}}$, where % error in the measurements of A, B, C & D are 0.4%, 0.2%, 0.3% & 0.1%.

293. If x = 10.0 ± 0.1, y = 10.0 ± 0.1 , then 2x-2y is equal to:

(a) 0.0 ± 0.1 (b) 0.0 ± 0.2

(c) 0.0 ± 0.4 (d) Zero

294. The radius of a spherical ball is 10.4 ± 0.4 cm. Find out the percentage error in the radius and volume.

295. The resistance $R=\frac{V}{i}$ where V= 100 ± 5 volts and i = 10 ± 0.2 amperes. What is the total error in R?

(a) 5% (b) 7%
(c) 5.2% (d) $\frac{5}{2}\%$

296. In an experiment, the following observations were recorded: L = 2.820 m, M = 3.00 kg, l = 0.087 cm, Diameter D = 0.041 cm Taking g = 9.81 m/s^2 using the formula, $Y = \frac{4MgL}{\pi D^2 l}$, the maximum permissible error in Y is
(a) 7.96% (b) 4.56%
(c) 6.50% (d) 8.42%

297. The period of oscillation of a simple pendulum is given by $T = 2\pi\sqrt{\frac{l}{g}}$; where l is about 100 cm and is known to have 1 mm accuracy. The period is about 2s. The time of 100 oscillations is measured by a stopwatch of least count 0.1 s. The percentage error in g is
(a) 0.1% (b) 1%
(c) 0.2% (d) 0.8%

298. Which of the following measurements is most precise?
(a) 5.00 mm (b) 5.00 cm
(c) 5.00 m (d) 5.00 km.

299. The mean length of an object is 5 cm. Which of the following measurements is most accurate?
(a) 4.9 cm (b) 4.805 cm
(c) 5.25 cm (d) 5.4 cm

300. Time intervals measured by a clock give the following readings 1.25 s, 1.24 s, 1.27 s, 1.21 s and 1.28 s. What is the percentage relative error of the observations?
(a) 2% (b) 4%
(c) 16% (d) 1.6%

Expert **Error Analysis**

301. If radius of the sphere is (5.3 ± 0.1) cm. Then percentage error in its volume will be
(a) $3+6.01\times\frac{100}{5.3}$ (b) $\frac{1}{3}\times0.01\times\frac{100}{5.3}$
(c) $\left(\frac{3\times0.1}{5.3}\right)\times100$ (d) $\frac{0.1}{5.3}\times\frac{100}{5.3}$

302. The pressure on a square plate is measured by measuring the force on the plate and the length of the sides of the plate. If the maximum error in the measurement of force and length are respectively 4% and 2%, The maximum error in the measurement of pressure is
(a) 1% (b) 2%
(c) 6% (d) 8%

303. While measuring the acceleration due to gravity by a simple pendulum, a student makes a positive error of 1% in the length of the pendulum and a negative error of 3% in the value of time period. His percentage error in the measurement of g by the relation $g = 4\pi^2\left(\frac{l}{T^2}\right)$ will be
(a) 2% (b) 4%
(c) 7% (d) 10%

304. A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it?
(a) A meter scale
(b) A Vernier calliper where the 10 divisions in vernier scale matches with 9 divisions in main scale and main scale has 10 divisions in 1 cm.
(c) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm.
(d) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm.

305. The period of oscillation of a simple pendulum is $T = 2\pi\sqrt{\frac{L}{g}}$. Measured value of L is 20.0 cm known to 1 mm accuracy and time for 100 oscillations of the pendulum is found to be 90 s using a wrist watch of 1s resolution. The accuracy in the determination of g is:
(a) 1% (b) 5%
(c) 2% (d) 3%

306. A person measures the depth of a well by measuring the time interval between dropping a stone and receiving the sound of impact with the bottom of the well. The error in his measurement of the time is δT 0.01seconds and he measures the depth of the well to be L = 20 meter. Take the acceleration due to gravity g = 10ms^{-2} and the velocity of sound is 300 ms^{-1} . then the fractional error in the measurements $\delta L/L$ is closest to

(a) 0.2% (b) 1%
(c) 3% (d) 5%

307. In the determination of young's Modulus $(Y = \frac{4MLg}{\pi l d^2})$ by using searl's method, a wire of length L = 2m and diameter d = 0.5mm is used. For a load M = 2.5kg, an extension l = 0.25mm in the length of the wire is observed. Quantities d and l are measured using a screw gauge and a micrometre, respectively. They have the same pitch of 0.5mm. The number of divisions on their circular scale is 100. The contributions to the maximum probable error of the Y measurement

(a) due to errors the in the measurements of d and l are the same.

(b) due to error the in the measurement of d is twice that due to error the in the measurement of l.

(c) due to error the in the measurement of l is twice that due to error the in the measurement of d.

(d) due to error the in the measurement of d is fore times that due to error the in the measurement of l.

308. The energy of a system as a function of time t is given as $E(t) = A^2 \exp(-\alpha t)$ where $\alpha = 0.2s^{-1}$. The measurement of A has an error of 1.25%. if the error in the measurement of time is 1.50%, the percentage error in the value of E(t) at t = 5s is

309. Two capacitors with capacitance value c_1 = 2000±10 pF and c_2 = 3000±15pF are connected in series. The voltage applied across this combination is V = 5.00±2.02V. the percentage error in the calculation of the energy stored in this combination of capacitors is____

310. An optical bench has 1.5m long scale having four equal divisions in each cm. While measuring the focal length of a convex lens, the lens is kept at 75 cm mark of the scale and the object pin is kept at 45 cm mark. The image of the object pin on the other side of the lens overlaps with image pin that is kept at 135cm mark. In this experiment, the percentage error in the measurement of the focal length of the lens is ----------

311. In an experiment to determine the acceleration due to gravity g, the formula used for the time period of a periodic motion is $T = 2\pi\sqrt{\frac{7(R-r)}{5g}}$. the values of R and r are measured to be (60±1)mm and (10±1)mm, respectively. In five successive measurements, the time is found to be 0.52s, 0.56s,0.57s,0.54s and 0.59s. the least count of the watch used for the measurement of time period is 0.01s. which of the following statement(s) is (are) true?

(a) the error in the measurement of r is 10%

(b) the error in the measurement of T is 3.75%

(c) the error in the measurement of T is 2%

(d) the error in the determined value of g is 11%

312. Using the expression $2d \sin\theta = \lambda$,one calculates the values of d by measuring the corresponding angles θ in the range 0 to 90°.The wavelength λ is exactly known and the error in θ is constant for all value of θ. As θ increase from 0°

(a)The absolute error in d remain constant

(b)The absolute error in d increases

(c)The fractional error in d remain constant

(d)The fractional error in d decreases

313. A student uses a simple pendulum of exactly 1 m length to determine g, The acceleration due to gravity. He uses a stopwatch with the least count of 1 sec for this and records 0.40 seconds for 20 oscillations. For this observation, which of following statement (s) is (are) true?

(a) Error ΔT in measuring T, the time period, is 0.05 seconds

(b) Error ΔT in measurig T, the time period, is 1 seconds

(c) Percentage error in the determination of g is 5%

(d) Percentage error in the determination of g is 2.5%

Beginner **Significant Figures**

314. Find out the number of significant figures in

the following numbers:
(a) 2.483 (b) 200.9
(c) 230400 (d) 308.600
(e) 0.002783 (f) 3.560×10^3
(g) 4 (h) 3600

315. State the number of significant figures in the following:
(a) $0.007\ m^2$ (b) 2.64×10^{24} kg
(c) $0.2370\ g\ cm^{-3}$ (d) 6.320 J
(e) $6.032\ N\ m^{-2}$ (f) $0.0006032\ m^2$

316. What is the number of significant figures in 0.310×10^3?
(a) 2 (b) 3
(c) 4 (d) 6

317. The respective number of significant figures for the number 23.023, 0.0003 and 2.1×10^{-3} are
(a) 5, 1, 2 (b) 5, 1, 5
(c) 5, 5, 2 (d) 4, 4, 2

318. The number of significant figures in all the given numbers 25.12, 2009, 4.156 and 1.217×10^{-4} is
(a) 1 (b) 2
(c) 3 (d) 4

319. The mass of a box measured by a grocer's balance is 2.300 kg. Two gold pieces of masses 20.15 g and 20.17 g are added to the box. What is (a) the total mass of the box, (b) the difference in the masses of the pieces to correct significant figures?

320. The length, breadth and thickness of a rectangular sheet of metal are 4.234 m, 1.005 m, and 2.01 cm respectively. Give the area and volume of the sheet to correct significant figures.

321. If the length of rod A is 3.25 ± 0.01 cm and that of B is 4.19 ± 0.01 cm then the rod B is longer than rod A by
(a) 0.94 ± 0.00 cm (b) 0.94 ± 0.01 cm
(c) 0.94 ± 0.02 cm (d) 0.94 ± 0.005 cm

322. Write the number of significant digits in
(a) 1001 (b) 100.1
(c) 100.10 (d) 0.001001

323. A body of mass m = 3.513 kg is moving along the x-axis with a speed of $5.00\ ms^{-1}$. The magnitude of its momentum is recorded as:
(a) $17.6\ kg\ ms^{-1}$ (b) $17.565\ kg\ ms^{-1}$
(c) $17.56\ kg\ ms^{-1}$ (d) $17.57\ kg\ ms^{-1}$

324. Find the value of the following operations to the correct significant figures:
(a) $\frac{4.11}{1.2} = ?$
(b) 0.307 + 0.52 + 0.4 = ?
(c) Area = L × B = 14.5 × 4.2 = ?

325. The thickness of a glass plate is measured to be 2.17 mm, 2.17 mm and 2.18 mm at three different places. Find the average thickness of the plate from this data to correct significant digits.

326. Solve with due regard to significant digits
(a) $\sqrt{6.5-6.32}$ (b) $\frac{2.91 \times 0.3842}{0.080}$

327. 5.74 g of a substance occupies a volume of 1.2 cm^3. Calculate its density with due regard for significant figures.

328. Round off the following numbers up to three significant figures:-
(a) 2.520 (b) 4.645
(c) 22.78 (d) 36.35

329. The number of significant figures in 0.06900 is
(a) 5 (b) 4
(c) 2 (d) 3

330. The sum of the numbers 436.32, 227.2 and 0.301 is approximately
(a) 663.821 (b) 664
(c) 663.8 (d) 663.82

331. A body travels uniformly a distance of (13.8 ± 0.2) m in time (4.0 ± 0.3) sec. Calculate its velocity.

332. The mass and volume of a body are 4.237 g and 2.5 cm^3, respectively. The density of the material of the body in correct significant figures is
(a) $1.6048\ g\ cm^{-3}$ (b) $1.69\ g\ cm^{-3}$
(c) $1.7\ g\ cm^{-3}$ (d) $1.695\ cm^{-3}$

333. The length and breadth of a rectangular sheet are 16.2 cm and 10.1 cm, respectively. The area of the sheet in appropriate significant figures and error is
(a) $164 \pm 3\ cm^2$ (b) $163.62 \pm 2.6\ cm^2$
(c) $163.6 \pm 2.6\ cm^2$ (d) $163.62 \pm 3\ cm^2$

334. Measure of two quantities along with the precision of respective measuring instrument is

A = 2.5 m s–1 ± 0.5 m s–1

B = 0.10 s ± 0.01 s

The value of A B will be

(a) (0.25 ± 0.08) m (b) (0.25 ± 0.5) m

(c) (0.25 ± 0.05) m (d) (0.25 ± 0.135) m

335. You measure two quantities as A = 1.0 m ± 0.2 m, B = 2.0 m ± 0.2 m. We should report correct value for $\sqrt{AB}$ as:

(a) 1.4 m ± 0.4 m (b) 1.41m ± 0.15 m

(c) 1.4m ± 0.3 m (d) 1.4m ± 0.2 m

336. The respective number of significant figures for the numbers 23.023, 0.0003 and 2.1×10^{-3} are

(a) 5, 1, 2 (b) 5, 1, 5

(c) 5, 5, 2 (d) 4, 4, 2

337. Taking into account of the significant figures, what is the value of 9.99 m – 0.0099 m?

(a) 9.98 m (b) 9.980 m

(c) 9.9 m (d) 9.9801 m

Beginner **Vernier Caliper**

338. One main scale division in Fortin's barometer is 1mm. Its 20 Vernier scale divisions coincide with 19 main scale divisions. What is the Vernier constant of the scale?

a) 0.1 cm b) 0.01 cm

c) 0.001 cm d) 0.005 cm

339. The Vernier constant of a travelling microscope is 0.001 cm. If 49 main scale divisions coincide with 50 vernier scale divisions, then the value of 1 main scale division is

a) 0.1 mm b) 0.4 mm

c) 0.5 mm d) 1mm

340. In the Vernier callipers, ten smallest divisions of the Vernier scale are equal to nine smallest divisions on the main scale. If the smallest division on the main scale is half millimetre, then the Vernier constant is:

a) 0.5mm b) 0.1mm

c) 0.05mm d) 0.005mm

341. One centimetre on the main scale of Vernier callipers is divided into ten equal parts. If 10 divisions of Vernier scale coincide with 8 small divisions of the main scale, the least count of the callipers is:

a) 0.005cm b) 0.05cm

c) 0.02 cm d) 0.01 cm

342. n divisions of Vernier scale of a Vernier callipers coincide with (n -1) divisions of main scale. What is the least count of the instrument if the length of one main scale division is 1 mm?

(a) 10n cm (b) n cm

(c)$\frac{1}{10n}$ cm (d) $\frac{1}{100n}$ cm

343. A Vernier callipers having 1 main scale division = 0.1 cm is designed to have a least count of 0.02 cm. If n be the number of divisions on Vernier scale and m be the length of Vernier scale, then

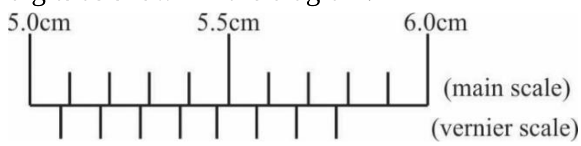
(a) n=10, m=0.5 cm

(b) n=9, m=0.4 cm

(c) n=10, m=0.8 cm

(d) n=10, m=0.2 cm

344. In the given Vernier calliper scale, the length of 1 main scale division is 1mm whereas the length of the Vernier scale is 7.65 mm. Find the reading on the scale correct to significant digits as shown in the diagram.



345. The length of cylinder is measured with the help of a Vernier callipers whose smallest division on the main scale is 0.5 mm and nine divisions of the main scale are equal to ten divisions of the Vernier scale. It is observed that 78th division of the main scale coincides with the sixth division of the Vernier scale. Find the length of the cylinder.

346. The Vernier callipers has 1mm marks on the main scale. It has 20 equal divisions on the vernier scale which match with 16 main scale divisions. For this Vernier callipers, the least count is

(a) 0.02mm (b) 0.05mm

(c) 0.1mm (d) 0.2mm

347. If nth division of main scale coincides with (n +

1)th divisions of Vernier scales. Given 1 main scale division is equal to 'a' units. Find the least count of Vernier.

348. The main scale of a Vernier caliper has n divisions/cm. n divisions of the Vernier scale coincide with (n–1) divisions of main scale. The least count of the Vernier calipers is

(a) $\frac{1}{(n+1)(n-1)}cm$ (b) $\frac{1}{n}cm$

(c) $\frac{1}{n^2}cm$ (d) $\frac{1}{n(n+1)}cm$

Expert **Vernier Caliper**

349. The main scale of a Vernier callipers reads in millimetre and its Vernier is divided into 10 divisions which coincide with 9 divisions of the main scale. When the two jaws of the instrument touch each other the seventh division of the Vernier scale coincide with a scale division and the zero of the Vernier lies to the right of the zero of main scale. Furthermore, when a cylinder is tightly placed along its length between the two jaws, the zero of the Vernier scale lies slightly to the left of 3.2 cm and the fourth Vernier division coincides with a scale division. Calculate the measured length of the cylinder.

350. In a Vernier callipers the main scale and the Vernier scale are made up different materials. When the room temperature increases by ΔT°C, it is found the reading of the instrument remains the same. Earlier it was observed that the front edge of the wooden rod placed for measurement crossed the Nth main scale division and N + 2 msd coincided with the 2nd vsd. Initially, 10 vsd coincided with 9 msd. If coefficient of linear expansion of the main scale is α_1 and that of the Vernier scale is α_2 then what is the value of α_1/α_2? (Ignore the expansion of the rod on heating)

(a) 1.8 / (N) (b) 1.8 /(N+2)

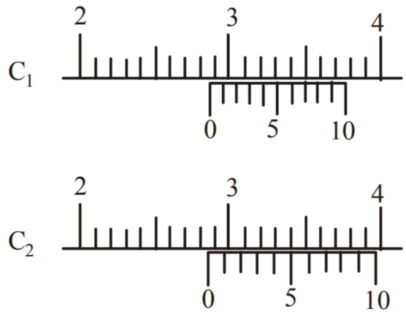
(c) 1.8 / (N–2) (d) None

351. A spectrometer gives the following reading when used to measure then angle of a prism.
Main scale reading : 58.5 degree
Vernier scale reading : 0.9 divisions
Given that 1 division on main scale corresponds to 0.5 degree. Total divisions on the Vernier scale is 30 and match with 29 divisions of the main scale. The angle of the prism from the above data:

(a) 58.59 degree (b) 58.77 degree

(c) 58.65 degree (d) 59 degree

352. There are to Vernier calliper both of which have cm divided into 10 equal division on the main scale. Vernier scale of one of the calliper into (c_1) has 10 equal division that corresponding to 9 main scale division. The Vernier scale of the other calliper (c_2) has 10 equal division that correspond to 11 main scale division . the readings of the two clippers are shown in the figure. The measured valued (in cm) by calliper c_1 and c_2,respectively,are



(a) 2.85 and 2.82 (b) 2.87 and 2.83

(c) 2.87 and 2.86 (d) 2.87 and 2.87

353. The diameter of a cylinder is measured using a Vernier calliper with no zero error. It is found that the zero of the Vernier scale lies between 5.10cm and 5.15cm of the main scale. The Vernier scale has 50 divisions equivalent to 2.45cm the 24th division of the Vernier scale exactly coincide with one of the main scale division. The diameter of the cylinder is

(a) 5.112cm (b) 5.124cm

(c) 5.126cm (d) 5.148cm

354. A steel wire of diameter 0.5mm and Young's modulus $2\times10^{11}Nm^{-2}$ carries a load of mass M. The Length of the wire with the load is 1.0m. A Vernier scale with 10 divisions is attached to end of this wire. Next To steel wire is a reference wire to which a main scale, of least count 1.0mm, is attached. The 10 divisions of the Vernier scale correspond to 9 divisions of the main scale. Initially, the zero of Vernier scale coincides with the zero of main scale. If the load on the steel wire is increased by 1.2kg,the Vernier scale division which coincides with a main scale division is _____ Take g = 10ms^{-2} and π = 3,2.

355. The side of a cube is measured by Vernier callipers (10 divisions of a Vernier scale coincide with 9 divisions of main scale, where 1division of main scale is 1 mm. The main scale reads 10mm and first division of Vernier scale coincides with the main scale. Mass of the cube is 2.736g. Find the density of the cube in appropriate significant figures.

Beginner **Screw Gauge**

356. The pitch of a screw gauge is 0.5 mm. Its head scale contains 50 divisions. The least count of the screw gauge is
(a) 0.001 mm (b) 0.01 mm
(c) 0.02 mm (d) 0.025 mm

357. A screw gauge gives the following reading when used to measure the diameter of a wire.
Main scale reading: 0 mm
Circular scale reading: 52 divisions
Given that 1 mm on main scale corresponds to 100 divisions of the circular scale. The diameter of wire from the above data is:
(a) 0.052 cm (b) 0.026 cm
(c) 0.005 cm (d) 0.52 cm

358. The pitch of a screw gauge is 0.5 mm and there are 50 divisions on the circular scale. In measuring the thickness of a metal plate, there are five divisions on the main scale and 34th division coincides with the reference line. Find the thickness of the metal plate.

359. A screw gauge gives the following reading when used to measure the diameter of a wire.
Main scale reading : 0 mm
Circular scale reading : 52 divisions
Given that 1 mm on main scale corresponds to 100 divisions of the circular scale. The diameter of wire from the above data is:
(a) 0.052 cm (b) 0.026 cm
(c) 0.005 cm (d) 0.52 cm

360. In a screw gauge, the zero of main scale coincides with fifth division of circular scale in figure (1). The circular division of screw gauge are 50. It moves 0.5 mm on main scale in one rotation. The diameter of the ball in figure (2) is

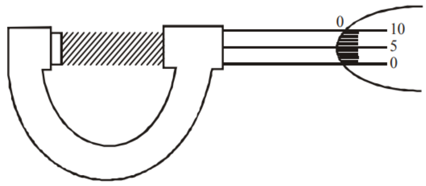


Figure (i)

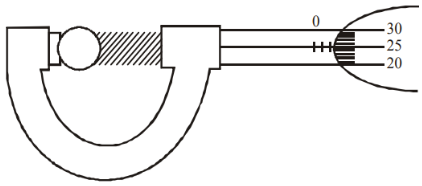


Figure (ii)

(a) 2.25mm (b) 2.20mm
(c) 1.20mm (d) 1.25mm

361. A screw gauge has least count of 0.01 mm and there are 50 divisions in its circular scale. The pitch of the screw gauge is
(a) 0.25 mm (b) 0.5 mm
(c)1.0 mm (d) 0.01 mm

362. A screw gauge gives the following readings when used to measure the diameter of a wire
Main scale reading: 0 mm
Circular scale reading : 52 divisions
Given that, 1 mm on main scale corresponds to 100 divisions on the circular scale. The diameter of the wire from the above data is
(a) 0.52 cm (b) 0.026 cm
(c) 0.26 cm (d) 0.052 cm

Expert **Screw Gauge**

363. Two full turns of the circular scale of a screw gauge cover a distance of 1mm on its main scale. The total number of divisions on the circular scale is 50. Further, it is found that the screw gauge has a zero error of -0.03 mm. While measuring the diameter of a thin wire, a student notes the main scale reading of 3 mm and the number of circular scale divisions in line with the main scale as 35. The diameter of the wire is
(a) 3.32 mm (b) 3.73 mm
(c) 3.67 mm (d) 3.38 mm

364. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of Aluminium. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the 45^{th} division coincides with the main scale line and the zero of the main scale is barely visible. What is the thickness of the sheet if the main scale reading is 0.5 mm and the 25^{th} division coincides with the main scale line?

(a) 0.70 mm (b) 0.50mm
(c) 0.75 mm (d) 0.80 mm

365. Two full turns of the circular scale of a screw gauge cover a distance of 1mm on its main scale. The total number of divisions on the circular scale is 50. Further, it is found that the screw gauge has a zero error of – 0.03 mm. While measuring the diameter of a thin wire, a student notes the main scale reading of 3 mm and the number of circular scale divisions in line with the main scale as 35. The diameter of the wire is

(a) 3.32 mm (b) 3.73 mm
(c) 3.67 mm (d) 3.38 mm

366. A screw gauge with a pitch of 0.5 mm and a circular scale with 50 divisions is used to measure the thickness of a thin sheet of Aluminium. Before starting the measurement, it is found that when the two jaws of the screw gauge are brought in contact, the 45^{th} division coincides with the main scale line and the zero of the main scale is barely visible. What is the thickness of the sheet if the main scale reading is 0.5 mm and the 25^{th} division coincides with the main scale line?

(a) 0.70 mm (b) 0.55 mm
(c) 0.75 mm (d) 0.80 mm

367. The density of a solid ball is to be determined in an experiment. The diameter of the ball is measured with a screw gauge, whose pitch is 0.5mm and there are 50 divisions on the circular scale. The reading on the main scale is 2.5mm and that on the circular scale is 20 divisions. If the measured mass of the ball has a relative error of 2%, the relative percentage error in the density is

(a) 0.9% (b) 2.4%
(c) 3.1% (d) 4.2%

368. Consider a Vernier callipers in which each 1cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale.in the Vernier callipers, 5 divisions of the Vernier scale coincide with 4 division on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then:

(a) If the pitch of the screw gauge is twice the least count of the Vernier calliper, the least count of the Screw gauge is 0.01mm
(b) If the pitch of the screw gauge is twice the least count of the Vernier calliper, the least count of the screw gauge is 0.005mm
(c) If the least count of the linear scale of a screw gauge is twice the least count of the Vernier callipers, the least Count of the screw gauge is 0.01mm
(d) If the least count of the linear scale of a screw gauge is twice the least count of the Vernier callipers, the least Count of the screw gauge is 0.005mm

369. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of –0.004 cm, the correct diameter of the ball is

(a) 0.053 cm (b) 0.525 cm
(c) 0.521 cm (d) 0.529 cm

Beginner Test-I

1. $\sin(\pi+\theta)\sin(\pi-\theta)\operatorname{cosec}^2\theta =$

(a) 1 (b) –1 (c) sin θ (d) – sin θ

2. $\tan\theta\sin\left(\frac{\pi}{2}+\theta\right)\cos\left(\frac{\pi}{2}-\theta\right) =$

(a) 1 (b) 0 (c) $\frac{1}{\sqrt{2}}$ (d) None

3. $\tan 75^o - \cot 75^o =$

(a) $2\sqrt{3}$ (b) $2+\sqrt{3}$ (c) $2-\sqrt{3}$ (d) None

4. cos 15° =

(a) $\sqrt{\frac{1+\cos 30°}{2}}$ (b) $\sqrt{\frac{1-\cos 30°}{2}}$ (c) $\pm\sqrt{\frac{1+\cos 30°}{2}}$ (d) $\pm\sqrt{\frac{1-\cos 30°}{2}}$

5. If $\sin A = \frac{1}{\sqrt{10}}$ and $\sin B = \frac{1}{\sqrt{5}}$ where A and B are positive acute angles, then $A+B=$

(a) π (b) $\frac{\pi}{2}$ (c) $\frac{\pi}{3}$ (d) $\frac{\pi}{4}$

6. $\frac{d}{dx}\left[\frac{3x+4}{4x+5}\right] =$

(a) $\frac{-1}{(4x+5)^2}$ (b) $\frac{1}{(4x+5)^2}$ (c) $\frac{-1}{(4x-5)^2}$ (d) None

7. $\int\left(10^x+e^x\right)dx =$

(a) $\frac{10^x}{\log_e^{10}}+e^x$ (b) $\frac{10^x}{\log_e^{10}}+e^x+c$ (c) $\frac{10^x}{\log_e^{10}}+e^{2x}+c$ (d) None

8. If the surface area of a spherical balloon is increasing at the rate of 900 cm^2/sec. then the rate of change of radius of balloon at instant when radius is 15 cm [in cm/sec]

(a) $\frac{22}{7}$ (b) 22 (c) $\frac{7}{22}$ (d) None of these

9. $\int \operatorname{cosec}^2 x\,dx$ is equal to

(a) $\cot x + C$ (b) $-\cot x + C$ (c) $\tan^2 x + C$ (d) $-\cot^2 x + C$

10. $\int \sec x \tan x\,dx =$

(a) $\sec x + \tan x + C$ (b) $\sec x + C$ (c) $\tan x + C$ (d) $-\sec x + C$

11. The value of $\int \frac{1}{x^4}dx$ is

(a) $\frac{1}{-3x^3}+c$ (b) $\frac{1}{3x^3}+c$ (c) $\frac{1}{-4x^3}+c$ (d) $-\frac{1}{3x^3}+c$

12. $\int \frac{3x^3-2\sqrt{x}}{x}dx =$

(a) $x^3-\sqrt{x}+c$ (b) $x^3+\sqrt{x}+c$ (c) $x^3-2\sqrt{x}+c$ (d) $x^3-4\sqrt{x}+c$

13. $\int_1^e \frac{1}{x} dx$ is equal to

(a) ∞ (b) 0 (c) 1 (d) log (1 + e)

14. Find the maximum and minimum magnitude of the resultant of two forces 16 N and 4 N.

15. If $\vec{P} = 6\hat{i} + 8j$ and $\vec{Q} = 4\hat{i} - 3j$, then calculate the following:

(a) $|\vec{P}|$ (b) $|\vec{Q}|$ (c) $|\vec{P} + \vec{Q}|$ (d) $|\vec{P} - \vec{Q}|$

16. Three forces $\vec{F_1}, \vec{F_2}$ and $\vec{F_3}$ are acting on a particle such that the particle remains in equilibrium. If $\vec{F_1} = (2\hat{i} + 3j)N$ and $\vec{F_2} = (2j + 2k)N$, Find $\vec{F_3}$.

17. Find the angle between $\vec{F} = 2\hat{i} - 4j$ and $\vec{F} = 4\hat{i} + 2j$.

18. If $\vec{P} = 6\hat{i} + 8j$ and $\vec{Q} = 4\hat{i} - 3j$, Find

(a) Unit vector along $\vec{P} + 3\vec{Q}$ (b) $\vec{P} \cdot \vec{Q}$ (c) $\vec{P} \times \vec{Q}$

19. Find the magnitude and direction of resultant of F= 10 i + 20j N

20. If $\vec{A} = 4\hat{i} - 3j$ and $\vec{B} = 6\hat{i} + 8j$ then magnitude and direction of $\vec{A} \times \vec{B}$ will be?

Beginner Test-II

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1. If the velocity of light is taken as the unit of velocity and year as the unit of time, what must be the unit of length? What is it called?

2. Why length, mass and time are chosen as base quantities in mechanics?

3. The mass and volume of a body are 4.237 g and 2.5 cm^3, respectively. The density of the material of the body in correct significant figures is

(a)1.6048 $g\ cm^{-3}$ (b)1.69 $g\ cm^{-3}$

(c)1.7 $g\ cm^{-3}$ (d)1.695 $g\ cm^{-3}$

4. The mass of a body as measured by two persons is 10.2 kg and 10.23 kg. Which one is more accurate and why?

5. In a number without decimal, what is the significance of zeros on the right of non-zero digits?

6. Why parallax method cannot be used for measuring distances of stars more than 100 light years away?

7. A new unit of length is chosen such that the speed of light in vacuum is unity. What is the distance between the sun and the earth in terms of the new unit, if light takes 8 min and 20 s to cover this distance?

8. A student measures the thickness of a human hair by looking at it through a microscope of magnification 100. He makes 20 observations and finds that the average width of the hair in the field of view of the microscope is 3.5 mm. What is the estimate on the thickness of hair?

9. The resistance *R* is the ratio of potential difference *V* and current *I*. What is the percentage error in *R* if *V* is $(100\ \pm 5)$ *V* and *I* is (10 ± 2) A?

10. The sides of a rectangle are (10.5 ± 0.2) cm and (5.2 ± 0.1) cm. Calculate its perimeter with error limits.

11. It is required to find the volume of a rectangular block. A vernier calliper is used to measure the length, width and height of the block. The measured values are found to be 1.37 cm, 4.11 cm and 2.56 cm, respectively. Calculate correctly, the volume of the block.

12. State the number of significant figures in the following.

(a) 0.0007 m^2 (b) 2.64 $\times$ 10^{24} kg (c) 0.2370 g/cm^3 (d) 6.320 J
(e) 6.032 N/m^2 (f) 0.0006032 m^2

13. Compute the following with regards to significant figures.

(a) 4.6×0.128 (b) $\frac{0.9995 \times 1.53}{1.592}$ (c) $876 + 0.4382$

14. The diameter of a wire as measured by a screw gauge was found to be 1.328, 1.330, 1.325, 1.334 and 1.336 cm. Calculate (a) mean value of diameter (b) absolute error in each measurement, (c) mean absolute error (d) fractional error (e) percentage error (f) diameter of wire.

15. If $x = a + bt + ct^2$,where x is metres and t is second, what is the dimensional formula of c?

16. Find the value of 60 W on a system having 100g, 20 cm and 1 min as the fundamental units?

17. The orbital velocity v of a satellite may depend on its mass m, distance r from the centre of earth and acceleration due to gravity g. Obtain an expression for orbital velocity?

18. Find an expression for viscous force *F* acting on a tiny steel ball of radius *r* moving in a viscous liquid of viscosity η with a constant speed *v* by the method of dimensional analysis.

19. Name at least seven physical quantities whose dimensions are $[ML^2T^{-2}]$

20. Name the physical quantity of the dimensions given that $[M^{-1}L^{-3}T^3A^2]$

21. Which of the following is the most precise device for measuring length: a Vernier Calipers with 20 divisions on the sliding scale a screw gauge of pitch 1 mm and 100 divisions on the circular scale an optical instrument that can measure length to within a wavelength of light?

22. A student measures the thickness of a human hair by looking at it through a microscope of magnification 100. He makes 20 observations and finds that the average width of the hair in the field of view of the microscope is 3.5 mm. What is the estimate on the thickness of hair?

23. Answer the following:

You are given a thread and a meter scale. How will you estimate the diameter of the thread?

A screw gauge has a pitch of 1.0 mm and 200 divisions on the circular scale. Do you think it is possible to increase the accuracy of the screw gauge arbitrarily by increasing the number of divisions on the circular scale?

The mean diameter of a thin brass rod is to be measured by Vernier calipers. Why is a set of 100 measurements of the diameter expected to yield a more reliable estimate than a set of 5 measurements only?

24. The photograph of a house occupies an area of 1.75 cm^2 on a 35 mm slide. The slide is projected on to a screen, and the area of the house on the screen is 1.55 m^2 . What is the linear magnification of the projector-screen arrangement?

25. State the number of significant figures in the following:

a) 0.007 m^2 b) 2.64 × 10^{24} kg c) 0.2370 g cm^{-3}
d) 6.320 J e) 6.032 N m^{-2} f) 0.0006032 m^2

26. The length, breadth and thickness of a rectangular sheet of metal are 4.234 m, 1.005 m, and 2.01 cm respectively. Give the area and volume of the sheet to correct significant figures.

27. The mass of a box measured by a grocer's balance is 2.300 kg. Two gold pieces of masses 20.15 g and 20.17 g are added to the box. What is (a) the total mass of the box, (b) the difference in the masses of the pieces to correct significant figures?

28. A physical quantity P is related to four observables a, b, c and d as follows:

$P=\frac{a^3b^2}{(\sqrt{c}d)}$

The percentage errors of measurement in a, b, c and d are 1%, 3%, 4% and 2%, respectively. What is the percentage error in the quantity P? If the value of P calculated using the above relation turns out to be 3.763, to what value should you round off the result?

29. A book with many printing errors contains four different formulas for the displacement y of a particle undergoing a certain periodic motion: (a = maximum displacement of the particle, v = speed of the particle. T = time-period of motion). Rule out the wrong formulas on dimensional grounds.

$y = a\sin\left(\frac{2\pi t}{T}\right)$

$y = \left(\frac{a}{T}\right)\sin\frac{t}{a}$

$y = a\sin vt$

$y = \left(a\sqrt{2}\right)\left(\sin\frac{2\pi t}{T} + \cos\frac{2\pi t}{T}\right)$

30. A famous relation in physics relates 'moving mass' m to the 'rest mass' m_0 of a particle in terms of its speed v and the speed of light, c. (This relation first arose as a consequence of special relativity due to Albert Einstein). A boy recalls the relation almost correctly but forgets where to put the constant c. He writes:

31. The unit of length convenient on the atomic scale is known as an angstrom and is denoted by Å : 1Å = $10^{-10}m$ The size of a hydrogen atom is about 0.5Å, what is the total atomic volume in m^3 of a mole of hydrogen atoms?

32. One mole of an ideal gas at standard temperature and pressure occupies 22.4 L (molar volume). What is the ratio of molar volume to the atomic volume of a mole of hydrogen?

(Take the size of hydrogen molecule to be about 1 A). Why is this ratio so large?

33. Explain this common observation clearly : If you look out of the window of a fast moving train, the nearby trees, houses etc. seem to move rapidly in a direction opposite to the train's motion, but the distant objects (hill tops, the Moon, the stars etc.) seem to be stationary. (In fact, since you are aware that you are moving, these distant objects seem to move with you).

34. The principle of 'parallax' is used in the determination of distances of very distant stars. The baseline AB is the line joining the Earth's two locations six months apart in its orbit around the Sun. That is, the baseline is about the diameter of the Earth's orbit ≈ 3×10^{11}m. However, even the nearest stars are so distant that with such a long baseline, they show parallax only of the order of 1" (second) of arc or so. A parsec is a convenient unit of length on the astronomical scale. It is the distance of an object that will show a parallax of 1" (second) of arc from opposite ends of a baseline equal to the distance from the Earth to the Sun. How much is a parsec in terms of meters?

35. The nearest star to our solar system is 4.29 light years away. How much is this distance in terms of parsecs? How much parallax would this star (named Alpha Centauri) show when viewed from two locations of the Earth six months apart in its orbit around the Sun?

36. Precise measurements of physical quantities are a need of science. For example, to ascertain the speed of an aircraft, one must have an accurate method to find its positions at closely separated instants of time. This was the actual motivation behind the discovery of radar in World War II. Think of different examples in modern science where precise measurements of length, time, mass etc. are needed. Also, wherever you can, give a quantitative idea of the precision needed.

37. Just as precise measurements are necessary in science, it is equally important to be able to make rough estimates of quantities using rudimentary ideas and common observations.

Think of ways by which you can estimate the following (where an estimate is difficult to obtain, try to get an upper bound on the quantity):

The total mass of rain-bearing clouds over India during the Monsoon. The mass of an elephant. The wind speed during a storm. The number of strands of hair on your head. The number of air molecules in your classroom.

38. The Sun is a hot plasma (ionized matter) with its inner core at a temperature exceeding 10^7 K, and its outer surface at a temperature of about 6000 K. At these high temperatures, no substance remains in a solid or liquid phase. In what range do you expect the mass density of the Sun to be, in the range of densities of solids and liquids or gases? Check if your guess is correct from the following data: mass of the Sun = 2.0 × 10^{30} kg, radius of the Sun = 7.0 × 10^8 m.

39. When the planet Jupiter is at a distance of 824.7 million kilometers from the Earth, its angular diameter is measured to be of arc. Calculate the diameter of Jupiter.

40. A man walking briskly in rain with speed v must slant his umbrella forward making an angle θ with the vertical. A student derives the following relation between θ and v: tan θ = v and checks that the relation has a correct limit: as v →0, θ → 0, as expected. (We are assuming there is no strong wind and that the rain falls vertically for a stationary man). Do you think this relation can be correct? If not, guess the correct relation.

Expert Test-I

1. If $3\sin\alpha = 5\sin\beta$, then $\dfrac{\tan\dfrac{\alpha+\beta}{2}}{\tan\dfrac{\alpha-\beta}{2}} =$

(a) 1 (b) 2 (c) 3 (d) 4

2. If $\tan A = -\dfrac{1}{2}$ and $\tan B = -\dfrac{1}{3}$, then A + B =

(a) $\dfrac{\pi}{4}$ (b) $\dfrac{3\pi}{4}$ (c) $\dfrac{5\pi}{4}$ (d) None

3. At the point (1, b) on the curve y = $2x^3$, the gradient of the curve is increasing K times as fast as x. Then K =

(a) 6 (b) 12 (c) 18 (d) 24

4. The maximum or minimum value of the function $y = x + \dfrac{1}{x}$ for x > 0 is

(a) 2 and is maximum (b) 2 and is minimum (c) Both (a) and (b) (d) None

5. The first derivative of the function $\left(\sin 2x \cos 2x \cos 3x + \log_2 2^{x+3}\right)$ with respect to x at x = π is

(a) 2 (b) –1 (c) $-2 + 2^{\pi}\log_e 2$ (d) $-2 + \log_e 2$

6. $\dfrac{d}{dx}\left[\log\left\{e^x\left(\dfrac{x-2}{x+2}\right)^{3/4}\right\}\right]$ equals to

(a) 1 (b) $\dfrac{x^2+1}{x^2-4}$ (c) $\dfrac{x^2-1}{x^2-4}$ (d) $e^x\dfrac{x^2-1}{x^2-4}$

7. If $x = \exp\left\{\tan^{-1}\left(\dfrac{y-x^2}{x^2}\right)\right\}$ then $\dfrac{dy}{dx}$ equals

(a) $2x\left[1+\tan(\log x)\right] + x\sec^2(\log x)$ (b) $x\left[1+\tan(\log x)\right] + \sec^2(\log x)$

(c) $2x\left[1+\tan(\log x)\right] + x^2\sec^2(\log x)$ (d) $2x\left[1+\tan(\log x)\right] + \sec^2(\log x)$

8. $\int (\sec x + \tan x)^2 \, dx =$

(a) $2(\sec x + \tan x) - x + c$ (b) $\frac{1}{3}(\sec x + \tan x)^3 + c$

(c) $\sec x(\sec x + \tan x) + c$ (d) $2(\sec x + \tan x) + c$

9. $\int \frac{\sin x + \cos x}{\sqrt{1 + \sin 2x}} dx =$

(a) $\sin x + c$ (b) $\cos x + c$ (c) $x + c$ (d) $x^2 + c$

10. $\int \frac{1 + \cos^2 x}{\sin^2 x} dx =$

(a) $-\cot x - 2x + c$ (b) $-2\cot x - 2x + c$ (c) $-2\cot x - x + c$ (d) $-2\cot x + x + c$

11. The value of $\int \frac{1}{(x-5)^2} dx$ is

(a) $\frac{1}{x-5} + c$ (b) $-\frac{1}{x-5} + c$ (c) $\frac{2}{(x-5)^3} + c$ (d) $-2(x-5)^3 + c$

12. $\int_0^{\pi/4} \tan^2 x dx =$

(a) $1 - \frac{\pi}{4}$ (b) $1 + \frac{\pi}{4}$ (c) $\frac{\pi}{4} - 1$ (d) $\frac{\pi}{4}$

13. $\int_2^4 (3x - 2)^2 dx$ equals

(a) 102 (b) 104 (c) 100 (d) 98

14. $\int_0^{-1} e^{2\ln x} =$

(a) 0 (b) 1/2 (c) 1/3 (d) 1/4

15. Find the angle between the vectors $\vec{A}$ and $\vec{B}$ if $|\vec{A} + \vec{B}| = |\vec{A} - \vec{B}|$

16. Find the magnitude of displacement of the particle if its position vector changes from $\vec{A_1} = 2\hat{i} + 3j + 5k$ to $\vec{r_2} = 4\hat{i} + 5j + 2k$. Also find the distance travelled by the particle along X, Y and Z axes respectively. All distances are in meter.

17. A car travels 6 km towards north at an angle of 45° to the east and then travels distance of 4 km towards north at an angle of 135° to the east. How far is the point from the starting point? What angle does the straight line joining its initial and final position makes with the east?

18. If for two vectors $\vec{A}$ and $\vec{B}$, sum $(\vec{A} + \vec{B})$ is perpendicular to the difference $(\vec{A} - \vec{B})$. Then, find the ratio of their magnitude.

19. Find the angles which a vector $\hat{i} + j + \sqrt{2}k$ makes with X, Y and Z axes respectively.

20. What is the angle between $\vec{P}$ and the resultant of $(\vec{P} + \vec{Q})$ and $(\vec{P} - \vec{Q})$

Expert Test-II

1. The angle of 1'(minute of arc) in radian is nearly equal to

(a) 2.91×10^{-4} rad
(b) 4.85×10^{-4} rad
(c) 4.80×10^{-6} rad
(d) 1.75×10^{-2} rad

2. The unit of thermal conductivity is :

(a) J m^{-1} K^{-1}
(b) Wm K^{-1}
(c) W m^{-1} K^{-1}
(d) J m K^{-1}

3. A screw gauge gives the following readings when used to measure the diameter of a wire Main scale reading: 0 mm Circular scale reading : 52 divisions Given that, 1 mm on main scale corresponds to 100 divisions on the circular scale. The diameter of the wire from the above data is

(a) 0.52 cm
(b) 0.026 cm
(c) 0.26 cm
(d) 0.052 cm

4. Time intervals measured by a clock give the following readings 1.25 s, 1.24 s, 1.27 s, 1.21 s and 1.28 s. What is the percentage relative error of the observations?

(a) 2%
(b) 4%
(c) 16%
(d) 1.6%

5. A screw gauge has least count of 0.01 mm and there are 50 divisions in its circular scale. The pitch of the screw gauge is

(a) 0.25 mm
(b) 0.5 mm
(c)1.0 mm
(d) 0.01 mm

6. Taking into account of the significant figures, what is the value of 9.99 m – 0.0099 m?

(a) 9.98 m
(b) 9.980 m
(c) 9.9 m
(d) 9.9801 m

7. The main scale of a Vernier caliper has n divisions/cm. n divisions of the Vernier scale coincide with (n–1) divisions of main scale. The least count of the Vernier calipers is

(a) $\frac{1}{(n+1)(n-1)} cm$
(b) $\frac{1}{n} cm$
(c) $\frac{1}{n^2} cm$
(d) $\frac{1}{n(n+1)} cm$

8. A student measured the diameter of a small steel ball using a screw gauge of least count 0.001 cm. The main scale reading is 5 mm and zero of circular scale division coincides with 25 divisions above the reference level. If screw gauge has a zero error of –0.004 cm, the correct diameter of the ball is

(a) 0.053 cm
(b) 0.525 cm
(c) 0.521 cm
(d) 0.529 cm

9. In an experiment, four quantities a, b, c and d are measured with percentage error 1%, 2%, 3% and 4% respectively. Quantity P is calculated P = $\frac{a^3b^2}{cd}$%. Error in P is

(a) 14%
(b) 10%
(c) 7%
(d) 4%

10. If force [F], acceleration [a] and time [T] are chosen as the fundamental physical quantities. Find the dimensions of energy.

(a) [F][a] [T]
(b) [F] [a] $[T^2]$
(c) [F][a] $[T^{-1}]$
(d) [F] $[a^{-1}]$[T]

11. If E and G respectively denote energy and gravitational constant. then $\frac{E}{G}$ has the dimensions of

(a) $[M^2][L^{-1}][T^0]$
(b) $[M][L^{-1}][T^{-1}]$
(c) $[M][L^0][T^0]$
(d) $[M^2][L^{-2}][T^{-1}]$

12. Dimensions of stress are

(a) $[ML^2T^{-2}]$
(b) $[ML^0T^{-2}]$
(c) $[ML^{-1}T^{-2}]$
(d) $[MLT^{-2}]$

13. A physical quantity of the dimensions of length that can be formed out of c, G and $\frac{e^2}{4\pi\varepsilon_0}$ is [c is velocity of light, G is universal constant of gravitation and e is charge]

(a) $\frac{1}{c^2}\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$
(b) $c^2\left[G\frac{e^2}{4\pi\varepsilon_0}\right]^{1/2}$
(c) $\frac{1}{c^2}\left[\frac{e^2}{G4\pi\varepsilon_0}\right]^{1/2}$
(d) $\frac{1}{c}G\frac{e^2}{4\pi\varepsilon_0}$

14. The diameter and height of a cylinder are measured by a meter scale to be 12.6 ± 0.1 cm and 34.2 ± 0.1 cm, respectively. What will be the value of its volume in appropriate significant figures?

(a) $4264\pm81\ \text{cm}^3$
(b) $4300\pm80\ \text{cm}^3$
(c) $4260\pm80\ \text{cm}^3$
(d) $4264.4\pm81.0\ \text{cm}^3$

15. The force of interaction between two atoms is given by $F=\alpha\beta\exp\left(-\frac{x^2}{\alpha kt}\right)$; where x is the distance, k is the Boltzmann constant and T is temperature and α and β are two constants. The dimension of β is

(a) $M^0\ L^2\ T^{-4}$
(b) M^2LT^{-4}
(c) MLT^{-2}
(d) $M^2\ L^2\ T^{-2}$

16. If speed (V), acceleration (A) and force (F) are considered as fundamental units, the dimension of Young's modulus will be

(a) $V^{-2}A^2F^{-2}$
(b) $V^{-2}A^2F^2$
(c) $V^{-4}A^2F$
(d) $V^{-4}A^{-2}F$

17. The least count of the main scale of a screw gauge is 1 mm. The minimum number of divisions on its circular scale required to measure 5μm diameter of a wire is

(a) 200
(b) 50
(c) 100
(d)500

18. If Surface tension (S), Moment of Inertia (I) and Planck's constant (h), were to be taken as the fundamental units, the dimensional formula for linear momentum would be:

(a) $S^{1/2}\Big|^{3/2}\ \mathrm{h}^{-1}$ (b) $S^{3/2}\Big|^{1/2}\ h^{0}$

(c) $S^{1/2}\Big|^{1/2}\ \mathrm{h}^{-1}$ (d) $S^{1/2}\Big|^{1/2}\ h^{0}$

19. In a simple pendulum experiment for determination of acceleration due to gravity (g), time taken for 20 oscillations is measured by using a watch of 1 second least count. The mean value of time taken comes out to be $30\ \mathrm{s}$. The length of pendulum is measured by using a meter scale of least count $1\ \mathrm{mm}$ and the value obtained is 55.0 cm. The percentage error in the determination of g is close to:

(a) 6.8% (b) 0.2%

(c) 3.5% (d) 0.7%

20. In the density measurement of a cube, the mass and edge length are measured as $(10.00 \pm 0.10)\mathrm{kg}$ and $(0.10 \pm 0.01)\mathrm{m}$, respectively. The error in the measurement of density is

(a) $0.31\ \mathrm{kg/m^3}$ (b) $1000\ \mathrm{kg/m^3}$

(c) $0.10\ \mathrm{kg/m^3}$ (d) $3100\ \mathrm{kg/m^3}$

21. The area of a square is $5.29\ \mathrm{cm}^2$. The area of 7 such squares taking into account the significant figures is

(a) $37.03\ \mathrm{cm}^2$ (b) $37.0\ \mathrm{cm}^2$

(c) $37.030\ \mathrm{cm}^2$ (d) $37\ \mathrm{cm}^2$

22. In the formula $X = 5YZ^2, X$ and Z have dimensions of capacitance and magnetic field, respectively. What are the dimensions of Y in SI units ?

(a) $\left[M^{-2}L^{-2}T^{6}A^{3}\right]$ (b) $\left[\mathrm{M^{-1}\ L^{-2}\ T^{4}\ A^{2}}\right]$

(c) $\left[\mathrm{M^{-2}\ L^{0}\ T^{-4}\ A^{-2}}\right]$ (d) $\left[\mathrm{M^{-3}\ L^{-2}\ T^{8}\ A^{4}}\right]$

23. A simple pendulum is being used to determine the value of gravitational acceleration g at a certain place. The length of the pendulum is $25.0\ \mathrm{cm}$ and a stopwatch with $1\ \mathrm{s}$ resolution measures the time taken for 40 oscillation to be $50\ \mathrm{s}$. The accuracy in g is

(a) 3.40% (b) 2.40%

(c) 5.40% (d) 4.40%

24. If the screw on a screw-gauge is given six rotations, it moves by $3\ \mathrm{mm}$ on the main scale. If there are 50 divisions on the circular scale the least count of the screw gauge is

(a) 0.01 cm (b) 0.001 mm

(c) 0.001 cm (d) 0.02 mm

25. A quantity f is given by $f = \sqrt{\dfrac{hc^5}{G}}$ where c is speed of light, G universal gravitational constant and h is the Planck's constant. Dimension of f is that of

(a) Energy
(b) Area
(c) Volume
(d) Momentum

26. For the four sets of three measured physical quantities as given below. Which of the following options is correct?

(i) $A_1 = 24.36, B_1 = 0.0724, C_1 = 256.2$

(ii) $A_2 = 24.44, B_2 = 16.082, C_2 = 240.2$

(iii) $A_3 = 25.2, B_3 = 19.2812, C_3 = 236.183$

(iv) $A_4 = 25, B_4 = 236.191, C_4 = 19.5$

(a) $A_1 + B_1 + C_1 = A_2 + B_2 + C_2 = A_3 + B_3 + C_3 = A_4 + B_4 + C_4$

(b) $A_1 + B_1 + C_1 < A_3 + B_3 + C_3 < A_2 + B_2 + C_2 < A_4 + B_4 + C_4$

(c) $A_1 + B_1 + C_1 < A_2 + B_2 + C_2 = A_3 + B_3 + C_3 < A_4 + B_4 + C_4$

(d) $A_4 + B_4 + C_4 < A_1 + B_1 + C_1 < A_3 + B_3 + C_3 < A_2 + B_2 + C_2$

27. The least count of the main scale of a vernier callipers is 1 mm. Its vernier scale is divided into 10 divisions and coincide with 9 divisions of the main scale. When jaws are touching each other, the 7^{th} division of vernier scale coincides with a division of main scale and the zero of vernier scale is lying right side of the zero of main scale. When this vernier is used to measure length of a cylinder the zero of the vernier scale between 3.1 cm and 3.2 cm and 4^{th} VSD coincides with a main scale division. The length of the cylinder is (VSD is vernier scale division)

(a) 3.21 cm
(b) 2.99 cm
(c) 3.07 cm
(d) 3.2 cm

28. If speed V, area A and force F are chosen as fundamental units, then the dimension of Young's modulus will be

(a) $FA^{-1}\text{ V}$
(b) FA^2V^{-1}
(c) FA^2V^{-2}
(d) FA^2V^{-3}

29. If momentum (P), area (A) and time (T) are taken to be the fundamental quantities then the dimensional formula for energy is

(a) $\left[P^{\frac{1}{2}}AT^{-1}\right]$
(b) $\left[P^2AT^{-2}\right]$
(c) $\left[PA^{\frac{1}{2}}T^{-1}\right]$
(d) $\left[PA^{-1}T^{-2}\right]$

30. Using screw gauge of pitch 0.1 cm and 50 divisions on its circular scale, the thickness of an object is measured. It should correctly be recorded as

(a) 2.124 cm
(b) 2.123 cm
(c) 2.125 cm
(d) 2.121 cm

31. Dimensional formula for thermal conductivity is (here K denotes the temperature)

(a) $MLT^{-2}\ K^{-2}$ (b) $MLT^{-3}\ K^{-1}$

(c) $MLT^{-3}\ K$ (d) $MLT^{-2}\ K$

32. A quantity x is given by $\left(IFv^2/WL^4\right)$ in terms of moment of inertia I, force F, velocity v, work W and length L. The dimensional formula for x is same as that of

(a) Coefficient of viscosity (b) Force constant

(c) Energy density (d) Planck's constant

33. A physical quantity z depends on four observables a,b,c and d, as $z=\frac{a^2b^{\frac{2}{3}}}{\sqrt{c}d^3}$. The percentages of error in the measurement of a,b,c and d are 2%, $1.5\%, 4\%$ and 2.5% respectively. The percentage of error in z is

(a) 13.5% (b) 14.5%

(c) 16.5% (d) 12.25%

34. A screw gauge has 50 divisions on its circular scale. The circular scale is 4 units ahead of the pitch scale marking, prior to use. Upon one complete rotation of the circular scale, a displacement of 0.5 mm is noticed on the pitch scale. The nature of zero error involved, and the least count of the screw gauge, are respectively.

(a) Positive, 0.1 mm (b) Positive, 10μm

(c) Negative, 2μm (d) Positive, 0.1μm

35. A student measuring the diameter of a pencil of circular cross-section with the help of a vernier scale records the following four readings 5.50 mm, 5.55 mm, 5.45 mm; 5.65 mm. The average of these four readings is 5.5375 mm and the standard deviation of the data is 0.07395 mm. The average diameter of the pencil should therefore be recorded as

(a) (5.5375 ± 0.0739)mm (b) (5.54 ± 0.07)mm

(c) (5.538 ± 0.074)mm (d) (5.5375 ± 0.0740)mm

36. The work done by a gas molecule in an isolated system is given by, $W=\alpha\beta^2 e^{-\frac{x^2}{\alpha kT}}$, where x is the displacement, k is the Boltzmann constant and T is the temperature. α and β are constants. Then the dimensions of β will be:

(a) $\left[M^2\ LT^2\right]$ (b) $\left[ML^2\ T^{-2}\right]$

(c) $\left[MLT^{-2}\right]$ (d) $\left[M^0LT^0\right]$

37. The period of oscillation of a simple pendulum is $T=2\pi\sqrt{\frac{L}{g}}$. Measured value of ' L ' is 1.0 m from meter scale having a minimum division of 1 mm and time of one complete oscillation is 1.95 s measured from stopwatch of 0.01 s resolution. The percentage error in the determination of ' g ' will be:

(a) 1.30%
(b) 1.33%
(c) 1.13%
(d) 1.03%

38. If the time period of a two meter long simple pendulum is 2 s, the acceleration due to gravity at the place where pendulum is executing S.H.M. is:

(a) 9.8 ms^{-2}
(b) $\pi^2\text{ ms}^{-2}$
(c) 16 m/s^2
(d) $2\pi^2\text{ ms}^{-2}$

39. If e is the electronic charge, c is the speed of light in free space and h is Planck's constant, the quantity $\frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{\hbar c}$ has dimensions of :

(a) $\left[MLT^{-1}\right]$
(b) $\left[MLT^{0}\right]$
(c) $\left[LC^{-1}\right]$
(d) $\left[M^0\ L^0\ T^0\right]$

40. In a typical combustion engine the work done by a gas molecule is given by $W=\alpha^2\beta e^{-\frac{\beta x^2}{kT}}$, where x is the displacement, k is the Boltzmann constant and T is the temperature, If α and β are constants, dimensions of α will be :

(a) $\left[MLT^{-1}\right]$
(b) $\left[M^0LT^0\right]$
(c) $\left[MLT^{-2}\right]$
(d) $\left[M^2LT^{-2}\right]$

41. Two resistors $R_1=(4\pm0.8)\Omega$ and $R_2=(4\pm0.4)\ \Omega$ are connected in parallel. The equivalent resistance of their parallel combination will be:

(a) $(4\pm0.4)\Omega$
(b) $(2\pm0.4)\Omega$
(c) $(2\pm0.3)\Omega$
(d) $(4\pm0.3)\Omega$

42. If ' C ' and ' V ' represent capacity and voltage respectively then what are the dimensions of λ where $C/N=\lambda$?

(a) $\left[M^{-1}\ L^{-3}I^{-2}\ T^{-7}\right]$
(b) $\left[M^{-2}\ L^{-4}I^{3}\ T^{7}\right]$
(c) $\left[M^{-2}\ L^{-3}I^{2}\ T^{6}\right]$
(d) $\left[M^{-3}\ L^{-4}\beta^{3}\ T^{7}\right]$

43. A wire of 1 W has a length of 1 m. It is stretched till its length increases by 25%. The percentage change in resistance to the nearest integer is

(a) 76%
(b) 56%
(c) 12.5%
(d) 25%

44. In order to determine the Young's Modulus of a wire of radius 0.2 cm (measured using a scale of least count $=0.001\text{ cm}$) and length 1 m (measured using a scale of least count $=1\text{ mm}$), a weight of mass 1 kg (measured using a scale of least count $=1\text{ g}$) was hanged to get the elongation of 0.5 cm (measured using a scale of least count 0.001 cm). What will be the fractional error in the value of Young's Modulus determined by this experiment?

(a) 1.4% (b) 0.14%

(c) 9% (d) 0.9%

45. The time period of a simple pendulum is given by $T = 2\pi\sqrt{\frac{1}{g}}$. The measured value of the length of pendulum is 10 cm known to a 1 mm accuracy. The time for 200 oscillations of the pendulum is found to be 100 second using a clock of 1 s resolution. The percentage accuracy in the determination of ' g ' using the pendulum is ' x '. The value of ' x ' to the nearest integer is,

(a) 3% (b) 5%

(c) 2% (d) 4%

46. In the experiment of Ohm's law, a potential difference of 5.0 V is applied across the end of a conductor of length 10.0 cm and diameter of 5.00 mm. The measured current in the conductor is 2.00 A. The maximum permissible percentage error in the resistivity of the conductor is:

(a) 3.0 (b) 3.9

(c) 7.5 (d) 8.4

47. The entropy of any system is given by $S = \alpha^2 \beta \ln\left[\frac{\mu k R}{J\beta^2} + 3\right]$ where α and β are the constants, μ, J, k and R are no. of moles, mechanical equivalent of heat, Boltzmann constant and gas constant respectively. [Take $S = \frac{dQ}{T}$]

Choose the incorrect option from the following

(a) S, β, k and μR have the same dimensions

(b) α and k have the same dimensions

(c) α and J have the same dimensions

(d) S and α have different dimensions

48. If time (t), velocity (v), and angular momentum (() are taken as the fundamental units. Then the dimension of mass (m) in terms of t, v, and l is:

(a) $\left[t^{-1}v^{1}r^{-2}\right]$ (b) $\left[t^{-1}v^{-2}r^{1}\right]$

(c) $\left[t^{1}v^{2}r^{-1}\right]$ (d) $\left[t^{-2}v^{-1}l^{1}\right]$

49. Which of the following equations is dimensionally incorrect?

Where $\text{t} =$ time, $\text{h} =$ height, $\text{s} =$ surface tension, $\theta =$ angle, $\rho =$ density , $a, r =$ radius, $\text{g} =$ acceleration due to gravity, $\text{v} =$ volume , $\text{p} =$ pressure, $\text{W} =$ work done, $\tau =$ torque $\text{e} =$ permittivity, $\varepsilon =$ electric field, $\text{J} =$ current density, $\text{L} =$ length

(a) $h = \frac{2\ s\cos\theta}{\text{prg}}$

(b) $W = \tau\theta$

(c) $V = \frac{\pi p a^4}{8\eta L}$

(d) $J = \varepsilon\frac{\partial E}{\partial t}$

50. If velocity $[V]$, time $[T]$ and force $[F]$ are chosen as the base quantities, the dimensions of the mass will be:

(a) $[FT^{-1}\ V^{-1}]$

(b) $[FVT^{-1}]$

(c) $[FT^2\ V]$

(d) $[FTV^{-1}]$

Pro Test-I

1. $\cos^2\alpha + \cos^2(\alpha + 120^o) + \cos^2(\alpha - 120^o)$ is equal to

(a) $\frac{3}{2}$ (b) 1 (c) $\frac{1}{2}$ (d) 0

2. $\frac{\sin 3\theta - \cos 3\theta}{\sin\theta + \cos\theta} + 1$

(a) $2\sin\ 2\theta$ (b) $2\cos 2\theta$ (c) $\frac{K+1}{K-1}\sin\theta$ (d) $\cot 2\theta$

3. The rate of change of the surface area of a sphere of radius r when the radius is increasing at the rate of 2cm/sec is proportional to

(a) $\frac{l}{r}$ (b) $\frac{l}{r^2}$ (c) r (d) r^2

4. The derivative of $f(x) = |x|^3$ at x = 0 is

(a) 0 (b) 1 (c) –1 (d) Not define

5. $\int\frac{\cos 2x}{\cos x}dx$ is equal to

(a) $2\sin x + \log(\sec x - \tan x) + c$

(b) $2\sin x - \log(\sec x - \tan x) + c$

(c) $2\sin x + \log(\sec x + \tan x) + c$

(d) $2\sin x - \log(\sec x + \tan x) + c$

6. $\int x\cos x^2\,dx$ is equal to

(a) $-\frac{1}{2}\sin^2 x + C$ (b) $\frac{1}{2}\sin^2 x + C$ (c) $-\frac{1}{2}\sin x^2 + C$ (d) $\frac{1}{2}\sin x^2 + C$

7. $\int\frac{(1+\log x)^2}{x}dx =$

(a) $(1+\log x)^3 + c$ (b) $3(1+\log x)^3 + c$ (c) $\frac{1}{3}(1+\log x)^3 + c$ (d) None of these

8. $\int_2^3\frac{dx}{x^2 - x} =$

(a) $\log\frac{2}{3}$ (b) $\log\frac{1}{4}$ (c) $\log\frac{4}{3}$ (d) $\log\frac{8}{3}$

9. $\int_{-\pi/4}^{\pi/2} e^{-x}\sin x dx =$

(a) $-\frac{1}{2}e^{-\pi/2}$ (b) $-\frac{\sqrt{2}}{2}e^{-\pi/4}$ (c) $-\sqrt{2}(e^{\pi/4}+e^{-\pi/4})$ (d) 0

10. $\int_{0}^{\pi/2}\sqrt{1+\sin 2x}\,dx$ equals

(a) 1 (b) 1/2 (c) 2 (d) None

11. If $\vec{a}=4\hat{i}+3j$ and $\vec{b}$ are two vectors perpendicular to each other in the xy-plane. Find all vectors in the same plane having projection 1 and 2 along $\vec{a}$ and $\vec{b}$ respectively

12. Find the value(s) of x for which the angle between the vectors $\vec{a}=2x^2\hat{i}-4xj+k$ and $\vec{b}=7\hat{i}-2j+xk$ is obtuse.

13. If $\vec{a}=\hat{i}+j+k$ and $\vec{b}=2\hat{i}+j+3k$ then find

(a) Component of $\vec{b}$ along $\vec{a}$

(b) Component of b perpendicular to $\vec{a}$

14. Let A_1 A_2 A_3 A_4 A_5 A_6 A_1 be a regular hexagon. Write the x-components of the vectors represented by the six sides taken in order. Use the fact that the resultant of these six vectors is zero, to prove that $\cos o+\cos\frac{\pi}{3}+\cos\frac{2\pi}{3}+\cos\frac{3\pi}{3}+\cos\frac{4\pi}{3}+\cos\frac{5\pi}{3}=0$. Use the know cosine values to verify the result.

15. The algebraic sum of modulus of two vectors acting at a point is 20 N. The resultant of these two vectors is perpendicular to the smaller vector and has magnitude of 10 N. If the smaller vector is of magnitude b, then the value of b is

(a) 5 N (b) 20 N (c) 7.5 N (d) None

Pro Test-II

1. To find the distance d over which a signal can be seen clearly in foggy conditions, the railways –engineer uses dimensions and assume that the distance depends on the mass density ρ of the fog, intensity (power/area) S of the light from the signal and its frequency f. The engineer finds d is proportional to $S^{1/n}$.the value of n is

2. Some time it is convenient to construct a system of units so that all quantities can be expressed in terms of only one physical quantity. In one such system, dimensions of different quantities are given in terms of a quantity X as follows. [position] = $[X^{\alpha}]$; [speed] = $[X^{\beta}]$; [acceleration] = $[X^{p}]$; [linear momentum] = $[X^{q}]$; [force] = $[X^{r}]$. Then

(a) α +p = 2β (b) p+q - r = β

(c) p – q + r = α (d) p + q + r =β

3. The length—scale (l) depends on the permittivity (ε) of a dielectric material. Boltzmann constant (K_B) , the absolute temperature (T) , the number per unit volume (n)\of certain charged particle and the charge (q) carried by each of the particles . Which of the following expression (s) for l is (are) dimension correct?

(a) $l=\sqrt{(\frac{nq^2}{\varepsilon k_B T})}$ (b) $l=\sqrt{(\frac{\varepsilon k_B T}{nq^2})}$

(c) $l = \sqrt{(\frac{q^2}{\varepsilon n^{2/3} k_B T})}$ (d) $l = \sqrt{(\frac{q^2}{\varepsilon n^{1/3} k_B T})}$

4. A gas bubble, from an explosion under water, oscillates with a period T proportional to $p^a d^b E^c$,where 'p' is the static pressure, 'd' is the density of water and 'E' is the total energy explosion. Find the values of a,b,c.

5. A person measures the depth of a well by measuring the time interval between dropping a stone and receiving the sound of impact with the bottom of the well. The error in his measurement of the time is δT 0.01seconds and he measures the depth of the well to be L = 20 meter. Take the acceleration due to gravity g = 10ms^{-2} and the velocity of sound is 300 ms^{-1} . then the fractional error in the measurements $\delta L/L$ is closest to

(a) 0.2% (b) 1% (c) 3% (d) 5%

6. The diameter of a cylinder is measured using a Vernier calliper with no zero error. It is found that the zero of the Vernier scale lies between 5.10cm and 5.15cm of the main scale. The Vernier scale has 50 divisions equivalent to 2.45cm the 24th division of the Vernier scale exactly coincide with one of the main scale divisions. The diameter of the cylinder is

(a) 5.112cm (b) 5.124cm

(c) 5.126cm (d) 5.148cm

7. The density of a solid ball is to be determined in an experiment. The diameter of the ball is measured with a screw gauge, whose pitch is 0.5mm and there are 50 divisions on the circular scale. The reading on the main scale is 2.5mm and that on the circular scale is 20 divisions. If the measured mass of the ball has a relative error of 2%, the relative percentage error in the density is

(a) 0.9% (b) 2.4% (c) 3.1% (d) 4.2%

8. The Vernier callipers has 1mm marks on the main scale. It has 20 equal divisions on the vernier scale which match with 16 main scale divisions. For this Vernier callipers, the least count is

(a) 0.02mm (b) 0.05mm (c) 0.1mm (d) 0.2mm

9. A students performs an experiment to determine the young's modulus of a wire, exactly 2m long, by searl' method. In a particular reading ,the student measures the extension in the length of the wire to be 0.8 mm with an uncertainty of ±0.04 mm at a load of exactly 1.0kg. The student also measures the diameter of the wire to be 0.4 mm with an uncertainty of ± 0.01 mm. Take g = 9.8m/s^2 (exact). The young's modulus obtained from the reading is

(a) $(2.0 \pm 0.3) \times 10^{11}$ N/m^2 (b) $(2.0 \pm 0.2) \times 10^{11}$ N/m^2

(c) $(2.0 \pm 0.1) \times 10^{11}$ N/m^2 (d) $(2.0 \pm 0.05) \times 10^{11}$ N/m^2

10. Two capacitors with capacitance value c_1 = 2000±10 pF and c_2 = 3000±15pF are connected in series. The voltage applied across this combination is V = 5.00±2.02V. the percentage error in the calculation of the energy stored in this combination of capacitors is____

11. An optical bench has 1.5m long scale having four equal divisions in each cm. While measuring the focal length of a convex lens, the lens is kept at 75 cm mark of the scale and the object pin is kept at 45 cm mark .The image of the object pin on the other side of the lens overlaps with image pin that is kept at 135cm mark. In this experiment, the percentage error in the measurement of the focal length of the lens is ----------

12. A steel wire of diameter 0.5mm and Young's modulus 2×10^{11}Nm^{-2} carries a load of mass M. The Length of the wire with the load is 1.0m. A Vernier scale with 10 divisions is attached to end of this wire. Next to steel wire is a reference wire to which a main scale, of least count 1.0mm, is attached. The 10 divisions of the Vernier scale correspond to 9 divisions of the main scale. Initially, the zero of Vernier scale coincides with the zero of main scale. If the load on the steel wire is increased by 1.2kg,the Vernier scale division which coincides with a main scale division is _____ Take g = 10ms^{-2} and π = 3,2.

13. In an experiment to determine the acceleration due to gravity g, the formula used for the time period of a periodic motion is T = $2\pi\sqrt{\frac{7(R-r)}{5g}}$. the values of R and r are measured to be (60±1)mm and (10±1)mm, respectively. In five successive measurements, the time is found to be 0.52s, 0.56s,0.57s,0.54s and 0.59s. the least count of the watch used for the measurement of time period is 0.01s. which of the following statement(s) is (are) true?

(a) the error in the measurement of r is 10%

(b) the error in the measurement of T is 3.75%

(c) the error in the measurement of T is 2%

(d) the error in the determined value of g is 11%

14. Consider a Vernier callipers in which each 1cm on the main scale is divided into 8 equal divisions and a screw gauge with 100 divisions on its circular scale.in the Vernier callipers, 5 divisions of the Vernier scale coincide with 4 division on the main scale and in the screw gauge, one complete rotation of the circular scale moves it by two divisions on the linear scale. Then:

(a) If the pitch of the screw gauge is twice the least count of the Vernier calliper, the least count of the Screw gauge is 0.01mm

(b) If the pitch of the screw gauge is twice the least count of the Vernier calliper, the least count of the screw gauge is 0.005mm

(c) If the least count of the linear scale of a screw gauge is twice the least count of the Vernier callipers, the least Count of the screw gauge is 0.01mm

(d) If the least count of the linear scale of a screw gauge is twice the least count of the Vernier callipers, the least Count of the screw gauge is 0.005mm

15. Using the expression 2d sinθ = λ,one calculates the values of d by measuring the corresponding angles θ in the range 0 to 90°.The wavelength λ is exactly known and the error in θ is constant for all value of θ. As θ increase from 0°

(a) The absolute error in d remain constant

(b) The absolute error in d increases

(c) The fractional error in d remain constant

(d) The fractional error in d decreases

Answer Key

1. (i) 5,-2 (ii) -2, $\frac{3}{2}$	2. (c)	3. No real roots
4. $\frac{-2}{\sqrt{3}}$ or $\frac{\sqrt{3}}{4}$	5. $\frac{-5}{\sqrt{2}}$ or $-\sqrt{2}$	6. 13 , 14
7. $\frac{a-b}{6}$ or $\frac{a+b}{6}$	8. 1/4	9. $x=\frac{a}{2}$
10. 8	11. 7 or $\frac{3}{2}$	12. (ii) , (iii) , (iv) , (v)
13. (c)	14. (b)	15. 78
16. (i) 1046.5 (ii) 286 (iii) -8930	17. 32^{nd} term	18. 20 or 76
19. 381	20. $\frac{1023}{512}$	21. 6560
22. -1	23. 2/3	24. $\frac{\left(\sqrt{2}-1\right)^4}{144}$
25. 7	26. 19, 38/3, 76/9, ….	27. (a) 0 (b) $\frac{\pi}{6}$ (c) $\frac{\pi}{4}$ (d) $\frac{\pi}{3}$ (e) $\frac{\pi}{2}$ (f) $\frac{2\pi}{3}$ (g) $\frac{5\pi}{6}$ (h) π (i) $\frac{7\pi}{6}$ (j) $\frac{4\pi}{3}$
28. (b)	29. (b)	30. $\frac{5\pi}{12}cm$
31. $25°12'$	32. $\frac{20\pi}{3}cm$	33. 40 m
34. (b)	35. (b)	36. 70 m
37. $22°30'$	38. (c)	39. (c)
40. 0	41. $\frac{11}{29}$	42. 3
43. $\frac{16}{29}$	44. $\frac{1}{3}$	45. (b)
46. (b)	47. (c)	48. (a) $\frac{1}{2}$ (b) $\frac{\sqrt{3}}{2}$
49. $60°$	50. $5\sqrt{3}$	51. (b)
52. (b)	53. $10\sqrt{3}$	54. (i) 1 (ii) 2 (iii) $\frac{3\sqrt{2}-\sqrt{6}}{8}$ (iv) $\frac{43-24\sqrt{3}}{11}$ (v) $\frac{67}{12}$
55. (a)	56. (d)	57. (a) $\frac{1}{2}$ (b) $\frac{1}{\sqrt{3}}$ (c) $-\frac{\sqrt{3}}{2}$ (d) $-\frac{1}{2}$ (e) $-1/\sqrt{2}$
58. (b)	59. (a)	60. (b)

61. (a)	62. (b)	63. (c)
64. (a)	65. (a)	66. (d)
67. (a) 60° (b) 30° (c) 30°	68. (b)	69. (a)
70. (a)	71. (b)	72. (a)
73. (c)	74. (b)	75. (d)
76. (b)	77. (b)	78. (c)
79. (d)	80. (d)	81. (d)
82. (d)	83. (b)	84. (b)
85. (d)	86. (c)	87. (d)
88. (b)	89. nx^{n-1}. $18x^2 - 9$	90. $\frac{1}{2\sqrt{x}} + \frac{8}{3\sqrt[3]{x^2}} - \frac{1}{2\sqrt[4]{x^3}}$
91. $6x^{-\frac{2}{5}} - \frac{7}{2}x^{\frac{5}{2}} + 16x^{\frac{5}{3}}$	92. $8\left(x - \frac{1}{x^2}\right)$	93. (a) $60x^4 + 12x^3 + 21x^2 + 2x - 9$ (b) $-x\frac{\sin x - \cos x}{x^2}$ (c) $\frac{\cos x + \text{x}\sin x}{\cos^2 x}$ (d) $\cos(5x^3 + 2x) \times (15x^2 + 2)$ (e) $15x^2 \cot 5x^3$ (f) 3 (g) $(e^{3x-2})(3)$ (h) $\frac{-3\cos 3x}{\sin^2 3x}$ (i) $\frac{e^{\sqrt{2x+17}}}{\sqrt{2x+17}}$ (j) $80 - 80xe^{-10x}$ (k) $2x(\sin 2x + \text{x}\cos 2x)$ (l) $e^x \ln(5x^3 + x^2) + \frac{e^x(15x+2)}{(5x^2+x)}$ (m) $\frac{2x(1-4x^2)\ln(1-4x^2)+8x^3}{(1-4x^2)[\ln(1-4x^2)]^2}$
94. (a) $\frac{2x-2}{x^3}$ (b) $(1-x)^{-\frac{3}{2}}(1+x)^{-\frac{1}{2}}$ (c) $\frac{4x}{(1-x^2)^2}\cos\left(\frac{1+x^2}{1-x^2}\right)$ (d) $\frac{-[(\cot x)(\sec^2 x+1)+(\tan x)(1+\text{co}\sec^2 x)]}{(\tan x-\cot x)^2}$ (e) $\left(\frac{e^{\sqrt{x}}}{2\sqrt{x}}\right)$ (f) $(1+e^x)^{-\frac{1}{2}}(1-e^x)^{-\frac{3}{2}}$	95. (c)	96. (a)
97. (a) $\frac{\cos(\sqrt{\sin x + \ln x})(\cos x - \sin x)}{2\sqrt{\sin x + \cos x}}$ (b) $\sqrt{\frac{1}{\sqrt{x}(1-x)}}$	98. (c)	99. $\frac{-2x}{3y^2}$
100. $-\frac{x}{y}$	101. $\frac{-8x+6x^5}{6y^2-1}$	102. $\frac{-3\cos 3x}{4y^3+14}$
103. $\frac{e^x-1}{\cos y}$	104. $-\frac{y}{x}$	105. (a) $\frac{dy}{dx} = \frac{(3 + x^2y^5)}{(24y^2 - 5x^3y^4)}$ (b)

		$\frac{dy}{dx} = \frac{2 - 2x\tan y - y^{10}\sec x\tan x}{(x^2\sec y + 10y^5\sec x)}$ (c) $\frac{dy}{dx} = \frac{2x - \frac{1}{x} - 2e^{2x+3y}}{\left(3e^{2n+3y} + \frac{3}{y}\right)}$
106. (a)	107. $\frac{1.4\pi\text{cm}}{\text{s}}$	108. $0.4\sqrt{3}$
109. 144π	110. $\frac{2\pi\text{cm}^3}{\text{s}}$	111. $\frac{1}{10\pi}$
112. $\frac{181}{3}$	113. -2	114. 22
115. $135°$	116. (d)	117. (a)
118. (a)	119. (c)	120. $x^6 - 6x^3 + 7x + c$
121. $10x^4 + 4x^3 - \frac{9}{2}x^2 + 14x + c$	122. $\frac{3t^8}{2} - \frac{t^3}{3} - \frac{t^2}{2} + 3t + c$	123. $2\omega^5 + \frac{9}{4}\omega^4 + \frac{7\omega^2}{2} + c$
124. $\frac{z^7}{7} + \frac{4z^5}{5} - \frac{z^3}{3} + c$	125. (a) $x^3 - 3x^2 + 3x + c$ (b) $2x^4 - \frac{x^3}{3} + \frac{5x^2}{2} - x + c$ (c) $\frac{x^6}{6} + \frac{x^5}{20} + \frac{x^4}{12} + c$ (d) $\frac{-x^5}{10} - \frac{x^4}{12} - \frac{x^3}{18} + c$ (e) $2x^4 - 24x^3 + 108x^2 - 216x + c$ (f) $625x + 50x^2 - \frac{1000x^{\frac{3}{2}}}{3} + c$ (g) $\frac{x^{11}}{11} - \frac{x^9}{9} + \frac{x^7}{7} - \frac{x^5}{5} + c$ (h) $\frac{-x^{-4}}{4} - \frac{x^{-2}}{2}$+ln |x|+c (i) $-\frac{4}{x^4} + \frac{3}{x^3} - \frac{2}{x^2} + c$	126. (d)
127. (a)	128. (a)	129. (a)
130. (c)	131. (c)	132. (a) $\frac{2x^{\frac{3}{2}}}{3} + \frac{5x^{\frac{6}{5}}}{6} + \frac{9x^{\frac{10}{9}}}{10} + C$ (b) $\frac{5x^{\frac{12}{5}} - 4x^3 + 3x^4}{12} + c$ (c) $-\frac{1}{5}\sqrt[3]{\frac{9}{x^5}} - \frac{7}{2}\sqrt[3]{\frac{x^2}{3}} + c$ (d) $\frac{\sqrt[3]{4x^4}}{8} - \frac{1}{x} + c$ (e) $\frac{2x^{\frac{7}{2}}}{7} - \frac{5x^{\frac{7}{5}}}{7} + c$ (f) $\frac{2\times x^{\frac{3}{2}}}{3} + \frac{6\times x^{\frac{13}{6}}}{13} + c$ (g) $\frac{16x^{\frac{53}{16}}}{53} + c$ (h) $\frac{3x^{\frac{1}{3}}}{4} - \frac{6x^{\frac{5}{2}}}{5} + \frac{3x^{\frac{3}{2}}}{13} + \text{c}$

		(i) $\frac{7x^{\frac{2}{7}}}{2}-\frac{4x^{-\frac{31}{12}}}{31}+c$
133. $-5\cos(2+6x^3)+c$	134. $-\sec(1-z)+c$	135. $-\ln(\cos x)+c$
136. $-\frac{1}{2}e^{(y^4-7y^2)}+C1$	137. $\ln(4\omega^2+6w-1)+c$	138. $\frac{(4x^2-12x)^5}{5}+C1$
139. $\frac{1}{24}x^{-6}+c$	140. $-\frac{1}{22}(4\omega^2-6\omega+7)^{11}+C$	141. (b)
142. (b)	143. (c)	144. (d)
145. (c)	146. (c)	147. (b)
148. (b)	149. $\ln(4\omega^2+6w-1)+c$	150. $\frac{1}{18}(\sin 3t-t^3)^6+c$
151. (a) $\frac{1}{3}(5+2x)^{\frac{3}{2}}+C$ (b) $\frac{1}{36}(3x^2-4)^6+C$ (c) $\frac{(\ln x)^3}{3}+C$ (d) $\frac{3}{\sqrt{5-2x}}+\mathrm{C}$ (e) $-\sin\left(\frac{1}{x}\right)+C$ (f) $\frac{-5}{4}(1-6x)^{\frac{2}{3}}+C$	152. -132.8	153. (b)
154. $7(e^{-2}-e^{-5})+2\ln\left(\frac{2}{5}\right)$	155. $-2-\pi$	156. (c)
157. (a)	158. (a)	159. (d)
160. (b)	161. 3	162. (c)
163. (c)	164. $\frac{182}{9}$	165. $\frac{91}{3}$
166. $-e^{-1}+1$	167. ln 2	168. $\frac{1}{8}(e^4-e)$
169. ln 2	170. $\frac{1}{9}\left[\sqrt[3]{33}-1\right]$	171. $\left[\frac{\pi}{4}\right]$
172. (b)	173. (d)	174. (c)
175. (b)	176. (d)	177. (c)
178. 12 N	179. (a) 10 units (b) 5 units (c) $5\sqrt{5}$ (d) $5\sqrt{5}$	180. 0°
181. (c)	182. (a)	183. (c)
184. (b)	185. (d)	186. (b)
187. (b)	188. (d)	189. 90°
190. (c)	191. (d)	192. (d)
193. $26\hat{i}+42\hat{j}$	194. $-90\hat{i}-50\hat{j}$	195. $\left(5\sqrt{2}-5\sqrt{3}\right)\hat{i}+\left(15-35\sqrt{2}\right)\hat{j}$
196. $\left(5\sqrt{2}-5\sqrt{3}\right)\hat{i}+\left(15-35\sqrt{2}\right)\hat{j}$	197. v	198. $\left(2+\frac{3}{\sqrt{2}}-\frac{7\sqrt{3}}{2}\right)\hat{\imath}+\left(2\sqrt{3}-\frac{3}{\sqrt{2}}+\frac{7}{2}\right)\hat{\jmath}$
199. (b)	200. 150°	201. 240°
202. magnitude of $3u$ is 3 times the magnitude of u but the direction does not change	203. 4.5	204. 59°
205. $-45°$	206. (a)	207. 100 N
208. (b)	209. (b)	210. (c)
211. (d)	212. (a)	213. (d)
214. (a)	215. (b)	215. (c)

216. (c)	217. (b)	218. (c)
219. (c)	220. (d)	221. (b)
222. (b)	223. (a)	224. (d)
225. (b)	226. 90°	227. (a)
228. (a)	229. (c)	230. $(0, \frac{1}{2})$
231. (b)	232. (c)	233. (b)
234. (a)	235. $8\sqrt{3}$	236. $50\hat{k}$
237. -2	238. (d)	239. (a),(d)
240. (a)	241. (a)	242. $\left(\frac{1}{\sqrt{6}}, \frac{1}{\sqrt{6}}, \frac{-2}{\sqrt{6}}\right)$
243. 0.514 , 0.810 , -0.281	244. $\vec{r} = \langle 2.5, -8.8, 4.1 \rangle$, $\cos\alpha = 0.249$ $\cos\beta = \frac{-8.8}{\sqrt{100.5}}$ $\cos\gamma = 0.409$	245. (a) $ML \cdot T^{-2}$ (b) AT (c) MLT^{-1} (d) $L^2 T^{-2}$ (e) $\frac{ML^{-1}T^{-2}L\text{^}3}{\text{mol } K}$ (f) $\frac{ML^2T^{-3}}{A^2}$ (g) $MA^{-1}T^{-2}$ (h) $ML^{-1}T^{-2}$
246. (c)	247. (c)	248. (d)
249. (b)	250. (c)	251. (d)
252. (d)	253. (d)	254. (d)
255. (a)	256. (c)	257. (b)
258. (a)	259. (d)	260. $[A] = MLT^{-3}, [B] = MLT^{-2}, [C] = MLT^{-1}$
261. (d)	262. $v \propto \sqrt{g\lambda}$	263. $[a] = [LT^{-1}]$, $[b] = [LT^{-2}]$
264. T	265. (c)	266. (a)
267. (a)	268. $T=p^{-5/6}d^{1/2}E^{1/3}$	269. $v = \frac{\sqrt{Y}}{\sqrt{\tau}}$
270. (a)	271. $[MLT^{-3}]$, $[MLT^{-4}]$	272. a = -5/6, b = 1/2 , c = 1/3
273. (b)	274. (a)	275. (a)
276. (d)	277. Calorie = $4.2\alpha^{-1}\beta^{-2}\gamma^2$ New unit	278. (a), (d)
279. 3	280. (b)	281. (a)
282. (a)	283. 4.1 cm, 4.24 cm , 4.093 cm	284. (a) 2.876 cm (b) 0.396,0.416,1.614,0.386,0.416 (c)0.6456 (d) 22.45%
285. (b)	286. 11%	287. (b)
288. (d)	289. (b)	290. (b)
291. (c)	292. 0.2116	293. (c)
294. 3.85% , 11.53%	295. (b)	296. (c)
297. (c)	298. (a)	299. (a)
300. (d)	301. (c)	302. (d)
303. (c)	304. (b)	305. (d)
306. (b)	307. (a)	308. 4%
309. 1.30%	310. 1.39%	311. (a),(b),(d)
312. (d)	313. (a),(c)	314. (a) 4 (b) 4 (c) 4 (d) 6 (e) 4 (f) 4 (g) 4 (h) 2
315. (a) 1 (b) 3 (c) 4 (d) 4	316. (b)	317. (a)

(e) 4 (f) 4		
318. (d)	319. 2.3 kg	320. $A = 8.721m^2, V = 0.0855\ \mathrm{m}^3$
321. (c)	322. (a) 4 (b) 4 (c) 5 (d) 4	323. (a)
324. (a) 3.4 (b) 1.2 (c) 61	325. 2.17 mm	326. (a) 0.4 (b) 14
327. 4.8 $\mathrm{g/cm}^3$	328. (a) 2.52 (b) 4.64 (c) 22.8 (d) 36.4	329. (b)
330. (b)	331. $(3.45 \pm 0.3)\mathrm{m/s}$	332. (c)
333. (a)	334. (a)	335. (d)
336. (a)	337. (a)	338. (d)
339. (c)	340. (c)	341. (c)
342. (c)	343. (c)	344. 5.094 cm
345. 3.63 cm	346. (d)	347. $\frac{a}{n+1}$ units
348. (c)	349. 3.09 cm	350. (b)
351. (c)	352. (b)	353. (b)
354. 3	355. 2.66g/cm^3	356. (b)
357. (a)	358. 2.84 mm	359. (a)
360. (c)	361. (b)	362. (d)
363. (d)	364. (d)	365. (d)
366. (d)	367. (c)	368. (b),(c)
369. (d)		

Answer Key- Beginner Test-I

1. (b)	2. (d)
3. (a)	4. (a)
5. (d)	6. (a)
7. (b)	8. (d)
9. (b)	10. (b)
11. (a)	12. (d)
13. (d)	14. (c)
15. $5\sqrt{5}$	16. $\mathbf{-2\hat{\imath}-5\hat{\jmath}-2\hat{k}}$
17. $90°$	18. a) $\frac{18\hat{\imath}-\hat{\jmath}}{\sqrt{325}}$ $(b) 0$ $(c) -50\hat{k}$
19. $\tan^{-1}(2)$	20. $50\hat{k}$

Answer Key- Beginner Test-II

1. 1 light year	2. In mechanics, length, mass and time are chosen as the base quantities because (i). There is nothing simpler to length, mass and time. (ii). All other quantities in mechanics can be expressed in terms of length, mass and time. (iii). Length, mass and time cannot be derived from any other quantity.
3. (c)	4. The value $m = 10.23\ kg$ is more accurate, being correct up to 2nd place of decimal
5. All such zeros are not significant e.g. $x = 678000$ has only three significant figures.	6. When a star is more than 100 light years away, then the parallax angle is so small that it cannot be measured accurately.
7. 500 new unit of length	8. 0.035 mm
9. $\pm 7\%$	10. $(31.4\ \pm 0.6)\ cm$
11. $(14.4\ \pm 0.2)\ cm^3$	12. (a) 1 (b) 3 (c) 4 (d) 4 (e) 4 (f) 4
13. (a) 0.59 (b) 0.961 (c) 876	14. (a) 1.330 (b) $\Delta D_1 = 0.002\ cm, \Delta D_2 = 0\ cm$ $\Delta D_3 = +0.005\ cm$ $\Delta D_4 = 0.004\ cm$ $\Delta D_5 = +0.004\ cm$ $\Delta D_6 = +0.006\ cm$ (c) 0.004 (d) ± 0.003 (e) $\pm 0.3\ \%$ (f) $1.330\ cm\ \pm 0.3\ \%$
15. $[LT^{-2}]$	16. $3.24 \times 10^9\ units$
17. $v = k\sqrt{rg}$	18. $F = kr\,\eta v$
19. 1. Work 2. Kinetic Energy 3. Potential Energy	20. Resistivity

4. Moment of force or torque 5. Surface energy 6. Rotational Kinetic Energy 7. Pressure energy	
21. optical instrument	22. 0.035 mm
23. Wrap the thread on a uniform smooth rod in such a way that the coils thus formed are very close to each other. Measure the length of the thread using a meter scale. The diameter of the thread is given by the relation, Diameter $=\frac{Length\ of\ thread\ along\ the\ smooth\ rod}{Number\ of\ turns}$ It is not possible to increase the accuracy of a screw gauge by increasing the number of divisions of the circular scale. Increasing the number divisions of the circular scale will increase its accuracy to a certain extent only.	24. 94.11
25. a) 7 b) 3 c) 4 d) 4 e) 4 f) 4	26. 8.72 m^2, 0.0855 m^3
27. 2.3 kg, 0.02 g	28. 13%, 3.763
29. y = a sin vt	30. $m = \frac{m_0}{\left(1-\frac{v^2}{c^2}\right)^{\frac{1}{2}}}$
31. 3.16 × 10^{-7} m^3	32. 7.08 × 10^4
33. Line of sight is defined as an imaginary line joining an object and an observer's eye. When we observe nearby stationary objects such as trees, houses, etc. while sitting in a moving train, they appear to move rapidly in the opposite direction because the line-of-sight changes very rapidly. On the other hand, distant objects such as trees, stars, etc. appear stationary because of the large distance. As a result, the line of sight does not change its direction rapidly.	34. 0.309 × $10^{17} m$
35. 1.32 $parsec$, $1.52''$	36. It is indeed very true that precise measurements of physical quantities are essential for the development of science. For example, ultra-shot laser pulses (time interval ~ 10^{-15} s) are used to measure

	time intervals in several physical and chemical processes-ray spectroscopy is used to determine the inter-atomic separation or inter-planer spacing. The development of mass spectrometer makes it possible to measure the mass of atoms precisely.
37. Refer Solution	38. Refer Solution
39. $1.435 \times 10^5 km$	40. $\tan\theta = \frac{v}{v'}$

Answer Key- Expert Test-I

1. (d)	2. (b)
3. (a)	4. (b)
5. (b)	6. (c)
7. (a)	8. (a)
9. (c)	10. (c)
11. (b)	12. (a)
13. (b)	14. (c)
15. 90°	16. $\sqrt{17}$, distance travelled in X axis $= 2$ m distance travelled in Y axis $= 2$ m distance travelled in Z axis $= 3$ m
17. $\sqrt{52}$ km, $\tan^{-1}(5)$	18. 1
19. $\alpha = 60°, \beta = 60°, \gamma = 45°$	20. 0

Answer Key- Expert Test-II

1. (a)	2. (c)
3. (d)	4. (d)
5. (b)	6. (a)
7. (c)	8. (d)
9. (a)	10. (b)
11. (a)	12. (c)
13. (a)	14. (c)
15. (b)	16. (c)
17. (a)	18. (d)
19. (a)	20. (d)
21. (b)	22. (d)
23. (d)	24. (c)
25. (a)	26. (c)
27. (c)	28. (a)
29. (c)	30. (a)
31. (b)	32. (c)
33. (b)	34. (b)
35. (b)	36. (c)
37. (c)	38. (d)
39. (d)	40. (b)
41. (c)	42. (b)

43. (b)	44. (a)
45. (a)	46. (b)
47. (b)	48. (b)
49. (c)	50. (d)

Answer Key- Pro Test-I

1. (a)	2. (a)
3. (c)	4. (b)
5. (d)	6. (d)
7. (c)	8. (b)
9. (a)	10. (c)
11. $a = 2i - j$	12. $0 < x < \frac{1}{2}$
13. (a) $\frac{6}{\sqrt{3}}$ (b) $\sqrt{2}$	14. Refer Solution
15. (c)	

Answer Key- Pro Test-II

1. 3	2. (a, b)
3. (b, d)	4. a = -5/6, b = 1/2 , c = 1/3
5. (b)	6. (b)
7. (c)	8. (d)
9. (b)	10. 1.30%
11. 1.39%	12. 0.3 mm
13. (a, b, d)	14. (b, c)
15. (d)	

Kinematics

Chapter Summary

Motion and Rest

Motion is relative. The same body can be in motion and at rest simultaneously at the same time with respect to two different observers.

Frame of Reference

This is a point in 3-D space about which the position or motion of a body is defined.

Distance: It is defined as the actual length of path covered by an object.

It is a +ve scalar quantity.

Its SI unit is m (meter).

Displacement: Displacement is the change in position vector i.e., vector joining initial and final position, or we can say it is a minimum possible distance between two positions.

It is a vector quantity.

Position vector of $A = \overrightarrow{OA} = \vec{r}_1$

Position vector of $B = \overrightarrow{OB} = \vec{r}_2$

Displacement from position A to $B = \overrightarrow{AB}$

$\overrightarrow{AB} = \overrightarrow{OB} - \overrightarrow{OA} = \vec{r}_2 - \vec{r}_1$

Speed: It is defined as the rate of change of distance, with respect to time.

$$(v) = \frac{ds}{dt}$$

It's the derivative of distance with respect to time.

If speed is uniform, then

$$\text{Speed} = \frac{\text{Distance}}{\text{time}} = \frac{S}{T}$$

It is a scalar quantity.

Its S.I. unit is m/s

Average Speed

The average speed of a particle is defined as ratio of total distance travelled to the total time taken

$$\text{Average Speed} = \frac{\text{Total Distance travelled}}{\text{Total time taken}}$$

Velocity

It is defined as the rate of change in displacement with respect to time. $v = \frac{d\vec{r}}{dt}$

It is a vector quantity.

Its S.I. unit is m/s

Average Velocity

The average velocity of a particle for a given interval of time is defined as the ratio of its displacement to the time taken.

Average velocity $= \vec{v}_{av} = \frac{\text{Displacement}}{\text{Time}} = \frac{\Delta \vec{S}}{\Delta t}$

Acceleration

It is defined as rate of change of velocity with respect to time.

$$\vec{a} = \lim_{\Delta t \to 0} \frac{\Delta \vec{v}}{\Delta t} = \frac{d\vec{v}}{dt}$$

Also, $v = \frac{dx}{dt}$, $a = \frac{dv}{dt} = \frac{d^2x}{dt^2} = \frac{vdv}{dx}$

It is a vector quantity

Its S.I. unit is m/s^2

Average acceleration

It is defined as ratio of change in velocity to the time interval in which change takes place.

Suppose a particle moving along x-axis has velocity v_1 at time t_1 and velocity v_2 at time t_2 average acceleration is given by

$$a_{av} = \frac{\text{change in velocity}}{\text{Time}}$$

Equations of Motion

If the acceleration of the particle is constant, then we can write these three useful equations of motion as:

$$v = u + at$$

$$S = ut + \frac{1}{2}at^2$$

$$v^2 = u^2 + 2as$$

Where, v=final velocity, u=initial velocity

S=displacement, t=time, a=constant acceleration

Motion Under Gravity

Case 1:

When an object is thrown in upward direction (taking positive) space with initial velocity v_0.

Acceleration $= -g$ (in downward direction)

So, equation of motion will be

$$v = v_0 - gt$$

$$h = v_0 t - \frac{1}{2}gt^2$$

$$v^2 = v_0^2 - 2gh$$

Case 2:

When an object is thrown in downward direction (taking positive) in space with initial velocity v_0.

Acceleration $= +g$ (in downward direction)

So, equation of motion will be

$$v = v_0 + gt$$

$$s = v_0 t + \frac{1}{2}gt^2$$

$$v^2 = v_0^2 + 2gh$$

Graphs in Motion

There are 3 commonly drawn graphs in motion:

Displacement–Time Graph

(i) Slope of positive vs. time graph gives velocity

(ii) Slope at a particular point of the graph gives instantaneous velocity

(iii) Slope of a line joining initial position to final position gives average velocity between two points.

(iv) The maximum slope at any point on the graphs gives the maximum velocity.

(v) When graph will be straight line parallel to x-axis, it means slope is zero so velocity will be zero.

$$v = \tan\theta = 0 = \tan 0°$$

(vi) Area of displacement-time graph has no significance.

Velocity–Time Graph

(i) Slope of velocity vs. time graph gives acceleration.

(ii) Area under curve gives displacement and area on negative side gives negative displacement.

Acceleration–Time Graph

1. The slope of acceleration vs. time graphs gives rate of change of acceleration with respect to time, which has no physical significance.

2. Area under curve of this graph gives change in velocity.

Projectile Motion

Motion along horizontal direction (*x*-axis)

$$u_x = u\cos\theta \text{ (remains constant)}$$

$$a_x = 0$$

$$\text{Range} = u_x t$$

$$\text{Range} = (u\cos\theta)t$$

Motion in vertical direction (*y*-axis)

$$u_y = u\sin\theta$$

$$a_y = -g \text{ (which is constant)}$$

$$v_y = u_y - gt$$

$$= u\sin\theta - gt$$

$$y = u_y t - \frac{1}{2}gt^2$$

$$= (u\sin\theta)t - \frac{1}{2}gt^2$$

Also we have,

$$v_y^2 = u_y^2 - 2gy$$

$$= (u\sin\theta)^2 - 2gy$$

Time of Flight

$$T = \frac{2u\sin\theta}{g}$$

Maximum Height

$$H = \frac{u^2\sin^2\theta}{2g}$$

Horizontal Range

Range of projectile is horizontal distance traveled by the particle during the time of flight

$$R = v_x t$$

$$R = (u\cos\theta)\left(\frac{2u\sin\theta}{g}\right)$$

$$R = \frac{u^2\sin 2\theta}{g}$$

For range to be maximum

$$R = \frac{u^2\sin 2\theta}{g}$$

$$\theta = 45°$$

$$R_{\max} = \frac{u^2}{g}$$

Equation of Trajectory

$$y = (\tan\theta)x - \frac{1}{2}g\frac{x^2}{u^2\cos^2\theta}$$

Relative Motion

If velocity A is $\vec{v}_A$ and that of B is $\vec{v}_B$ with respect to a stationary frame, then from the definition, relative velocity of A with respect to B, $\vec{v}_{AB}$ is given by

$$\vec{v}_{AB} = \vec{v}_A - \vec{v}_B$$

River-Boat Problems

River-boat problem is based on concept of relative velocity and resultant velocity. In this problem we come-across three terms

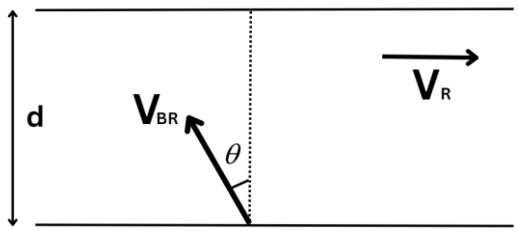
$\vec{v}_{RG}$ = velocity of river with respect to ground

$\vec{v}_{BR}$ = velocity of boatman with respect to river or velocity of boatman in still water

$\vec{v}_{BG}$ = velocity of boatman with respect to ground.

d = width of the river

Let the river is flowing along *x*-axis with velocity $\vec{v}_{RG}$



General Time taken to cross the river is t

$$t = \frac{d}{V_{BR}\cos\theta}$$

Case-I

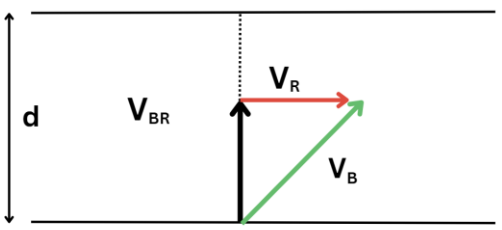
When a boat tends to cross a river in shortest time

For shortest time,

$\cos\theta$ has to be maximum $= 1$

$\theta = 0°$

$$t_{\min} = \frac{d}{V_{BR}}$$



In this case, drift would happen.

So, drift $= V_R \times t_{min}$

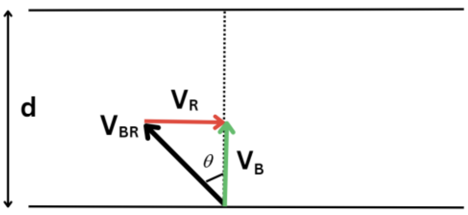
$$Drift = \frac{d}{V_{BR}} V_R$$

Case-II

When a boat-man wants to reach the point just opposite from where he started

When boat-man wants to cross the river in shortest path, horizontal distance (drift) covered must be zero.

$$\sin\theta = \frac{V_R}{V_{BR}},\ \theta = \sin^{-1}\left(\frac{V_R}{V_{BR}}\right)$$



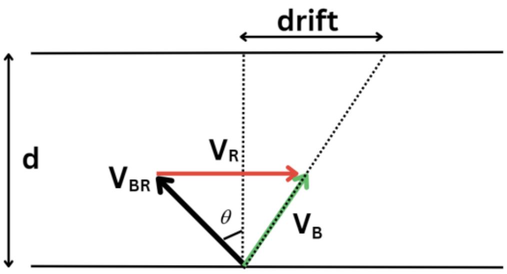
Hence, time will be given by,

$$t = \frac{d}{V_{BR}\cos\theta}$$

$$Drift = Zero$$

Case-III

General Case



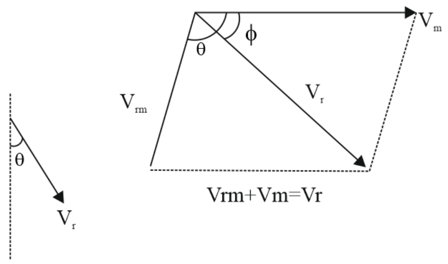
Time in general case is given by

$$t = \frac{d}{V_{BR}\cos\theta}$$

Drift will be given by

$$Drift = \frac{d}{V_{BR}\cos\theta}(V_R - V_{BR}\sin\theta)$$

Rain Man Problems



$\vec{V}_{rm}$ = Velocity of rain w.r.t man

$\vec{V}_r$ = Velocity of rain w.r.t ground

$\vec{V}_m$ = Velocity of man w.r.t ground

Applying the concept of relative velocity,

$\vec{V}_r = \vec{V}_{rm} + \vec{V}_m$

$\vec{V}_r$ is vector addition of $\vec{V}_{rm} + \vec{V}_m$

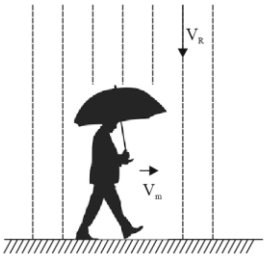
Now, depending on the velocity of the man, $\vec{V}_m$ *and* $\vec{V}_{rm}$ can change, but the sum of these two vectors will be equal to $\vec{V}_r$

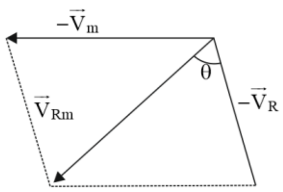
If rain is falling vertically with a velocity $\vec{V}_R$ and and observer is moving horizontally with velocity $\vec{V}_m$, the velocity of rain relative to observer will be:

$\vec{V}_{Rm} = \vec{V}_R - \vec{V}m$

$or\ V_{Rm} = \sqrt{V_R^2 + V_m^2}$

and direction $\theta = tan^{-1}\left(\frac{V_m}{V_R}\right)$ with the vertical as shown in figure





Wind Airplane Problems

Velocity of airplane with respect to wind

$\vec{v}_{aw} = \vec{v}_a - \vec{v}_w$

or $\vec{v}_a = \vec{v}_{aw} + \vec{v}_w$

Where, $\vec{v}_a$ = velocity of airplane w.r.t. ground and, $\vec{v}_w$ = velocity of wind

Circular Motion

Circular motion is a type of motion in which a particle moves around a fixed point such that, its distance from a fixed point is constant.

Angular displacement: When a particle moves on a circular path, angle made at center is called angular Displacement.

It is represented by the symbol θ

Its Unit is radian.

Angular velocity (ω)

Angular velocity is rate of change of angular displacement

Angular velocity $\omega = \dfrac{d\theta}{dt}$

If angular velocity is constant, $\theta = \omega t$

Or, $(\omega) = \dfrac{\Delta\theta}{\Delta t} = \dfrac{\theta}{t}$

Its unit is radian per second

Angular Acceleration (α)

Angular acceleration is defined as rate of change of angular velocity

$\alpha = \lim\limits_{\Delta t \to 0} \dfrac{\Delta\omega}{\Delta t} = \dfrac{d\omega}{dt}$

Types of Circular Motion

(a) Uniform circular motion

(b) Non-uniform circular motion

(a) Uniform circular motion: When a particle moves on a circular path in such a way that its angular speed is constant, such type of motion is called uniform circular motion.

Since ω is constant, angular acceleration α is zero.

- In this motion speed is constant but velocity is not constant since direction changes continuously so acceleration is also non-uniform.
- In uniform circular motion tangential acceleration will be zero.
- Time period is time taken in one complete revolution. It is denoted by T.

$T = \dfrac{2\pi}{\omega}$

- Frequency (n) is number of revolutions per second and $n = \dfrac{1}{T}$

(b) Non-uniform circular motion: Such type of motion in which angular speed is not constant.

- In this type of motion velocity changes with magnitude as well as direction both.
- Angular acceleration $(\alpha) = \dfrac{d\omega}{dt} \neq 0$
- Tangential acceleration $(a) = \dfrac{dv}{dt} \neq 0$

Centripetal Acceleration

When an object moves on a circular path with constant angular speed, an acceleration acts at each point of the path **direction towards the center of** the circle is called **centripetal acceleration.**

Centripetal acceleration $a_c = \dfrac{v^2}{r} = \omega^2 r$

Direction of Acceleration

It's direction of acceleration is radially inwards.

Relation between linear kinematic variable and angular kinematic variable

- Linear velocity, $V = \omega R$
- Tangential acceleration, $a_t = \alpha R$
- Radial or centripetal acceleration, $a_r = \omega^2 R$
- Total acceleration, $a = \sqrt{\alpha^2 R^2 + \omega^4 R^2}$ at an angle of $\tan^{-1}\left(\dfrac{a_t}{a_r}\right)$ with radius

Centripetal force: $F_r = M\omega^2 R = \dfrac{MV^2}{R}$

towards the center

Centrifugal force: $F_r = M\omega^2 R = \dfrac{MV^2}{R}$,

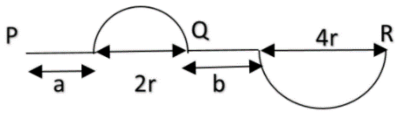
away from the center

Beginner — Distance and Displacement

1. An athlete completes one round of a circular track of radius R in 40 s. What will be his displacement at the end of 2 min. 20 s?
(a) Zero (b) 2R
(c) 2πR (d) 7πR

2. A person moves 30 m north and then 20 m towards east and finally $30\sqrt{2}$ m in south-west direction. The displacement of the person from the origin will be
(a) 10 m along north (b) 10 m long south
(c) 10 m along west (d) Zero

3. A car starts from P and follows the path as shown in figure. Finally, car stops at R. Find the distance travelled and displacement of the car if



$a = 7m$, $b = 8\ m$ and $r = \frac{11}{\pi} m$? [Take $= \frac{22}{7}$]

4. When a person leaves his home for sightseeing by his car, the meter reads 12352 km. When he returns home after two hours the reading is 12416 km. During the journey, he stays for 15 minutes at midway.
(a) What is the average speed of the car during this period?
(b) What is the average velocity?

Expert — Distance and Displacement

5. A wheel of radius 1 meter rolls forward half a revolution on a horizontal ground. The magnitude of the displacement of the point of the wheel initially in contact with the ground is
(a) 2π (b) $\sqrt{2}\pi$
(c) $\sqrt{\pi^2+4}$ (d) π

6. A body starts from origin and moving in north direction with the speed 20 m/s and moves for 3 seconds. After that it turns right and moves with speed 30 m/s for next 3 seconds. Thereafter, it turns 135° clockwise and starts moving with 10 m/s for next 20 seconds. Find
(a) Total distance travelled by the body
(b) Magnitude of displacement & its direction

7. A body starts from origin and moving in north direction with the constant speed 20 m/s in a circular motion clockwise direction. The time period of its motion is 8 seconds. Find the distance & displacement in 5 seconds.

Beginner — Speed and Velocity

8. One car moving on a straight road covers one third of the distance with 20 km/hr and the rest with 60 km/hr. The average speed is
(a) 40 km/hr (b) 80 km/hr
(c) $46\frac{2}{3}$ km/hr (d) 36 km/hr

9. Boston Red Sox pitcher Roger Clemens could routinely throw a fastball at a horizontal speed of 160 km/hr. How long did the ball take to reach home plate 18.4 m away?

10. A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 km/h. Finding the market closed, he instantly turns and walks back home with a speed of 7.5 km/h. The average speed of the man over the interval of time 0 to 40 min. is equal to
(a) 5 km/h (b) $\frac{25}{4}$ km/h
(c) $\frac{30}{4}$ km/h (d) $\frac{45}{8}$ km/h

11. If a car covers 2/5th of the total distance with v_1 speed and 3/5th distance with v_2 then average speed is?

Expert — Speed and Velocity

12. The distance travelled by a particle in time t is given by $s = (2.5)t^2$. Find (a) the average speed of the particle during the time 0 to 5.0 s, and (b) the instantaneous speed at $t = 5.0\ s$.

13. $x = t^2 - 4t$ Find out the average speed and velocity in 5 seconds of its motion.

14. A particle travels half of its journey with speed v_0 and remaining half it travels in two equal time intervals with speeds v_1 and v_2. Find out the average velocity of the particle.

Beginner — Acceleration & Calculus

15. A particle moves along a straight line such that its displacement at any time t is given by $S = t^3 - 6t^2 + 3t + 4$ meters. The velocity when the acceleration is zero is
(a) 3ms^{-1} (b) -12ms^{-1}
(c) 42 ms^{-1} (d) -9ms^{-1}

16. The displacement of a particle is given by $y = a + bt + ct^2 - dt^4$. The initial velocity and acceleration are respectively
(a) $b, -4d$ (b) $-b, 2c$
(c) $b, 2c$ (d) $2c, -4d$

17. A particle moves along x-axis as $x = 4(t-2) + a(t-2)^2$ Which of the following is true?

(a) The initial velocity of particle is 4
(b) The acceleration of particle is $2a$
(c) The particle is at origin at $t = 0$
(d) None of these

18. The velocity of a body depends on time according to the equation $v = 20 + 0.1t^2$. The body is undergoing

(a) Uniform acceleration
(b) Uniform retardation
(c) Non-uniform acceleration
(d) Zero acceleration

19. Starting from rest, acceleration of a particle is a = 2(t – 1). The velocity of the particle at t = 5s is

(a) 15 m/sec (b) 25 m/sec
(c) 5 m/sec (d) None of these

20. The position of a particle as a function of time t, is given by $x(t) = at + bt^2 - ct^3$ where, a, b and c are constants. When the particle attains zero acceleration, then its velocity will be:

(a) $a + \frac{b^2}{4c}$ (b) $a + \frac{b^2}{3c}$
(c) $a + \frac{b^2}{c}$ (d) $a + \frac{b^2}{2c}$

21. If the velocity of a particle is $v = At + Bt^2$, where A and B are constants, then the distance travelled by it
between 1s and 2s is

(a) 3A + 7B (b) $\frac{3}{2}A + \frac{7}{3}B$
(c) $\frac{A}{2} + \frac{B}{3}$ (d) $\frac{3}{2}A + 4B3$

Expert **Acceleration & Calculus**

22. The displacement x of a particle varies with time t as $x = \alpha t^2 - \beta t^3$

(a) particle will return to its starting point after time $\frac{\alpha}{\beta}$
(b) the particle will come to rest after time $\frac{2\alpha}{3\beta}$
(c) the initial velocity of the particle was zero, but its initial acceleration was not zero.
(d) no net force act on the particle at time $\frac{\alpha}{3\beta}$

23. A particle moves along a straight line such that the relation between time t and displacement s is $s^2 = t$, then

(a) Acceleration is positive and directly proportional to v^2
(b) Acceleration is positive and directly proportional to v^3
(c) Acceleration is negative and directly proportional to v^2
(d) Acceleration is negative and directly proportional to v^3

24. A particle moves along x-axis and displacement varies with time t as $x = \left(t^3 - 3t^2 - 9t + 5\right)$. Then

(a) in the interval 3< t< 5, the particle is moving in +x direction
(b) the particle reverses its direction of motion twice in entire motion if it starts at t = 0
(c) the average acceleration from $1 \le t \le 2$ seconds is 6m/s^2.
(d) in the interval $5 \le t \le 6$ seconds, the distance travelled is equal to the displacement.

25. The relation between time and distance is $t = \alpha x^2 + \beta x$, where α and β are constants. The retardation is

(a) $2\alpha v^3$ (b) $2\beta v^3$
(c) $2\alpha\beta v^3$ (d) $2\beta^2 v^3$

26. Position of a particle moving along x – axis is given by $x = 2 + 8t - 4t^2$ where t is time in sec. The distance travelled by the particle in the first two seconds is:

(a) 2 units (b) 8 units
(c) 10 units (d) 16 units

27. A particle is moving with speed $v = \sqrt{x}$ along positive x-axis. Calculate the speed of the particle at time t = τ (assume that the particle is at origin at t = 0).

(a) $\frac{b^2\tau}{4}$ (b) $\frac{b^2\tau}{2}$
(c) $b^2\tau$ (d) $\frac{b^2\tau}{\sqrt{2}}$

28. Two cars P and Q start from a point at the same time in a straight line and their positions are represented by $X_P(t) = at + bt^2$ and $X_Q(t) = ft - t^2$. At what time do the cars have the same velocity?

(a) $\frac{a-f}{1+b}$ (b) $\frac{a+f}{2(b-1)}$

(c) $\frac{a+f}{2(1+b)}$ (d) $\frac{f-a}{2(1+b)}$

29. In an arcade video game a spot is programmed to move across the screen according to $x = 9.00t - 0.750t^3$, where x is distance in centimeters measured from the left edge of the screen and t is time in seconds. When the spot reaches a screen edge, at either x = 0 or x = 15.0 cm, t is reset to 0 and the spot starts moving again according to x(t).
(a) At what time after starting is the spot instantaneously at rest?
(b) Where does this occur?
(c) What is its acceleration when this occurs?
(d) In what direction is it moving just prior to coming to rest?
(e) Just after?
(f) When does it first reach an edge of the screen after t = 0?

30. A particle is moving in a straight line. The velocity v of the particle varies with time t, as $v = t^2 - 4t$, then the distance travelled by the particle in t = 0 to t = 6s (where t is in seconds and v is in m/s).

(a) $\frac{64}{3}m$ (b) zero

(c) $\frac{32}{3}m$ (d) None of these

31. A particle moves along a straight line such that its displacement x changes with time t as $x=\sqrt{at^2+2bt+c}$ where a, b and c are constants, then the acceleration varies as

(a) $\frac{1}{x}$ (b) $\frac{1}{x^2}$

(c) $\frac{1}{x^3}$ (d) $\frac{1}{x^4}$

Pro	**Acceleration & Calculus**

32. Given $a = 5\ m/s^2$, Initial position = 5m, Initial velocity = 2 m/s. Find the following functions: x=f(t), v=f(t), v=f(x)

33. Given $v = x^2$, Initial position = 5 m
Find the following:
a=f(x), x=f(t), v=f(t), a=f(t)

34. A radius vector of a particle varies with time t as $r = at(1 - \alpha t)$, where a is a constant vector and α is a positive factor. Find:
(a) The velocity v and the acceleration w of the particle as functions of time;
(b) The time interval Δt taken by the particle to return to the initial points, and the distance s covered during that time.

35. At the moment t = 0, a particle leaves the origin and moves in the positive direction of the x-axis. Its velocity varies with time as $v=v_0\left(1-\frac{t}{\tau}\right)$, where v_0 is the initial velocity vector whose modulus equals $v_0 = 10.0\ cms^{-1}$; τ = 5.0 s. Find:
(a) The x coordinate of the particle at the moments of time 6, 10, and 20 s;
(b) The moments of time when the particle is at the distance 10.0 cm from the origin;
(c) The distance s covered by the particle during the first 4.0 and 8.0 s; draw the approximate plot s(t).

36. The velocity of a particle moving in the positive direction of the x axis varies as $v=\alpha\sqrt{x}$, where α is a positive constant. Assuming that at the moment t = 0 the particle was located as the point x = 0, Find:
(a) The time dependence of the velocity and the acceleration of the particle;
(b) The mean velocity of the particle averaged over the time that the particle takes to cover the first s meters of the path.

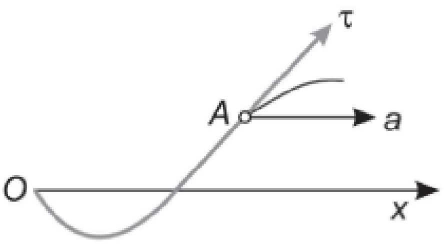
37. A point moves rectilinearly with deceleration whose modulus depends on the velocity v of the particle as $w=\alpha\sqrt{v}$, where α is a positive constant. At the initial moment the velocity of the point is equal to v_0. What distance will it traverse before it stops? What time will it take to cover the distance?

38. A radius vector of a point A relative to the origin varies with time t as $r = at\,i - bt^2 j$, where a and b are positive constants, and i and j are the unit vectors of the x and y axes. Find :
(a) the equation of the point's trajectory y(x); plot this function;
(b) the time dependence of the velocity v and acceleration w vectors, as well as of the moduli of these quantities;
(c) The time dependence of the angle α between the vectors w and v;

(d) The mean velocity vector averaged over the first t seconds of motion, and the modulus of this vector

39. A point moves in the plane xy according to the law $x = a\sin\omega t$, y = a (1 - cos ωt), where a and ω are positive constants, Find:
(a) The distance s traversed by the point during the time x;
(b) The angle between the point's velocity and acceleration vectors

40. A particle A moves in one direction along a given trajectory with a tangential acceleration $w_\tau = a\tau$, where a is a constant vector coinciding in direction with the x axis (Fig.), and τ is a unit vector coinciding in direction with the velocity vector at a given point. Find how the velocity of the particle depends on x provided that its velocity is negligible at the point x = 0.



41. A particle moves along the plane trajectory y[x) with velocity v whose modulus is constant. Find the acceleration of the particle at the point x = 0 and the curvature radius of the trajectory at that point if the trajectory has the form.
(a) Of a parabola y = ax^2;
(b) Of an ellipse $(x/a)^2 + (y/b)^2 = 1$; a and b are constants here.

42. A particle travels according to the equation a = A – Bv where a is the acceleration. A and B are constants, v is the velocity of the particle. Find its velocity as a function of time. Also find its terminal velocity.

43. A particle of mass 10^{-2} kg is moving along the positive x-axis under the influence of a force $F(x) = -\frac{k}{2x^2}$, where k = 10^{-2} Nm^2. At time t = 0, it is at x = 1.0 m and its velocity is v = 0. Find its velocity when it reaches x = 0.5 m.

44. A particle starts from rest, with an acceleration $a = \frac{\lambda}{x^2}$, where λ > 0 and x is the distance of the particle from a fixed-point O. The particle is at a distance μ from O, when it is at rest. Its velocity when at a distance 2 μ from O is

(a) $\sqrt{\frac{\lambda}{\mu}}$ (b) $\sqrt{\frac{\lambda}{2\mu}}$

(c) $\sqrt{\frac{2\lambda}{\mu}}$ (d) None

45. A particle starts from a point x = 0 along the positive X – axis with a velocity v, varying with x as $v = \mu\sqrt{x}$, the average velocity of the particle over the first s meters of its path is

(a) $\mu\sqrt{s}$ (b) $\mu\sqrt{\frac{s}{2}}$

(c) $2\mu\sqrt{s}$ (d) $\frac{\mu}{2}\sqrt{s}$

46. A particle moving in a straight line has velocity (v) and displacement(s) related as $v = 4\sqrt{1+s}$, where velocity (v) is in m/s and displacement (s) is in meters. Then (at t = 0, s = 0)
(a) Acceleration of the particle is 8 m/s^2
(b) Velocity of the particle at t = 2s is 20 m/s
(c) Displacement of the particle at t = 2s is 24
(d) Displacement of the particle at t = 1s is 8 m

47. Velocity v of a moving particle, on x – axis varies with its x – coordinate as $V = \beta x^{\frac{1}{3}}$ when β is a positive constant. Assuming the particle to start from origin.
(a) Acceleration of particle is variable.
(b) Mean velocity of point averaged over time τ from starting is $\left(\frac{2\beta}{3}\right)^{\frac{3}{2}}\sqrt{T}$.
(c) Mean velocity of point averaged over the time taken by the point to move from the origin to the point where its x – coordinate becomes x_0 is $\frac{2\beta x_0^{\frac{1}{3}}}{3}$
(d) All above statements are false

Beginner **Equation of Motion**

48. A particle starts from rest, moves with constant acceleration of 5 m/s^2 for 10 seconds. After that it moves with constant speed for next 2 minutes. Then it retards and comes to rest in 30 seconds. Find the followings:
(a) Total time
(b) Maximum Velocity
(c) Total distance
(d) Average velocity in 1 minute
(e) Ratio of distance travelled in 3rd & 3 seconds

49. A particle starting from rest travels a distance x in first 2 seconds and a distance y in next two seconds, then
(a) y = 8x (b) y = 2x
(c) y = 3x (d) y = 4x

50. A particle experiences a constant acceleration for 20 sec after starting from rest. If it travels a distance S_1 in the first 10 sec and a distance S_2 in the next 10 sec, then
(a) $S_1 = S_2$ (b) $S_1 = S_2/3$
(c) $S_1 = S_2/2$ (d) $S_1 = S_2/4$

51. How long does it take an object to travel a distance of 30m from rest at a constant acceleration of 2m/s^2?
Possible Answers:
(a) 2.7s (b) 12.6s
(c) 10.9s (d) 7.3s
(e) 5.5s

52. A race car accelerates uniformly from 18.5 m/s to 46.1 m/s in 2.47 seconds. Determine the acceleration of the car and the distance traveled.

53. An engineer is designing the runway for an airport. Of the planes that will use the airport, the lowest acceleration rate is likely to be 3m/s^2. The takeoff speed for this plane will be 65m/s. Assuming this minimum acceleration, what is the minimum allowed length for the runway?

54. A bullet leaves a rifle with a muzzle velocity of 521 m/s. While accelerating through the board of the rifle, the bullet moves a distance of 0.840 m. Determine the acceleration of the bullet (assume uniform acceleration).

55. The head of a rattlesnake can accelerate $50\frac{m}{s^2}$ in striking a victim. If a car could do as well, how long would it take to reach a speed of $100\frac{km}{hr}$ from rest?

56. A body moving with uniform acceleration has a velocity of $12.0\frac{cm}{s}$ when its x coordinate is 3.00 cm. If its x coordinate 2.00 s later is –5.00 cm, what is the magnitude of its acceleration?

57. A jet plane lands with a velocity of $100\frac{m}{s}$ and can accelerate at a maximum rate of $-5.0\frac{m}{s^2}$ as it comes to rest. (a) From the instant it touches the runway, what is the minimum time needed before it stops? (b) Can this plane land at a small airport where the runway is 0.80 km long?

58. A bullet fired into a fixed target loses half of its velocity after penetrating 3 cm. How much further it will penetrate before coming to rest if it faces constant resistance to motion?
(a) 1.5 cm (b) 1.0 cm
(c) 3.0 cm (d) 2.0 cm

59. A bullet traveling horizontally loses $\frac{1}{5}$th of its velocity crossing wooden plank. How many such planks are required to stop the bullet?
(a) ≈ 3 (b) ≈ 4
(c) ≈ 5 (d) ≈ 6

60. The initial velocity of a body moving along a straight line is 7 m/s. It has a uniform acceleration of 4 m/s^2. The distance covered by the body 5th second of its motion is
(a) 25 m (b) 35 m
(c) 50 m (d) 85 m

61. A particle travels 10m in first 5 s and 10m in next 3 s. Assuming constant acceleration what is the distance travelled in next 2 s
(a) 8.3 m (b) 9.3 m
(c) 10.3 m (d) None of above

Expert **Equation of Motion**

62. An electron with initial velocity $v_0 = 1.50\times10^5\frac{m}{s}$ enters a region 1.0 cm long where it is electrically accelerated, as shown in fig. It emerges with velocity $v = 5.70\times10^6\frac{m}{s}$. What was its acceleration, assumed constant? (Such a process occurs in the electron gun in a cathode-ray tube, used in television receivers and oscilloscopes.)

63. A car moving with a velocity of 10 m/s can be stopped by the application of a constant force F in a distance of 20 m. If the velocity of the car is 30 m/s, it can be stopped by this force in

(a) $\frac{20}{3}m$ (b) 20 m
(c) 60 m (d) 180 m

64. In a journey of 4 km a train travels with a constant acceleration for the first three-tenths of a km, at a uniform speed of 30 km/hr for the next 3 km and with a constant retardation for the rest of the distance. Find the time taken for the journey in minutes.

65. A bullet of mass 20g has an initial speed of 1 ms^{-1}, just before it starts penetrating a mud wall of thickness 20 cm. If the wall offers a mean resistance of 2.5×10^{-2} N, the speed of the bullet after emerging from the other side of the wall is close to:

(a) 0.1 ms^{-1} (b) 0.7 ms^{-1}
(c) 0.3 ms^{-1} (d) 0.4 ms^{-1}

66. A car accelerates from rest at a constant rate α for some time after which it decelerates at a constant rate β to come to rest. If the total time lapse is /seconds, Evaluate.

(a) Maximum velocity reached, and
(b) Total distance travelled

Pro **Equation of Motion**

67. A car, starting from rest, accelerates at the rate f through a distance S, then continues at constant speed for time t and then decelerates at the rate $\frac{f}{2}$ to come to rest. If the total distance traversed is 15 S, then

(a) $S = \frac{1}{2} ft^2$ (b) $S = \frac{1}{4} ft^2$
(c) $S = \frac{1}{72} ft^2$ (d) $S = \frac{1}{6} ft^2$

68. A body A starts from rest with an acceleration a_1. After 2 seconds, another body B starts from rest with an acceleration a_2. If they travel equal distances in the 5th second, after the start of A, then the ratio $a_1 : a_2$ is equal to

(a) 5 : 9 (b) 5 : 7
(c) 9 : 5 (d) 9 : 7

69. A car starts moving rectilinearly, first with acceleration w = 5.0 ms^{-2} (the initial velocity is equal to zero), then uniformly, and finally, decelerating at the same rate w, comes to a stop. The total time of motion equals τ = 25 s. The average velocity during that time is equal to <v> = 72 kmh^{-1}. How long does the car move uniformly?

70. Two ends of a train moves with speed 20 m/s and 60 m/s while crossing a given point. Calculate the velocity of train, when the midpoint of the train crosses the given point.

71. A body is moving from rest under constant acceleration and let S_1 be the displacement in the first $(p-1)$ sec and S_2 be the displacement in the first p sec. The displacement in $(p^2 - p + 1)^{th}$ sec. will be

(a) $S_1 + S_2$ (b) $S_1 S_2$
(c) $S_1 - S_2$ (d) S_1 / S_2

Beginner **Motion under Gravity**

72. A body is projected vertically upwards with 40 m/s from ground. Find the followings:

(a) Time of flight
(b) Maximum height
(c) Average speed and velocity in 5 sec
(d) Distance travelled in last second of its motion

73. If a 15kg ball takes five seconds to strike the ground when released from rest, at what height was the ball dropped? Possible Answers:

(a) 50m (b) 75m
(c) 125m (d) 250m

74. A person on top of a 200m tall building drops a rock. How long will it take for the rock to reach the ground? Ignore air resistance.

(a) t = 40.8s (b) t = 6.4s
(c) t = 7.3s (d) 113.4s

75. An object is released from rest and falls a distance h during the first second of time. How far will it fall during the next second of time?

(a) h (b) 2h
(c) 3h (d) 4h

76. Starting from rest, object 1 falls freely for 4.0 seconds, and object 2 falls freely for 8.0 seconds. Compared to object 1, object 2 falls:

(a) Half as far
(b) Twice as far

(c) three times as far
(d) four times as far

77. A ball which is dropped from the top of a building strikes the ground with a speed of 30 m/s. Assume air resistance can be ignored. The height of the building is approximately:
(a) 15 m (b) 30 m
(c) 45 m (d) 75 m

78. Two bodies of different mass m_a and m_b are dropped from two different heights a and b. The ratio of the time taken by the two to cover these distances are
(a) a : b (b) b : a
(c) $\sqrt{a} : \sqrt{b}$ (d) $a^2 : b^2$

79. A body starts to fall freely under gravity. The distances covered by it in first, second and third *seconds* are in ratio
(a) 1:3:5 (b) 1:2:3
(c) 1:4:9 (d) 1:5:6

80. A body falls freely from rest, covers as much distance in the last second of its motion as it covers in the first three seconds. The body has fallen for a time of
(a) 3 s (b) 5 s
(c) 7 s (d) 9 s

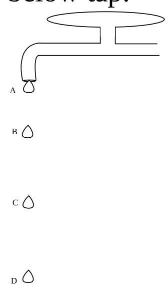
81. A body is released from the top of a tower of height h. It takes t sec to reach the ground. Where will be the ball after time t/2 sec
(a) At h/2 from the ground
(b) At h/4 from the ground
(c) Depends upon mass and volume of the body
(d) At 3h / 4 from the ground

82. A ball is released from the top of a tower of height *h* meters. It takes *T* seconds to reach the ground. What is the position of the ball in *T*/3 seconds?
(a) *h*/9 *meters* from the ground
(b) 7*h*/9 *meters* from the ground
(c) 8*h*/9 *meters* from the ground
(d) 17*h*/18 *meters* from the ground

83. A stone is dropped into water from a bridge 44.1 *m* above the water. Another stone is thrown vertically downward 1 *sec* later. Both strike the water simultaneously. What was the initial speed of the second stone?
(a) 12.25 *m / s* (b) 14.75 *m / s*
(c) 16.23 *m / s* (d) 17.15 *m / s*

84. Water drops fall at regular intervals from a tap which is 5 *m* above the ground. The third drop is leaving the tap at the instant the first drop touches the ground. How far above the ground is the second drop at that instant?
(a) 2.50 *m* (b) 3.75 *m*
(c) 4.00 *m* (d) 1.25 *m*

85. Water drops fall at regular interval from a tap. At an instant, when the 4th drop is about to leave tap, find ratio of separation between 3 successive drops below tap.



86. A ball is thrown vertically downward with a velocity of 20 m/s from the top of a tower. It hits the ground after some time with a velocity of 80 m/s. The height of the tower is (g =10 m/s^2)
(a) 340 m (b) 320 m
(c)300 m (d) 360 m

Expert **Motion under Gravity**

87. A body is projected vertically upwards with 40m/s from the tower of height 80m. Find the followings:
(a) Maximum height
(b) Time of flight
(c) Velocity of strike
(d) Distance travelled in last second
(e) Average Speed & Average Velocity in 9 seconds

88. A stone is thrown vertically upward with an initial velocity v_o. Find out the distance travelled in time $4v_o/3g$.

89. A stone is dropped from rest from top of a cliff. A 2nd stone is thrown vertically down from same point with 30 m/s velocity 2s later. At what distance from top of the hill, will the two stones meet. (g = 10 m/s^2)

90. A body is thrown vertically upwards with velocity *u*. The distance travelled by it in the fifth and the sixth seconds are equal. The velocity *u* is given by (g = 9.8 m/s^2)
(a) 24.5 *m/s* (b) 49.0 *m/s*
(c) 73.5 *m/s* (d) 98.0 *m/s*

91. A particle is dropped under gravity from rest from a height h ($g = 9.8$ m/sec^2) and it travels a distance 9h/25 in the last second, the height h is

(a) 100 m (b) 122.5 m
(c) 145 m (d) 167.5 m

92. A balloon rises from rest on the ground with constant acceleration $\frac{g}{8}$. A stone is dropped from balloon when the balloon has risen to a height of h = 10 m. Find the time taken by the stone to reach the ground. $\left(g = 10 m/s^2\right)$

93. A body A of mass 4 kg is dropped from a height of 100 m. Another body B of mass 2 kg is dropped from a height of 50m at the same time.

(a) Both the bodies reach the ground simultaneously
(b) A takes nearly 0.7^{th} of time required by B.
(c) B takes nearly 0.7^{th} of time required by A.
(d) A takes double the time required by B.

94. A ball is dropped from the top of a 100 m high tower on a planet. In the last $\frac{1}{2}$ s before hitting the ground, it covers a distance of 19 m. Acceleration due to gravity (in ms^{-2}) near the surface on that planet is ________.

95. A person sitting in the ground floor of a building notices through the window of height 1.5 m, a ball dropped from the roof of the building crosses the window in 0.1 s. What is the velocity of the ball when it is at the topmost point of the window? (g = 10 m/s^2)

(a) 15.5 m/s (b) 14.5 m/s
(c) 4.5 m/s (d) 20 m/s

96. A stone falls freely under gravity. It covers distances h_1, h_2, and h_3, in the first 5s, the next 5s and the next 5s respectively. The relation between h_1, h_2, and h_3, is

(a) $h_1 = 2h_2 = 3h_3$ (b) $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$
(c) $h_2 = 3h_1$ and $h_3 = 3h_2$ (d) $h_1 = h_2 = h_3$

Pro **Motion under Gravity**

97. A balloon starts from ground with 1.25 m/s^2 acceleration. After 8 s, a stone is released from balloon. Find time in which stone will strike ground. Find distance covered by stone and its displacement from point from where it was released. Find also height of balloon when the stone strikes ground. g = 10 m/s^2.

98. A rocket is fired vertically upwards with an acceleration 20 m/s^2. After 1 min of its flight, all its fuel gets used up. Find the maximum height reached by the rocket and total time taken by the rocket to reach the ground. Also find the velocity of strike. (velocity at which it will hit the ground)

99. A man with a balloon rising vertically with an acceleration of 4.9 m/sec^2 releases a ball 2 sec after the balloon is let go from the ground. The greatest height above the ground reached by the ball is (g = 9.8 m/sec^2)

(a) 14.7 m (b) 19.6 m
(c) 9.8 m (d) 24.5 m

100. A very large number of balls are thrown vertically upwards in quick succession in such a way that the next ball is thrown when the previous one is at the maximum height. If the maximum height is 5m, the number of balls thrown per minute is (take $g = 10 ms^{-2}$)

(a) 120 (b) 80
(c) 60 (d) 40

101. A stone is dropped from a height h. Simultaneously another stone is thrown up from the ground with such a velocity that it can reach a height of 4h. Find the time when the two stones cross each other.

102. A balloon is ascending vertically with an acceleration of 0.2 m/s ^{2}. Two stones are dropped from it at an interval of 2 sec. Find the distance between them 1.5 sec after the second stone is released. (Use g=9.8m/s ^{2})

103. A lift ascends with a constant acceleration of 4 m/s^2, then with a constant velocity v, and then moves with a constant retardation of 4 m/s2 to finally come to rest. If the total height ascended is 20 m and the total time taken is 6 s, then the time during which the lift was moving with constant velocity v is

(a) 2 s (b) 3 s
(c) 4 s (d) 5 s

104. A ball is thrown upward from the ground with velocity u. It is at a point 100 m high at two times t_1 and t_2 respectively. If g = 10 m/s^2, then

(a) $t_1 \cdot t_2 = 20$ (b) $t_1 + t_2 = 20$

(c) $t_1 t_2 = \frac{u}{5}$ (d) $t_1 + t_2 = \frac{u}{5}$

105. A particle is projected vertically upward, and it reaches a height h from the ground in t_1 sec and reaches ground from that same height is t_2 sec, then

(a) Initial velocity of projection is $\frac{g(t_1+t_2)}{2}$

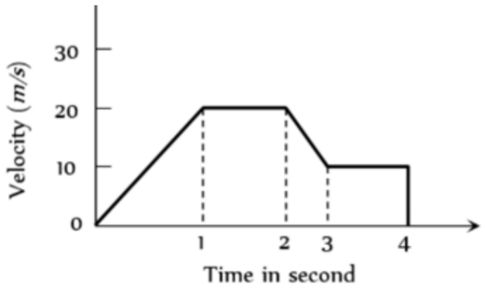
(b) Velocity at half of its maximum height will be $\frac{g(t_1+t_2)}{2\sqrt{2}}$

(c) Maximum distance travelled by particle in vertical direction is $\frac{g}{2}(t_1+t_2)^2$

(d) All of the above

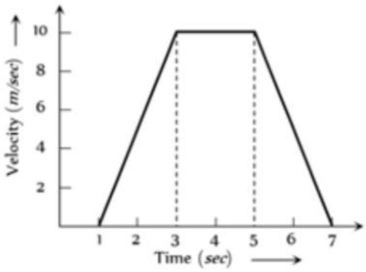
Beginner **Graphs in Motion**

106. The variation of velocity of a particle with time moving along a straight line is illustrated in the following figure. The distance travelled by the particle in four second is



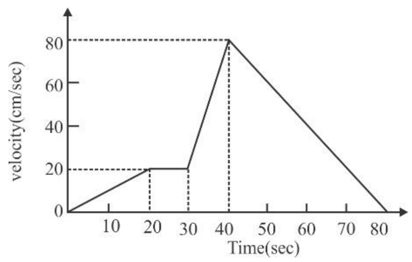
(a) 60 m (b) 55 m
(c) 25 m (d) 30 m

107. In the following graph, distance travelled by the body in meters is



(a) 200 (b) 250
(c) 300 (d) 400

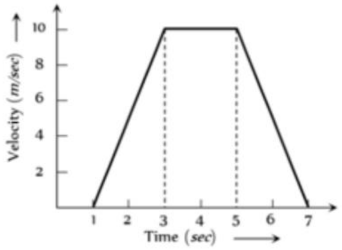
108. The v – t graph of a moving object is given in figure. The maximum acceleration is



109. The displacement-time graph for two particles A and B are straight lines inclined at angles of 30^o and 60^o with the time axis. The ratio of velocities of $V_A : V_B$ is

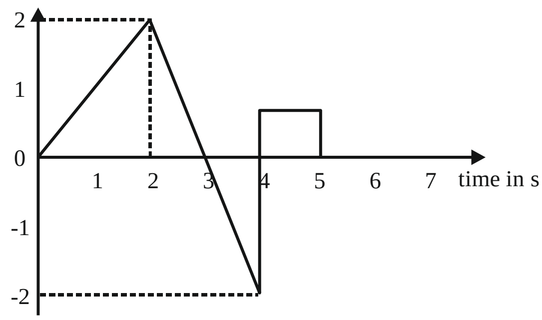
(a) $1:2$ (b) $1:\sqrt{3}$
(c) $\sqrt{3}:1$ (d) $1:3$

110. For the velocity-time graph shown in figure below the distance covered by the body in last two seconds of its motion is what fraction of the total distance covered by it in all the seven seconds



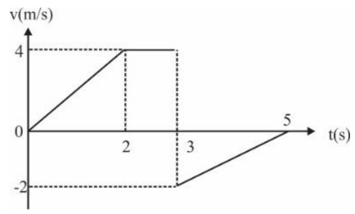
(a) $\frac{1}{2}$ (b) $\frac{1}{4}$
(c) $\frac{1}{3}$ (d) $\frac{2}{3}$

111. The velocity-time graph of a body moving along a straight line is as follows:

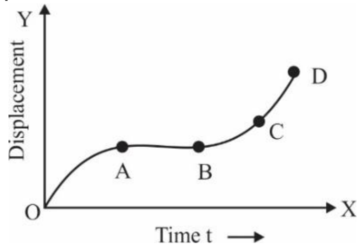


The displacement of the body in 5 s is
(a) 5 m (b) 2 m
(c) 4 m (d) 3 m

112. For a particle moving along x-axis, velocity-time graph is as shown in figure. Find the distance travelled and displacement of the particle. Also find the average velocity of the particle in interval 0 to 5 second.

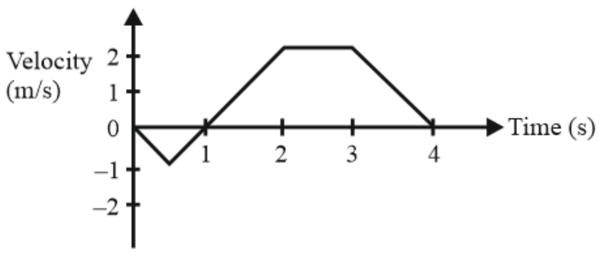


113. The graph between the displacement *x* and time *t* for a particle moving in a straight line is shown in figure. During the interval *OA, AB, BC and CD, the acceleration of the particle for interval OA, AB, BC, CD are*



(a) + , 0 , + , + (b) – , 0 , + , 0
(c) + , 0 , – , + (d) – , 0 , – , 0

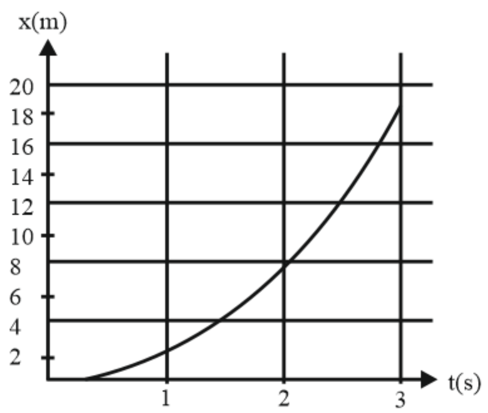
114.



The graph above shows the velocity versus time for an object moving in a straight line. At what time after t = 0 does the object again pass through its initial position?

(a) 1 s (b) Between 1 and 2 s
(c) 2 s (d) Between 2 and 3 s

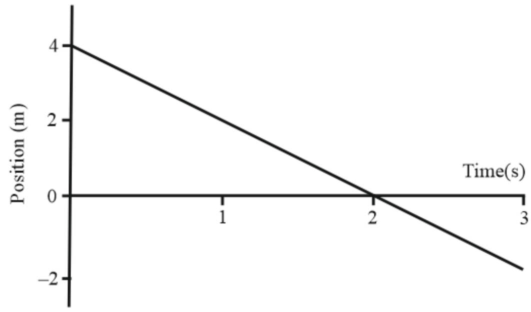
115.



The graph above represents position x versus time t for an object being acted on by a constant force. The average speed during the interval between 1 s and 2 s is most nearly

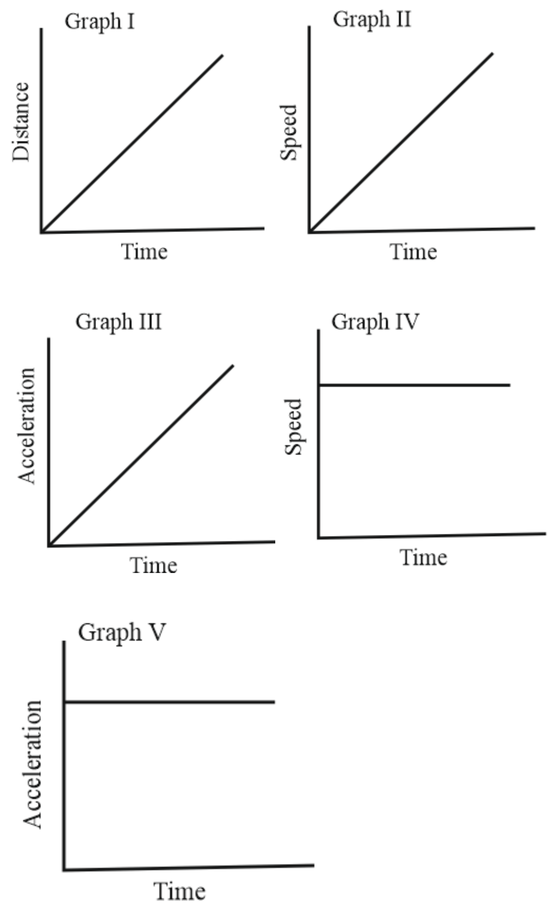
(a) 2 m/s (b) 4 m/s
(c) 5 m/s (d) 6 m/s

116. The position vs. time graph for an object moving in a straight line is shown below. What is the instantaneous velocity at t = 2 s?



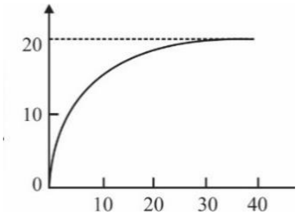
(a) –2 m/s (b) 1/2 m/s
(c) 0 m/s (d) 2 m/s

117. Which of the following graphs could represent the motion of an object moving with a constant speed in a straight line?



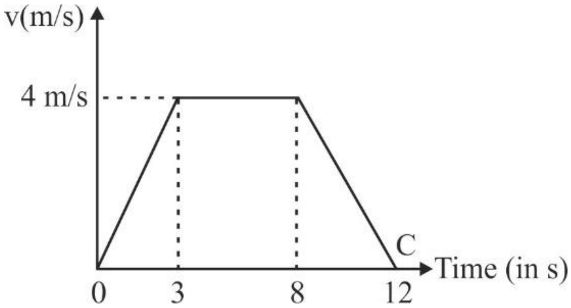
(a) Graph I only (b) Graphs II and V only
(c) Graph II only (d) Graphs I and IV only

118. The dispalacement of a particle as a function of time is shown in the figure, the figure shows that



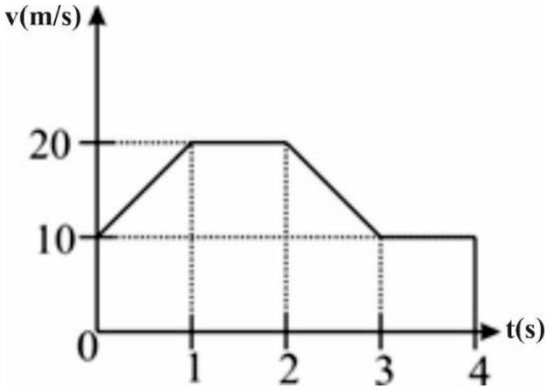
(a) The particle starts with certain velocity, but the motion is retarded and finally the particle stops
(b) The velocity of the particle is constant throughout.
(c) The acceleration of the particle is constant throughout.
(d) The particle starts with constant velocity, then motion is accelerated and finally the particle moves with another constant velocity.

119. From the velocity – time graph given of a particle moving in a straight line, one can conclude that



(a) Its average velocity during the 12 second interval is 24/7 m/s
(b) Its velocity for the first 3 seconds is uniform and is equal to 4 m/s
(c) The body has a constant velocity between t = 3s and t = 8s
(d) The body has a uniform velocity from t = 8s to t = 12s

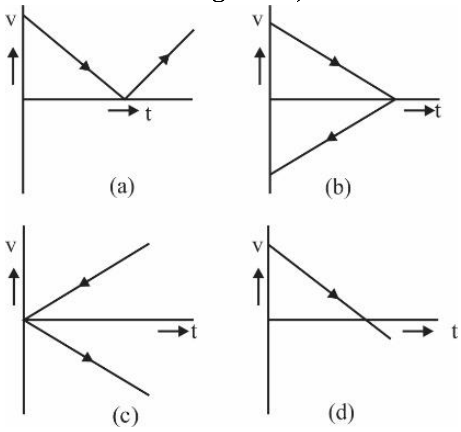
120. Figure given below shows the variation of velocity with time for a particle moving along a straight line, the average velocity, during the entire motion is



(a) 15 m/s (b) 7.5 m/s
(c) 6.25 m/s (d) 13.75 m/s

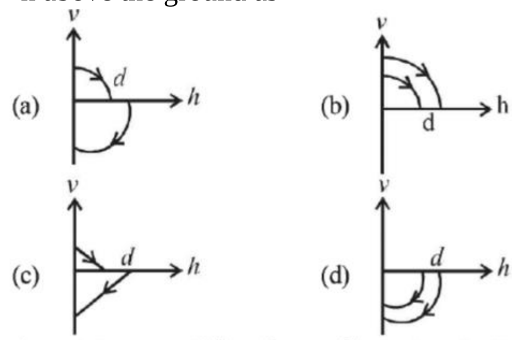
Expert **Graphs in Motion**

121. A ball is thrown vertically upwards, which of the following graph/graphs represents velocity-time graph of the ball during its flight (air resistance is neglected)

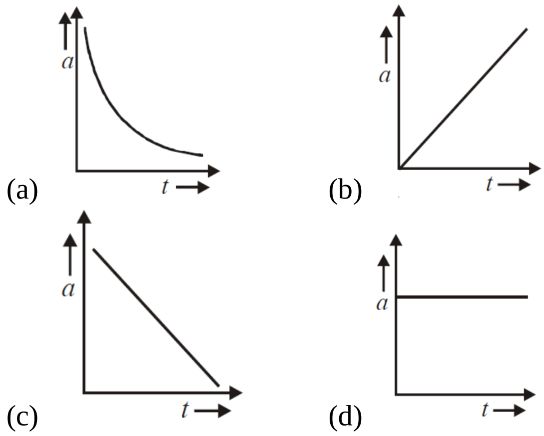


(a) a (b) b
(c) c (d) d

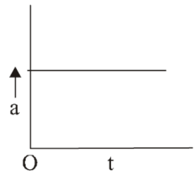
122. A ball is dropped vertically from a height d above the ground. It hits the ground and bounces up vertically to a height d/2. Neglecting subsequent motion and air resistance, its velocity v varies with the height h above the ground as

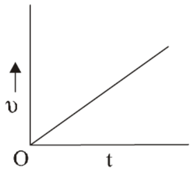


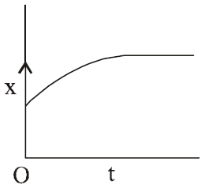
123. The distance travelled by a body moving along a line in time t is proportional to t^3. The acceleration-time (a, t) graph for the motion of the body will be

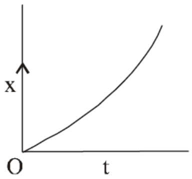


124. A particle starts from origin O from rest and moves with a uniform acceleration along the positive x-axis. Identify all figures that correctly represents the motion qualitatively (a = acceleration, v = velocity, x = displacement, t = time)

(A) 

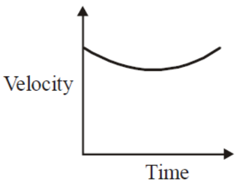
(B) 

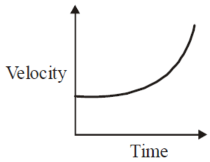
(C) 

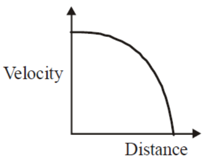
(D) 

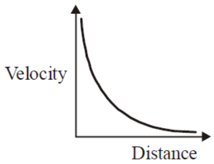
(a) (B), (C) (b) (A)
(c) (A), (B), (C) (d) (A), (B), (D)

125. Which graph corresponds to an object moving with a constant negative acceleration and a positive velocity ?

(a) 

(b) 

(c) 

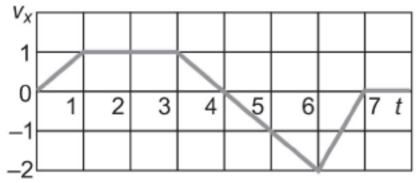
(d) 

Pro **Graphs in Motion**

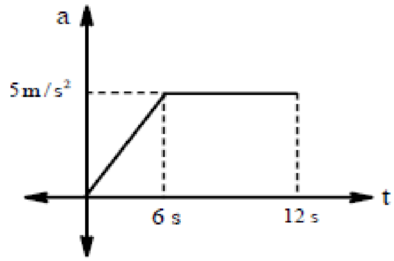
126. A body starts from rest with an acceleration 5 m/s^2 for 10 second. Then it moves with constant speed for next 30 second. After that it experiences a constant retardation of 10 m/s^2 for the next 20 seconds. Plot x-t, v-t & a-t graphs.

127. A ball is dropped from a height of 19.6 m above the ground. It rebounds from the ground and raises itself up to the same height. Take the starting point as the origin and vertically downward as the positive x-axis. Draw approximate plots of x versus t, v versus t and a versus t. Neglect the small interval during which the ball was in contact with the ground.

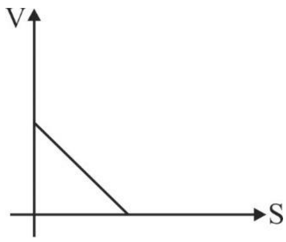
128. A point travels along the x axis with a velocity whose projection v_x is presented as a function of time by the plot in Fig. Assuming the coordinate of the point x = 0 at the moment t = 0, draw the approximate time dependence plots for the acceleration w_x, the x coordinate, and the distance covered s.



129. Given below is an a – t graph, the particle starts from rest at origin. Find displacement at t =12s.

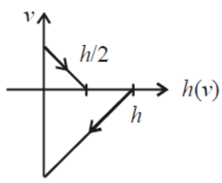


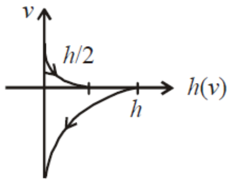
130. Velocity-displacement graph of a particle moving in a straight line is as shown in the figure.

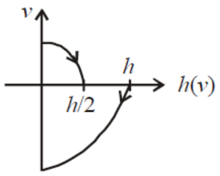


(a) Magnitude of acceleration of particle is decreasing
(b) Magnitude of acceleration of particle is increasing
(c) Acceleration versus displacement graph is straight line
(d) Acceleration versus displacement graph is parabola

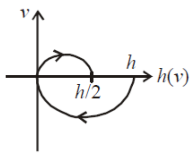
131. A Tennis ball is released from a height h and after freely falling on a wooden floor it rebounds and reaches height $\frac{h}{2}$. The velocity versus height of the ball during its motion may be represented graphically by:(graph are drawn schematically and on not to scale)

(a) 

(b) 



(c)



(d)

Beginner **General Relative Motion 1D**

132. Two trains, each 50 *m* long are travelling in opposite direction with velocity 10 *m/s* and 15 *m/s*. The time of crossing is

(a) $2s$ (b) $4s$

(c) $2\sqrt{3}s$ (d) $t = \frac{v_1 - v_2}{a}$

133. Two cars *A* and *B* at rest at same point initially. If A starts with uniform velocity of 40 m/sec and B starts in the same direction with constant acceleration of $4m/s^2$, then B will catch A after how much time?

(a) 10 sec (b) 20 sec

(c) 30 sec (d) 35 *sec*

134. A body *A* moves with a uniform acceleration a and zero initial velocity. Another body B starts from the same point moves in the same direction with a constant velocity v. The two bodies meet after a time t. The value of t is

(a) $\frac{2v}{a}$ (b) $\frac{v}{a}$

(c) $\frac{v}{2a}$ (d) $\sqrt{\frac{v}{2a}}$

135. A body *A* is projected upwards with a velocity of $98m/s$. A second body B is projected upwards with the same initial velocity, but after 4 sec of projection of body A. Both the bodies will meet after

(a) 6 sec (b) 8 sec

(c) 10 sec (d) 12 sec

136. An elevator, in which a man is standing, is moving upward with a constant acceleration of 1 m/s2. At some instant when speed of elevator is 10 m/s, the man drops a coin from a height of 2 m. Find the time taken by the coin to reach the floor. ($g = 9.8\ m/s^2$)

137. Train A and train B are running on parallel tracks in the opposite directions with speeds of 36 km/hour and 72 km hour, respectively. A person is walking in train A in the direction opposite to its motion with a speed of 1.8 km hour. Speed (in ms–1) of this person as observed from train B will be close to : (take the distance between the tracks as negligible)

(a) 29.5 ms-1 (b) 28.5 ms–1

(c) 31.5 ms^{-1q} (d) 30.5 ms^{-1}

Expert **General Relative Motion 1D**

138. An elevator car, whose floor to ceiling distance is equal to 2.7 m, starts ascending with constant acceleration of $1.2m/s^2$. 2 sec after the start, a bolt begins falling from the ceiling of the car. The free fall time of the bolt is

(a) $\sqrt{0.54}\,s$ (b) $\sqrt{6}\,s$

(c) 0.7 s (d) 1 *s*

139. A motorist while driving at a speed of 72 km/hr sees a boy standing on the road at a distance of 52 m. He applies the brake and stops his car at a distance of 2 m from the boy. Find the acceleration caused due to the application of brake and time taken to stop the car.

140. A student is standing at a distance of 50 metres from the bus. As soon as the bus begins its motion with an acceleration of $1ms^{-2}$, the student starts running towards the bus with a uniform velocity u. Assuming the motion to be along a straight road, the minimum value of u, so that the student can catch the bus is

(a) 5 ms–1 (b) 8 ms–1

(c) 10 ms^{-1} (d) 12 ms^{-1}

141. Two trains each of length 90 m moving in opposite directions along parallel tracks meet when their speeds are 60 km/hr and 40 km/hr. If their accelerations are 0.3 m/s2 and 0.15 m/s2 respectively, Find the time they take to pass each other.

(a) 8 s (b) 4 s

(c) 2 s (d) 6.17 s

142. A man standing in an elevator observes a screw falling from the ceiling. The ceiling is 3m above the floor.

(a) If the elevator is moving upward with a speed of 2.2m/s, how long does it take for the screw to hit the floor?

(b) How long is the screw in the air if the elevator starts from rest when the screw falls and moves upward with a constant acceleration of $a = 4.0m/s^2$?

143. A police van moving on a highway with a speed of 30 km h^{-1} fires a bullet at a thief's car speeding away in the same direction with a speed of 192 km h^{-1}. If the muzzle speed of the bullet is 150 m/s. At what speed does the bullet hits the thief's car?

Pro — General Relative Motion 1D

144. A train of 150 m length is going towards north direction at a speed of $10m/\sec$. A parrot flies at the speed of $5\ m/\sec$ towards south direction parallel to the railway track. The time taken by the parrot to cross the train is

(a) 12 *sec* (b) 8 *sec*
(c) 15 *sec* (d) 10 *sec*

145. Two trains travelling on the same track are approaching each other with equal speeds of 40 *m/s*. The drivers of the trains begin to decelerate simultaneously when they are just 2.0 *km* apart. Assuming the decelerations to be uniform and equal, the value of the deceleration to barely avoid collision should be

(a) 11.8 m/s^2 (b) 11.0 m/s^2
(c) 2.1 m/s^2 (d) 0.8 m/s^2

146. A motorboat going downstream overcame a raft at a point A; τ = 60 min later it turned back and after some time passed the raft at a distance ℓ = 6.0 km from the point A. Find the flow velocity assuming the duty of the engine to be constant.

147. A train of length ℓ = 350 m starts moving rectilinearly with constant acceleration w = 3.0 × 10^{-2} ms^{-2}; t = 30 s after the start the locomotive headlight is switched on (event 1), and τ = 60 s after that event the tail signal light is switched on (event 2). Find the distance between these events in the reference frames fixed to the train and the Earth. How and at what constant velocity V relative to the Earth must a certain reference frame K move for the two events to occur in it at the same point?

148. An elevator car whose floor-to-ceiling distance is equal to 2.7 m starts ascending with constant accelerating 1.2 ms^{-2}; 2.0 s after the start a bolt begins falling from the ceiling of the car. Find:

(a) The bolt's free fall time;
(b) The displacement and the distance covered by the bolt during the free fall in the reference frame fixed to the elevator shaft.

149. A police jeep is chasing a thief with a velocity of 45 km/h, thief in another jeep is moving with velocity 153 km/h. Police fires a bullet with muzzle velocity of 180 m/s. The velocity with which it will strike the car of the thief is

(a) 150 m/s (b) 27 m/s
(c) 450 m/s (d) 250 m/s

150. Two trains each having a speed of 30 km/h are headed at each other on the same straight track. A bird that can fly at 60 km/h flies off from one train when they are 60 km apart and heads directly for the other train. On reaching the other train it flies directly back to the first, and so forth

(a) What is the total distance the bird travels?
(b) How many trips can the bird make from one train to the other before they crash?

151. Consider two cities P and Q between which consistent bus service is available in both directions every x minutes. A morning jogger is jogging towards Q from P with a speed of 10km/h. Every 18 mins a bus crosses this jogger in its own direction of motion and every 6 minutes another bus crosses in opposite direction. What is the time period between two consecutive buses and also find the speed of buses?

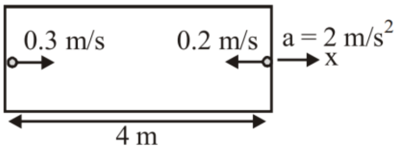
152. Two bodies start moving in straight line simultaneously from point O. The first body moves with constant velocity of 40 m/s & and the second body starts from rest with a constant acceleration of 4 m/s^2

(a) Time that elapses before the second body catches up with the first body is 20s.
(b) Greatest distance between the two bodies prior to their meeting is 200m.
(c) Time elapsed when the distance between them is maximum is 10s.
(d) All above statements are false.

153. A car is standing 200 m behind a bus, which is also at rest. The two start moving at the same instant but with different forward accelerations. The bus has acceleration 2 m/s^2 and the car has acceleration 4 m/s^2. The car will catch up with the bus after a time of:

(a) $\sqrt{110}s$ (b) $\sqrt{120}s$
(c) $10\sqrt{2}s$ (d) 15 s

154. A rocket is moving in a gravity free space with a constant acceleration of $2ms^{-2}$ along + x direction (see figure). The length of a chamber inside the rocket is 4m. A ball is thrown from the left end the chamber in + x direction with a speed of 0.3m/s related to the rocket. At the same time, another ball is thrown in –x direction with a speed of 0.2m/s from its right end relative to the rocket. The time in seconds when the two balls hit each other is



Beginner	**Projectile Motion**

155. A body is projected with a velocity of 30 ms^{-1} at an angle of 30° with the vertical. Find the maximum height, time of flight and the horizontal range.

156. A ball is thrown from a field with a speed of 12.0 m/s at an angle of 45° with the horizontal. At what distance will it hit the field again? Take g = 10.0 m/s^2

157. A projectile is fired horizontally with a velocity of 98 m/s from the top of a hill 490m high. Find: $(take\ g\ \ 9.8\, m/s^2)$

(a) The time taken to reach the ground

(b) The distance of the target from the foot of hill

(c) The velocity with which the particle hits the ground

158. A cricketer hits a ball with a velocity 25 m/s at 60° above the horizontal. How far above the ground it passes over a fielder 50 m from the bat? (Assume the ball is struck very close to the ground)

(a) 8.2 m (b) 9.0 m

(c) 11.6 m (d) 12.7 m

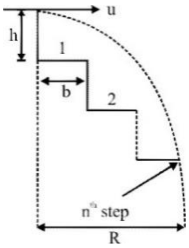
159. A stone is projected from the ground with velocity 25 m/s. Two seconds later, it just clears a wall 5 m high. The angle of projection of the stone is (g= 10 m / sec^2)

(a) 30° (b) 45°

(c) 50.2° (d) 60°

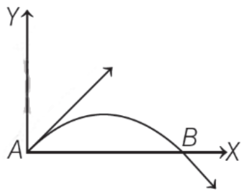
160. Two paper screens A and B are separated by a distance of 100 m. A bullet pierces A and then B. The hole in B is 10 cm below the hole in A. If the bullet is traveling horizontally at the time of hitting the screen A, calculate the velocity of the bullet when it hits the screen A. Neglect the resistance of paper and air.

161. A ball rolls off top of a stairway with a horizontal velocity u m/s. If the steps are h m high and b meters wide, the ball will just hit the edge of the n^{th} step, Find n.



162. A ball is thrown horizontally from a cliff such that it strikes ground after 5 sec. The line of sight from the point of projection to the point of hitting makes an angle of 37° with the horizontal. What is the initial velocity of projection?

163. The velocity of a projectile at the initial point A is $\left(2\hat{i}+3j\right)$ m/s. Its velocity (in m/s) at point B is



(a) $-2\hat{i} - 3j$ m/s (b) $-2\hat{i} + 3j$ m/s

(c) $2\hat{i} - 3j$ m/s (d) $2\hat{i} + 3j$ m/s

Expert	**Projectile Motion**

164. A particle is projected with velocity 20 m/s at an angle of 45° with horizontal. [take $g = 10\, m/s^2$] Find outthe –

(a) Horizontal Range

(b) Maximum Height

(c) Time of flight

(d) Time at which its velocity becomes perpendicular to its initial velocity

165. From top of cliff 75 m high, a body is projected with 20 m/s velocity at angle 30° with horizontal in upward inclined direction. Determine time of flight, horizontal range covered & velocity with which it strikes the ground (g = 10.0 m/s^2)

166. A body is projected from the top of a tower of height 120 m with a speed 20 m/s at an angle of 37^0 with horizontal. Find the time taken by the body to reach the ground.

167. A body is projected with u velocity at an angle α with horizontal. Find out the time taken by the body, when its final velocity becomes perpendicular to its initial velocity.

168. A particle is projected upwards with a velocity of 100 m/sec at an angle of 60° with the vertical. Find the time when the particle will move perpendicular to its initial direction, taking g =10 m/sec ^{2}

169. Two bodies were thrown simultaneously from the same point: one, straight up, and the other, at an angle of θ = 60° to the horizontal. The initial velocity of each body is equal to v_0 = 25 m/s, neglecting the air drag, find the distance between the bodies t = 1.70 s later.

170. A particle is projected from a point P with a velocity v at an angle θ with horizontal. At a certain point Q, it moves at right angle to its initial direction. Then

(a) Velocity of particle at Q is v sin θ

(b) Velocity of particle at Q is v cot θ

(c) Time of flight from P to Q is (v/g) cosec θ

(d) Time of flight from P to Q is (v/g) sec θ

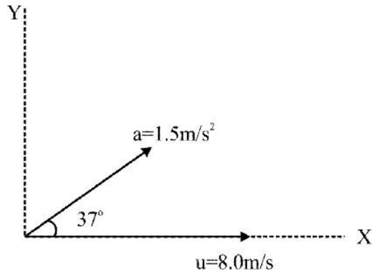
171. The position of a projectile launched from the origin at t = 0 is given by $\vec{r} = \left(40\hat{i} + 50\hat{j}\right)$ m at t = 2s. If the projectile was launched at an angle θ from the horizontal, then θ is (take g = 10 ms^{-2})

(a) $\tan^{-1}\frac{2}{3}$ (b) $\tan^{-1}\frac{3}{2}$

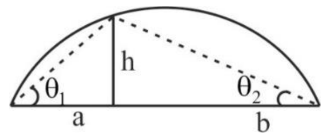
(c) $\tan^{-1}\frac{7}{4}$ (d) $\tan^{-1}\frac{4}{5}$

Pro **Projectile Motion**

172. A particle moves in the $X - Y$ plane with a constant acceleration of 1.5 m/s^2 in the direction making an angle of 37° with the x-axis. At $t = 0$ the particle is at the origin and its velocity is 8.0m/s along the x-axis. Find the velocity and the position of the particle at $t = 4.0\ s$.



173. A ball is projected at an angle of 45°, so as to cross a wall at a distance 'a' from the point of projection. It falls at a distance 'b' on the other side of the wall. If h is the height of the wall, then



(a) $h = a\sqrt{2}$ (b) $h = b\sqrt{2}$

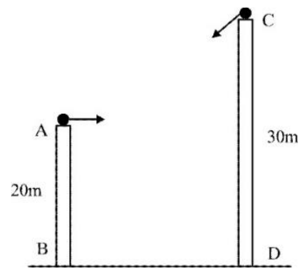
(c) $h = \frac{\sqrt{2}ab}{a+b}$ (d) $h = \frac{ab}{a+b}$

174. A cannon and a target are 5.10 km apart and located at the same level. How soon will the shell launched with the initial velocity 240 m/s reach the target in the absence of air drag?

175. Two towers AB and CD are situated at a distance d apart as shown in the figure below. AB is 20 m high and CD is 30 m high from the ground. An object of mass m is thrown from the top of AB horizontally with a velocity of 10m/s towards CD. Simultaneously another object of mass 2kg is thrown from the top of CD at an angle 60° to the horizontal towards AB with the same magnitude of initial velocity as that of the first object. The two objects move in the same vertical plane, collide in mid-air and stick to each other.

(a) Calculate the distance d between the towers.

(b) Find the position where the objects hit the ground.

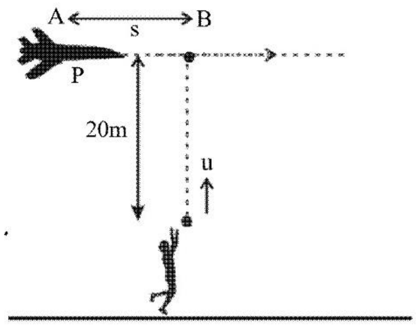


176. A toy plane P starts flying from point A along a straight horizontal line 20m above ground level starting with zero initial velocity and acceleration 2 m/s^2 as shown. At the same instant, a man throws a ball vertically upwards with initial velocity 'u'. Ball touches (coming to rest) the base of the plane at point B of plane's journey when it is vertically above the man. 's' is the distance of point B from point A. Just after the contact of ball with the plane, acceleration of plane increases to 4m/s^2. Find:

(a) Initial velocity 'u' of ball.

(b) Distance 's'.

(c) Distance between man and plane when the man catches the ball back. ($g = 10\,m/s^2$)



177. Two guns, situated on the top of a hill of height 10m, fire one shot each with the same speed $5\sqrt{3}$ m/s at some interval of time. One-gun fires horizontally and other fires upward at an angle of 60° with the horizontal. The shots collide in air at a point P. Find

(a) the time-interval between the firings, and (b) the coordinates of the point P. Take origin of the coordinate system at the foot of the hill right below the muzzle and trajectories in $x-y$ plane.

178. A particle is projected from the ground with an initial speed of v at an angle θ with horizontal. The average velocity of the particle between its point of projection and highest point of trajectory is

(a) $\frac{v}{2}\sqrt{1+\cos^2\theta}$ (b) $\frac{v}{2}\sqrt{1+\cos^2\theta}$

(c) $\frac{v}{2}\sqrt{1+3\cos^2\theta}$ (d) v cos θ

179. A gun kept on a straight horizontal road is used to hit a car, traveling along the same road away from the gun with a uniform speed of $72 \times \sqrt{2}\,km/hr$. The car is at a distance of 50 metre from the gun, when the gun is fired at an angle of 45° with the horizontal. Find (i) the distance of the car from the gun when the shell hits it, (ii) the speed of projection of the shell from the gun. [$g = 10\,m/s^2$]

180. A projectile crosses half its maximum height at a certain instant of time and again 10 s later. Calculate the maximum height. If the angle of projection was 30°, calculate the horizontal distance it travelled in the above 10 s.

181. A particle is projected with a velocity $2\sqrt{gh}$ so that it just clears two walls of equal height 'a' which are at a distance 2a apart. Find the time of passing between the walls.

182. A particle is projected in the X-Y plane. 2 sec after projection the velocity of the particle makes an angle 45° with the x - axis. 4 sec after projection, it moves horizontally. Find the velocity of projection (use g = 10 ms^{-2}).

183. A rocket is launched at an angle 53° to the horizontal with an initial speed of 100 ms^{-1}. It moves along its initial line of motion with an acceleration of 30 ms–2 for 3 seconds. At this time its engine falls & the rocket proceeds like a free body. Find:

(a) the maximum altitude reached by the rocket

(b) total time of flight.

(c) the horizontal range. [use sin 53° = 4/5]

184. A large number of bullets are fired in all directions with the same speed v. The maximum area on the ground on which these bullets will spread is

(a) $\frac{\pi v^2}{g}$ (b) $\frac{\pi v^4}{g^2}$

(c) $\frac{\pi^2 v^4}{g^2}$ (d) $\frac{\pi^2 v^2}{g^2}$

185. A shell is fired from a fixed artillery gun with an initial speed u such that it hits the target on the ground at a distance R from it. If t_1 and t_2 are the values of the time taken by it to hit the target in two possible ways, the product t_1t_2 is :

(a) R/4g (b) R/g

(c) R/2g (d) 2R/g

186. Two particles are projected from the same point with the same speed u such that they have the same range R, but different maximum heights, h_1 and h_2. Which of the following is correct ?

(a) $R^2 = 4h_1h_2$ (b) $R^2 = 16\,h_1\,h_2$

(c) $R^2 = 2\,h_1\,h_2$ (d) $R^2 = h_1\,h_2$

187. Two guns A and B can fire bullets at speeds 1 km/s and 2 km/s respectively. From a point on a horizontal ground, they are fired in all possible directions. The ratio of maximum areas covered by the bullets fired by the two guns, on the ground is:

(a) 1:16 (b) 1:2

(c) 1:4 (d) 1:8

188. Two bullets are fired horizontally and simultaneously towards each other from roof tops of two buildings 100 m apart and of same height of 200 m with the same velocity of 25 m/s. When and where will the two bullets collides. ($g = 10\ m/s^2$)

(a) After 2s at a height 180 m

(b) After 2s at a height of 20 m

(c) After 4s at a height of 120 m

(d) They will not collide

Beginner **Equation of Trajectory**

189. The equation of a projectile is $y = \sqrt{3}x - \frac{gx^2}{2}$, find the angle of projection. Also find the speed of projectionwhere at $t = 0, x = 0$ and $y = 0$

190. A body is projected with a velocity of $30\ ms^{-1}$. It crosses a vertical tower of height 10 m after 5 sec. The angle of projection will be-

(a) $\sin^{-1}(0.633)$ (b) $\sin^{-1}(0.734)$

(d) $\sin^{-1}(0.883)$ (d) $\sin^{-1}(0.5)$

191. A projectile is given an initial velocity of $(\hat{i}+2\hat{j})$ m/s, where $\hat{i}$ is along the ground and $\hat{j}$ is along the vertical. If $g = 10\ m/s^2$, the equation of its trajectory is

(a) $y = x - 5x^2$ (b) $y = 2x - 5x^2$

(c) $4y = 2x - 5x^2$ (d) $4y = 2x - 25x^2$

192. The equation of trajectory of a projectile is $y = \left(\frac{x}{\sqrt{3}} - \frac{gx^2}{20}\right)$, where x and y are in meter.

The maximum range of the projectile is (take $g = 10\ m/s^2$)

(a) $\frac{8}{3}m$ (b) $\frac{4}{3}m$

(c) $\frac{3}{4}m$ (d) $\frac{3}{8}m$

193. The trajectory of a projectile in a vertical plane is $y = ax - bx^2$, where a, b are constants, x and y are respectively the horizontal and vertical distances of the projectile from the point of projection. The maximum height attained is

(a) $\frac{a^2}{4b}$ (b) $\frac{a^2}{8b}$

(c) $\frac{a^2}{2b}$ (d) $\frac{a^2}{2gb}$

194. Equation of trajectory of a projectile is given by $y = -x^2 + 10x$ where x and y are in meters and x is along horizontal and y is vertically upward and particle is projected from origin. Then which of the following option is/are correct?

($g = 10\ m/s^2$)

(a) Initial speed of particle is $\sqrt{505}$ m/s

(b) Horizontal range is 10 m

(c) Maximum height is 25 m

(d) Angle of projection with horizontal is $\tan^{-1}(5)$

195. The trajectory of a particle in a vertical plane is $4y = 3x - \frac{x^2}{4}$, x and y are the horizontal and vertical distances of the projectile from the point of projection. The angle of projection from the horizontal and the maximum height attained by the particle are

(a) 45°, $\frac{3}{4}$ units (b) 53°, $\frac{9}{2}$ units

(c) 37°, $\frac{9}{4}$ units (d) 60°, $\frac{9}{16}$ units

196. The trajectory of a projectile near the surface of the earth is given as $y = 2x - 9x^2$. If it were launched at an angle θ_0 with speed v_0 then ($g = 10\ ms^{-2}$):

(a) $\theta_0 = \sin^{-1}\frac{1}{\sqrt{5}}$ and $v_0 = \frac{5}{3}ms^{-1}$

(b) $\theta_0 = \cos^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}ms^{-1}$

(c) $\theta_0 = \cos^{-1}\left(\frac{1}{\sqrt{5}}\right)$ and $v_0 = \frac{5}{3}ms^{-1}$

(d) $\theta_0 = \sin^{-1}\left(\frac{2}{\sqrt{5}}\right)$ and $v_0 = \frac{3}{5}ms^{-1}$

Expert **Equation of Trajectory**

197. A particle moves in x-y plane with constant acceleration ‘a’ directed along the negative y-axis. The equation of motion of the particle has the form $y = px - qx^2$ where p and q are positive constants. Find the velocity of the particle at the origin.

198. A particle is moving with a velocity $\vec{v} = K(y\hat{i} + x\hat{j})$, where K is a constant. The general equation for its path is:

(a) $y = x^2$ + constant

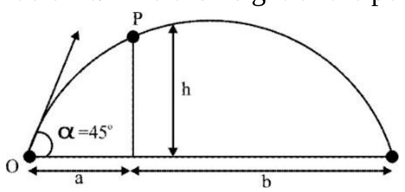
(b) $y^2 = x$ + constant

(c) $y^2 = x^2$ + constant

(d) xy = constant

199. Marshall throws a ball at an angle of 60°. If it moves at the rate of 6 m/s and Steve catches it after 4s. Calculate the vertical distance covered by it.

200. From a point on the ground at a distance a from the foot of a pole, a ball is thrown, at an angle of 45°, which just touches the top of the pole and strikes the ground at a distance of b, on the other side of it. Find the height of the pole.



Pro **Equation of Trajectory**

201. From a point on the ground at a distance 10 m from the foot of a vertical wall, a ball is thrown at an angle of 45° which just clears the top of the wall and afterwards strikes the ground at a distance 5 m on the other side. Find the height of the wall.

202. A point moves in the plane xy according to the law x = at, y = at (1 - α t), where a and α are positive constants, and t is time. Find:

(a) The equation of the point's trajectory y(x); plot this function;

(b) The velocity v and the acceleration w of the point as functions of time;

(c) The moment t_0 at which the velocity vector forms an angle $\frac{\pi}{4}$ with the acceleration vector.

203. A cannon fires successively two shells with velocity v_0 = 250 m/s; the first at the angle θ_1 = 60° and the second at the angle θ_2 = 45° to the horizontal, the azimuth being the same. Neglecting the air drag, find the time interval between firings leading to the collision of the shells

204. A particle moves in the plane xy with constant acceleration w directed along the negative y axis. The equation of motion of the particle has the form $y = ax - bx^2$ where a and b are positive constants. Find the velocity of the particle at the origin of coordinates.

205. A particle moves in the plane xy with velocity v = ai + bxj, where i and j are the unit vectors of the x and j axes, and a and b are constants. At the initial moment of time the particle wave located at the point x = y = 0.

Find:

(a) The equation of the particle's trajectory y(x);

(b) The curvature radius of trajectory as a function of x.

206. With what minimum speed must a particle be projected from origin so that it is able to pass through a given point (30m, 40m). Take g = 10 m/s^2

(a) 60 m/s (b) 30 m/s

(c) 50 m/s (d) None

207. If T is the total time of flight, H the maximum height and R is the horizontal range of a projectile. Then x and y co-ordinates at any time t are related as

(a) $y = 4H\left(\frac{t}{T}\right)\left(1-\frac{t}{T}\right)$

(b) $y = 4H\left(\frac{T}{t}\right)\left(1-\frac{T}{t}\right)$

(c) $y = H\left(\frac{x}{R}\right)\left(1-\frac{x}{R}\right)$

(d) None of these

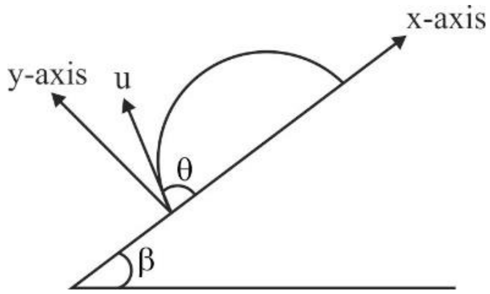
208. A particle is moving in x-y plane such that x = t + sin(t) meter, y = cos (t) meter. t is the time in sec. Find the length of the path taken by the particle from t = 0 to t = 2π sec.

209. A ball projected from ground at an angle of 45° just clears a wall in front. If point of projection is 4 m from the foot of wall and ball strikes the ground at a distance of 6 m on the other side of the wall, the height of the wall is :

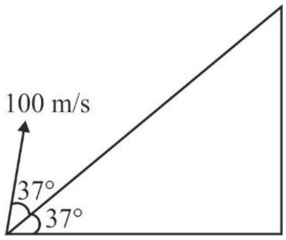
(a) 4.4m (b) 2.4m
(c) 3.6m (d) 1.6m

Beginner Projectile Motion on an Inc. Plane

210. A particle is projected at an angle θ with an inclined plane making an angle β with the horizontal as shown in figure, speed of the particle is u, after time t find:
(a) x component of acceleration?
(b) y component of acceleration?
(c) x component of velocity?
(d) y component of velocity?
(e) x component of displacement?
(f) y component of displacement?
(g) y component of velocity when particle is at maximum distance from the incline plane?

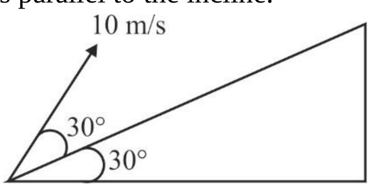


211. Find out the following for the below shown projectile motion

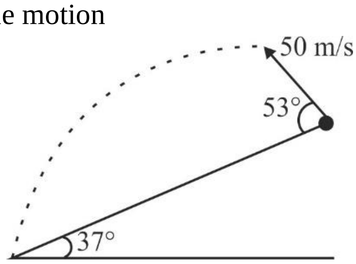


(a) Time of flight (b) Range
(c) V strike (d) Angle of Strike

212. Find the time when the velocity of projectile becomes parallel to the incline.



213. Find out the following for the below shown projectile motion

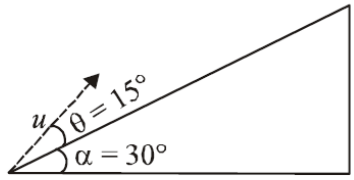


(a) Time of Flight (b) Range
(c) V strike

214. A particle is projected horizontally with a speed u from the top of a plane inclined at an angle θ with the horizontal. How far from the point of projection will the particle strikes the plane?

215. A ball is projected on smooth inclined plane in direction perpendicular to line of greatest slope with
velocity of 8m/s. Find its speed after 1 sec.

216. A plane is inclined at an angle $\alpha = 30°$ with respect to the horizontal. A particle is projected with a speed $u = 2\ ms^{-1}$, from the base of the plane, as shown in figure. The distance from the base, at which the particle hits the plane is close to: (Take $g = 10\ ms^{-2}$)

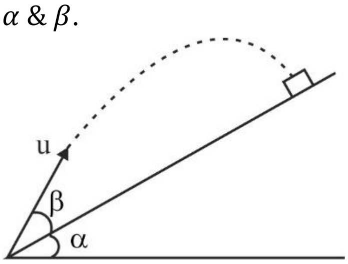


(a) 20 cm (b) 18 cm
(c) 26 cm (d) 14 cm

217. When an object is shot from the bottom of a long smooth inclined plane kept at an angle 60° with horizontal, it can travel a distance x_1 along the plane. But when the inclination is decreased to 30° and the same object is shot with the same velocity, it can travel x_2 distance. Then $x_1 : x_2$ will be
(a) $\sqrt{2}:1$ (b) $1:\sqrt{3}$
(c) $1:2\sqrt{3}$ (d) $1:\sqrt{2}$

Expert Projectile Motion on an Inc. Plane

218. It the particle hits the incline plane perpendicularly, then find the relation between α & β.



219. A body falling freely from a given height H hits an inclined plane in its path at a height h. As a result of this impact, the direction of the velocity of the body becomes horizontal. For what value of (h / H) the body will take maximum time to reach the ground?

220. A ball starts falling with zero initial velocity on a smooth inclined plane forming an angle α with the horizontal. Having fallen the distance h, the ball rebounds elastically off the inclined plane. At what distance from the impact point will the ball rebound for the second time?

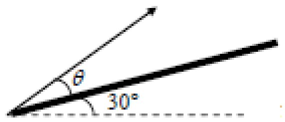
221. A particle is projected with a certain velocity at an angle α above the horizontal from the foot of an inclined plane of inclination 30°. If the particle strikes the plane normally then α is equal to

(a) $30° + \tan^{-1}\left(\frac{1}{2\sqrt{3}}\right)$ (b) 45°

(c)60° (d) $30° + \cot^{-1}\left(\frac{2}{\sqrt{3}}\right)$

222. A particle is thrown horizontally with relative velocity 10 m/s from an inclined plane, which is also moving with acceleration 10 m/s^2 vertically upward. Find the time after which it lands on the plane (g = 10 m/s^2)

223. A particle is projected up an inclined as shown in figure. For maximum range over the inclined plane, the value of θ should be



(a) 45° (b) 15°

(c) 30° (d) 60°

Beginner **General Relative Motion 2D**

224. A particle A is moving along a straight line with velocity 3 m/s and another particle B has a velocity 5 m/s at an angle 30° to the path of A. Find the velocity of B with respect to A.

225. Two parallel rail tracks run north south. Train A moves due north with a speed of 54kmh^{-1} and train B moves due south with a speed of 90 kmh^{-1}. A monkey runs on the roof of train A with a velocity of 18km/h w.r.t. train A in a direction opposite to that of A. Calculate the –

(a) relative velocity of B with respect to A

(b) relative velocity of ground with respect to B

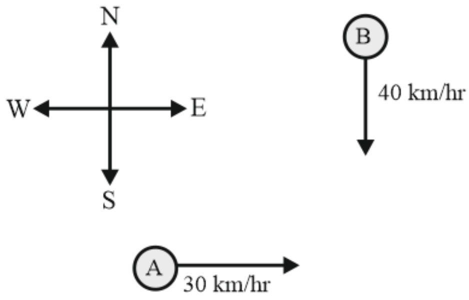
(c) velocity of a monkey as observed by a man standing on the ground.

(d) velocity of monkey as observed by a passenger of train B.

226. A bird is flying due east with a velocity of 4ms^{-1}. The wind starts to blow with a velocity of 3ms^{-1} due north. What is the magnitude of relative velocity of bird w.r.t. wind? Find out its direction also.

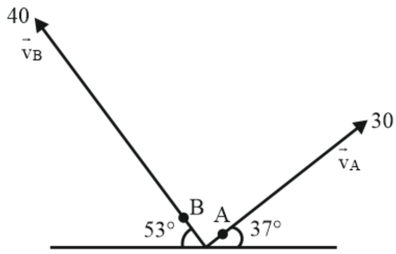
227. A plane is traveling at velocity 100 km/hr, in the southward direction. It encounters wind traveling in the west direction at a rate of 25 km/hr. Calculate the resultant velocity of the plane.

228. Two particles A and B are moving with velocities 30 km/h and 40 km/h respectively towards an intersection as shown in the figure. Find the velocity of particle A with respect to the velocity of particle B.



229. A vehicle is moving at a speed of 3i + 4j m/s. The person inside the car thinks the bird is flying at a velocity of 2i + 2j m/s. Find the speed of the bird with respect to the car.

230. Two particles A and B are projected in air. A is thrown with a speed of 30m/s and B with a speed of 40 m/s as shown in the figure. What is the separation between them after 1 sec?



Expert **General Relative Motion 2D**

231. Three particles A, B and C are situated at the vertices of an equilateral triangle ABC of side d at $t = 0$. Each of the particles moves with constant speed v. A always has its velocity along AB, B along BC, and C along CA. At what time will the particles meet each other?

232. A particle is moving along the x-axis with its coordinate with time 't' given by x(t) = 10+ 8t – 3t^2. Another particle is moving along the y-axis with its coordinate as a function of time given by y(t) = 5 – 8t^3. At t = 1 s, the speed of the second particle as measured in the frame of the first particle is given as $\sqrt{v}$. Then v (in m/s) is _____.

233. An aeroplane pilot wishes to fly due west. A wind of 100 km/h is blowing toward the south.
(a) If the speed of the plane (its speed in still air) is 300km/h, in which direction should the pilot head?
(b)What is the speed of the plane w.r.t ground? Illustrate with a vector form.

234. A train is moving along a straight line with a constant acceleration 'a'. A boy standing in the train throws a ball forward with a speed of 10m/s, at an angle of 60° to the horizontal. The boy has to move forward by 1.15m inside the train to catch the ball back at the initial height. The acceleration of the train, in m/s^2,is

Pro **General Relative Motion 2D**

235. A shell is fired from a cannon on ground with speed $50\sqrt{2}$ m/s, at angle 45° with the horizontal. There is a bus moving away from the shell at a constant speed of 20 m/s. If the shell strikes the bus, find the distance of the bus from the cannon at the instant the shell was fired.

236. Two particles, 1 and 2 moves with constant velocities v_1 and v_2. At the initial moment their radius vectors are equal to r_1 and r_2. How must these four vectors be interrelated for the particles to collide?

237. A ship moves along the equator to the east with velocity v_0 = 30 kmh^{-1}. The southeastern wind blows at an angle ϕ = 60° to the equator with velocity v = 15 kmh^{-1}. Find the wind velocity v' relative to the ship and the angle ϕ' between the equator and the wind direction in the reference frame fixed to the ship.

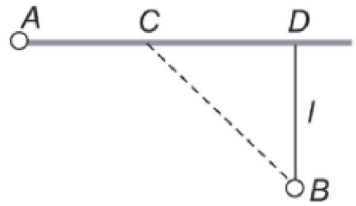
238. Two particles move in a uniform gravitational field with an acceleration g. At the initial moment the particles were located at one point and moved with velocities v_1= 3.0 ms^{-1} and v_2 = 4.0 ms^{-1} horizontally in opposite directions. Find the distance between the particles at the moment when their velocity vectors become mutually perpendicular.

239. Three points are located at the vertices of an equilateral triangle whose side equals α . They all start moving simultaneously with velocity v constant in modulus, with the first point heading continually for the second, the second for the third, and the third for the first. How soon will the points converge?

240. Point A moves uniformly with velocity v so that the vector v is continually "aimed" at point B which in its turn moves rectilinearly and uniformly with velocity u < v. At the initial moment of time $v \perp u$ and the points are separated by a distance l. How soon will the points converge?

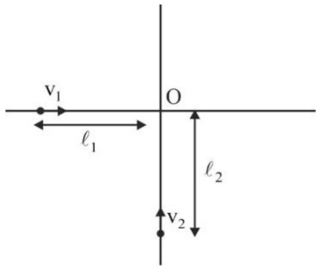
241. Two particles, 1 and 2, move with constant velocities v_1 and v_2 along two mutually perpendicular straight lines toward the intersection point O. At the moment t = 0 the particles were located at the distances l_1 and l_2 from the point O. How soon will the distance between the particles become the smallest? What is it equal to?

242. From point A located on a highway (Fig.) one has to get by car as soon as possible to point B located in the field at a distance l from the highway. It is known that the car moves in the field η times slower than on the highway. At what distance from point D one must turn off the highway?



243. A balloon starts rising from the surface of the Earth. The ascension rate is constant and equal to v_0. Due to the wind the balloon gathers the horizontal velocity component v_x = ay, where a is a constant and y is the height of ascent. Find how the following quantities depend on the height of ascent;
(a) The horizontal, drift of the balloon x(y);
(b) The total, tangential, and normal accelerations of the balloon.

244. Two particles moves along x and y axis with velocity v_1 and v_2 as shown in fig. towards intersection O. At the moment t= 0, the particles were at l_1 , l_2 form O respectively. Find the time, when they are the nearest & also calculate the shortest distance between them.

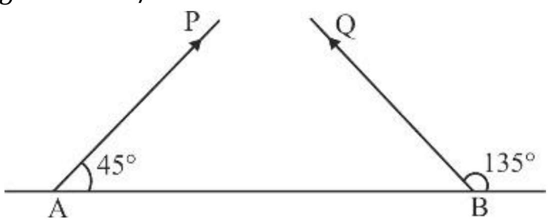


245. Two ships A and B are 10 km apart on a line running south to north. Ship A farther north, is streaming west at 20 km/hr and ship B streaming north at 20 km/hr. What is their distance of closest approach and how long do they take to reach it?

246. A political party must start its procession in an area where wind is blowing at a speed of 41.4km/h and party flags on the vehicles are fluttering along north-east direction. If the procession starts with a speed of 40km/h towards north, find the direction of flags on the vehicles.

247. A bullet is fired horizontally aiming at an object which starts falling at the instant the bullet is fired. Show that the bullet will hit the object.

248. Particles P and Q of mass 20gm and 40gm, are simultaneously projected from points A and B on the ground. The initial velocities of P and Q make 45° and 135° angles, respectively, with the horizontal AB as shown in the figure below. Each particle has an initial speed of 49 m/s. The separation AB is 245 m. Both particles travel in the same vertical plane and undergo a collision. After the collision, P retraces its path. Determine the position of Q when it hits the ground. How much time after the collision does the particle Q take to reach the ground? Take $g = 9.8\,m/s^2$.



249. Two particles start simultaneously from the same point and move along two straight lines, one with uniform velocity u and other with a uniform acceleration a. If α is the angle between the lines of motion of two particles, then the least value of relative velocity will be at time given by

(a) $\frac{v}{a}\sin\alpha$ (b) $\frac{v}{a}\sin\alpha$

(c) $\frac{v}{a}\tan\alpha$ (d) $\frac{v}{a}\cos\alpha$

Beginner **Rain Man Problems**

250. Rain is falling vertically downward with velocity 10 m/s. (a) The man on ground walks with 5 m/s. In what direction he should hold his umbrella in order to not get wet?

(b) What should be man's speed on ground so that he will hold his umbrella at 37 degree in front and not get wet?

251. A man standing on a road must hold his umbrella at 30° with the vertical to keep the rain away. He throws the umbrella and starts running at 10 km/h. He finds that raindrops are hitting his head vertically. Find the speed of raindrops with respect to

(a) the road, (b) the moving man

252. A person standing on a road must hold his umbrella at 60° with the vertical to keep the rain away. He throws the umbrella and starts running at $20ms^{-1}$. He finds that raindrops are falling on him vertically. Find the speed of the rain drops with respect to

(a)the road, and

(b) the moving person.

253. A man running on a horizontal road at 8 km/h finds the rain falling vertically. He increases his speed to 12 km/h and finds that the drops make angle 30° with the vertical. Find the speed and direction of the rain with respect to the road.

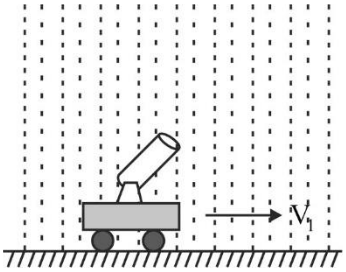
254. To a man walking at the rate of 2km/hour with respect to ground, the rain appears to fall vertically. When he increases his speed to 4km/hour in same direction of his motion, rain appears to meet him at an angle of 45° with horizontal, Find the real direction and speed of the rain.

255. Rain pouring at 37° with vertical has 10 m/s speed. A person runs against rain with 8 m/s & sees rain making angle β with vertical. Find β.

256. Rain is falling vertically with a speed of $12ms^{-1}$. A cyclist is moving east to west with a speed of $12\sqrt{3}ms^{-1}$. In order to protect himself from rain at what angle he should hold his umbrella?

Expert **Rain Man Problems**

257. A pipe which can rotate in a vertical plane is mounted on a cart. The cart moves uniformly along a horizontal path with a speed V_1=2m/s. At what angle α to the horizontal should the pipe be placed so that drops of rain falling vertically with a velocity V_2=6m/s move parallel to the axis of the pipe without touching its walls? Consider the velocity of the drops as constant due to the resistance of the air.



258. Rain is falling vertically with a speed of 20 ms^{-1} relative to air. A person is running in the rain with a velocity of 5 ms^{-1} and a wind is also blowing with a speed of 15 ms^{-1} (both towards east). Find the angle with the vertical at which the person should hold his umbrella so that he may not get drenched.

259. When a man moves down the inclined plane with a constant speed 5m/s which makes an angle of 37° with the horizontal, he finds that the rain is falling vertically downward. When he moves up the same inclined plane with the same speed, he finds that the rain makes an angle $\theta = \tan^{-1}\left(\frac{7}{8}\right)$ with the horizontal. The speed of the rain is

(a) $\sqrt{116}$ m/s (b) $\sqrt{32}$ m/s

(c) 5 m/s (d) $\sqrt{73}$ m/s

Beginner **River Boat Problems**

260. A man can row a boat with a speed of 4 km/h in still water. He is crossing a river, where river speed = 2 km/h.

(a) In what direction with the river flow will his boat be headed if he wants to reach a point on the other bank directly opposite to starting point?

(b) If width of river is 4 km, how long will it take him to cross the river in part (a) condition?

(c) In what direction should he be heading with the boat if he wants to cross the river in shortest time?

(d) Find the min. time to cross the river.

261. A man can swim in still water at a speed of 3 km/h. He wants to cross a river that flows at 2 km/h and reach the point directly opposite to his starting point.

(a) In which direction should he try to swim, find the angle his body makes with the river flow.

(b) How much time (in min) will he take to cross the river if the river is 500 m wide?

262. A river 400 m wide is flowing at a rate of 2.0 m/s. A boat is sailing at a velocity of 10 m/s with respect to the water, in a direction perpendicular to the river.

(a) Find the time taken by the boat to reach the opposite bank.

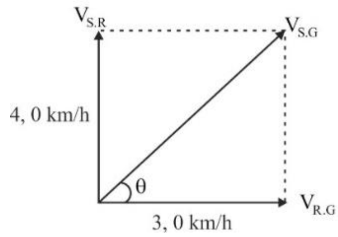
(b) How far from the point directly opposite to the starting point does the boat reach the opposite bank?

263. A man can swim at a speed of 3 km/h in still water. He wants to cross a 500 m wide river flowing at 2 km/h. He keeps himself always at an angle of 120° with the river flow while swimming.

(a) Find the time he takes to cross the river.

(b) At what point on the opposite bank will he arrive?

264. A swimmer can swim in still water at a rate 4.0 km/hr. If he swims in a river flowing at 3.0 km/hr and keeps his direction (with respect to water) perpendicular to the current, find his velocity with respect to the ground.



265. A swimmer's speed in the direction of flow of a river is 12 km h^{-1}. Against the direction of flow of the river the swimmer's speed is 6 km h^{-1}. Calculate the swimmer's speed in still water and the velocity of the river flow.

266. A river flows due south with a speed of 2.0 m/s. A man steers a motorboat across the river; his velocity relative to the water is 4m/s due east. The river is 800 m wide.

(a) What is his velocity (magnitude & direction) relative to the earth?

(b) How much time is required to cross the river?

(c) How far south of his starting point will he reach the opposite bank?

267. A man can swim at a speed of 5 km/h with respect to water. He wants to cross a 1.5 km wide river flowing at 3 km/h. He keeps himself always at angle 60° with the flow direction while swimming. Find the time taken by him to cross river.

268. A river is flowing from west to east at a speed of 5 metres per minute. A man on the south bank of the river, capable of swimming at 10 metres per minute in still water, wants to swim across the river in the shortest time. He should swim in a direction.

(a) due north

(b) 30° east of north

(c) 30° west of north

(d) 60° east of north

269. A man can swim in still water at 6 km/hr. He wants to reach a point just opposite to his starting point. In which direction he should swim, if the river is flowing at 3 km/hr?

(a) 120° with the river flow

(b) 150° with the river flow

(c) 90° with the river flow

(d) None

270. The speed of a swimmer in still water is 20 m/s. The speed of river water is 10 m/s and is flowing due east. If he is standing on the south bank and wishes to cross the river along the shortest path the angle at which he should make his strokes w.r.t. north is given by

(a) 0° (b) 60° west

(c) 45° west (d) 30° west

Expert River Boat Problems

271. A swimmer crosses a river of width 'd' flows at velocity v'. While swimming, he keeps himself always at an angle 120° with the river flow and reaches the other end, he finds a drift of $d/2$ in the direction of flow of river. Then find the speed of swimmer with respect to river.

272. River is flowing with a velocity $\vec{V}R = 4\hat{i}$ m/s. A boat is moving with a velocity of $\vec{V}BR = \left(-2i + 4j\right)$ m/s relative to river. The width of the river is 100 m along y-direction. Choose the correct alternative (s)

(a) The boat will cross the river in 25s

(b) Absolute velocity of boat is $2\sqrt{5}$ m/s

(c) Drift of the boat along the river current is 50 m

(d) The boat can never cross the river.

Pro River Boat Problems

273. A man can row a boat in still water at 3 km/h. He can walk at a speed of 5 km/h in the shore. The water in the river flows at 2 km/h. If the man rows across the river and walks along the shore to reach the opposite point on the riverbank. Find the direction in which he should row the boat so that he could reach the opposite shore in the least possible time. Width of river = 500 m.

274. A boat moves relative to water with a velocity which is η = 2.0 times less than the river flow velocity. At what angle to the stream direction must the boat move to minimize drifting? Find the minimum drift achieved.

275. Two swimmers leave point A on one bank of the river to reach point B lying right across on the other bank. One of them crosses the river along the straight line AB while the other swims at right angles to the stream and then walks the distance that he has been carried away by the stream to get to point B. What was the velocity u of his walking if both swimmers reached the destination simultaneously? The stream velocity v_0 =2.0 kmh^{-1} and the velocity v' of each swimmer with respect to water equals 2.5 kmh^{-1}.

276. Two boats, A and B move away from a buoy anchored at the middle of a river along the mutually perpendicular straight lines; the boat A along the river, and the boat B across the river. Having moved off an equal distance from the buoy the boats returned. Find the ratio of times of motion of boats $\frac{\tau_A}{\tau_B}$ if the velocity of each boat with respect to water is η = 1.2 times greater than the stream velocity.

277. A boat moves relative to water with a velocity which is n = 2.0 times less than the river flow velocity. At what angle to the stream direction must the boat move to minimize drifting?

278. A swimmer starts from point A on the bank of 200 m wide river, crosses the river to reach opposite bank. He returns to the point B on the original bank such that AB = 300m in the downstream direction. Find the magnitude and the direction of the velocity of the swimmer relative to the bank if his velocity w.r.t. to river is always perpendicular to the bank.

279. A boat starts from rest from one end of a bank of a river of width d flowing with velocity u. The boat is steered with constant acceleration a in a direction perpendicular to the bank. If point of start is origin, direction of bank is x axis and perpendicular to bank is y axis. Find the equation of trajectory of the boat.

280. Ship A is sailing towards north-east with velocity $\vec{v}_A = 30\hat{i} + 50j$ km/hr where points east and, north. Ship B is at a distance of 80 km east and 150 km north of Ship A and is sailing towards west at 10 km/hr. A will be at minimum distance from B in:

(a) 4.2 hrs. (b) 2.6 hrs.
(c) 3.2 hrs. (d) 2.2 hrs.

Beginner **Circular Motion**

281. A disc of radius 10 cm is rotating about its axis at an angular speed of 20 rad/s. Find the linear speed of
(a) a point on the rim,
(b) the middle point of a radius

282. A body is whirled in a horizontal circle of radius 20 cm. It has angular velocity of 10 rad/s. What is its linear velocity at any point on circular path?

(a) 10 m/s (b) 2 m/s
(c) 20 m/s (d) $\sqrt{2}$ m/s

283. A wheel rotates with a constant acceleration of 2.0 rad/s^2. If the wheel starts from rest, how many revolutions will it make in the first 10 seconds?

284. The wheel of a motor, accelerated uniformly from rest, rotates through 2.5 radian during the first second. Find the angle rotated during the next second.

285. A wheel is making revolutions about its axis with uniform angular acceleration. Starting from rest, it reaches 100 rev/sec in 4 seconds. Find the angular acceleration. Find the angle rotated during these four seconds.

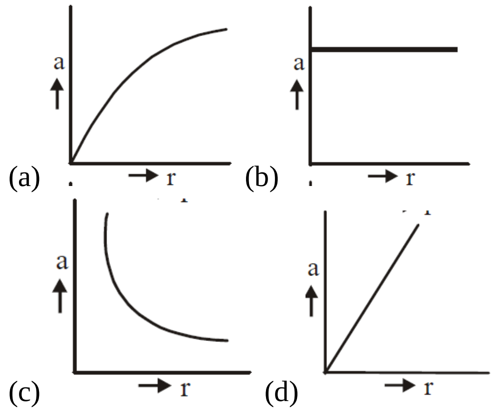
286. A body rotates about a fixed axis with an angular acceleration of 1rad/s^2. Through what angle does it rotate during the time in which its angular velocity increase from 5 rad/s to 15 rad/s.

287. Find the angular velocity of a body rotating with an acceleration of 2 rev/s^2 as it completes the 5th revolution after the start.

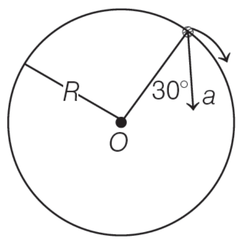
288. When a ceiling fan is switched off, its angular velocity reduces to half its initial value after it completes 36 rotations. The number of rotations it will make further before coming to rest is (Assuming angular retardation to be uniform)

(a) 18 (b) 12
(c) 36 (d) 48

289. If a body moving in circular path maintains constant speed of 10 ms^{-1}, then which of the following correctly describes relation between acceleration and radius?



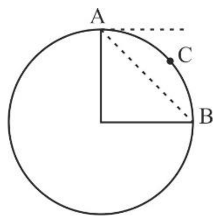
290. In the given figure, a =15 m/s^2 represents the total acceleration of a particle moving in the clockwise direction in a circle of radius R = 2.5 m at a given instant of time. The speed of the particle is



(a) 4.5 m/s (b) 5.0 m/s
(c) 5.7 m/s (d) 6.2 m/s

Expert **Circular Motion**

291. A man is running with constant speed along a circular path of radius $2\sqrt{2}$m. He completes 1 round in 10 second. Find average velocity in first 2.5 sec.



(a) 1.6 m/s (b) 2.6 m/s
(c) 1.0 m/s (d) 3.0 m/s

292. A particle moves in a circle of radius 1.0 cm at a speed given by v = 2.0 t where v is in cm/s and t in seconds.

(a)Find the radial acceleration of the particle at t = 1 s.

(b)Find the tangential acceleration at t = 1 s.

(c)Find the magnitude of the net acceleration at t = 1 s.

293. The speed of a particle moving in a circle of radius r = 2 m varies with time t as v = t^2 where t is in second and v in m/s. Find the radial, tangential and net acceleration at t = 2s

294. During uniform circular motion of a particle, which of the following is incorrect?

(a) Distance-time graph is a straight line
(b) Distance-time graph is a parabola
(c) Displacement-time graph is a straight line
(d) Displacement-time graph is a parabola

295. A particle is moving along a circular path with a constant speed of 10 ms^{-1}. What is the magnitude of the change in velocity of the particle, when it moves through an angle of 60° around the centre of the circle?

(a) $10\sqrt{3}$ m/s (b) zero
(c) $10\sqrt{2}$ m/s (d) 10m/s

296. Velocity of a particle moving in a curvilinear path varies with time as $\vec{v}=\left(2t\hat{i}+t^2\,j\right)$ m/s

Here, t is in second. At t = 1s

(a) Acceleration of particle is 8 m/s^2

(b) Tangential acceleration of particles $\frac{6}{\sqrt{5}}$ m/s^2

(c) Radial acceleration of particle is $\frac{2}{\sqrt{5}}$ m/s^2

(d) Radius of curvature to the path is $\frac{5\sqrt{5}}{2}$ m

297. A particle is moving in a circular path of radius 10 cm. Its linear speed is given by v = 10 cm/s. Find the angle between acceleration and radius at t = 2s.

Pro **Circular Motion**

298. A particle moves on a circle of radius r with centripetal acceleration as function of time as $a_c = k^2rt^2$, where k is a positive constant. Find the following quantities as function of time at an instant:

(a) the speed of the particle,
(b) the tangential acceleration of the particle,
(c) the resultant acceleration, and
(d) angle made by the resultant with tangential direction

299. A point traversed half a circle of radius R = 160 cm during time interval τ = 10.0 s. Calculate the following quantities averaged over that time:

(a) mean velocity (v);
(b) modulus of the mean velocity vector | v |;
(c) modulus of the mean vector of the total acceleration | (w) | if the point moved with constant tangent acceleration.

300. A point moves along a circle with a velocity v = at, where a = 0.50 ms^{-2}. Find the total acceleration of the point at the moment when it covered the n^{th} (n = 0.10) fraction of the circle after the beginning of motion.

301. A point moves with deceleration along the circle of radius R so that at any moment of time its tangential and normal accelerations are equal in moduli. At the initial moment t = 0 the velocity of the point equals v_0. Find :

(a) The velocity of the point as a function of time and as a function of the distance covered s;

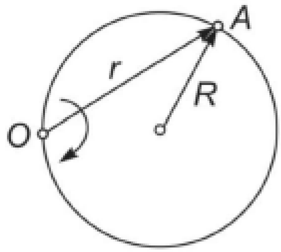
(b) The total acceleration of the point as a function of velocity and the distance covered.

302. A point moves along an arc of a circle of radius R. Its velocity depends on the distance covered s as $v = a\sqrt{s}$, where a is a constant. Find the angle α between the vector of the total acceleration and the vector of velocity as a function of s.

303. A particle moves along an arc of a circle of radius R according to the law l = a sin ωt, where l is the displacement from the initial position measured along the arc, and a and ω are constants. Assuming R = 1.00 m, a = 0.80 m and ω = 2.00 rad s^{-1} .
Find:
(a) The magnitude of the total acceleration of the particle at the points l=0 and l= ± a;
(b) The minimum value of the total acceleration w_{min} and the corresponding displacement l_m.

304. A point moves in the plane so that its tangential acceleration $w_\tau = a$,and its normal acceleration $w_n = bt^4$, where a and b are positive constants, and t is time. At the moment t = 0 the point was at rest. Find how the curvature radius R of the point's trajectory and the total acceleration w depend on the distance covered s.

305. A particle A moves along a circle of radius R=50 cm so that its radius vector r relative to the point O(fig) rotates with the constant angular velocity $\omega = 0.40 rad\ s^{-1}$. Find the modulus of the velocity of the particle, and the modulus and direction of its total acceleration.



306. A wheel rotates around a stationary axis so that the rotation angle ϕ varies with time as ϕ = at^2, where a = 0.20 rad s^{-2}.Find the total acceleration w of the point A at the rim at the moment t = 2.5 s if the linear velocity of the point A at this moment v = 0.65 ms^{-1}.

307. A shell acquires the initial velocity v = 320 ms^1, having made n = 2.0 turns inside the barrel whose length is equal to l =2.0 m. Assuming that the shell moves inside the barrel with a uniform acceleration, find the angular velocity of its axial rotation at the moment when the shell escapes the barrel.

308. A solid body rotates about a stationary axis according to the law ϕ = at -bt^2, where a = 6.0 rad s^{-1} and b =2.0 rad s^{-2}.
Find:
(a) The mean values of the angular velocity and angular acceleration averaged over the time interval between t = 0 and the complete stop;
(b) The angular acceleration at the moment when the body stops

309. A solid body starts rotating about a stationary axis with an angular acceleration $\beta = at$, where a = 2.0 x 10^{-2} rad/s^2. How soon after the beginning of rotation will the total acceleration vector of an arbitrary point of the body form an angle α = 60° with its velocity vector?

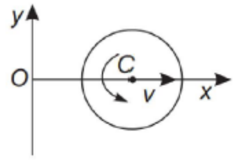
310. A solid body rotates with deceleration about a stationary axis with an angular deceleration $\beta \propto \sqrt{\omega}$, where ω is its angular velocity. Find the mean angular velocity of the body averaged over the whole time of
rotation if at the initial moment of time its angular velocity was equal to ω_0 .

311. A solid body rotates about a stationary axis so that its angular velocity depends on the rotation angle ϕ as $\omega = \omega_0 - \alpha\phi$, where ω_0 and a are positive constants. At the moment t =0 and the angle ϕ =0. Find the time dependence of
(a) The rotation angle
(b) The angular velocity.

312. A solid body starts rotating about a stationary axis with an angular acceleration $\beta = \beta_0 \cos\phi$, where β_0 is a constant vector and ϕ is an angle of rotation from the initial position. Find the angular velocity of the body as a function of the angle ϕ . Draw the plot of this dependence.

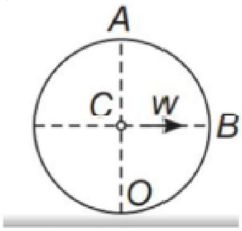
313. A rotating disc (Fig.) moves in the positive direction of the x axis. Find the equation y(x) describing the position of the instantaneous axis of rotation, if at the initial moment the axis C of the disc was located at the point O after which it moved.
(a) With a constant velocity v, while the disc started rotating counterclockwise with a constant angular acceleration β (the initial angular velocity is equal to zero).

(b) With a constant acceleration w (and the zero initial velocity), while the disc rotates counterclockwise with a constant angular velocity ω.

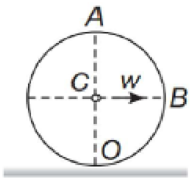


314. A point A is located on the rim of a wheel of radius R = 0.50 m which rolls without slipping along a horizontal surface with velocity v = 1.00 m/s.
Find :
(a) The modulus and the direction of the acceleration vector of the point A;
(b) The total distance s traversed by the point A between the two successive moments at which it touches the surface.

315. A ball of radius R = 10.0 cm rolls without slipping down an inclined plane so that its centre moves with constant acceleration w =2.50 cms^{-2}; t = 2.00 s after the beginning of motion its position corresponds to that shown in Fig.
Find :
(a) The velocities of the points A, B, and O;
(b) The accelerations of these points.



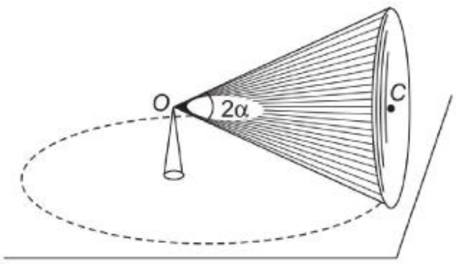
316. A cylinder rolls without slipping over a horizontal plane. The radius of the cylinder is equal to r. Find the curvature radii of trajectories traced out by the points A and B (see Fig.).



317. Two solid bodies rotate about stationary mutually perpendicular intersecting axes with constant angular velocities ω_1 =3.0 rad s^{-1} and ω_2 = 4.0 rad s^{-1}. Find the angular velocity and angular acceleration of one body relative to the other.

318. A solid body rotates with angular velocity $\omega = ati + bt^2t$, where a = 0.50 rad s^{-2} ,b =0.060 rad s^{-2} , and i and j are the unit vectors of the x and y axes. Find:
(a) The moduli of the angular velocity and the angular acceleration at the moment t = 10.0 s.
(b) The angle between the vectors of the angular velocity and the angular acceleration at that moment.

319. A round cone with half-angle $\alpha = 30°$ and the radius of the base R = 5.0 cm rolls uniformly and without slipping over a horizontal plane as shown in fig. The cone apex is hinged at the point O which is on the same level with the point C, the cone base centre. The velocity of point C is v = 10.0 cm s^{-1}. Find the moduli of
(a) The vector of the angular velocity of the cone and the angle it forms with the vertical
(b) The vector of the angular acceleration of the cone.



320. A solid body rotates with a constant angular velocity ω_0 = 0.50 rad s^{-1} about a horizontal axis AB. At the moment t = 0 the axis AB starts turning about the vertical with a constant angular acceleration β_0 =0.10 rad s^{-2}. Find the angular velocity and angular acceleration of the body after t =3.5s.

321. A body is projected at t = 0 with a velocity 10 ms^{-1} at an angle of 60° with the horizontal. The radius of curvature of its trajectory at t = 1s is R. Neglecting air resistance and taking acceleration due to gravity g = 10 ms^{-2}, the value of R is:

(a) 10.3m (b) 2.8m
(c) 2.5m (d) 5.1 m

Expert **Miscellaneous Problems**

322. Velocity and acceleration of a particle at some instant of time are $\vec{v} = \left(3\hat{i} + 4\hat{j}\right)$ m/s and $\vec{a} = -\left(6\hat{i} + 8\hat{j}\right) m/s^2$ respectively. At the same instant particle is at origin. Maximum x-coordinate of particle will be

(a) 1.5 m (b) 0.75 m

(c) 2.25m (d) 4.0m

323. A particle starts from the origin at t = 0 with an initial velocity of 3.0 $\hat{i}$ m/s and moves in the x–y plane with a constant acceleration (6.0 $\hat{i}$ +4.0 $\hat{j}$) m/s^2. The x-coordinate of the particle at the instant when its y-coordinate is 32 m is D meters. The value of D is:

(a) 32 (b) 50

(c) 60 (d) 40

324. A particle moves from the point (2.0 $\hat{i}$ +4.0 $\hat{j}$) m, at t = 0, with an initial velocity (5.0 $\hat{i}$ +4.0 $\hat{j}$) ms^{-1}. It is acted upon by a constant force which produces a constant acceleration (4.0 $\hat{i}$ +4.0 $\hat{j}$) ms^{-2}. What is the distance of the particle from the origin at time 2s?

(a) 15m (b) $20\sqrt{2}$ m

(c) 5m (d) $10\sqrt{2}$ m

Beginner Test-I

1. The displacement-time graph for two particles *X* and *Y* are straight lines making angles of 30° and 60° with the time axis. What is the ratio of the velocities of *Y* and *X*?

2. The position coordinate of a moving particle is given by $x = 6 + 18t + 9t^2$, where *x* is in meters and *t* in seconds. What is the velocity at $t = 2s$?
We know that, velocity is rate of change of displacement i.e. $v = \frac{dx}{dt}$

3. For which condition, the magnitude of average velocity is equal to the average speed for a particular motion?

4. A drunkard walking in a narrow lane takes 5 steps forwards and 3 steps backward, followed again 5 steps forwards and 3 steps backward, and so on. Each step is 1 m long and requires 1 s. Determine how long the drunkard takes to fall in a pit 13 m away from that start.

5. The position of an object moving along *x*-axis is given by $x = a + bt^2$, where $a = 8.5m$, $b = 2.5m$ and *t* is measured in seconds. What is its velocity at $t = 0\ s$ and $t = 2.0\ s$? What is the average velocity between $t = 0\ s$ and $= 4.0\ s$?

6. A man walks on a straight road from his home to a market 2.5 km away with a speed of 5 km/h. Finding the market closed, he instantly turns and walks back with a speed of 7.5 km/h. What is the (i) magnitude of average velocity and (ii) average speed of the man, over interval of time (a) 0 to 30 min (b) 0 to 50 min (c) 0 to 40 min?

7. A particle moving in a straight line covers half the distance with a speed of 3 m/s. The other half of the distance is covered in two equal intervals of time with speeds of 4.5 m/s and 7.5 m/s, respectively. Find the average speed of the particle during this motion.

8. If position of a particle at instant *t* is given by $x = 2t^3$, find the acceleration on the particle.

9. At $t = 0$, a particle is at rest at origin. Its acceleration is $2\ m/s^2$ for the first 3s and $-2\ m/s^2$ for next 3s. Plot the acceleration *versus* time and velocity *versus* time graph.

10. A police van moving on a highway with a speed of $30\ kmh^{-1}$ fires a bullet at a thief's car speeding away in the same direction with a speed of $90\ km\ h^{-1}$.
If the muzzle speed of the bullet is $150\ ms^{-1}$ with what speed does the bullet hit the thief's car? (Note, obtain that speed which is relevant for damaging the thief's car?)

11. Two trains *A* and *B* of length 400 m each are moving on two parallel tracks with a uniform speed of $72\ km\ h^{-1}$ in the same direction with *A* ahead of *B*. The driver of *B* decides to overtake *A* and accelerates by $1\ ms^{-2}$. If after 50 s, the guard of *B* just brushes past the driver of *A*, what was the original distance between them?

12. A jet plane beginning its take off moves down the runway at a constant acceleration of $4.00\ m/s^2$.
(a). Find the position and velocity of the plane 5.00 s after it begins to move.
(b). If a speed of $70.0\ m/s$ is required for the plane to leave the ground, how long a runway is required?

13. A ball is dropped from a height of 90 m on a floor. At each collision with the floor, the ball loses one tenth of its speed. Plot the speed-time graph of its motion between $t = 0$ to 12s. ($g = 10\ ms^{-2}$)

14. State which of the following situations are possible and give an example for each of these?
(a). An object with a constant acceleration but with zero velocity.
(b). An object moving in a certain direction with acceleration in the perpendicular direction.

15. A train passes a station *A* at $40\ kmh^{-1}$ and maintains its speed for 7 km and is then uniformly retarded, stopping at *B* which is 8.5 km from *A*. *A* second train starts from *A* at the instant the first train passes and being accelerated some part of the journey and uniformly retarded for the rest, stops at *B* at the same times as the first train. Calculate the maximum speed of the second train, use only the graphical method.

16. A car moving along a straight highway with a speed of 126 km h^{-1} is brought to a stop within a distance of 200 m. What is the retardation of the car (assumed uniform), and how long does it take for the car to stop?

17. Two trains A and B of length 400 m each are moving on two parallel tracks with a uniform speed of 72 km h^{-1} in the same direction, with A ahead of B. The driver of B decides to overtake A and accelerates by 1 m/s^2 . If after 50 s, the guard of B just brushes past the driver of A, what was the original distance between them?

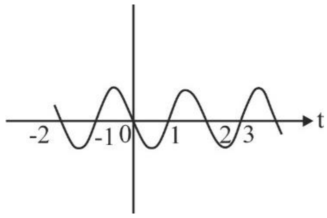
18. On a two-lane road, car A is travelling with a speed of 36 km h^{-1} . Two cars B and C approach car A in opposite directions with a speed of 54 km h^{-1} each. At a certain instant, when the distance AB is equal to AC, both being 1 km, B decides to overtake A before C does. What minimum acceleration of car B is required to avoid an accident?

19. Two towns A and B are connected by a regular bus service with a bus leaving in either direction every T minutes. A man cycling with a speed of 20 km h^{-1} in the direction A to B notices that a bus goes past him every 18 min in the direction of his motion, and every 6 min in the opposite direction. What is the period T of the bus service and with what speed (assumed constant) do the buses ply on the road?

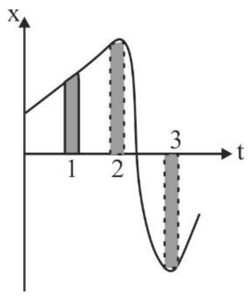
20. A player throws a ball upwards with an initial speed of 29.4 m s^{-1} . What is the direction of acceleration during the upward motion of the ball? What are the velocity and acceleration of the ball at the highest point of its motion?

Choose the x = 0 m and t = 0 s to be the location and time of the ball at its highest point, vertically downward direction to be the positive direction of x-axis, and give the signs of position, velocity and acceleration of the ball during its upward, and downward motion. To what height does the ball rise and after how long does the ball return to the player's hands? (Take g = 9.8 m s^{-2} and neglect air resistance).

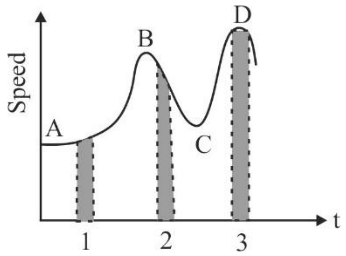
21. Figure gives the x-t plot of a particle executing one-dimensional simple harmonic motion. Give the signs of position, velocity and acceleration variables of the particle at t = 0.3 s, 1.2 s, – 1.2 s.



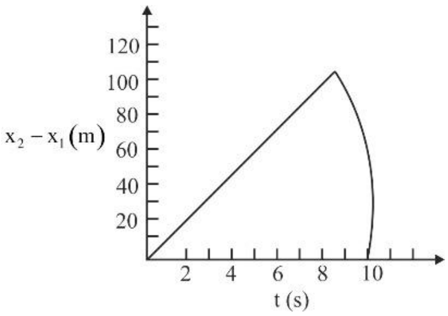
22. Figure gives the x-t plot of a particle in one-dimensional motion. Three different equal intervals of time are shown. In which interval is the average speed greatest, and in which is it the least? Give the sign of average velocity for each interval.



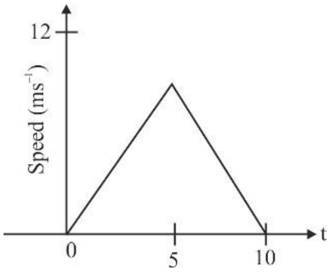
23. Figure gives a speed-time graph of a particle in motion along a constant direction. Three equal intervals of time are shown. In which interval is the average acceleration greatest in magnitude? In which interval is the average speed greatest? Choosing the positive direction as the constant direction of motion, give the signs of v and a in the three intervals. What are the accelerations at the points A, B, C and D?



24. Two stones are thrown up simultaneously from the edge of a cliff 200 m high with initial speeds of 15 m/s and 30 m/s. Verify that the graph shown in Fig. correctly represents the time variation of the relative position of the second stone with respect to the first. Neglect air resistance and assume that the stones do not rebound after hitting the ground. Take g = 10 m/s^2. Give the equations for the linear and curved parts of the plot.



25. The speed-time graph of a particle moving along a fixed direction is shown in Fig. 3.28. Obtain the distance traversed by the particle between (a) t = 0 s to 10 s, (b) t = 2 s to 6 s. (Fig.)
What is the average speed of the particle over the intervals in (a) and (b)?



Beginner Test-II

1. The magnitude of vectors A, B and C are 12, 5 and 13 units respectively and $A + B = C$, find the angle between A and B.

2. What is the angle between A and B, if A and B denote the adjacent sides of a parallelogram drawn from a point and the area of the parallelogram is 1/2 AB?

3. The sum and difference of two vectors are perpendicular to each other. Prove that the vectors are equal in magnitude.

4. There are two displacement vectors, one of magnitude 3m and the other of 4 m. How would the two vectors be added so that the magnitude of the resultant vectors be (a) 7 m (b) 1 m and (c) 5 m?

5. Show that vectors $A = 2\hat{\imath} - 3\hat{\jmath} - \hat{k}$ and $B = -6\hat{\imath} + 9\hat{\jmath} + 3\hat{k}$ are parallel.

6. A boat is moving with a velocity $(3\hat{\imath} + 4\hat{\jmath})$ with respect to ground. The water in the river is moving with a velocity $-3\hat{\imath} - 4\hat{\jmath}$ with respect to ground. What is the relative velocity of boat with respect to water?

7. A football is kicked into the air vertically upwards. What is its (a). Acceleration and (b). Velocity at the highest point?

8. An aircraft is flying at a height of 3400 m above the ground. If the angle subtended at a ground observation point by the aircraft positions 10 s apart is 30°, what is the speed of the aircraft?

9. A man can swim with a speed of 4 km/h in still water. How long does he take to cross a river 1 km wide, if the river flows steadily 3 km/h and he makes his strokes normal to the river current. How far down the river does he go when he reaches the other bank?

10. A bullet fired at an angle of 30° with the horizontal hits the ground 3 km away. By adjusting its angle of projection, can one hope to hit a target 5 km away? Assume the muzzle speed to be fixed, and neglect air resistance.

11. A biker stands on the edge of a cliff 490 m above the ground and throws a stone horizontally with the initial speed of 15 m/s. Neglecting air resistance, find the time taken by the stone to reach the ground and the speed with which it hits the ground. Consider $g = 9.8\ m/s^2$.

12. A stone tied to the end of a string 80 cm long is whirled in a horizontal circle with a constant speed. If the stone makes 14 revolutions in 25 s, what is the magnitude and direction of acceleration of the stone?

In uniform circular motion a centripetal acceleration, $a_c = \frac{v^2}{r} = r\omega^2$ acts on the body whose direction is always towards the centre of the path.

13. The position of a particle is given by $r = 3.0t\ \hat{t} - 2.0t^2\hat{\jmath} + 4.0\ \hat{k}$ where, t is in seconds and the coefficients have the proper units for r to be in metres.

(a) Find the v and a of the particle.

(b) What is the magnitude and direction of velocity of the particle at $t = 2s$?

14. Rain is falling vertically with a speed of 30 m/s. A woman rides a bicycle with a speed of 10 m/s in the north to south direction. What is the direction in which she should hold her umbrella?

15. A cyclist is riding with a speed of 27 kmh^{-1}. As he approaches, a circular turn on the road of radius 80 m, he applies brakes and reduces his speed at the constant rate of 0.5 ms^{-2}. What is the magnitude and direction of the net acceleration of the cyclist on the circular turn?

16. The maximum height attained by a projectile is increased by 10% by increasing its speed of projection, without changing the angle of projection. What will the percentage increase in the horizontal range?

17. A man can swim at the rate of 5 km/h in still water. A river 1 km wide flows at the rate of 3km/h. A swimmer wishes to cross the river straight.

(a). Along what direction must he strike?

(b). What should be his resultant velocity?

(c). How much time he would take to cross?

18. A hunter aims his gun and fires a bullet directly at a monkey in a tree. At the instant, the bullet leaves the barrel of the gun, the monkey drops. Will the bullet hit the monkey? Substantiate your answer with proper reasoning.

19. On an open ground, a motorist follows a track that turns to his left by an angle of 60° after every 500 m. Starting from a given turn, specify the displacement of the motorist at the third, sixth and eighth turn. Compare the magnitude of the displacement with the total path length covered by the motorist in each case.

20. A passenger arriving in a new town wishes to go from the station to a hotel located 10 km away on a straight road from the station. A dishonest cabman takes him along a circuitous path 23 km long and reaches the hotel in 28 min. What is (a) the average speed of the taxi, (b) the magnitude of average velocity? Are the two equal?

21. Rain is falling vertically with a speed of 30 m s^{-1} . A woman rides a bicycle with a speed of 10 m s^{-1}in the north to south direction. What is the direction in which she should hold her umbrella?

22. A man can swim with a speed of 4.0 km/h in still water. How long does he take to cross a river 1.0 km wide if the river flows steadily at 3.0 km/h and he makes his strokes normal to the river current? How far down the river does he go when he reaches the other bank?

23. In a harbour, wind is blowing at the speed of 72 km/h and the flag on the mast of a boat anchored in the harbour flutters along the N-E direction. If the boat starts moving at a speed of 51 km/h to the north, what is the direction of the flag on the mast of the boat?

24. The ceiling of a long hall is 25 m high. What is the maximum horizontal distance that a ball thrown with a speed of 40 m s^{-1} can go without hitting the ceiling of the hall?

25. A cricketer can throw a ball to a maximum horizontal distance of 100 m. How much high above the ground can the cricketer throw the same ball?

Expert Test-I

1. Preeti reached the metro station and found that the escalator was not working. She walked up the stationary escalator in time t_1. On other days, if she remains stationary on the moving escalator, then the escalator takes her up in time t_2. The time taken by her to walk up on the moving escalator will be

(a) $\frac{t_1 + t_2}{2}$

(b) $\frac{t_1 t_2}{t_2 - t_1}$

(c) $\frac{t_1 t_2}{t_2 + t_1}$

(d) $t_1 - t_2$

2. If the velocity of a particle is v = At + Bt^2, where A and B are constants, then the distance travelled by it between 1s and 2s is

(a) 3A + 7B

(b) $\frac{3}{2}A + \frac{7}{3}B$

(c) $\frac{A}{2} + \frac{B}{3}$

(d) $\frac{3}{2}A + 4B3$

3. Two cars P and Q start from a point at the same time in a straight line and their positions are represented by $X_P(t) = at + bt^2$ and $X_Q(t) = ft - t^2$. At what time do the cars have the same velocity?

(a) $\frac{a - f}{1 + b}$

(b) $\frac{a + f}{2(b - 1)}$

(c) $\frac{a + f}{2(1 + b)}$

(d) $\frac{f - a}{2(1 + b)}$

4. A car starts from rest and accelerates at 5 m/s^2. At t = 4s, a ball is dropped out of a window by a person sitting in the car. What is the velocity and acceleration of the ball at t = 6 s?
(Take, g =10 m/ s^2)

(a) 20 m/s, 5 m/s^2

(b) 20 m/s, 0

(c) $20\sqrt{2}$ m/s, 0

(d) $20\sqrt{2}$ m/s, 10 m/s^2

5. A small block slides down on a smooth inclined plane, starting from rest at time t = 0. Let s_n be the distance travelled by the block in the interval t = n – 1 to t = n. Then, the ratio $\frac{s_n}{s_{n+1}}$ is

(a) $\frac{2n-1}{2n}$

(b) $\frac{2n-1}{2n+1}$

(c) $\frac{2n+1}{2n-1}$

(d) $\frac{2n}{2n-1}$

6. A person sitting in the ground floor of a building notices through the window of height 1.5 m, a ball dropped from the roof of the building crosses the window in 0.1 s. What is the velocity of the ball when it is at the topmost point of the window? (g = 10 m/s^2)

(a) 15.5 m/s (b) 14.5 m/s
(c) 4.5 m/s (d) 20 m/s

7. A ball is thrown vertically downward with a velocity of 20 m/s from the top of a tower. It hits the ground after some time with a velocity of 80 m/s. The height of the tower is (g =10 m/s^2)
(a) 340 m (b) 320 m
(c) 300 m (d) 360 m

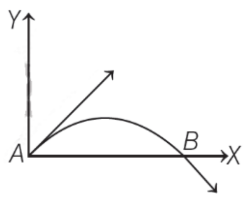
8. A person standing on the floor of an elevator drops a coin. The coin reaches the floor in time t_1 if the elevator is at rest and in time t_1 if the elevator is moving uniformly. The which of the following option is correct?
(a) $t_1 < t_2$ or $t_1 > t_2$ depending upon whether the lift is going up or down
(b) $t_1 < t_2$
(c) $t_1 > t_2$
(d) $t_1 = t_2$

9. A toy car with charge q moves on a frictionless horizontal plane surface under the influence of a uniform electric field **E**. Due to the force q**E**, its velocity increases from 0 to 6 m/s in one second duration. At that instant, the direction of the field is reversed. The car continues to move for two more seconds under the influence of this field. The average velocity and the average speed of the toy car between 0 to 3 seconds are respectively
(a) 1 m/s, 3.5 m/s (b) 1 m/s, 3 m/s
(c) 2 m/s, 4 m/s (d) 1.5 m/s, 3 m/s

10. A stone falls freely under gravity. It covers distances h_1, h_2, and h_3, in the first 5s, the next 5s and the next 5s respectively. The relation between h_1, h_2, and h_3, is
(a) $h_1 = 2h_2 = 3h_3$ (b) $h_1 = \frac{h_2}{3} = \frac{h_3}{5}$
(c) $h_2 = 3h_1$ and $h_3 = 3h_2$ (d) $h_1 = h_2 = h_3$

11. The x and y coordinates of the particle at any time are $x = 5t - 2t^2$ and $y = 10t$ respectively, where x and y are in meters and in seconds. The acceleration of the particle at t = 2s is
(a) 0 (b) 5 m/s^2
(c) –4 m/s^2 (d) –8 m/s^2

12. The velocity of a projectile at the initial point A is $(2\hat{i} + 3\hat{j})$ m/s. Its velocity (in m/s) at point B is



(a) $-2\hat{i} - 3\hat{j}$ m/s (b) $-2\hat{i} + 3\hat{j}$ m/s
(c) $2\hat{i} - 3\hat{j}$ m/s (d) $2\hat{i} + 3\hat{j}$ m/s

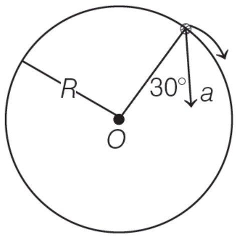
13. The speed of a swimmer in still water is 20 m/s. The speed of river water is 10 m/s and is flowing due east. If he is standing on the south bank and wishes to cross the river along the shortest path the angle at which he should make his strokes w.r.t. north is given by
(a) 0° (b) 60° west
(c) 45° west (d) 30° west

14. A particle moving in a circle of radius R with a uniform speed takes a time T to complete one revolution. If this particle were projected with the same speed at an angle o to the horizontal, the maximum height attained by it equals 4R. The angle of projection θ is then given by

(a) $\theta = \cos^{-1}\left(\frac{gT^2}{\pi^2 R}\right)^{\frac{1}{2}}$ (b) $\theta = \cos^{-1}\left(\frac{\pi^2 R}{gT^2}\right)^{\frac{1}{2}}$

(c) $\theta = \sin^{-1}\left(\frac{\pi^2 R}{gT^2}\right)^{\frac{1}{2}}$ (d) $\theta = \sin^{-1}\left(\frac{2gT^2}{\pi^2 R}\right)^{\frac{1}{2}}$

15. In the given figure, a =15 m/s^2 represents the total acceleration of a particle moving in the clockwise direction in a circle of radius R = 2.5 m at a given instant of time. The speed of the particle is



(a) 4.5 m/s (b) 5.0 m/s
(c) 5.7 m/s (d) 6.2 m/s

16. Two cars P and Q start from a point at the same time in a straight line and their positions are represented by $x_p(t) = at + bt^2$ and $x_Q(t) = ft - t^2$. At what time do the cars have the same velocity?

(a) $\frac{a+f}{2(1+b)}$ (b) $\frac{f-a}{2(1+b)}$
(c) $\frac{a-b}{1+b}$ (d) $\frac{a+f}{2(b-1)}$

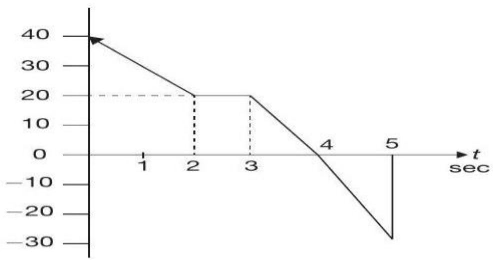
17. A body is moving with velocity 30 m/s towards East. After 10 s, its velocity becomes 40 m/s towards the North. Find the average acceleration of the body.

(a) 7 m/s^2 (b) $\sqrt{7}$ m/s^2
(c) 5 m/s^2 (d) 1 m/s^2

18. A body starts from rest and is uniformly accelerated for 30 s. The distance travelled in the first 10 s is x_1, next 10 s is x_2 and the last 10 s is x_3. Then, $x_1 : x_2 : x_3$ is the same as:

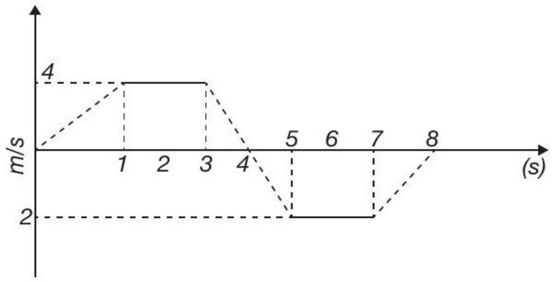
(a) 1: 2: 4 (b) 1: 2: 5
(c) 1: 3: 5 (d) 1: 3: 9

19. In the following velocity-time graph of a body, the distance and displacement travelled by the body in 5 s in metres will be:



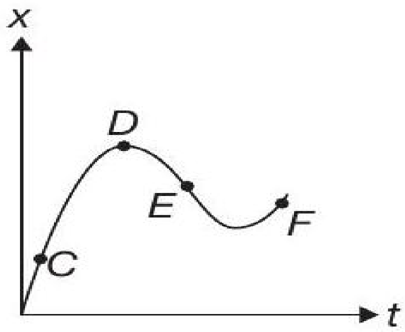
(a) 75,115 (b) 105,75
(c) 45,75 (d) 95,55

20. The $v-t$ graph of a linear motion is shown in the adjoining figure. The distance from the origin after 8 s is:



(a) 18 m (b) 16 m
(c) 8 m (d) 6 m

21. The displacement-time graph of a moving particle is shown in the figure. The instantaneous velocity of the particle is negative at which point?



(a) C (b) D
(c) E (d) F

22. A lift is coming from 8^{th} floor and is just about to reach 4^{th} floor. Taking ground floor as origin and positive direction upwards for all quantities, which one of the following is correct?
(a) $x<0, v<0, a>0$
(b) $x>0, v<0, a<0$
(c) $x>0, v<0, a>0$
(d) $x>0, v>0, a<0$

23. At a metro station, a girl walks up a stationary escalator in time t_1. If she remains stationary on the escalator, then the escalator take her up in time t_2. Find the time taken by her to walk up on the moving escalator.
(a) $(t_1+t_2)/2$
(b) $t_1 t_2/(t_2-t_1)$
(c) $t_1 t_2/(t_2+t_1)$
(d) t_1-t_2

24. A projectile is fired from the surface of the Earth with a velocity of $5\ \mathrm{ms}^{-1}$ at angle θ with the horizontal. Another projectile fired from another planet with a velocity of $3\ \mathrm{ms}^{-1}$ at the same angle follows a trajectory that is identical with the trajectory of the projectile fired from the Earth. Find the acceleration due to gravity on the planet (in ms^{-2}) (given, $\mathrm{g}=9.8\ \mathrm{ms}^{-2}$).
(a) 3.5 (b) 5.9
(c) 16.3 (d) 110.8

25. A particle is moving westward with a velocity $\vec{V}_1 = 5$ m/s. If velocity changed to $\vec{V}_2 = 5$ m/s northward, then find the change in velocity vector $(\Delta\vec{V} = \vec{V}_2 - \vec{V}_1)$.

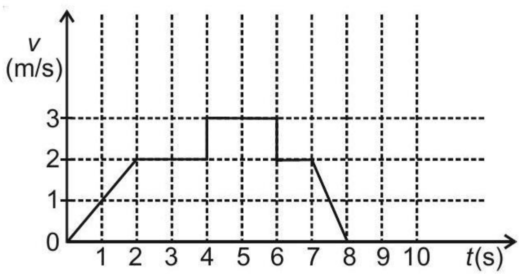
(a) $5\sqrt{2}$ m/s towards north east
(b) 5 m/s towards north west
(c) Zero
(d) $5\sqrt{2}$ m/s towards north west

Expert Test-II

1. In a car race on straight road, car A takes a time t less than car B at the finish and passes finishing point with a speed 'V' more than that of car B. Both the cars start from rest and travel with constant accelerate a_1 and a_2 respectively. Then 'v' is equal to

(a) $\frac{a_1+a_2}{2}t$
(b) $\frac{2a_1a_2}{a_1+a_2}t$
(c) $\sqrt{2a_1a_2}t$
(d) $\sqrt{a_1a_2}t$

2. A particle starts from the origin at time $t = 0$ and moves along the positive x-axis. The graph of velocity with respect to time is shown in figure. What is the position of the particle time $t = 5$ s ?



(a) 9 m
(b) 6 m
(c) 10 m
(d) 3 m

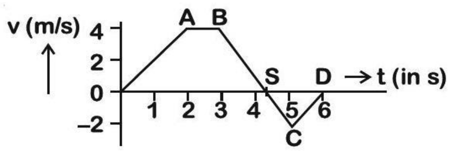
3. A passenger train of length 60 m travels at a speed of 80 km/hr. Another freight train of length 120 m travels at a speed of 30 km/hr. The ratio of times taken by the passenger train to completely cross the freight train when : (i) they are moving in the same direction, and (ii) in the opposite directions is

(a) $\frac{25}{11}$
(b) $\frac{5}{2}$
(c) $\frac{11}{5}$
(d) $\frac{3}{2}$

4. A helicopter rises from rest on the ground vertically upwards with a constant acceleration g. A food packet is dropped from the helicopter when it is at a height h. The time taken by the packet to reach the ground is close to [g is the acceleration due to gravity]

(a) $t = 3.4\sqrt{\left(\frac{h}{g}\right)}$
(b) $t = 1.8\sqrt{\frac{h}{g}}$
(c) $t = \sqrt{\frac{2h}{3g}}$
(d) $t = \frac{2}{3}\sqrt{\left(\frac{h}{g}\right)}$

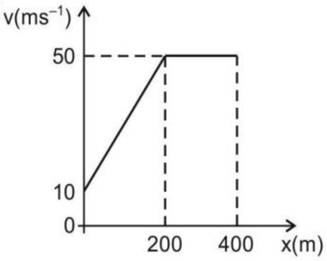
5. The velocity (v) and time (t) graph of a body in a straight-line motion is shown in the figure. The point S is at 4.333 seconds. The total distance covered by the body in 6 s is



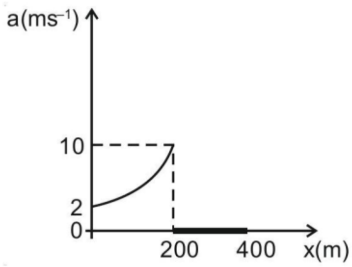
(a) $\frac{37}{3}$ m (b) 11 m

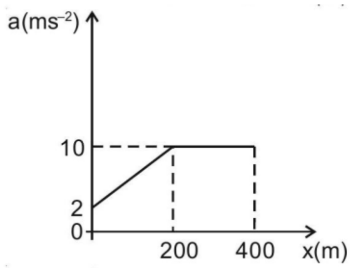
(c) 12 m (d) $\frac{49}{4}m$

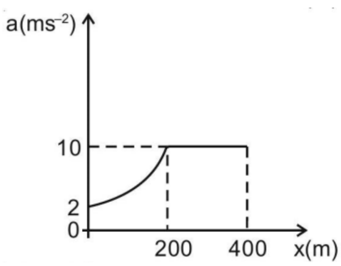
6. The velocity-displacement graph describing the motion of a bicycle is shown in the figure.

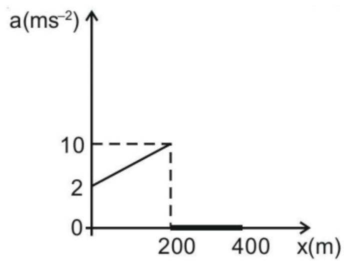


The acceleration-displacement graph of the bicycle's motion is best described by :

(a)


(b)


(c)


(d)


7. A boy reaches the airport and finds that the escalator is not working. He walks up the stationary escalator in time t_1. If he remains stationary on a moving escalator then the escalator takes him up in time t_2. The time taken by him to walk up on the moving escalator will be:

(a) $t_2 - t_1$ (b) $\frac{t_1 t_2}{t_2 - t_1}$

(c) $\frac{t_1 + t_2}{2}$ (d) $\frac{t_1 t_2}{t_2 + t_1}$

8. A balloon was moving upwards with a uniform velocity of 10 m/s. An object of finite mass is dropped from the balloon when it was at a height of 75 m from the ground level. The height of the balloon from the ground when object strikes the ground was around (take the value of g as 10 m/s^2)

(a) 250 m (b) 125 m

(c) 300 m (d) 200 m

9. A ball is thrown up with a certain velocity so that it reaches a height ' h '. Find the ratio of the two different times of the ball reaching $\frac{h}{3}$ in both the directions.

(a) $\frac{1}{3}$ (b) $\frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}}$

(c) $\frac{\sqrt{3}-1}{\sqrt{3}+1}$ (d) $\frac{\sqrt{2}-1}{\sqrt{2}+1}$

10. Two buses P and Q start from a point at the same time and move in a straight line and their positions are represented by $X_P(t) = \alpha t + \beta t^2$ and $X_Q(t) = ft - t^2$. At what time, both the buses have same velocity?

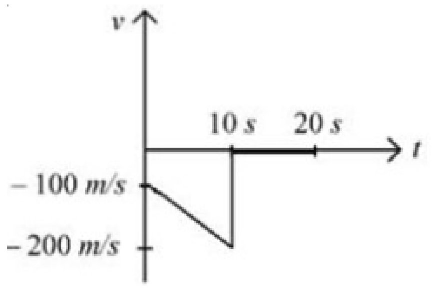
(a) $\frac{\alpha - f}{1+\beta}$ (b) $\frac{\alpha + f}{2(\beta - 1)}$

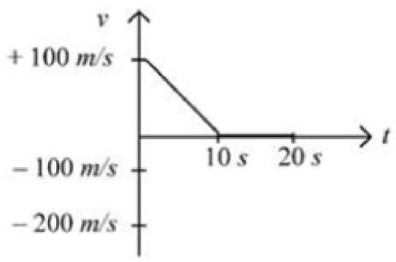
(c) $\frac{\alpha + f}{2(1+\beta)}$ (d) $\frac{f - \alpha}{2(1+\beta)}$

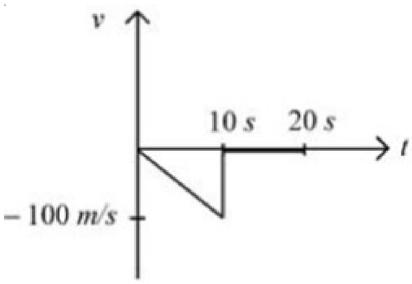
11. Two balls A and B are placed at the top of 180 m tall tower. Ball A is released from the top at $t = 0 \text{ s}$. Ball B is thrown vertically down with an initial velocity u at $t = 2 \text{ s}$. After a certain time, both balls meet 100 m above the ground. Find the value of u in ms^{-1} [use $g = 10 \text{ ms}^{-2}$]

(a) 10 (b) 15 (c) 20 (d) 30

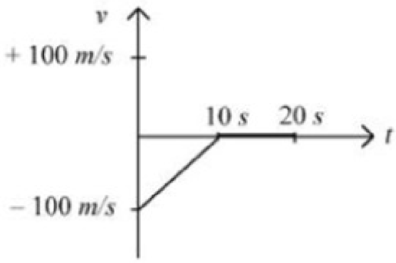
12. A bullet is shot vertically downwards with an initial velocity of 100 m/s from a certain height. Within 10 s, the bullet reaches the ground and instantaneously comes to rest due to the perfectly inelastic collision. The velocity-time curve for total time $t = -20 \text{ s}$ will be (Take $g = 10 \text{ m/s}^2$)

(a) 

(b) 



(c)



(d)

13. A ball is thrown up vertically with a certain velocity so that, it reaches a maximum height h. Find the ratio of the times in which it is at height $\frac{h}{3}$ while going up and coming down respectively

(a) $\frac{\sqrt{2}-1}{\sqrt{2}+1}$

(b) $\frac{\sqrt{3}-\sqrt{2}}{\sqrt{3}+\sqrt{2}}$

(c) $\frac{\sqrt{3}-1}{\sqrt{3}+1}$

(d) $\frac{1}{3}$

14. A ball is released from a height h. If t_1 and t_2 be the time required to complete first half and second half of the distance respectively. Then, choose the correct relation between t_1 and t_2.

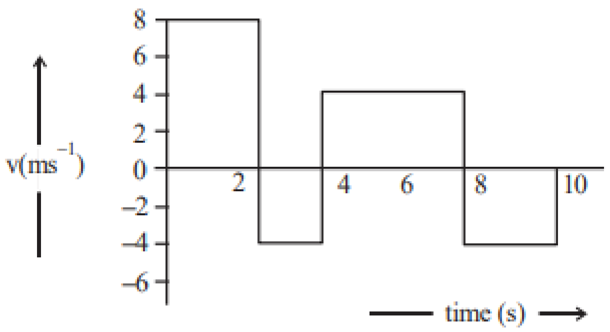
(a) $t_1 = \left(\sqrt{2}\right)t_2$

(b) $t_1 = \left(\sqrt{2}-1\right)t_2$

(c) $t_2 = \left(\sqrt{2}+1\right)t_1$

(d) $t_2 = \left(\sqrt{2}-1\right)t_1$

15. The velocity time graph of a body moving in a straight line is shown in figure.



The ratio of displacement to distance travelled by the body in time 0 to $10\ \text{s}$ is

(a) $1:1$

(b) $1:4$

(c) $1:2$

(d) $1:3$

16. A child of mass $5\ \text{kg}$ is going round a merry-go-round that makes 1 rotation in $3.14\ \text{s}$. The radius of the merrygo-round is $2\ \text{m}$. The centrifugal force on the child will be

(a) $40\ \text{N}$

(b) $100\ \text{N}$

(c) $80\ \text{N}$

(d) $50\ \text{N}$

17. A small block of mass $100\ \text{g}$ is tied to a spring of spring constant $7.5\ \text{N/m}$ and length $20\ \text{cm}$. The other end of spring is fixed at a particular point A. If the block moves in a circular path on a smooth horizontal surface with constant angular velocity 5 rad/s about point A, then tension in the spring is -

(a) 0.75 N (b) 1.5 N

(c) 0.25 N (d) 0.50 N

18. The initial speed of a projectile fired from ground is u. At the highest point during its motion, the speed of projectile is $\frac{\sqrt{3}}{2}u$. The time of flight of the projectile is:

(a) $\frac{u}{2g}$ (b) $\frac{u}{g}$

(c) $\frac{2u}{g}$ (d) $\frac{\sqrt{3}u}{g}$

19. Two objects are projected with same velocity 'u' however at different angles α and β with the horizontal. If $\alpha+\beta=90^\circ$, the ratio of horizontal range of the first object to the 2^{nd} object will be :

(a) $4:1$ (b) $2:1$

(c) $1:2$ (d) $1:1$

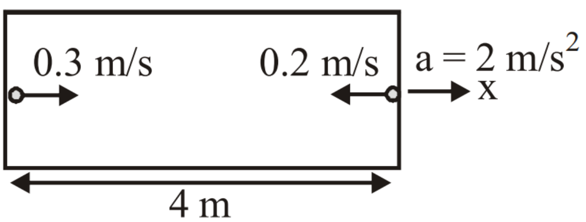
20. A passenger sitting in a train A moving at $90\ \text{km/h}$ observes another train B moving in the opposite direction for $8\ \text{s}$. if the velocity of the train B is $54\ \text{km/h}$, then length of train B is:

(a) 120 m (b) 200 m

(c) 320 m (d) 80 m

Pro Test-I

1. A rocket is moving in a gravity free space with a constant acceleration of 2ms^{-2} along + x direction (see figure). The length of a chamber inside the rocket is 4m. A ball is thrown from the left end the chamber in + x direction with a speed of 0.3m/s related to the rocket. At the same time, another ball is thrown in –x direction with a speed of 0.2m/s from its right end relative to the rocket. The time in seconds when the two balls hit each other is



2. A particle of mass m moves on the x axis as following: it start from rest at t = 2 from the point x = 0 and comes to rest at t = 1 at the point x = 1. No other information is available about its motion at intermediate time ($0<t<1$). If α denotes the instantaneous acceleration of the particle, then:

(a) α cannot remain positive for all t in the interval $0<t<1$.

(b) $|\alpha|$ cannot exceed 2 at any point in its path.

(c) $|\alpha|$ must be ≥ 4 at some point or points in its path.

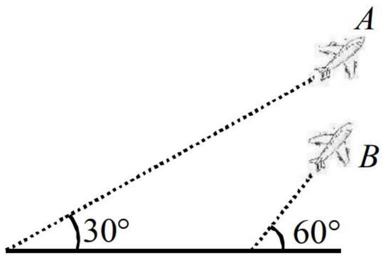
(d) α must change sign during the motion, but no other assertion can be made with information given.

3. A car accelerates from rest at a constant rate α for some time after which it decelerates at a constant rate β to come to rest. If the total time lapse is t seconds, Evaluate.

(a) Maximum velocity reached, and

(b) Total distance travelled

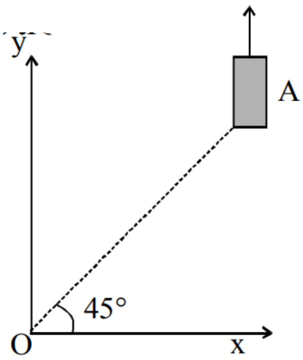
4. Airplanes A and B are flying with constant velocity in the same vertical plane at angles 30° and 60° with respect to the horizontal respectively as shown in figure. The speed A is $100\sqrt{3}$m/s. At time t = 0s, an observer in A finds B at a distance of 500m. The observer sees B moving with constant velocity perpendicular to the line of motion of A. If at t = $t_{\circ}$, A just escapes being hit by B, $t_{\circ}$ in seconds is



5. On a frictionless horizontal surface, assumed to be the x-y plane, a small trolley A is moving along straight line parallel to the y-axis (see figure) with a constant velocity of ($\sqrt{3}$ - 1) m/s. At a particular instant, when the line OA makes an angle of 45° with the x-axis, a ball is thrown angle the surface from the origin of O. Its velocity makes an angle ϕ with the x-axis and it hits the trolley

(a) The motion of the ball is observed from the frame of the trolley. Calculate the angle θ made by the velocity vector of the ball the x-axis in this frame.

(b) Find the speed of the ball with respect of the surface, if ϕ = $4\theta/4$.



Pro Test-II

1. Two vectors $\vec{A}$ and $\vec{B}$ are defined as $\vec{A}$ = a$\hat{i}$ and $\vec{B}$ = a(cos$\omega t\hat{\imath}$ + sin$\omega t\hat{\jmath}$), where a is constant and $\omega = \pi/6$ rad/s. If $|\vec{A}+\vec{B}| = \sqrt{3}|\vec{A}-\vec{B}|$ at time t = τ for the first time, the value of τ, in seconds, is ____

2. Starting at a time t = 0 from the origin with speed 1m/s, a particle follows a two dimensional trajectory in the x-y plane so that its coordinates are related by the equation y = $\frac{x^2}{2}$. The x and y components of its acceleration are denoted by a_x and a_y respectively. Then

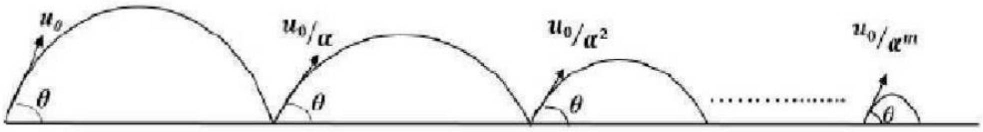
(a) a_x = 1ms-2 implies that when the particle is at the origin, a_y = 1ms^{-2}

(b) a_x = 0 implies a_y = 1ms^{-2} at all times

(c) at t = 0 ,the particle's velocity points in the x-direction

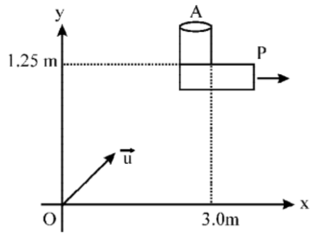
(d) a_x = 0 implies that at t = 1s,the angle between the particle's velocity and the x axis is 45°

3. A ball is thrown from ground at angle θ with horizontal and with an initial speed u_0. For the resulting projectile motion, the magnitude of average velocity of the ball up to the point when it hits the ground for first time V_1. After hitting the ground, the ball rebounds at the same angle θ but with a reduced speed of u_0/a. Its motion continues for a long time as shown in figure. If the magnitude of average velocity of the ball for entire duration of motion is $0.8V_1$, the value α is _____

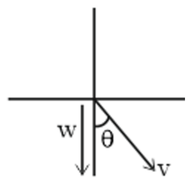


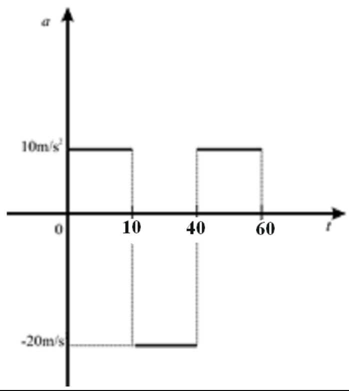
4. A train is moving along a straight line with a constant acceleration 'a'. A boy standing in the train throws a ball forward with a speed of 10m/s, at an angle of 60° to the horizontal. The boy has to move forward by 1.15m inside the train to catch the ball back at the initial height. The acceleration of the train, in m/s^2,is

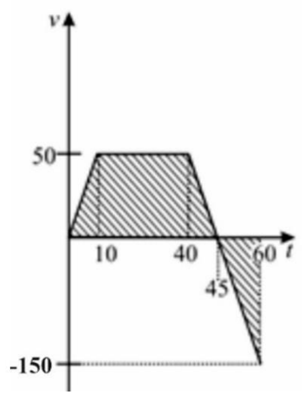
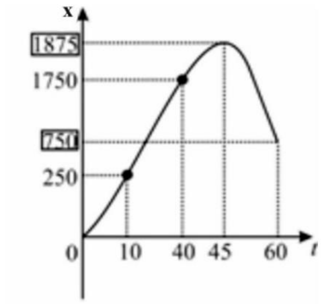
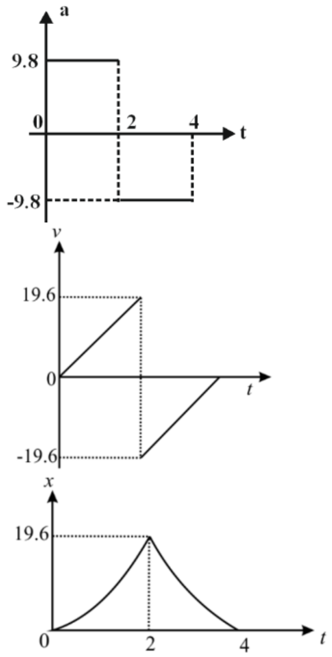
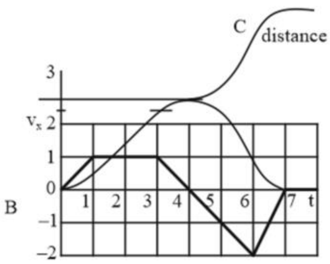
5. An object A is kept fixed at the point x = 3 m and y = 1.25m on a plank P raised above the ground at time t = 0 the planks starts moving along the positive x-axis direction with an acceleration $1.5m/s^2$. At the same instant a stone is projected from the origin with a velocity $\vec{u}$ as shown. A stationary person of the ground observes the stone hitting the object during its downward motion at an angle of $d45^\circ$ to the horizontal. All the motions are in the X-Y plane. Find $\vec{u}$ and the time after which the stone hits the object. Take g = 10m/s



Answer Key

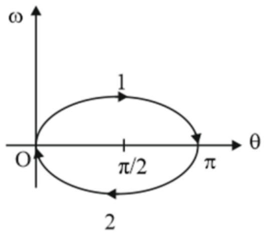
1. (b)	2. (c)	3. 48m, 36m
4. 32 km/hr, 0	5. (c)	6. 350m, 96.3m
7. 100m, 47.05m	8. (d)	9. 0.414 seconds
10. (d)	11. $\frac{5v_1v_2}{3v_1+2v_2}$	12. 12.5 m/s, 25 m/s
13. 2.6 m/s, 1 m/s	14. $\frac{2v_0(v_1+v_2)}{v_1+v_2+2v_0}$	15. (d)
16. (c)	17. (b)	18. (c)
19. 15 m/s	20. (b)	21. (b)
22. (a, b, c, d)	23. (d)	24. (a,d)
25. (a)	26. (b)	27. (b)
28. (d)	29. (a) 2.00 s (b) 12.0 cm (c) –9.00 m/s^2 (d) 2.00 s (e) 2.00 s (f) 3.46s	30. (a)
31. (c)	32. $\frac{5}{2}t^2$ + 2t + 5	33. (a) a = $2x^3$ (b) x = $\frac{5}{1-5t}$ (c) v = $\frac{25}{(1-5t)^2}$ (d) a = $\frac{250}{(1-5t)^3}$
34. $-2\alpha\vec{a}$, $\frac{a}{2\alpha}$	35. (a) 0.24, 0, -4 (b) 11s, 1.1s, 9s (c) 24 cm, 34 cm	36. $\frac{\alpha^2}{2}$, $\frac{\alpha\sqrt{S}}{2}$
37. $v=0, \quad x=\frac{2}{3a}v_0^{\frac{3}{2}}$, $v=0,\ t=\frac{2\sqrt{v_0}}{a}$	38. (a) $y=-b\left(\frac{x^2}{a^2}\right)$  (b) $v=a\hat{i}-2bt\vec{j}$, $w=-2b\hat{j}$ (c) $\tan\theta=\frac{a}{2bt}$ (d) $\vec{v}_{av}=a\hat{i}-bt\hat{j}$	39. $a\omega t$, $\theta=\frac{\pi}{2}$
40. $\sqrt{2ax}$	41. $\frac{1}{2a}$, $\pm\frac{a^2}{b}$	42. infinity, A/B
43. -1 m/s	44. (a)	45. (d)
46. (a, b, c, d)	47. (a,b,c)	48. 160 sec, 50 m/s, 7km, $\frac{275}{6}m/s$, 5:9
49. 160 sec, 50 m/s, 7km, $\frac{275}{6}m/s$, 5:9	50. (b)	51. (e)
52. 11.2 m/s^2 , 79.8 m	53. 704 m	54. 1.62 × 10^5 m/s^2

55. 0.55s	56. $16.0\frac{cm}{s^2}$.)	57. 20s, 1.0 km
58. (b)	59. (a)	60. (a)
61. (a)	62. $1.62\times10^{15}\frac{m}{s^2}$	63. (d)
64. 10 min	65. (b)	66. $\frac{t\alpha\beta}{(\alpha+\beta)}$, $\frac{1}{2}(\frac{\alpha\beta}{\alpha+\beta})t^2$
67. (c)	68. (a)	69. $\sqrt{\tau\left(\tau-\frac{4v}{\omega}\right)}$
70. $20\sqrt{5}$ m/s	71. (a)	72. 8sec, 80m, 17 m/s, 15 m/s, 35m
73.(c)	74. (b)	75. (c)
76. (d)	77. (b)	78. (c)
79. (a)	80. (b)	81. (d)
82. (c)	83. (a)	84. (b)
85. 1 : 3 :5	86. (c)	87. 160m, $4(1+\sqrt{2})$ sec, $40\sqrt{2}$m/s, $(40\sqrt{2}-5)$, 205m, 5 m/s
88. $\frac{4v_0^2}{9g}$	89. 80 m	90. (b)
91. (b)	92. 2sec	93. (c)
94. 8 m/s^2	95. (b)	96. (b)
97. 4 sec, 50m, 90m	98. 108km, $600\sqrt{6}$ m/s	99. (a)
100. (c)	101. $\sqrt{\frac{h}{8g}}$.	102. 49.4 m
103. (c)	104. (a, d)	105. (a, b)
106. (b)	107. (a)	108. $\frac{6cm}{s^2}$
109. (d)	110. (b)	111. (d)
112. 1.2 m/s	113. (b)	114. (b)
115. (d)	116. (a)	117. (d)
118. (a)	119. (c)	120. (a)
121. (d)	122. (a)	123. (b)
124. (d)	125. (c)	126. 

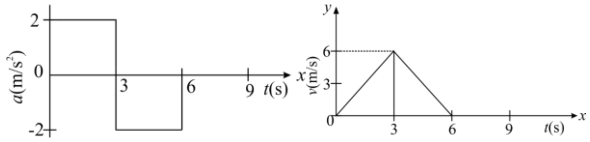
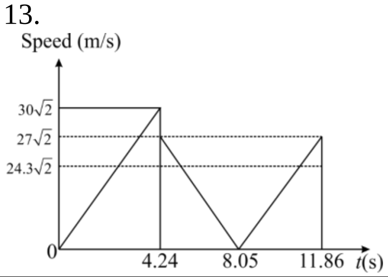
		 
127. 	128. 	129. 210 m
130. (a),(c)	131. (c)	132. (b)
133. (b)	134. (a)	135. (d)
136. 0.61 sec	137. (a)	138. (c)
139. 5 sec	140. (c)	141. (d)
142. 0.69 sec	143. 105 m/s	144. (d)
145. (d)	146. $\frac{\ell}{2\tau}$	147. -4m/s
148. 0.7 s, Δs=-0.7m, s=1.3 m	149. (a)	150. 60km, 1 hr
151. v = 20 kmh^{-1} and x = 9min	152. (a),(b),(c)	153. (c)
154. 8 sec	155. 33.75 m , $3\sqrt{3}sec, 77.94\ m$	156. 14.4 m

157. (a) 10 sec (b) 980 m (c) $98\sqrt{2}$ m/s	158. (a)	159. (a)
160. $500\sqrt{2}$ m/s	161. $\frac{2hu^2}{gb^2}$	162. $\frac{100}{3}$ m/s
163. (c)	164. (a) 40m (b) 10m (c) $2\sqrt{2}$ sec (d) $2\sqrt{2}$ sec	165. 5 sec, $50\sqrt{3}$m, $10\sqrt{3}$ m/s
166. 6.24 sec	167. $\frac{u}{g\sin\alpha}$	168. 20 sec
169. 22 m	170. (b),(c)	171. (c)
172. 13.3 m/s	173. (d)	174. $\frac{4u^2 \pm \sqrt{16u^4 - 4g^2 4R^2}}{2g^2}$
175. 11.547 m	176. (a) 20m/s (b) 4m (c) 24.4m	177. (a) 1s (b) $(5\sqrt{3},5)$
178. (c)	179. 320 m , $40\sqrt{2}$	180. (a) 245 m (b) 1200 m
181. $\frac{\sqrt{\frac{h}{g}}}{\cos\theta}$	182. $20\sqrt{5}$ m/s	183. 997.8, 35.5 , 3966 m
184. (b)	185. (d)	186. (b)
187. (a)	188. (a)	189. $\theta = 60°$, 2m/s
190. (c)	191. (b)	192. (b)
193. (a)	194. (c)	195. (c)
196. (c)	197. $\sqrt{\frac{g(1+p^2)}{2q}}$	198. (c)
199. -272.032 m	200. $\frac{ab}{a+b}$	201. $3\frac{1}{3}m$
202. (a) $y = x\left(1-\frac{\alpha x}{a}\right)$ (b) $\vec{v} = a\hat{i} + a(1-2\alpha t)\hat{j}$, $a = -2a\alpha$ (c) $t = 0, \frac{1}{2\alpha}$	203. $x\tan\theta_2 - \frac{gx^2}{2v_0^2\cos^2\theta_2}$	204. $\sqrt{\frac{\omega}{2b}}\left(1+a^2\right)$
205. (a) $y = \frac{bx^2}{2a}$ (b) R=$\frac{\left(a^2+b^2x^2\right)^{3/2}}{a^2b}$	206. (b)	207. (a)
208. 8 m	209. (b)	210. (a) $-g\sin\beta$ (b) $-g\cos\beta$ (c) $u\cos\theta - g\sin\beta.t$ (d) $u\sin\theta - g\cos\beta.t$ (e) $u\cos\theta t - ½ g\sin\beta.t^2$ (f) $u\sin\theta t - \frac{1}{2}g\cos\beta t^2$ (g) 0
211. 15 s, 525 m , $20\sqrt{13}\,m$	212. 2/3 sec	213. (a) 10 sec (b) 600 m (c) $10\sqrt{97}\,m$
214. $\frac{2u^2\tan\theta\sec\theta}{g}$	215. 10 m/s	216. (a)
217. (b)	218. $\tan\alpha\tan\beta = 0.5$	219. 1/2

220. $8h\sin\alpha$	221. (d)	222. $\frac{1}{\sqrt{3}} sec$
223. (c)	224. 4.7m/s	225. (a) 144km/h (b)90km/h (c) 36km/h
226. $5ms^{-1}$	227. 10625 km^2/hr^2	228. 50
229. $\sqrt{61}$ m/s	230. 50 m	231. $\frac{2d}{3v}$
232. 580 m/s	233. (a) $sin^{-1}\left(\frac{1}{3}\right)$ N of W. (b) $200\sqrt{2}$ kmh^{-1}	234. 5
235. 10	236. $\frac{\vec{v}_2-\vec{v}_1}{\lvert\vec{v}_2-\vec{v}_1\rvert}=\frac{\vec{r}_1-\vec{r}_2}{\lvert\vec{r}_1-\vec{r}_2\rvert}$	237. $\frac{15\sin 60°}{30+15\cos 60°}$
238. $v_1t+v_2t=(v_1+v_2)\frac{\sqrt{v_1v_2}}{g}$	239. $\frac{2\ell}{3v}$	240. $\frac{v\ell}{v^2-u^2}$
241. $\frac{\lvert \ell_1v_2-\ell_2v_1\rvert}{\sqrt{v_1^2+v_2^2}}$	242. $\frac{\ell}{\sqrt{\eta^2-1}}$	243. (a) $\frac{ay^2}{2v_0}$ (b) $\frac{a_x.v_0}{\sqrt{a^2y^2+v_0^2}}$
244. $\frac{l_1v_1+l_2v_2}{v_1^2+v_2^2}$, $\frac{\lvert v_1l_2-v_2l_1\rvert}{\sqrt{v_1^2+v_2^2}}$	245. $5\sqrt{2}$ km , 15 min	246. $tan^{-1}\left(\frac{1}{3}\right) S\ of\ E$
247. Refer Solution	248. 122.5 m	249. (d)
250. (a) $\theta' = tan^{-1}(0.5)$ from vertical (b) 37°	251. (a) 20km/h (b) $10\sqrt{3}$ km/h	252.
253. (a) $\frac{40\sqrt{3}}{3}ms^{-1}$ $(b)\frac{20\sqrt{3}}{3}ms^{-1}$	254. $2\sqrt{2}$ km/h	255. $\beta = tan^{-1}\left(\frac{7}{4}\right)$
256. Since the v_{rain} w.r.t cyclist make an angle of 30° with the x axis, he must hold the umbrella at an angle of 60° to the vertical.	257. $tan^{-1}(3)$	258. $tan^{-1}\left(\frac{1}{2}\right)$
259. (b)	260. (a) 120° (b) $\frac{2}{\sqrt{3}}hr$ (c) 0° (d)$1hr$	261. (a) 131.7° (b) 13.4 min
262. (a) 40 sec (b) 80 m	263. (a) $\frac{1}{3\sqrt{3}}$ hrs (b) $\frac{1}{6\sqrt{3}}$km	264. 5km/h
265. 12km/h	266. (a) 4.5 (b) 200 s (c) 400m	267. 0.35 hr
268. (a)	269. (a)	270. (d)
271. $4(2-\sqrt{3})V$	272. (a),(b),(c)	273. $sin^{-1}\left(\frac{-3}{7}\right)$
274. 120 , $w\sqrt{3}$	275. $\frac{v_0\sqrt{v'^2-v_0^2}}{v'-\sqrt{v'^2-v_0^2}}$	276. $\frac{\eta}{\sqrt{\eta^2-1}}$
277. $\sin^{-1}\frac{1}{\eta}+\frac{\pi}{2}$	278. $tan^{-1}\left(\frac{4}{3}\right),\frac{5}{3}V_w$	279. $\frac{ax^2}{2u^2}$
280. (b)	281. (a) 2m/s (b) 1m/s	282. (b)
283. 16	284. 7.5 rad	285. 400 π radians
286. 100 rad	287. $2\sqrt{5}$ rad/s	288. (b)
289. (c)	290. (c)	291. (c)
292. (a) 4 cm (b) 2cm (c) $\frac{\sqrt{20}cm}{s^2}$	293. $8ms^{-2}, 4ms^{-2}, \sqrt{80}ms^{-2}$	294. (b),(c),(d)

295. (d)	296. (d)	297. 180°
298. (a) krt (b) kr (c) $kr\sqrt{k^2t^4+1}$ (d) $tan^{-1}(kt^2)$	299. (a) $\frac{\pi R}{\tau}$ (b) $\frac{2R}{\tau}$ (c) $\frac{2\pi R}{\tau^2}$	300. $a\sqrt{(4\eta\pi)^2+1}$
301. (a) $v_0e^{-S/R}$ (b) $\sqrt{2}\frac{v_0^2e^{-2S/R}}{R^2}$	302. $\tan^{-1}\frac{2S}{R}$	303. $a_p = a\omega^2$, $a\sqrt{1-\left(\frac{R}{\sqrt{2}a}\right)^2}$
304. R= $\frac{a^3}{2bs}$, $a_T = \sqrt{a^2+b^2\left(\frac{2s}{a}\right)^4}$	305. (a) $\lvert v\rvert = 2\omega R = 0.4m/s$ (b) $\lvert a_T\rvert = 4\omega^2R = 0.32m/s^2$	306. $v\sqrt{\frac{1}{t^2}+4a^2t^2}$
307. $\frac{2\pi n v}{\ell}$	308. (a) $-\sqrt{3ab}$ (b) $-2\sqrt{3ab}$	309. $\left(\frac{4\tan\alpha}{a}\right)^{1/3}$
310. $\frac{\omega_0}{3}$	311. (a) $\theta = \frac{\omega_0}{a}\left(1-e^{-at}\right)$ (b) $\omega = \omega_0e^{-at}$	312. $\omega = \pm\sqrt{2\beta_0\sin\phi}$ 
313. (a) $y = \frac{v^2}{\beta x}$ (b) $y = \sqrt{\frac{2ax}{\omega}}$	314. (a) $v = 2v\sin\frac{\omega t}{2}$ (b) 8R	315. (a) $v_A = 2v, v_B = \sqrt{2}v, v_O = 0$ $A: a = \sqrt{(2a)^2+\left(\frac{a^2t^2}{R}\right)^2}$ (b) $B: a = \sqrt{\left(\frac{a^2t^2}{R}-a\right)^2+a^2}$ $C: a = a_n = \frac{a^2t^2}{R}$
316. $2\sqrt{2}R$	317. (a) $\lvert\vec{\omega}_2\rvert = \sqrt{\vec{\omega}_2^2+\vec{\omega}_1^2}$ (b) $\lvert\alpha_{2\|1}\rvert = \sqrt{\omega_2\omega_1}$	318. (a) $\lvert\omega\rvert = \sqrt{(at)^2+\left(bt^2\right)^2}$ $\lvert\alpha\rvert = \sqrt{a^2+(2bt)^2}$ (b) $\theta = \cos^{-1}\frac{a^2t+2b^2t^3}{\lvert\omega\rvert\lvert\alpha\rvert}$
319. (a) $\frac{v}{R\cos\alpha}$ (b) $\frac{v^2\tan\alpha}{R^2}$	320. (a) $\sqrt{(\beta_0t)^2+\omega_0^2}$ (b) $\beta_0\sqrt{1+\omega_0^2t^2}$	321. (b)
322. (b)	323. (c)	324. (b)

Answer Key- Beginner Test-I

1. 3:1	2. 54 m/s
3. When a particle is moving along a straight line with the fixed direction.	4. 37 steps
5. 1.5 m/s	6. (i)(a) 5km/h (b) 5km/h (ii)(a) 0 (b) 6km/h (iii) (a) 1.875km/h (b) 5.625 km/h
7. 4m/s	8. 12t
9. 	10. 105 ms^{-1}
11. 450 m	12. (a) 50 m (b) 613 m
13. 	14. (a). When an object is projected upwards, its velocity at the top-most point is zero even though the acceleration on itis 9.8 m/s^2 (g). (b). When a stone tied to a string is whirled in a circular path, the acceleration acting on it is always at right angles
15. 68kmh^{-1}	16. 11.44 s
17. 1250 m	18. 1m/s^2
19. 9 min	20. 6s
21. Negative, Negative, Positive (at t = 0.3 s) Positive, Positive, Negative (at t = 1.2 s) Negative, Positive, Positive (at t = –1.2 s)	22. Interval 3 (Greatest), Interval 2 (Least) Positive (Intervals 1 & 2), Negative (Interval 3)
23. Refer Solution	24. Refer Solution
25. (a) 60 m, 6 m/s (b) 36 m, 9 m/s	

Answer Key- Beginner Test-II

1. 90^0	2. 30^0
3. Refer Solution	4. (a) 0^0 (b) 180^0 (c) 90^0
5. Refer Solution	6. $6\hat{\imath} + 8\hat{\jmath}$
7. (a)-g (b) 0	8. 182.2 ms^{-1}
9. 750 m	10. bullet cannot hit the target
11. 10 s	12. 9.90 ms^{-2}, directed towards the center
13. (a) $[3.0\hat{\imath} - 4.0\hat{\jmath}t]\ ms^{-2}, -4.0\ \hat{\jmath}\ ms^{-2}$ (b) 8.54 ms^{-1}, 69.5° below the X-axis	14. South
15. 0.86 ms^{-2}, $54^\circ\ 28'$	16. 10%
17. (a) $\cos\ \alpha\ =\ 53^\circ\ 8'$ upstream (b) 4 km/h (c) 15 min	18. Refer Solution
19. Refer Solution	20. (a) 49.29km/h (b) 21.43km/h
21. south	22. 15 min , 750 m
23. East	24. 150.5 m

25. 50 m	

Answer Key- Expert Test-I

1. (c)	2. (b)
3. (d)	4. (d)
5. (b)	6. (b)
7. (c)	8. (d)
9. (b)	10. (b)
11. (c)	12. (c)
13. (d)	14. (d)
15. (c)	16. (b)
17. (c)	18. (c)
19. (b)	20. (a)
21. (c)	22. (a)
23. (c)	24. (a)
25. (a)	

Answer Key- Expert Test-II

1. (d)	2. (a)
3. (c)	4. (a)
5. (a)	6. (d)
7. (d)	8. (b)
9. (b)	10. (d)
11. (d)	12. (a)
13. (b)	14. (d)
15. (d)	16. (a)
17. (a)	18. (b)
19. (d)	20. (c)

Answer Key- Pro Test-I

1. 8 s	2. (a, c, d)
3. $v = \frac{t\alpha\beta}{(\alpha+\beta)}$, $s = \frac{1}{2}\left(\frac{\alpha\beta}{\alpha+\beta}\right)t^2$	4. 5s
5. 45 degree with +x axis, 2 m/s	

Answer Key- Pro Test-II

1. 2s	2. (a, b, c, d)
3. 4	4. 5m/s^2
5. ($3.75\hat{\imath} + 6.25\hat{\jmath}$)m/s , t=1 s	

Force

Chapter Summary

Force

Force is an agent or a cause which can accelerate a body or a system of bodies. It can affect the following:

1.Changes or tends to change state of motion

2.Changes or tends to change momentum

3.Changes or tends to change shape and size of objects.

Types of Force

There are various classification of forces.

Classification #01 (Based on Fundamental Nature)

1. **Gravitational Force**
   The force between any two masses in the universe. Its always attractive in nature.
2. **Electromagnetic Forces**
   The force due to interaction of charge particles. It can be attractive or repulsive in nature.
3. **Nuclear Forces** (i)
   The force between nucleons (neutrons and (ii) protons inside a nucleus of an atom). Its always attractive in nature. (i

Classification #02 (Based on Contact Nature)

Force arises from interaction of bodies either due to contact or from a distance. So, it can be classified as contact force and non-contact force.

1. **Contact force** is such type of force, which arises when a body is in physical contact with another.
   Eg: Normal Reaction, Tension, String Force and Friction force etc.
2. **Non-contact Force** is such type of force, which does not involve physical contact between two bodies, but act through empty space. It is also known as field force.
   Eg: Gravitational Force, Magnetic Force, Nuclear force etc.

Classification #03 (Based on Energy Loss)

1. **Conservative Forces:** If under the action of a force work done in a round trip is zero or work is path independent, the force is said to be conservative otherwise not.
   Eg: Gravity, Spring Force etc.
2. **Non-Conservative Forces:** In presence of Non-conservative force there is loss of mechanical energy, which is usually converted into heat frictional and viscous forces are non-conservative forces.

Classification #04 (Based on the System)

Force can also be classified as **internal** and **external**.

1. **Internal Forces:** Forces are those, which arise from the interactions with other particles that are parts of the system
2. **External Forces:** Forces are those, which arise from the interactions with other particles that are outside the system

Note:

1. Same force can be external or internal depending on the system.
2. Total internal force acting on a system is always zero as these are parts of action pairs and cancel.

Examples of Forces:

(a) Weight (W): The weight of a body is the force by which it is pulled by the gravity of earth. If a body of mass 'm' is located at a point where acceleration due to gravity is $\vec{g}$, the weight $\vec{W} = m\vec{g}$

Magnitude $= mg$

Direction will towards the centre of earth or always in downward direction.

(b) Normal Reaction (R): When a body is pressed against a rigid surface, the body experiences a force, which is perpendicular to the surface in contact. This force is called normal force or normal reaction'.

(i) Magnitude of normal reaction is given by the force perpendicular to the surface on which body is kept in figure (a) $R = mg$

(ii) Direction of normal reaction in figure (a) is perpendicular to the surface in upward direction and in figure (b) is perpendicular to the incline surface.

(iii) Point of application is on the surface of contact.

(iv) Line of each is perpendicular to the contact surface.

(c) String Tension (T): String tension is an elastic force. Whenever a body is connected with another body or ceiling through a string and string is in tension. It acts in opposite direction to the applied force on the string; it means it pulls another body (in contact) to which it is connected.

String is assumed to be inextensible & massless. This is why the magnitude of string tension in whole string is taken same

(d) Spring's Force: Spring can be of many types such as helical or spiral and are stretchable or compressible.

Regarding spring it is worth noting that :

(i) Spring are assumed to be massless. This is why the restoring *elastic force* in a spring is assumed to be the same everywhere.
(ii) For small stretch or compression, springs obey Hook's law, i.e., for a spring Force $\propto$ stretch (or compression)
i.e., $F = -k\ x$

(e) Friction Force

Whenever the surface of a body slides over that of another, each body exerts a force of friction on the other, parallel to the surface. ***The force of friction*** on each body is in a direction *opposite to its motion relative to the other body.*

The ***force of friction*** comes into action only when there is a relative motion between the two contact surfaces or when an attempt is made to have it.

It is a *self adjusting force;* it can adjust its magnitude to any between zero and the limiting (maximum) value i.e. $0 \le f \le_{\max}$

The frictional force acting between any two surfaces at rest with respect to each respect other is called the force of ***static frication.*** And the frictional force acting between surfaces in relative motion with respect to each other is called the force of ***kinetic friction or sliding friction.***

Laws of Friction

The limiting (or maximum) force of friction is proportional to the normal force that keeps the two surfaces in contact with each other, and is independent of the area of contact between the two surfaces. Mathematically,

$f_{\max} = \mu N$

Properties of Friction

1. If the body does not move, then the static frictional force f_s and the external force F parallel to the surface are equal in magnitude and f_s is directed opposite to F. If the external force F increase f_s increases.

2. The maximum value of static friction is given by

$$f_{s(\max)} = \mu_s N$$

Where $\mu_s =$ static coefficient of friction and N is the magnitude of the normal reaction. If the external force F exceeds $f_{s(\max)}$ then the body slides on the surface.

3. If the body begins to slide along the surface, the magnitude of the frictional force rapidly decreases to a constant value of f_k given by

$f_k = \mu_k N$

where μ_k is the coefficient of kinetic friction.

(a) The friction force on a stationary block is zero.
(b) As long as the external force is less than the maximum friction force $f_s = F$.
(c) At the limiting case $f_{s(\max)} = F,$ the block is about to side.
(d) As the value of ***F*** slightly increases beyond $f_{s(\max)}$, the block "breaks away" accelerating suddenly to the right.
(e) If the block is to move with a constant velocity, the applied force must be reduced, because $\mu_k < \mu_s$.

Angle of Friction

Suppose a body is placed on an inclined surface whose angle of inclination θ varies between 0 to $\pi/2$ The *coefficient of friction* between the body and the surface is μ_s. Let the initial value of θ be zero and if we slowly start increasing the value of θ, then at a particular value of $\theta = \phi$ the block just *starts to move*. This value of $\theta = \phi$ is called the **angle of friction.** Mathematically, if the block is just about to move, then $mg \sin\theta = f$

When $\theta = \phi$, $mg\ \sin\ \phi = f_{\max}$

Or $mg\ \sin\phi = \mu_s N = \mu_s mg\ \cos\phi$ or $\tan\phi = \mu_s$

Thus $\phi = \tan^{-1}\mu_s$

The angle of friction is that minimum angle of inclination of the inclined plane at which a body placed at rest on the inclined plane is about to slide down.

When $\theta \le \phi$ (or $\tan^{-1}\mu_s$) the body is in equilibrium.

When the angle of inclination is more than the angle of friction $(\theta > \phi)$ the block starts sliding down with acceleration. And, if we wish to keep it in equilibrium an external force has to be applied.

Inertia: If you attempt to change the velocity of an object, the object resists this change.

Inertia is solely a property of an individual object; it is a measure of the response of an object to an external force. It can be defined in this way: It is the property of a body by virtue of which it opposes any change in its state rest or uniform motion.

Mass is used to measure inertia. The greater the mass of a body, the less that body changes its state of motion under the action of an applied force.

Mass : "Mass is an inherent property of a body which is measure of the object's inertia (Which is a tendency to resist acceleration when a force acts on it) and is independent of body's surroundings and of the method used to measure it".

It is a scalar quantity. The Sl unit of mass is the kilogram (kg). Mass is the quantity that obeys the rules of ordinary algebra.

Linear Momentum

It is defined as the total quantity of motion contained in a body and is measured as the product of mass of body and its velocity. It is denoted of *p*.

It is a vector quantity

Suppose a particle of mass *m* moves with velocity *v*.

$$\vec{p} = m\vec{v}$$

Change in Linear Momentum or Impulse (I)

It is the change in momentum of a body or system of particles. It is given by

$$\vec{I} = \overrightarrow{\Delta p} = m\Delta\vec{v} = m(v_f - v_i)$$

Newton's First Law

An object at rest remains at rest and an object in motion will continue in motion with a constant velocity (that is, constant speed in a straight line) unless it experiences a net external unbalanced force. In simpler terms, we can say that when the net force on a body is zero, its acceleration is zero

i.e., $\sum\vec{F} = 0,$

then, $\vec{a} = 0.$

Newton's Second Law

The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.

In other words,

According to Newton's second law of motion, "The rate of change of linear momentum of a body is directly proportional to the external force applied on the body and this change always takes place in the direction of the applied force".

$$\vec{F} \propto \frac{d\vec{P}}{dt}$$

Thus we can relate mass and force through the following mathematical statement of Newton's second law:

$$\sum\vec{F} = m\vec{a}$$

You should note that equation is a vector expression and hence is equivalent to the following three component equations:

$$\sum F_x = ma_x$$

$$\sum F_y = ma_y$$

$$\sum F_z = ma_z$$

Newton's Third Law

According to Newton's third law "for a every action there is an equal opposite reaction and they act two different bodies and simultaneously".

Pseudo Force

Suppose a ball is on the frictionless floor of a car and the brakes are applied. Since there is no net force on the ball an observer on the ground will see the ball continue to move at the velocity of the car just before the brakes were applied. However, relative to an observer in the car, the ball accelerates in the forward direction, even though there is no net force on it. To explain the acceleration of the ball with respect to the car (non-inertial frame) one has to invent a fictitious force called the pseudo force. It is an imaginary force which acts an all the occupants of an accelerated frame. The direction of the force is opposite to the direction of the frame acceleration.

$$\mathbf{F_p = -ma}$$

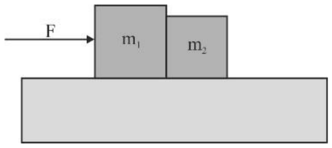
This *pseudo force* is real enough to throw you forward when a bus suddenly stops. It is fictitious in the sense that it has no physical origin that is not caused by one of the basic interaction in nature. Its action does not have the reaction required by the third law.

Centripetal force

If a particle moves with speed *v* in a circle of radius *r*, it has an acceleration of magnitude v^2/r directed toward the centre of the circle. This ***centripetal acceleration*** is related to the change in the direction of the velocity of the particle. As with any acceleration, there must be a resultant force in the direction of the acceleration to produce it. This resultant force is called the ***centripetal force.***

Beginner **Free Body Diagram**

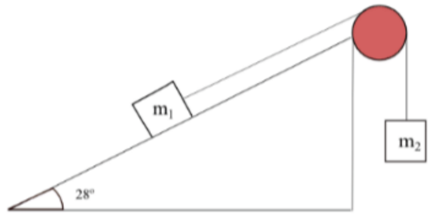
1. Draw the Free Body Diagram of following system:



(a) m_1 (b) m_2

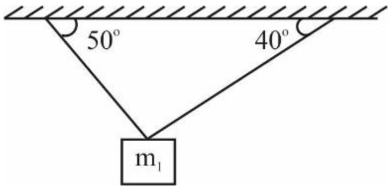
(c) $m_2 + m_1$

2. Draw the Free Body Diagram of following system:

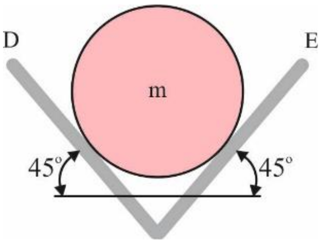


(a) m_1 (b) m_2

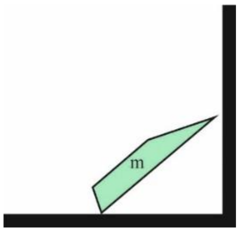
3. Draw the Free Body Diagram of mass m_1.



4. Draw the Free Body Diagram of mass m.



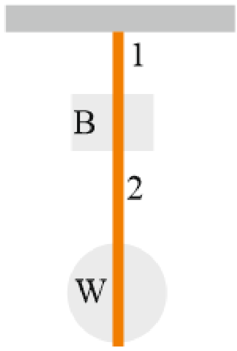
5. Draw the Free Body Diagram of mass m.



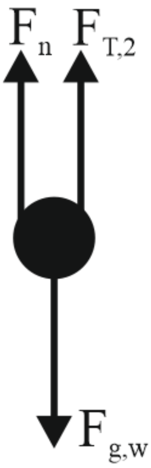
6. A book is at rest on a tabletop. Diagram the forces acting on the book.

7. An egg is free-falling from a nest in a tree. Neglect air resistance. Diagram the forces acting on the egg as it is falling.

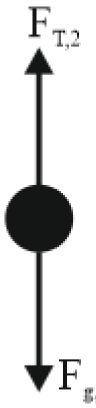
8. A block of cheese B hangs from the ceiling by rope 1. A wheel of cheese W hangs from the block of cheese by rope 2.



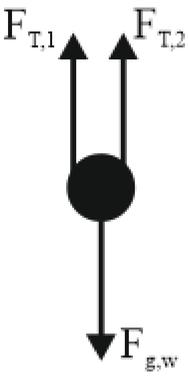
What is the correct free body diagram for the wheel of cheese W?



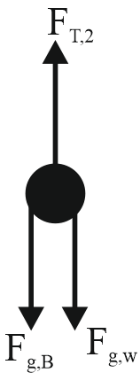
(a)



(b)

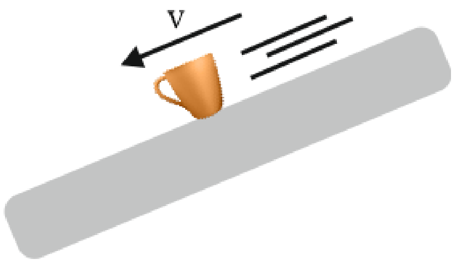


(c)

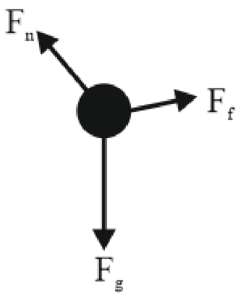


(d)

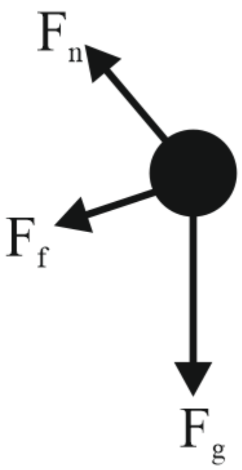
9. A cup is sliding down an inclined surface that is not smooth.



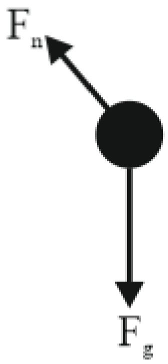
What is the correct free body diagram for the cup?



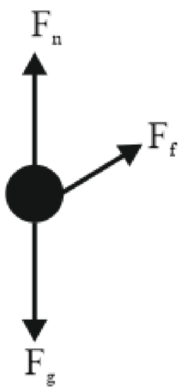
(a)



(b)

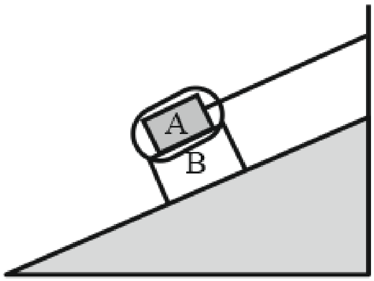


(c)



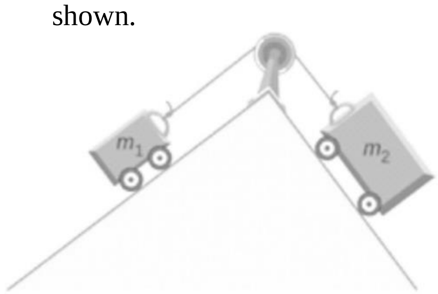
(d)

10. Construct the free-body diagram for object A and object B in (figure).



Expert **Free Body Diagram**

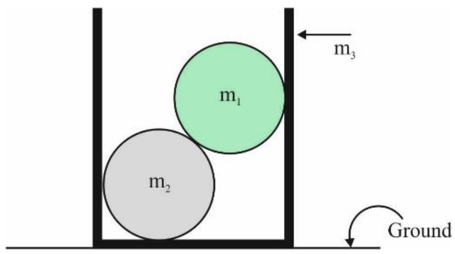
11. Draw the free-body diagram for the situation shown.



12. A rightward force is applied to a book in order to move it across a desk at constant velocity. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

13. A car is coasting to the right and slowing down. Diagram the forces acting upon the car.

14. Draw the Free Body Diagram of following system:



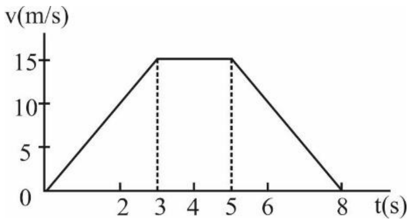
(a) m_1 (b) m_2
(c) m_3 (d) $m_1 + m_2$
(e) $m_1 + m_2 + m_3$

Beginner **Newtons 2nd Law**

15. A bullet of mass 10 gm is fired from a rifle with a velocity of 800 m/s. After passing through a mud wall 180 cm thick, the velocity drops to 100 m/s. Calculate the average resistance of the wall.

16. A bullet moving at 250 m/s penetrates 5 cm into a tree limb before coming to rest. Assuming that the force exerted by the tree limb is uniform, find its magnitude. Mass of the bullet is 10 g.

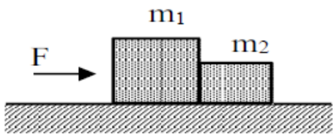
17. A particle of mass 50 g moves on a straight line. The variation of speed with time is shown in figure. Find the force acting on the particle at t = 2, 4 and 6 seconds.



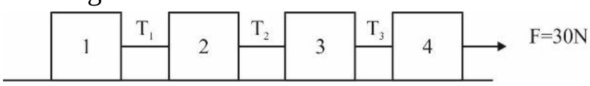
18. A body of mass 2 kg moving on a horizontal surface with an initial velocity of 4 m/sec comes to rest after 2 sec. If one wants to keep this body moving on the same surface with a velocity of 4 m/sec, the force required is

(a) 8 N (b) 4 N
(c) Zero (d) 2 N

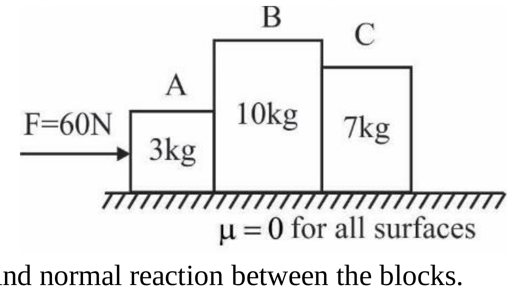
19. Two blocks of masses m_1 = 2 kg and m_2 = 1 kg are in contact on a smooth horizontal surface as shown in the figure. A horizontal force F = 3N is applied on the block m1. Find the contact force between blocks.



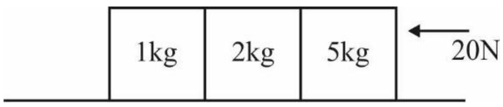
20. Find the value of tensions T_1, T_2 & T_3 in the string.



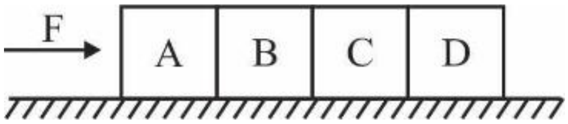
21. Find out the mutual contact forces between A and B and between blocks B and C in the arrangement shown in the diagram.



22. Find normal reaction between the blocks.



23. Four identical blocks each of mass *m* are kept on a horizontal frictionless plane in contact with adjacent blocks as shown in figure. A force *F* is applied on the system



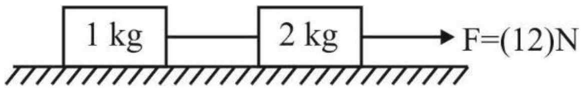
(a) Acceleration of each block is $\frac{F}{4m}$

(b) Net force on the block C is $\frac{F}{4}$

(c) Net force on the block A is $\frac{3F}{4}$

(d) Force by the block C on the D is $\frac{F}{8}$

24. In the shown arrangement,

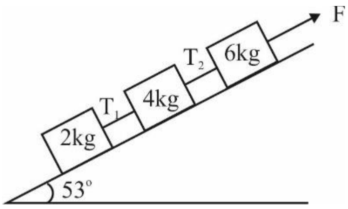


If coefficient of friction between blocks and surface is 0.1 the tension in the string would be

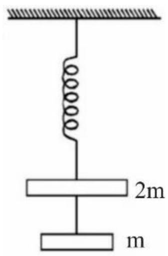
(a) 4N (b) 3N
(c) 2N (d) 1N

25. Three blocks of masses 2kg, 4kg and 6kg are connected by string and resting on a frictionless incline of 53° as shown. A force of 120N is applied upward along the incline to the 6 kg block. If the strings are ideal, the ratio T_1/T_2 will be ($g = 10\ ms^{-2}$)

(a) 1: 1 (b) 1: 2
(c) 1: 3 (d) 1: 4



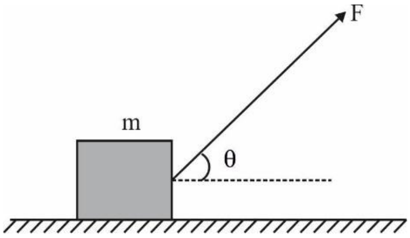
26. The string between blocks of mass m and 2m is massless and inextensible. The system is suspended by a massless spring as shown. If the string between masses m and 2m is cut, find the magnitudes of accelerations of mass 2m and m (immediately after cutting)



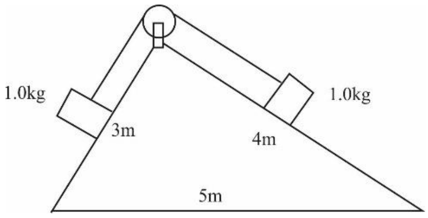
(a) g, g (b) $g, \frac{g}{2}$

(c) $\frac{g}{2}, g$ (d) $\frac{g}{2}, \frac{g}{2}$

27. A block of mass m = 10 kg is pulled by a force F =100N at an angle θ = 30 with the horizontal along a smooth horizontal surface. What is the acceleration of the block? (g = 10 m/s^2)



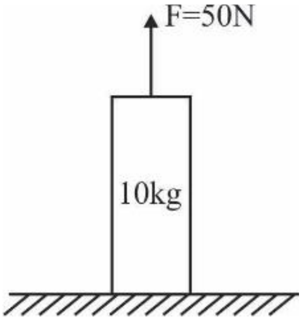
28. Consider the situation shown in figure. All the surfaces are frictionless and the string and the pulley are light. Find the magnitude of the acceleration of the two blocks.



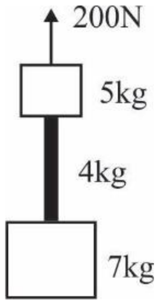
29. A ball of mass 0.2 kg falls from a height of 45 m. On striking the ground, it rebounds in 0.1 s with two thirds of the velocity with which it struck the ground. Calculate

(a) Change the momentum of the ball during the collision with the ground,

(b) The average force on the ball due to the impact



30. Two blocks shown in the figure are connected by a heavy uniform rope of mass 4 kg. An upward force of 200 N is applied as shown in the fig.



(a) What is the acceleration of the system?

(b) What is the tension at the top of heavy rope?

(c) What is the tension at the midpoint of the rope?

31. A block weighing 100 kg is placed on an inclined plane of height 6 m and base 8 m. The co-efficient of friction is 0.3 (g =9.8 m/s^2)

(a) Would the block slide down the inclined plane due to its own weight?

(b) What force parallel to the inclined plane must be applied to just support the block on the plane?

(c) What force parallel to the inclined plane is required to keep the block moving up the plane at constant velocity?

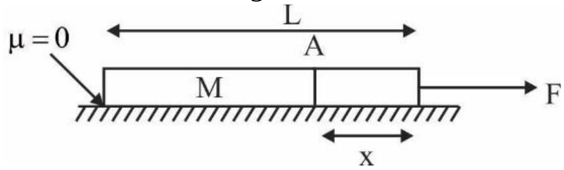
(d) If an upward force of 940 N parallel to the inclined plane is applied to the block, what will be its acceleration?

(e) How far will the block move in 1 s starting from rest if a force of 940 N is applied on it up the incline?

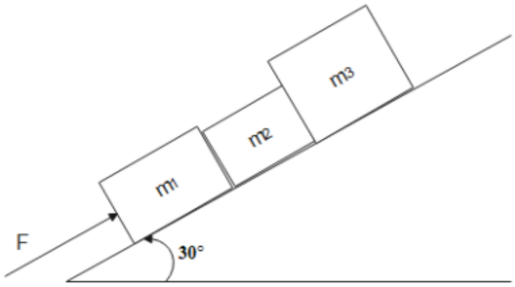
(f) What will happen if an upward force of 500 N parallel to the inclined plane is applied?

(g) If an upward force of 260 N parallel to the inclined plane is applied what will happen? How far will the block move in 1 s starting from rest?

32. Find the tension in rope at section A, at a distance x from the right end.



33. Three blocks m_1 = 3 kg, m_2 = 2 kg, m_3 = 5 kg, lie on an inclined frictionless surface as shown in fig.



(a) What force (F) parallel to the incline is needed to push the blocks up the plane with an acceleration a = 2 m/s^2?

(b) Find the contact force between m_1& m_2& m_3?

34. A block rests on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of static friction between the block and the plane is 0.8. If the frictional force on the block is 10 N, the mass of the block (in kg) is (take g = 10 m/s^2)

(a) 1.6 (b) 4.0
(c) 2.0 (d) 2.5

35. When forces F_1, F_2, F_3 are acting on a particle of mass m such that F_2 and F_3 are mutually perpendicular, then the particle remains stationary. If the force F_1 is now removed then the acceleration of the particle is

(a) F_1/m (b) F_2F_3/mF_1
(c) $(F_2 - F_3)$/m (d) F_2/m

36. Speeds of two identical cars are u and 4u at the specific instant. The ratio of the respective distances in which the two cars are stopped from that instant is

(a) 1 : 1 (b) 1 : 4
(c) 1 : 8 (d) 1 : 16

37. A light string passing over a smooth light pulley connects two blocks of masses m_1 and m_2 (vertically). If the acceleration of the system is g/8, then the ratio of the masses

(a) 8 : 1 (b) 9 : 7
(c) 4 : 3 (d) 5 : 3

38. A block of mass M is pulled along a horizontal frictionless surface by a rope of mass m. If a force P is applied at the free end of the rope, the force exerted by the rope on the block is

(a) $\frac{Pm}{M+m}$ (b) $\frac{Pm}{M-m}$
(c) P (d) $\frac{PM}{M+m}$

39. A rocket with a lift-off mass 3.5×10^4 kg is blasted upwards with an initial acceleration of 10m/s^2. Then the initial thrust of the blast is

(a) 3.5×10^5 N (b) 7.0×10^5 N
(c) 14.0×10^5 N (d) 1.75×10^5 N

40. A ball of mass 0.2 kg is thrown vertically upwards by applying a force by hand. If the hand moves 0.2 m while applying the force and the ball goes up to 2 m height further, find the magnitude of the force. (Consider g = 10 m/s^2).

(a) 4 N (b) 16 N
(c) 20 N (d) 22 N

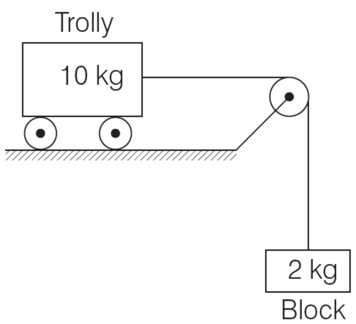
41. A player caught a cricket ball of mass 150 g moving at a rate of 20 m/s. If the catching process is completed in 0.1s, the force of the blow exerted by the ball on the hand of the player is equal to

(a) 150 N (b) 3N
(c) 30N (d) 300 N

42. A particle moves in the X-Y plane under the influence of a force such that its linear momentum is $\vec{p}(t) = A[\hat{\imath}\cos(kt) - \hat{\jmath}\sin(kt)]$, where A and k are constants. The angle between the force and the momentum is

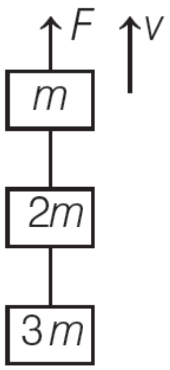
(a) 0° (b) 30°
(c) 45° (d) 90°

43. Calculate the acceleration of the block and trolley system shown in the figure. The coefficient of kinetic friction between the trolley and the surface is 0.05. (g =10 m/s^2, mass of the string is negligible and no other friction exists).



(a) 1.25 m/s^2 (b) 1.50 m/s^2
(c) 1.66 m/s^2 (d) 1.00 m/s^2

44. Three blocks with masses m, 2m and 3m are connected by strings, as shown in the figure. After an upward force F is applied on block m, the masses move upward at constant speed v. What is the net force on the block of mass 2m ? (g is the acceleration due to gravity).



(a) Zero (b) 2 mg
(c) 3 mg (d) 6 mg

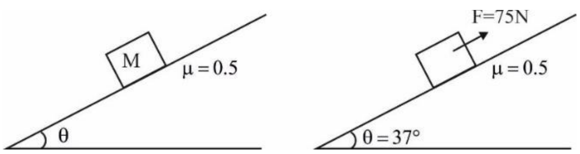
Expert **Newtons 2nd Law**

45. A block slides down an inclined plane of slope θ with constant velocity. It is then projected up the plane with an initial speed v_0. How far up the incline will it move before coming to rest?

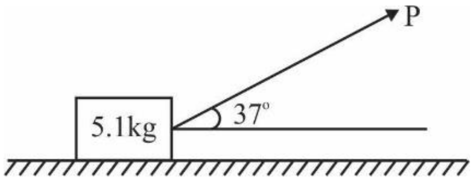
(a) $\frac{v_0^2}{4g\sin\theta}$ (b) $\frac{v_0^2}{g\sin\theta}$

(c) $\frac{v_0^2}{2g\sin\theta}$ (d) $\frac{v_0^2}{2g}$

46. A block of mass M= 10 kg is placed on an inclined plane, inclined at angle θ =37° with the horizontal. The coefficient of friction between the block and inclined is μ=0.5.
(a) Calculate the acceleration of the block when it is released.
(b) Now a force F= 75 N is applied on block as shown. Find out the acceleration of the block. If the block is initially at rest.
(c) In case (b), how much force should be added to 75 N of force so that block the starts to move up the incline.
(d) What is the minimum force by which 75N force should be replaced with so that block does not move?



47. A 5.1 kg block is pulled along a frictionless floor by a cord that exerts a force P = 10 N at an angle θ = 37° above the horizontal, as shown in the figure.



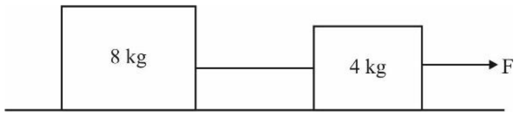
(a) What is the acceleration of the block?
(b) The force P is slowly increased. What is the value of P just before the block breaks off the floor?
(c) What is the acceleration of the block just before it is lifted off the floor?
(d) Suppose the surfaces are tough with μ =0.4, for what value of P the block just begins to move?

48. A smooth block is released at rest on a 45° incline and then slides a distance 'd'. The time taken to slide is 'n' times as much to slide on rough incline than on a smooth incline. The coefficient of friction is

(a) $\mu_k = \sqrt{1-\frac{1}{n^2}}$ (b) $\mu_k = 1-\frac{1}{n^2}$

(c) $\mu_s = \sqrt{1-\frac{1}{n^2}}$ (d) $\mu_s = 1-\frac{1}{n^2}$

49. Two blocks of masses 8 kg and 4 kg are connected by a heavy string and placed on rough horizontal plane. The 4 kg block is pulled with a constant force F as shown in figure. The coefficient of friction between the box and the ground is 0.5. What is the value of F so that tension in the string is constant throughout during the motion of the blocks?



(a) 40 N (b) 30 N
(c) 45 N (d) 60 N

50. A machine gun is mounted on a 2000 kg car on a horizontal frictionless surface. At some instant the gun fires bullets of mass 10 gm with a velocity of 500 m/sec with respect to the car. The number of bullets fired per second is ten. The average thrust on the system is
(a) 550 N (b) 50 N
(c) 250 N (d) 250 dyne

51. A box of mass 8 kg is placed on a rough inclined plane of inclination **θ**. Its downward motion can be prevented by applying an upward pull F and it can be made to slide upwards by applying a force 2F. The coefficient of friction between the box and the inclined plane is

(a) $\frac{1}{3}\tan\theta$ (b) $3\tan\theta$

(c) $\frac{1}{2}\tan\theta$ (d) $2\tan\theta$

52. A mass of M kg is suspended by a weightless string. The horizontal force that is required to displace it until the string makes an angle of 45° with the initial vertical direction is

(a) Mg($\sqrt{2}$ + 1) (b) Mg$\sqrt{2}$

(c) $\frac{Mg}{\sqrt{2}}$ (d) Mg($\sqrt{2}$ – 1)

53. A block is moving on an inclined plane making an angle 45°with the horizontal and the coefficient of friction is μ. The force required to just push it up the inclined plane is 3 times the force required to just prevent it from sliding down. If we define N = 10 μ, then N is

54. A block of base 10 cm × 10 cm and height 15cm is kept on an inclined plane. The coefficient of friction between them is $\sqrt{3}$. The inclination $\theta$of this inclined plane from the horizontal plane is gradually increased from 0°. Then

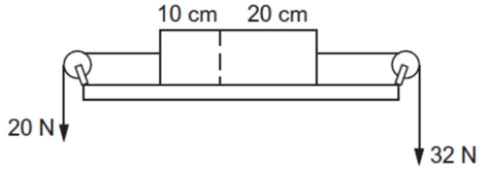
(a) at $\theta = 30°$, the block will start sliding down the plane.

(b) the block will remain at rest on the plane up to certain θ and then it will topple

(c) at $\theta = 60°$, the block will start sliding down the plane and continue to do so at higher angles

(d) at $\theta = 60°$, the block will start sliding down the plane and on further increasing θ, it will topple at certain θ.

55. Figure shows a uniform rod of length 30 cm having a mass of 3.0 kg. The strings shown in the figure are pulled by constant forces of 20 N and 32 N. Find the force exerted by the 20 cm part of the rod on the 10 cm part. All the surfaces are smooth and the strings and the pulleys are light



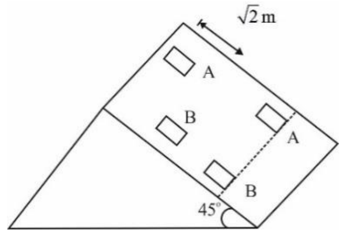
56. A knife edge of mass M is dropped from a height ‘h’ on a wooden floor with its tip pointing in downward direction. If the blade penetrates a distance ‘s’ into the wood, the average resistance offered by the wood to the blade is

(a) Mg (b) $Mg\left(1+\frac{h}{s}\right)$

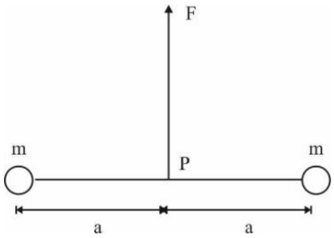
(c) $Mg\left(1-\frac{h}{s}\right)$ (d) $Mg\left(1+\frac{h}{s}\right)^2$

Pro **Newtons 2nd Law**

57. Two blocks A and B of equal masses are placed on rough inclined plane as shown in figure. When and where will the two blocks come on the same line on the inclined plane if they are released simultaneously? Initially the block A is $\sqrt{2}$ m behind the block B. Co-efficient of kinetic friction for the blocks A and B are 0.2 and 0.3 respectively (g = 10 m/s^2).



58. Two particles of mass m each are tied at the ends of a light string of length 2a. The whole system is kept on a frictionless horizontal surface with the string held tight so that each mass is at a distance ‘a’ from the centre P (as shown in the figure). Now, the mid-point of the string is pulled vertically upwards with a small but constant force F. As a result, the particles move towards each other on the surface. The magnitude of acceleration, when the separation between them becomes 2x, is

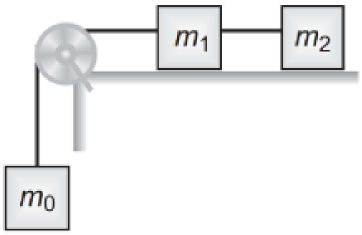


(a) $\frac{F}{2m}\frac{a}{\sqrt{a^2-x^2}}$ **(b)** $\frac{F}{2m}\frac{x}{\sqrt{a^2-x^2}}$

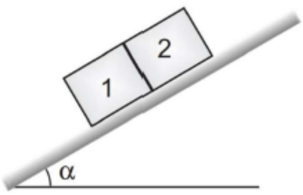
(c) $\frac{F}{2m}\frac{x}{a}$ **(d)** $\frac{F}{2m}\frac{\sqrt{a^2-x^2}}{x}$

59. An aerostat of mass m starts coming down with a constant acceleration w. Determine the smallest mass to be dumped for the aerostat to reach the upward acceleration of the same magnitude. The air drag is to be neglected.

60. In the arrangement of Fig. the masses m_0, m_1, and m_2 of bodies are equal, the masses of the pulley and the threads are negligible, and there is no friction in the pulley. Find the acceleration w with which the body m_0 comes down, and the tension of the thread binding together the bodies m_1 and m_2, if the coefficient of friction between these bodies and the horizontal surface is equal to k. Consider possible cases.

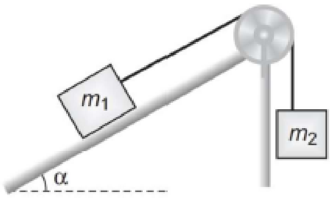


61. Two touching bars 1 and 2 are placed on an inclined plane forming an angle α with the horizontal (Fig). The masses of the bars are equal to m_1 and m_2, and the coefficients of friction between the inclined plane and these bars are equal to k_1 and k_2 respectively, with $k_1 > k_2$.
Find:
(a) The force of interaction of the bars in the process of motion;
(b) The minimum value of the angle α at which the bars start sliding down.

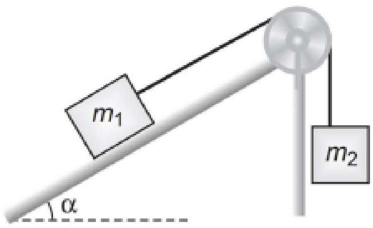


62. A small body was launched up an inclined plane set at an angle α = 15° against the horizontal. Find the coefficient of friction, if the time of the ascent of the body is η = 2.0 times less than the time of its descent.

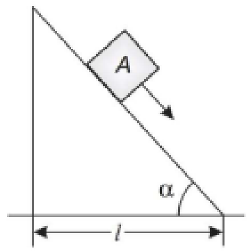
63. The following parameters of the arrangement of Fig. are available; the angle α which the inclined plane forms with the horizontal, and the coefficient of friction k between the body m1 and the inclined plane. The masses of the pulley and the threads, as well as the friction in the pulley, are negligible. Assuming both bodies to be motionless at the initial moment, find the mass ratio m2/ m1 at which the body m2
(a) Starts coming down
(b) Starts going up;
(c) Is at rest.



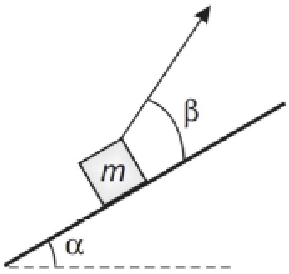
64. The inclined plane of Fig. forms an angle $\alpha = 30°$ with the horizontal. The mass ratio $\frac{m_2}{m_1} = \eta = \frac{2}{3}$. The coefficient of friction between the body m_1 and the inclined plane is equal to k = 0.10. The masses of the pulley and the threads are negligible. Find the magnitude and the direction of acceleration of the body m_2 when the formerly stationary system of masses starts moving.



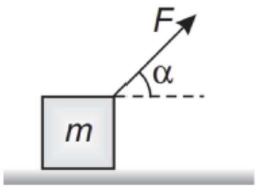
65. A small body A starts sliding down from the top of a wedge (fig.) whose base is equal to l=2.10 m. The coefficient of friction between the body and the wedge surface is k = 0.140. At what value of the angle α will the time of sliding be the least? What will it be equal to ?



66. A bar of mass m is pulled by means of a thread up an inclined plane forming an angle α with the horizontal (fig.). The coefficient of friction is equal to k. Find the angle β which the thread must form with the inclined plane for the tension of the thread to be minimum. What is it equal to?



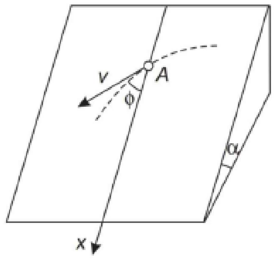
67. At the moment t = 0 the force F = at is applied to a small body of mass m resting on a smooth horizontal plane (a is a constant). The permanent direction of this forms an angle a with the horizontal (Fig.).
Find:
(a) The velocity of the body at the moment of its breaking off the plane
(b) The distance traversed by the body up to this moment.



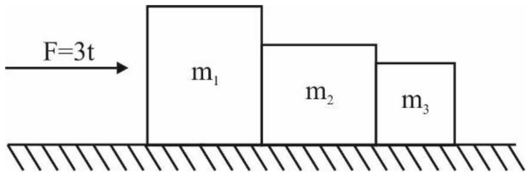
68. A bar of mass m resting on a smooth horizontal plane starts moving due to the force F = mg/3 of constant magnitude. In the process of its rectilinear motion the angle α between the direction of this force and the horizontal varies as α = as, where a is a constant and s is the distance traversed by the bar from its initial position. Find the velocity of the bar as a function of the angle α.

69. A horizontal plane with the coefficient of friction k supports two bodies: a bar and an electric motor with a battery on a block. A thread attached to the bar is wound on the shaft of the electric motor. The distance between the bar and the electric motor is equal to l. When the motor is switched on, the bar, whose mass is twice as great as that of the other body, starts moving with a constant acceleration w. How soon will the bodies collide?

70. A small disc A is placed on an inclined plane forming an angle α with the horizontal (Fig.) and is imparted an initial velocity v0. Find how the velocity of the disc depends on the angle ϕ if the friction coefficient k = tan α and at the initial moment $\phi_0 = \frac{\pi}{2}$.



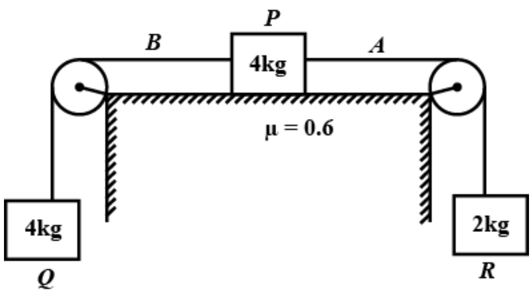
71. A time dependent force F = 3t (F in Newton and t in second) acts on three blocks m_1, m_2 and m_3 kept in contact on a rough ground as shown. Co-efficient of friction between blocks and ground is 0.4. If m_1, m_2 and m_3 are 3 kg, 2 kg and 1 kg respectively, the time after which the blocks start to move is (g = 10 ms^{-2})



(a) 4 sec (b) 8 sec
(c) $\frac{8}{3}$ sec (d) $\frac{4}{3}$ sec

72. A balloon is descending with a constant acceleration 'a' less than the acceleration due to gravity. The mass of the balloon, with its basket and content is M. What mass m, of blast (sand bags) should be released so that the balloon will begin to accelerate upward with constant acceleration 'a'? (Neglect air resistance)

73. A block *P* of mass 4 kg is placed on horizontal rough surface with coefficient of friction μ = 0.6. And two blocks *R* and *Q* of masses 2 kg and 4 kg connected with the help of massless strings *A* and *B* respectively passing over frictionless pulleys as shown, then (g = 10m/s^2)

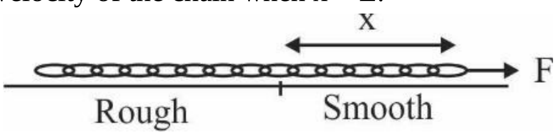


(a) Acceleration of block P is zero.
(b) Tension in string A is 20 N.

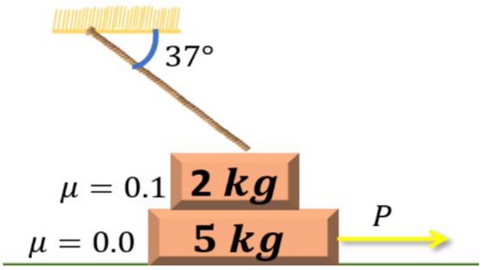
(c) Tension in string B is 40 N.

(d) Contact force on block P by table is $20\sqrt{5}$ N.

74. A chain of mass per unit length λ = 2 kg/m is pulled up by a constant force F. Initially the chain is lying on a rough surface and passes onto the smooth surface. The co-efficient of friction between chain and rough surface is μ = 0.1. The length of the chain is L. Find the velocity of the chain when x = L.



75. Two blocks of masses 2 kg and 5 kg are kept on a smooth horizontal surface. The coefficient of friction between the blocks is 0.1. A massless and inextensible string is tied on the upper block as shown. The minimum value of a horizontal force P such that the blocks start slipping over each other is $\frac{20\alpha}{43}N$. Find α

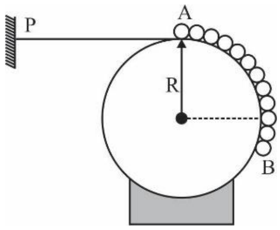


76. A car begins to move at time t = 0 and then accelerates along a straight track with a speed given by $v(t) = 2t^2\ ms^{-1}$ for $0 \le t \le 2$

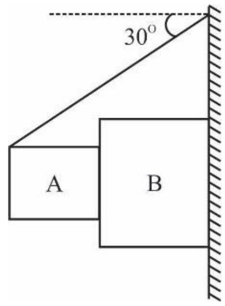
After the end of acceleration, the car continues to move at a constant speed. A small block initially at rest on the floor of the car begins to slip at t = 1sec. and stops slipping at t = 3 sec. Find the coefficient of static and kinetic friction between the block and the floor.

77. A smooth right circular cone of semi vertical angle α = tan–1(5/12) is at rest on a horizontal plane. A rubber ring of mass 2.5kg which requires a force of 15N for an extension of 10cm is placed on the cone. Find the increase in the radius of the ring in equilibrium.

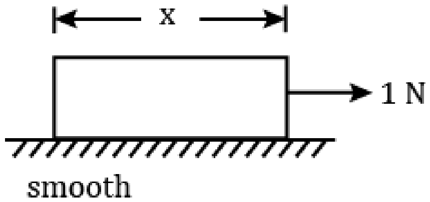
78. A uniform flexible chain of length 1.50 m rests on a fixed smooth sphere of radius R = 2/π m such that one end A of chain is at top of the sphere while the other end B is hanging freely. Chain is held stationary by a horizontal thread PA as shown in fig. Calculate the acceleration of the chain when the thread is burnt.



79. Two blocks A and B of mass 10 kg and 20 kg respectively are placed as shown in figure. Coefficient of friction between all the surfaces is 0.2. Then find tension in string and acceleration of block B. ($g = 10\ m/s^2$)



80. A rope of length L has its mass per unit length λ varies according to the function λ (x) = ex/L. The rope is pulled by a constant force of 1N on a smooth horizontal surface. Find the tension in the rope at x = L/2.



81. A body of mass m is thrown straight up with velocity v0. Find the velocity v' with which the body comes down if the air drag equals kv^2, where *k* is a constant and v is the velocity of the body.

82. The upper half of an inclined plane with inclination ϕ is perfectly smooth while the lower half is rough. A body starting from rest at the top will again come to rest at the bottom if the coefficient of friction for the lower half is given by

(a) 2 cos ϕ (b) 2 sin ϕ

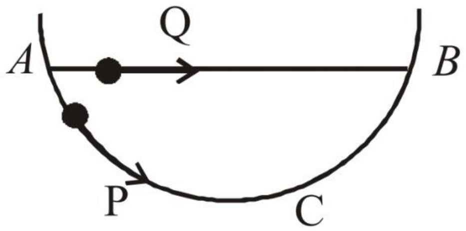
(c) tan ϕ (d) 2 tan ϕ

83. A block of mass m is placed on a surface with a vertical cross section given by y = $\frac{x^3}{6}$. If the coefficient of friction is 0.5, the maximum height above the ground at which the block can be placed without slipping is:

(a) $\frac{1}{6}m$ (b) $\frac{2}{3}m$

(c) $\frac{1}{3}m$ (d) $\frac{1}{2}m$

84. A particle P is us sliding down a frictionless hemispherical bowl. It passes the point A at t = 0. At this instant of time the horizontal component of its velocity is v. A bead Q of the same mass as P is ejected from A at t = 0 along the horizontal string AB, with the speed v. Friction between the bead and the string may be neglected let t_P and t_Q be the respective time taken by P and Q to reach the point B. Then:



(a) $t_P < t_Q$ (b) $t_P = t_Q$

(c) $t_P > t_Q$ (d) $\frac{t_P}{t_Q} = \frac{length\ of\ arc\ ACB}{lenth\ of\ arc\ AB}$

Pro **Calculus Based Newton's Law**

85. Having gone through a plank of thickness h, a bullet changed its velocity from v_0 to v. Find the time of motion of the bullet in the plank, assuming the resistance force to be proportional to the square of the velocity.

86. A small bar starts sliding down an inclined plane forming an angle α with the horizontal. The friction coefficient depends on the distance x covered as k = αx, where α is a constant. Find the distance covered by the bar till it stops, and its maximum velocity over this distance.

87. A body of mass m rests on a horizontal plane with the friction coefficient k .At the moment f = 0 a horizontal force is applied to it, which varies with time as F = at, where a is a constant vector. Find the distance traversed by the body during the first t seconds after the force acting began.

88. A body of mass m is thrown straight up with velocity v_0. Find the velocity v' with which the body comes down if the air drag equals kv^2, where k is a constant and v is the velocity of the body.

89. At the moment t = 0 a stationary particle of mass m experiences a time-dependent force F = at (τ -1), where a is a constant vector, τ is the time during which the given force acts. Find

(a) The momentum of the particle when the action of the force discontinued;

(b) The distance covered by the particle while the force acted.

90. At the moment t = 0 a particle of mass m starts moving due to a force F = F_0 sin ωt, where F_0 and ω are constants. Find the distance covered by the particle as a function of t. Draw the approximate plot of this function.

91. At the moment t = 0 a particle of mass m starts moving due to a force F = F_0 cos ωt, where F_0 and ω are constants. How long will it be moving until it stops for the first time? What distance will it traverse during that time? What is the maximum velocity of the particle over this distance?

92. A motorboat of mass m moves along a lake with velocity v_0. At the moment t = 0 the engine of the boat is shut down. Assuming the resistance of water to be proportional to the velocity of the boat F = – r v, find:

(a) How long the motorboat moved with the shutdown engine;

(b) The velocity of the motorboat as a function of the distance covered with the shutdown engine, as well as the total distance covered till the complete stop;

(c) The mean velocity of the motorboat over the time interval (beginning with the moment t =0), during which its velocity decreases η times.

93. A particle of mass m moves in a certain plane P due to a force F whose magnitude is constant and whose vector rotates in that plane with a constant angular velocity ω. Assuming the particle to be stationary at the moment t = 0, Find:

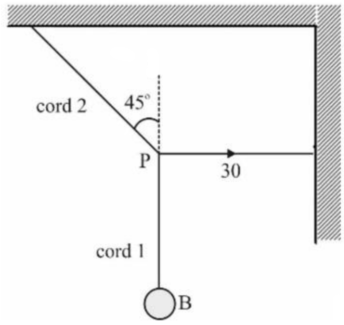
(a) Its velocity as a function of time;

(b) The distance covered by the particle between two successive stops, and the mean velocity over this time.

94. A chain of length ℓ is placed on a smooth spherical surface of radius R with one of its ends fixed at the top of the sphere. What will be the acceleration w of each element of the chain when its upper end is released? It is assumed that the length of the chain $\ell < \frac{1}{2}\pi R$.

Beginner **Equilibrium of Forces**

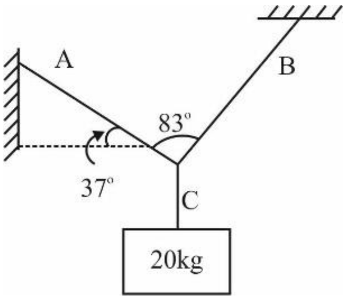
95. In the figure, the tension in the horizontal cord is 30N. Find the weight of the body B.



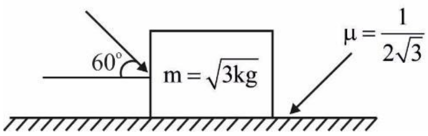
96. A block of mass 20 kg is balanced by three strings A, B&C as shown in figure. Ratio of tensions in strings A and B (T_A/T_B) is

(a) $\frac{5}{8}$ (b) $\frac{5\sqrt{3}}{8}$

(c) $\frac{5}{6}$ (d) $\frac{8}{5}$



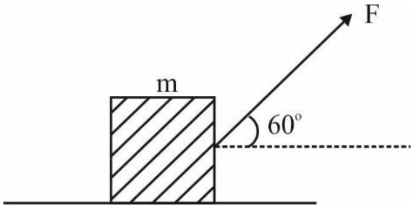
97. What is the maximum value of the force F such that the block shown in the arrangement, does not move?



(a) 20N (b) 10N

(c) 12N (d) 15N

98. A mass m rests on a horizontal surface. The coefficient of friction between the mass and the surface is μ. If the mass is pulled by a force F as shown in figure, the limiting friction between the mass and the surface will be



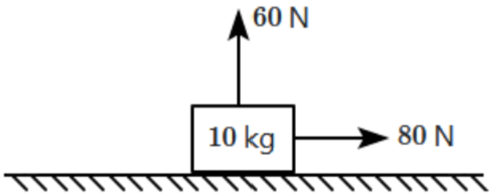
(a) μ mg

(b) $\mu\left[mg-\left(\sqrt{3}/2\right)F\right]$

(c) $\mu\left[mg-\left(F/2\right)\right]$

(d) $\mu\left[mg+\left(F/2\right)\right]$

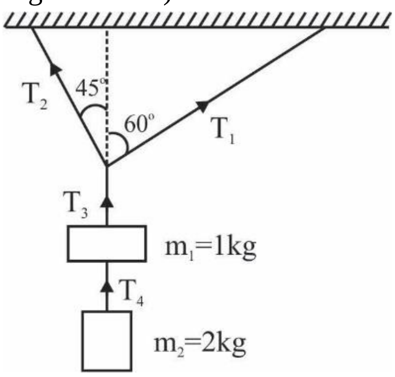
99. A block is placed on a smooth horizontal surface, and forces are applied to it as shown in the diagram. Take g = 10m/s^2. The normal reaction acting on the block is:



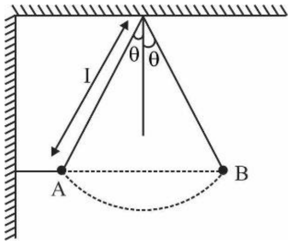
(a) 100N (b) 60 N

(c) 40 N (d) 20 N

100. Find out tension T_1, T_2, T_3 and T_4 in the arrangement shown in the figure. (Take g = 10 m/s^2)



101. A ball is held at rest in position A shown in the figure by two light cords. The horizontal cord is cut and the ball swings as a pendulum. What is the ratio of tension in the supporting cord of length l, in position A, to that in position B?

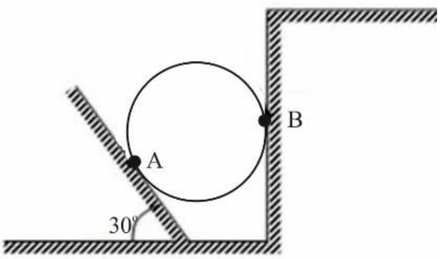


Expert **Equilibrium of Forces**

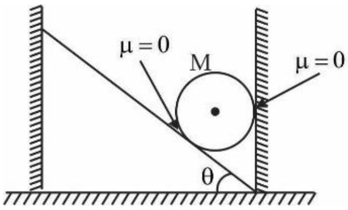
102. The 50 kg homogeneous smooth sphere rests on the 30° incline A and bears against the smooth vertical wall B. The contact force at B is (g = 10 m/s^2)

(a) 250 N (b) zero

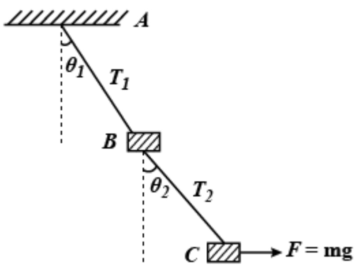
(c) $\frac{500}{\sqrt{3}}N$ (d) 500 N



103. Find the normal reaction forces acting on the vertical wall (say N_1) and the fixed inclined surface (say N_2) respectively by the sphere of mass M



104. The blocks *B* and *C* in the figure have mass *m* each. The strings *AB* and *BC* are light, having tensions T_1 and T_2 respectively. The system is in equilibrium with a constant force *mg* acting on *C*.



(a) $\tan\theta_1 = 1/2$ (b) $\tan\theta_2 = 1/2$

(c) $T_1 = \sqrt{5}$ mg (d) $T_2 = \sqrt{2}$ mg

105. A body of mass m is kept on a rough horizontal surface (coefficient of friction = μ). Horizontal force is applied on the body, but it does not move. The resultant of normal reaction and the frictional force acting on the object is given F, where F is

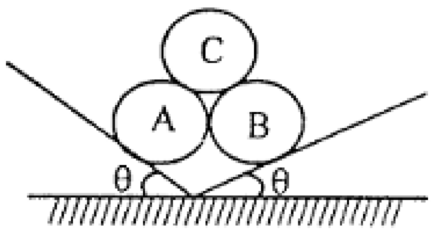
(a) $|F| = mg + \mu\, mg$ (b) $|F| = \mu mg$

(c) $|F| \le mg\sqrt{1+\mu^2}$ (d) $|F| = mg$

Pro **Equilibrium of Forces**

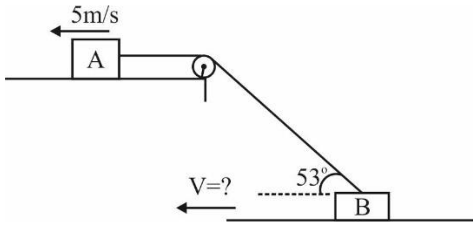
106. A block placed on a horizontal surface is being pushed by a force F making an angle θ with the vertical. The coefficient of friction between block and surface is μ. Find the value of θ at which minimum force is required to move the block.

107. Three identical rigid circular cylinders A, B and C are arranged on smooth inclined surfaces as shown in figure. Find the least value of θ that prevent the arrangement from collapse.

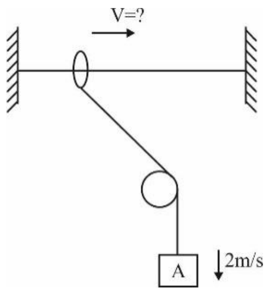


Beginner **String Constrain**

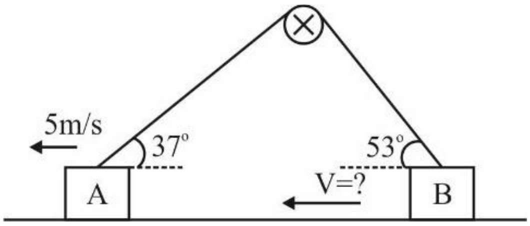
108. Find the velocity of the block B.



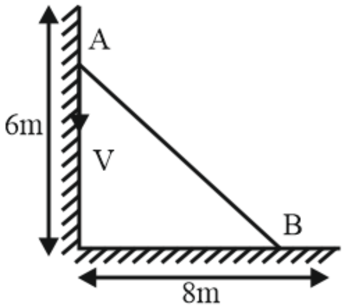
109. Find the velocity of ring kept on a linear horizontal rod.



110. Find the velocity of block B.

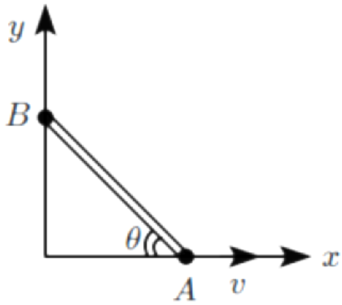


111. A ladder rests against a smooth vertical wall as shown in the figure. The floor is also smooth. The mass of the ladder is 75 kg. If upper-end A is moving with velocity v vertically downward, then the horizontal velocity of lower end B is:



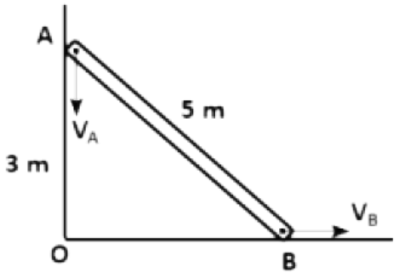
(a) v
(b) $\frac{3}{4}v$
(c) $\frac{4}{3}v$
(d) $\frac{3}{5}v$

112. A rod of mass m length l is moving between perpendicular smooth walls as shown. When the rod is at an angle θ with horizontal its end A is moving right with speed v. The speed of end B is:



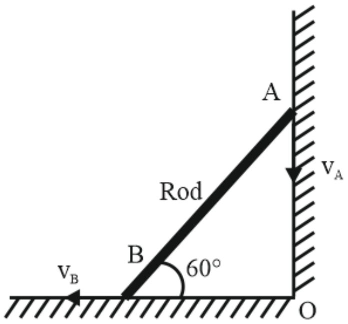
(a) v cot θ
(b) v tan θ
(c) v cos θ
(d) v sin θ

113. The figure shows a rod of length 5 m. Its ends, A and B, are restrained to moving in horizontal and vertical guides. When the end A is 3 m above O, it moves at 4 m/s. The velocity of end B at that instant is:



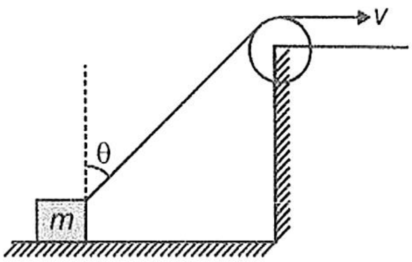
(a) 2 m/s
(b) 3 m/s
(c) 4 m/s
(d) 0.20 m/s

114. A rod supported on the wall starts slipping down. If the speed v_A of upper-end A is 5 m/s, then the speed v_B with which end B will move to left, as shown in the figure, is



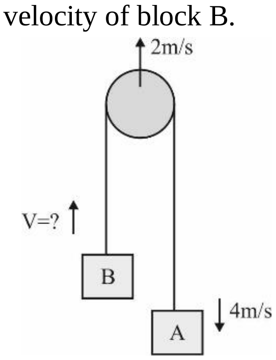
(a) 5 m/s
(b) 10 m/s
(c) $5\sqrt{3}$ m/s
(d) $\frac{5}{\sqrt{3}}$ m/s

115. If the block is being pulled by the rope moving at speed v as shown, then the horizontal velocity of the block is:

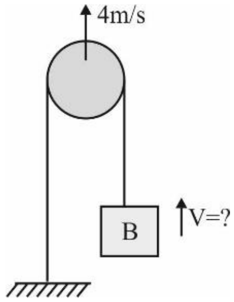


(a) v
(b) v cos θ
(c) $\frac{v}{\cos\theta}$
(d) $\frac{v}{\sin\theta}$

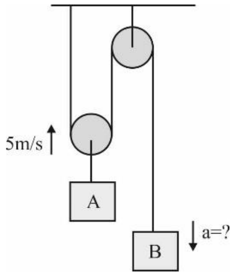
116. Find the velocity of block B.



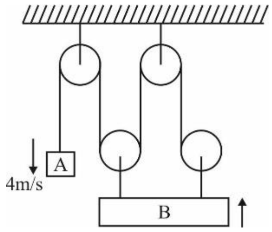
117. Find the velocity of block B.



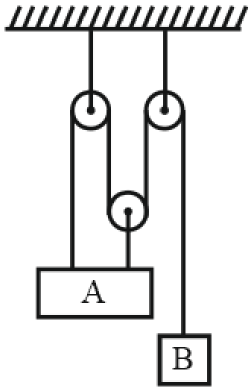
118. Find the acceleration of block B.



119. Find the velocity of block B.

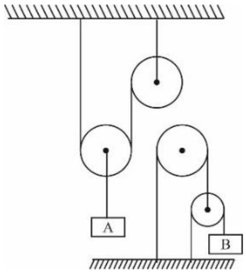


120. At a given instant, A is moving with velocity of 5 m/s upwards. What is velocity of B at this time?



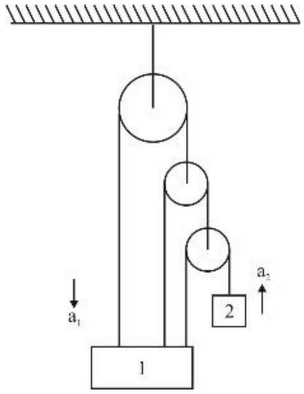
(a) 15 m/s ↓ (b) 15 m/s ↑
(c) 5 m/s ↓ (d) 5 m/s ↑

121. Block A moves upward with acceleration $\frac{1}{2}$ m/s^2. The acceleration of block B in downward direction will be.



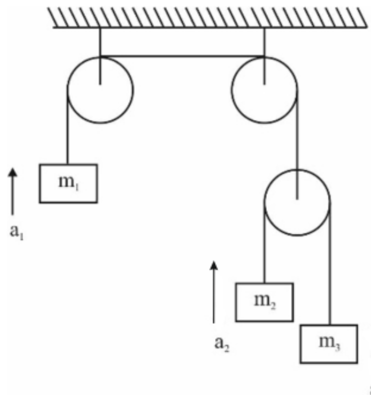
(a) 2 m/s^2 (b) 3 m/s^2
(c) 4 m/s^2 (d) 6 m/s^2

122. Using constraint equations, relation between a_1 and a_2 will be

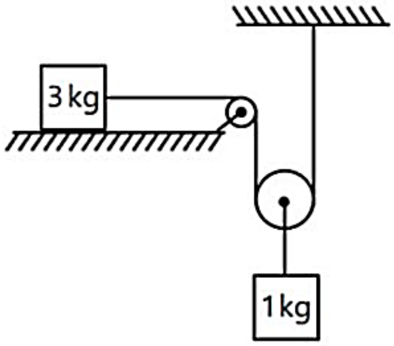


(a) $a_1 = 3a_2$ (b) $a_2 = 3a_1$
(c) $a_2 = 6a_1$ (d) $a_2 = 7a_1$

123. Find the relation between acceleration of each block.

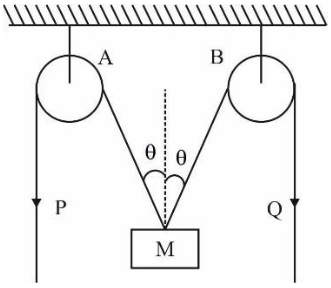


124. In the figure shown the horizontal surface is smooth and the strings are inextensible and the massless pulleys are light. If the acceleration of block 1 kg is a, then acceleration of 3 kg is:



(a) zero (b) 2a
(c) $\frac{a}{2}$ (d) $\frac{a}{4}$

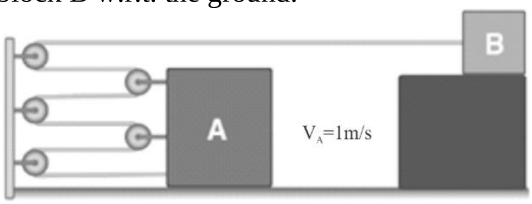
125. In the arrangement shown in the fig, the ends P and Q of a stretchable string move downwards with uniform speed U. Pulleys A and B are fixed. Mass M moves upward with a speed of



(a) 2 U cosθ (b) U/cos θ
(c) 2U/cos θ (d) U cos θ

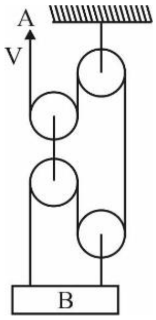
Expert **String Constrain**

126. In the system shown in the figure below, if block A is pulled towards the right at a constant speed of 1 m/s, find the speed of block B w.r.t. the ground.



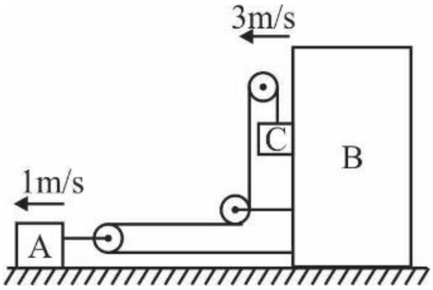
(a) 1 m/s (b) 3 m/s
(c) 4 m/s (d) 5 m/s

127. In the arrangement shown, end A of light inextensible string is pulled up with constant velocity v. The velocity of block B is

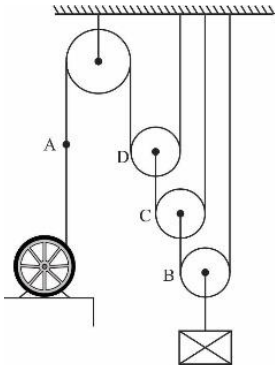


(a) v/2 (b) v
(c) v/3 (d) 3v

128. The velocities of A and B are shown in the figure. Find the speed (in m/s) of block C. (Assume that the pulleys and string are ideal)



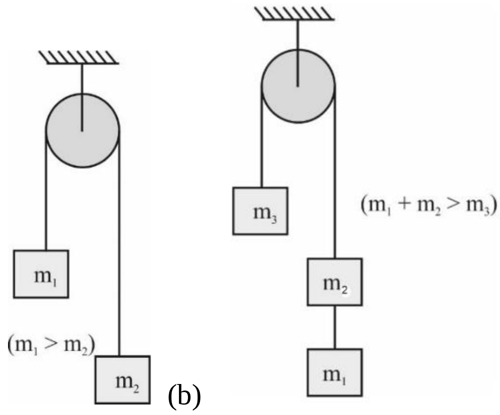
129. Starting from rest, the cable is wound onto the drum of the motor at a rate of $V_A = (24t^2)$ m/s, where t in seconds. Determine the time (in s) needed to lift the load by a distance of 27m.



Beginner **Pulley Problems**

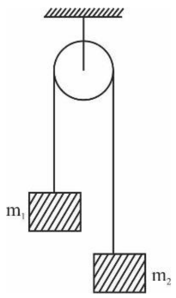
130. Find acceleration & tension in the string in the following systems: (Take m_1=2 kg, m_2 = 4 kg, m_3 = 5 kg)

(a)



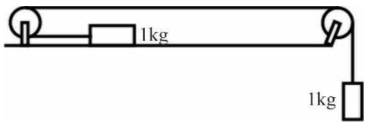
(b)

131. Two masses m_1 = 5 kg and m_2 = 10 kg tied to a string are hanging over a light frictionless pulley. What is the acceleration of the masses when left free to move? (g = 10 m/s^2)

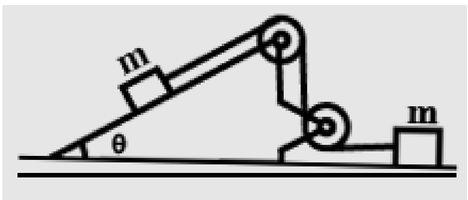


(a) 5 m/s^2 (b) 9.8 m/s^2
(c) 3.3 m/s^2 (d) 4.8 m/s^2

132. Calculate the tension in the string shown in figure. The pulley and the string are light and all surfaces are frictionless. Take g = 10 m/s^2.



133. For the system shown in the figure, the pulleys are light and frictionless. The tension in the string will be

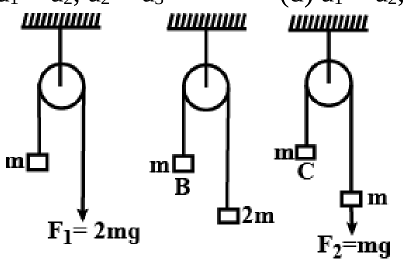


(a) $\frac{2}{3}mg\sin\theta$ (b) $\frac{3}{2}mg\sin\theta$

(c) $\frac{1}{2}mg\sin\theta$ (d) 2 mg sin θ

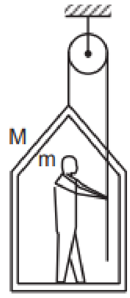
134. In the figure, the blocks A, B and C of mass m each have acceleration a_1, a_2 and a_3 respectively. F_1 and F_2 are external forces of magnitudes 2mg and mg respectively. Choose the correct option among the following

(a) a1 = a_2 = a_3 (b) $a_1 > a_3 > a_2$
(c) $a_1 = a_2$, $a_2 > a_3$ (d) $a_1 > a_2$, $a_2 = a_3$



Expert **Pulley Problems**

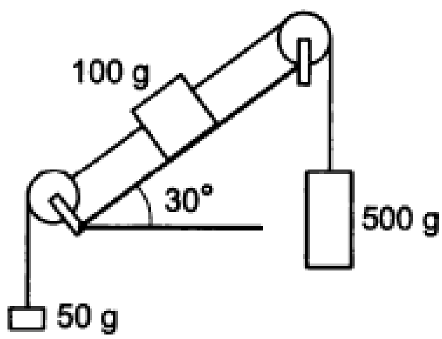
135. A man of mass m stands on a crate of mass M. He pulls on a light rope passing over a smooth light pulley. The other end of the rope is attached to the crate. For the system to be is equilibrium, the force exerted by the man on the rope will be:



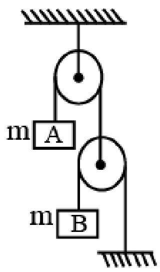
(a) mg (b) Mg

(c) $\frac{1}{2}(M+m)g$ (d) (m + M)g

136. Find the acceleration of the 500 g block in figure.



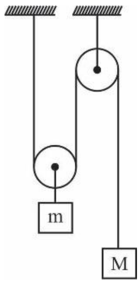
137. Two blocks A and B of equal masses m are suspended with ideal pulley and string arrangement as shown. The acceleration of mass B is



(a) $\frac{g}{3}$ (b) $\frac{5g}{3}$

(c) $\frac{2g}{3}$ (d) $\frac{2g}{5}$

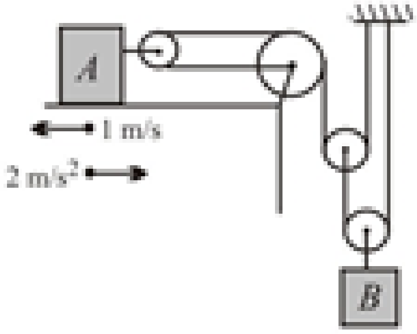
138. Two masses M and m are connected by the arrangement shown in figure. What is the downward acceleration of mass M?



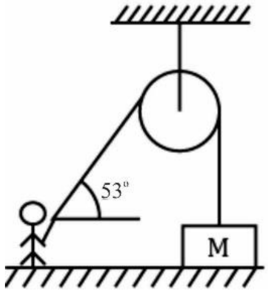
(a) $\left(\frac{2M-m}{3M+m}\right)g$ (b) $\left(\frac{2M-m}{4M+m}\right)2g$

(c) $\left(\frac{M-m}{M+m}\right)g$ (d) $\left(\frac{M}{2M+m}\right)g$

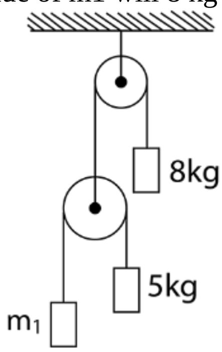
139. In the given figure, find the velocity (in cm/s) and acceleration (in m/s^2) of B, if velocity and acceleration of A are as shown.



140. A man of mass 63 kg is pulling a mass M by an inextensible light rope passing through a smooth and mass less pulley as shown in figure. The coefficient of friction between the man and the ground is μ = 3/5. Find the maximum value of M that can be pulled by the man without slipping on the ground.

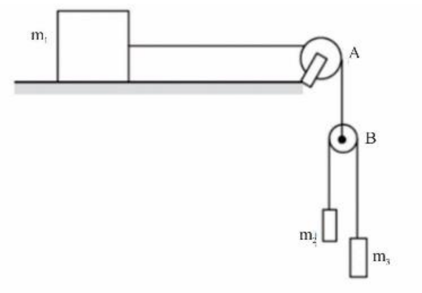


141. At what value of m1 will 8 kg mass be at rest.



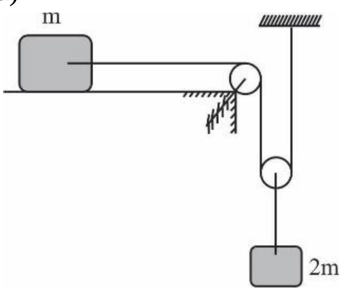
Pro **Pulley Problems**

142. Three blocks of masses m_1, m_2 and m_3 are connected as shown in the figure. All the surfaces are frictionless, and the strings and the pulleys are light. Find the acceleration of m_1.

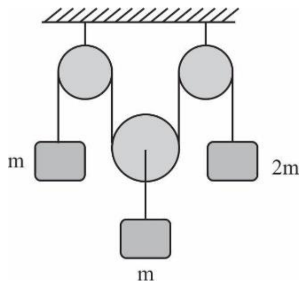


143. Find the acceleration and Tension in the strings in the following system.
(Take m=1 kg)

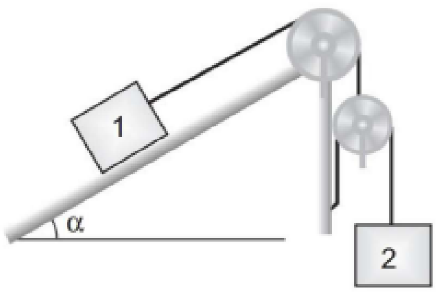
a)



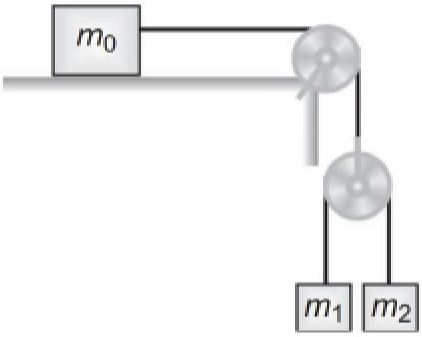
b)



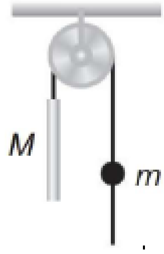
144. Find the acceleration w of the body 2 in the arrangement shown in Fig. if its mass is η times as great as the mass of bar 1 and the angle that the inclined plane forms with the horizontal is equal to α. The masses of the pulleys and the threads, as well as the friction, are assumed to be negligible. Look into possible cases.



145. In the arrangement shown in Fig. the bodies have masses m_0, m_1, m_2, the friction is absent, the masses of the pulleys and the threads are negligible. Find the acceleration of the body *m1*. Look into possible cases.

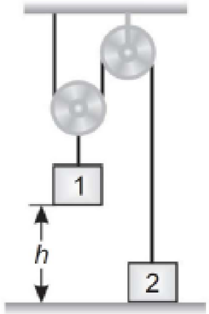


146. In the arrangement shown in Fig. the mass of the rod M exceeds the mass *m* of the ball. The ball has an opening permitting it to slide along the thread with some friction. The mass of the pulley and the friction in its axle are negligible. At the initial moment the ball was located opposite the lower end of the rod. When set free, both bodies began moving with constant accelerations. Find the friction force between the ball and the thread it *t* seconds after the beginning of motion the ball got opposite the upper end of the rod. The rod length equals *l*.



147. In the arrangement shown in Fig. the mass of ball 1 is $\eta = 1.8$ times as great as that of rod 2. The length of the latter is l = 100 cm. The masses of the pulleys and the threads, as well as the friction, are negligible. The ball is set on the same level as the lower end of the rod and then released. How soon will the ball be opposite the upper end of the rod?

148. In the arrangement shown in Fig. the mass of body 1 is $\eta = 4.0$ times as great as that of body 2. The height h = 20 cm. The masses of the pulleys and the threads, as well as the friction, are negligible. At a certain moment body 2 is released and the arrangement set in motion. What is the maximum height that body 2 will go up to?



149. A fixed pulley carries a weightless thread with masses m_1 and m_2 at its ends. There is friction between the thread and the pulley. It is such that the thread starts slipping when the ratio

$\frac{m_2}{m_1} = \eta_0$.

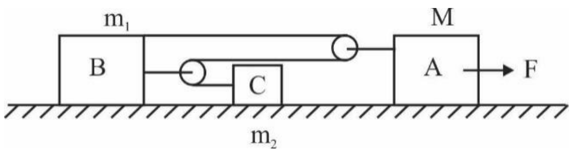
Find

(a) The friction coefficient;

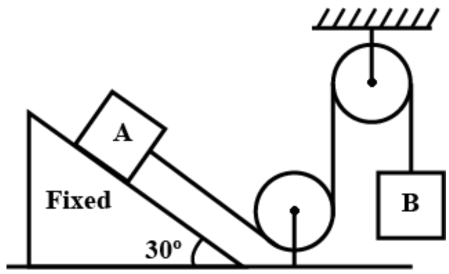
(b) The acceleration of the masses when

$\frac{m_2}{m_1} = \eta > \eta_0$.

150. Find the acceleration of block C.



151. Two blocks A and B of equal mass m are connected through a mass less string and arranged as shown in the figure. Friction is absent everywhere. When the system is released from rest



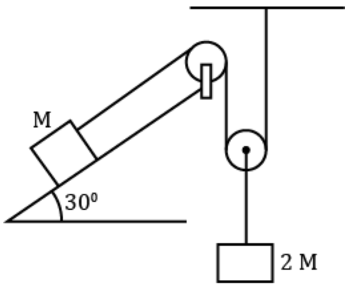
(a) tension in the string is $\frac{mg}{2}$

(b) tension in the string is $\frac{mg}{4}$

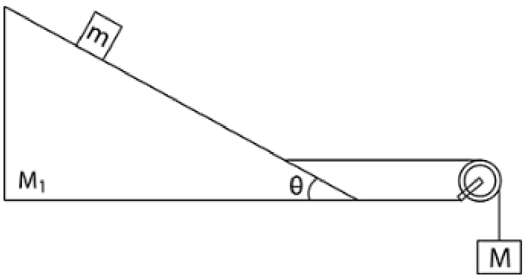
(c) Acceleration of A is $\frac{g}{2}$

(d) Acceleration of A is $\frac{3g}{4}$

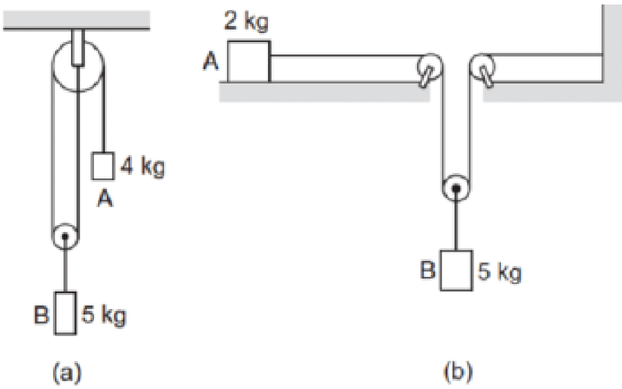
152. Find the acceleration of the block of mass M in the situation shown in figure. All the surfaces are frictionless and the pulleys and the string are light.



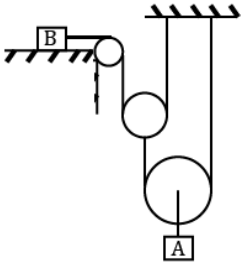
153. Find the mass M of the hanging block in figure, which will prevent the smaller block from slipping over the triangular block. All the surfaces are frictionless, and the string and the pulley are light.



154. Find the acceleration of the blocks A and B in the three situations shown in figure.



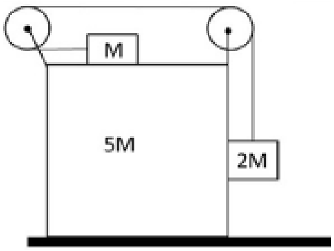
155. The block B has a mass of 10 kg. The coefficient of friction between block B and the surface is μ = 0.5. Determine the acceleration of the block A of mass 16 kg. Neglect the mass of the pulleys and cords. (Take g = 10 m/s^2).



(a) zero (b) 2m/s^2

(c) 1 m/s^2 (d) None of these

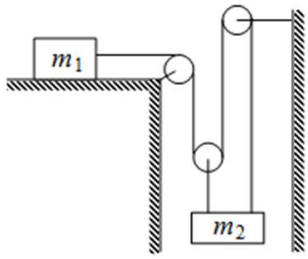
156. In the system shown, pulleys and the string are light. Find the acceleration of the wedge of mass 5M. (there is no friction anywhere)



(a) Zero (b) g/2

(c) g/3 (d) g/4

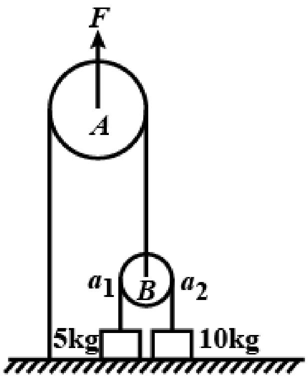
157. Two blocks m1 and m_2 of equal masses as shown in figure. Assume ideal pulleys and strings and neglect friction at all the surfaces. The acceleration of the two blocks will be



(a) $\frac{4g}{13}, \frac{g}{13}$ (b) $\frac{2g}{7}, \frac{g}{7}$

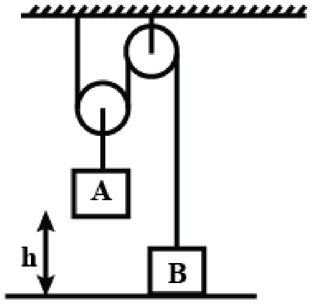
(c) $\frac{3g}{10}, \frac{g}{10}$ (d) $\frac{g}{4}, \frac{g}{4}$

158. In the given figure pulleys are mass less and frictionless and strings are light and inextensible. A force is applied on pulley A in vertically upward direction. At any time acceleration of 5 kg is a_1 (upward) and 10 kg is a_2 (upward) then (g = 10 m/s^2)



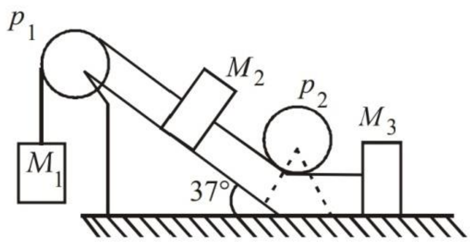
(a) $a_1 = 0$, $a_2 = 0$ if F = 100 N
(b) a1 = 5 m/s^2 and $a_2 = 0$ if F = 300 N
(c) a_1 = 15 m/s^2 and a_2 = 2.5 m/s^2 if F = 500
(d) acceleration of the masses is independent of F

159. In the given arrangement the mass of particle *A* is **η** = 4 times as great as that of body *B*. The height h = 20 cm. The masses of the pulleys and the threads, as well as the friction, are negligible. At a certain moment body *A* is released and the arrangement set in motion. What is the maximum height that body *B* will go up to?



(a) 60 cm (b) 50 cm
(c) 40 cm (d) 30 cm

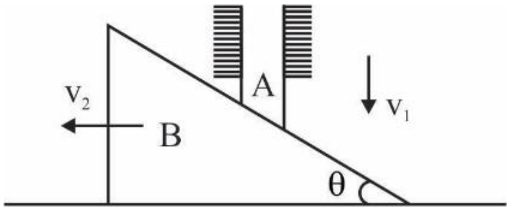
160. Masses M_1, M_2 and M_3 are connected by string of negligible mass which pass over massless and friction less pulleys P_1 and P_2 as shown in fig. The masses move such that the portion of the string between P_1 and P_2 in parallel to the inclined plane and the portion of the string between P_2 and M_3 is horizontal. The masses M_2 and M_3 are 4.0kg each and the coefficient of kinetic friction between the masses and the surfaces in 0.25. the inclined plane makes an angle of 37° with the horizontal.



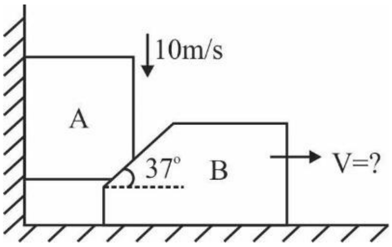
If the mass M_1 moves downwards with a uniform velocity, find
(a) the mass of M_1
(b) the tension in the horizontal portion of the string (g = 9.8m/sec^2, sin37° ≈ 3/5)

Beginner **Wedge Constrain**

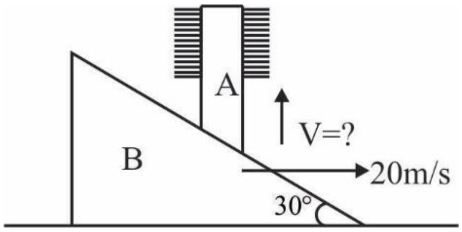
161. Find the relation between v_1 & v_2.



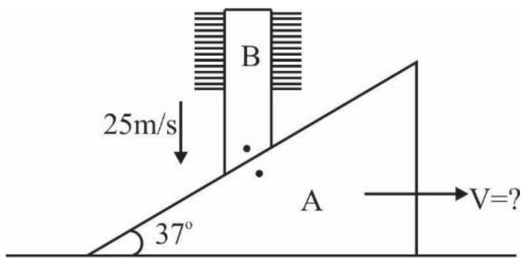
162. Find v.



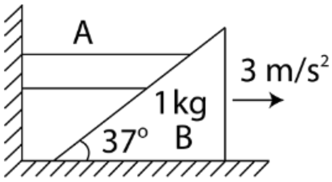
163. Find v.



164. Find v.

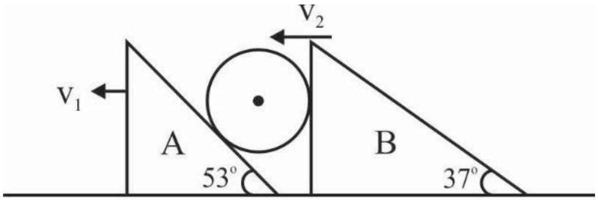


165. Find force in Newton which mass A exerts on mass B if B is moving towards right with 3 ms^{-2}. Also find mass of A.

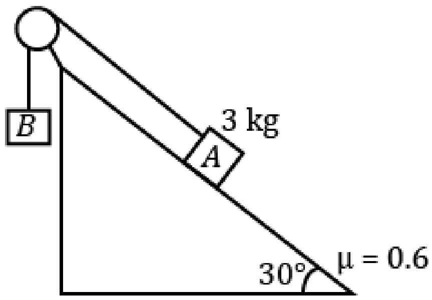


Expert **Wedge Constrain**

166. Find the velocity of middle block C in vector form.



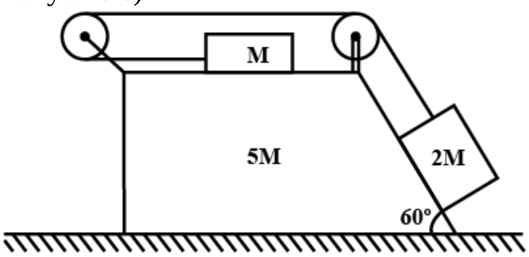
167. Two blocks A and B of equal mass 3 kg each are connected over a mass less pulley as shown in figure. The block A is placed on a rough inclined plane of angle 30°. The coefficient of friction between block A and inclined plane is 0.6. The friction force acting on the block A is



(a) Zero (b) 15.6 N
(c) 18 N (d) 15 N

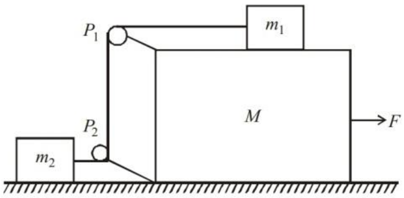
Pro **Wedge Constrain**

168. In the system shown, the acceleration of the wedge of mass 5M is (there is no friction anywhere)



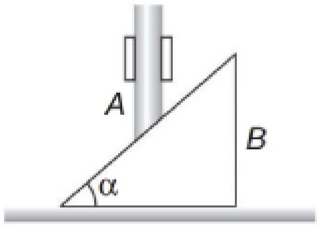
(a) Zero (b) g/2
(c) g/3 (d) g/4

169. In the figure masses m_1 , m_2 and M are 20kg, 5kg and 50kg respectively. The coefficient of friction between M and ground is zero. The coefficient of friction between m_1 and M and the between m_2 and ground is 0.3. The pulleys and the string are massless. The string is perfectly horizontal between P_1 and m_1 and also between P_2 and m_2 the string is perfectly vertical between P_1 and P_2 . An external horizontal force F is applied to the mass M. Take g = 10m/s^2

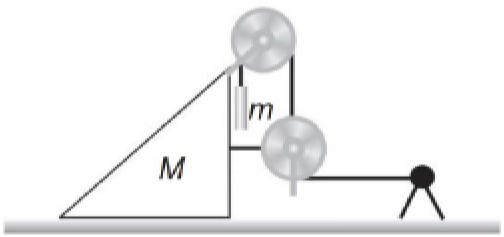


(a) Draw a free body diagram for mass M, clearly showing all the forces.
(b) Let the magnitude of the force of frictional between m_1 and M be f_1 and that between m_2 and ground be f_2 for a particular F it is found that $f_1 = 2f_2$ find f_1 and f_2 , write questions of motion of all the masses . Find F, tension in the string and acceleration of the masses.

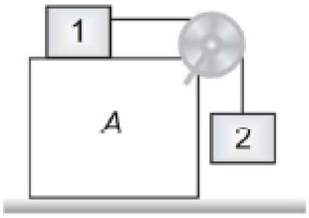
170. Find the accelerations of rod A and wedge B in the arrangement shown in Fig. if the ratio of the mass of the wedge to that of the rod equals η, and the friction between all contact surfaces is negligible.



171. In the arrangement shown in Fig. the masses of the wedge M and the body m are known. The appreciable friction exists only between the wedge and the body m, the friction coefficient being equal to k. The masses of the pulley and the thread are negligible. Find the acceleration of the body m relative to the horizontal surface on which the wedge slides.



172. What is the minimum acceleration with which bar A (Fig.) should be shifted horizontally to keep bodies 1 and 2 stationary relative to the bar? The masses of the bodies are equal, and the coefficient of friction between the bar and the bodies is equal to k. The masses of the pulley and the threads are negligible, the friction in the pulley is absent.



Beginner **Two Block Problems**

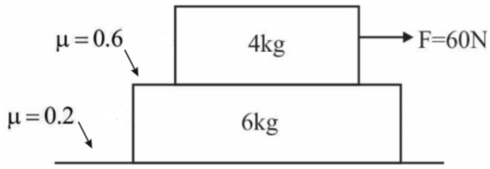
173. Find the acceleration of each mass.

174. Find the acceleration of each mass.

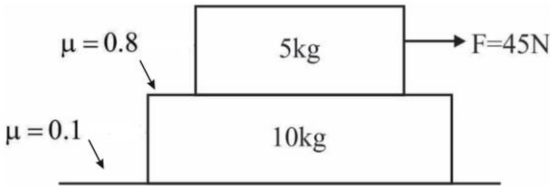
175. Find the acceleration of each mass.

176. Find the acceleration of each mass.

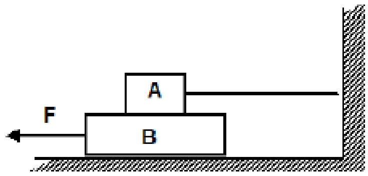
177. Find the acceleration of each mass.



178. Find the acceleration of each mass.



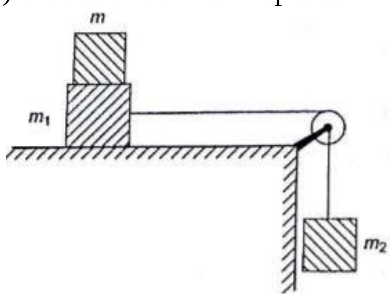
179. Block A in the figure weighs 0.4 kg and block B weighs 0.5kg. The coefficient of sliding friction between all surfaces is 0.25.



(a) Find the force F necessary to drag block B to the left at constant speed.

(b) Find the tension in the string.

180. Two blocks of masses m_1 = 4kg and m_2 = 6 kg are connected by a string of negligible mass passing over a frictionless pulley as shown in Fig. The coefficient of friction between block m_1 and the horizontal surface is 0.4. When the system is released, the masses m_1 and m_2 start accelerating. What additional mass m should be placed over mass m_1 so that the masses (m_1 + m) slide with a uniform speed?

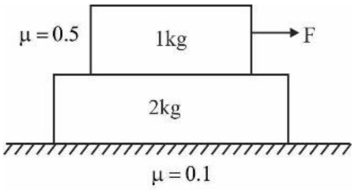


(a) 9 kg (b) 10 kg
(c) 11 kg (d) 12 kg

181. Block A of mass 2 kg is placed over a block B of mass 8 kg. The combination is placed on a rough horizontal surface. If g = 10 ms^{-2}, coefficient of friction between B and floor = 0.5, coefficient of friction between A and B = 0.4 and a horizontal force of 10 N is applied on 8 kg block, then the force of friction between A and B is

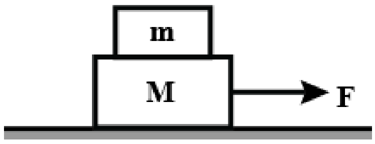
(a) 10 N
(b) 5 N
(c) 4 N
(d) none of these

182. What should be minimum value of F so that 2 kg slides on ground but 1 kg does not slide on it? [$g = 10\ m/sec^2$]



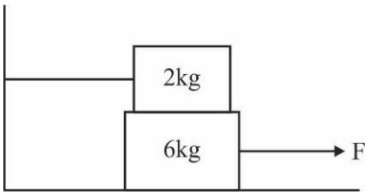
Expert **Two Block Problems**

183. A block of mass m is placed on another block of mass M lying on smooth horizontal surface, as shown in the figure. The co-efficient of friction between the blocks is μ. What is the maximum horizontal force F that can be applied to the block M so that the blocks move together?



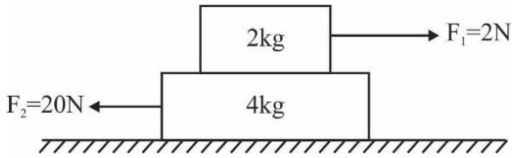
(a) (M + m) Kg (b) (M – m) Kg
(c) (M – mg) Kg (d) None of these

184. A block of mass 2 kg is resting over another block of mass 6 kg. 2 kg block is connected to one end of a string fixed to a vertical wall as shown. If the coefficient of friction between the blocks is 0.4, the force required to pull out the 6 kg block with an acceleration of 1.5 m/s^2 will be ($g = 10\ ms^{-2}$)



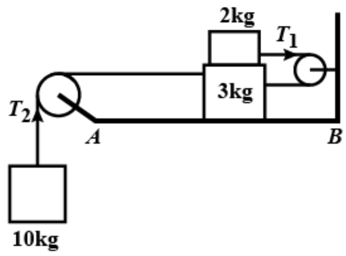
(a) 17 N (b) 9 N
(c) 8 N (d) 1 N

185. In the arrangement shown in figure, coefficient of friction between the two blocks is μ = 1/2. The force of friction acting between the two blocks is [Horizontal surface of ground is smooth]



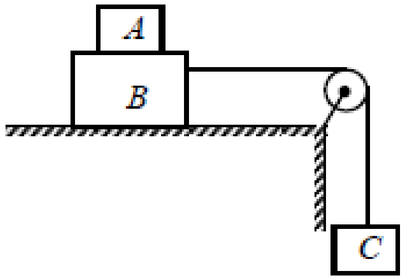
(a) 8 N (b) 10 N
(c) 6 N (d) 4 N

186. Coefficient of friction between the two blocks is 0.3 where as the surface *AB* is smooth. ($g = 10\ ms^{-2}$)



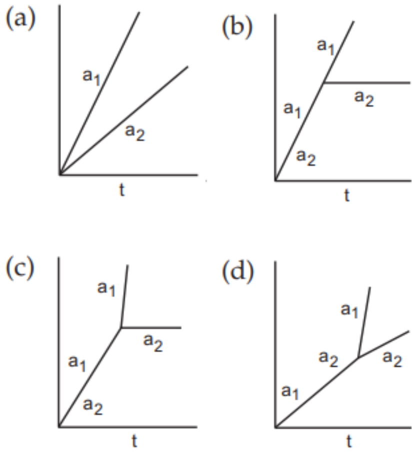
(a) Acceleration of the system of masses is 5.86 ms^{-2}
(b) Tension T_1 in the string is 17.7 N
(c) Tension T_2 in the string is about 41.4 N
(d) Acceleration of 10 kg mass is 7.55 ms^{-2}

187. Two block *A* and *B* each of mass *m* is placed as shown, coefficient of friction between *A* and *B* is 0.5 and surface is smooth. Block *B* is connected to a block *C* of mass *M* with the help of massless string. Then



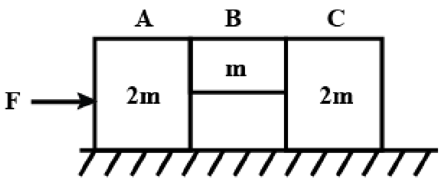
(a) If M = 2m, acceleration of block A and B is g/2
(b) If M = 2m, friction force between A and B is $\frac{1}{2}$ mg
(c) Relative motion start between blocks A and B if M > 2m
(d) For any value of M acceleration of block A and B are equal

188. Block A is placed on block B, whose mass is greater than that of A. There is friction between the blocks, while the ground is smooth. A horizontal force P, increasing linearly with time, begins to act on A. The accelerations a_1 and a_2 of A and B respectively are plotted against time (t). Choose the correct graph.



Pro **Two Block Problems**

189. The system is pushed by a force F as shown in figure. All surfaces are smooth except between B and C. Friction coefficient between B and C is μ. Minimum value of F to prevent block B from slipping is



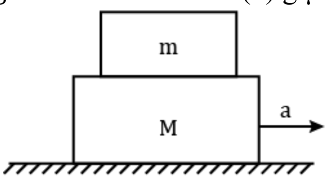
(a) $\left(\frac{3}{2\mu}\right)mg$ (b) $\left(\frac{5}{2\mu}\right)mg$

(c) $\left(\frac{5}{2}\right)\mu mg$ (d) $\left(\frac{3}{2}\right)\mu mg$

190. A block of mass m is placed on the top of another block of mass M as shown in the figure. The coefficient of friction between them is μ. The maximum acceleration with which the block M may move so that m also moves along with it is

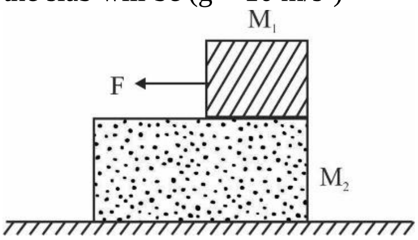
(a) μg (b) g/μ

(c) μ^2/g (d) g/μ^2



191. A plank of mass m_1 with a bar of mass m_2 placed on it lies on a smooth horizontal plane. A horizontal force growing with time t as F = at (a is constant) is applied to the bar. Find how the accelerations of the plank w_1 and of the bar w_2 depend on t, if the coefficient of friction between the plank and the bar is equal to k. Draw the approximate plots of these dependences.

192. A block of mass M_1 = 10 kg is placed on a slab of mass M_2 = 30 kg. The slab lies on a frictionless horizontal surface as shown in figure. The coefficient of static friction between the block and slab is μ_s = 0.25 and that of dynamic friction is μ_k = 0.12. A force F = 40 N acts on block M_1. The acceleration of the slab will be (g = 10 m/s^2)



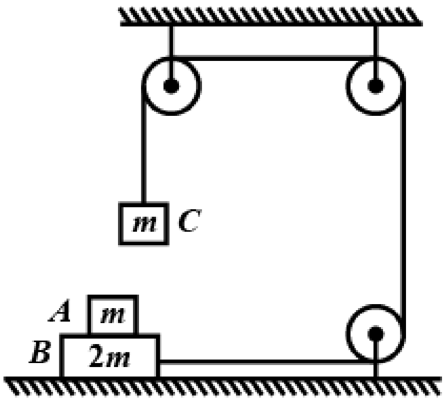
(a) 0.5 m/s^2 (b) 0.4 m/s^2

(c) 1 m/s^2 (d) $\frac{5}{6}ms^{-2}$

193. In the arrangement shown in the figure, there is a friction force between the blocks of masses m and 2m. Block of mass 2m is kept on a smooth horizontal plane. The mass of the suspended block is m. If block A is stationary with respect to block of mass 2m. The minimum value of coefficient of friction between m and 2m is

(a) 1/2 (b) $1/\sqrt{2}$

(c) 1/4 (d) 1/3



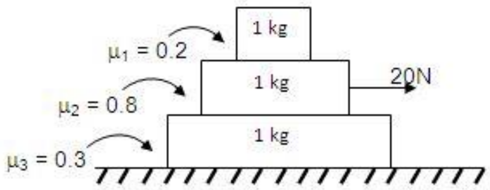
194. Three blocks are kept stationary over one another as shown in the fig. A horizontal force of 20 N is acting on the middle block as shown in the figure. Choose the correct statement

(a) The acceleration of the lowest block will be 4.5 m/s^2

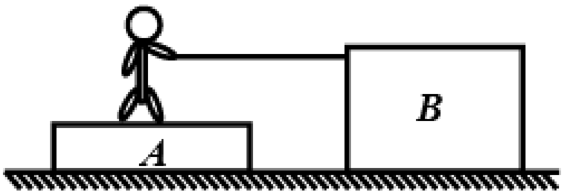
(b) The acceleration of uppermost block will be 2 m/s^2

(c) The frictional force between middle and lower block will be 12 N

(d) The frictional force between middle and upper block will be 2 N



195. In adjacent figure, a boy, on a horizontal platform A, kept on a smooth horizontal surface, holds a rope attached to a box B. Boy pulls the rope with a constant force of 50 N. The co-efficient of friction between boy and platform is 0.5. (Mass of boy = 80 kg, mass of platform 120kg, mass of box = 100 kg)



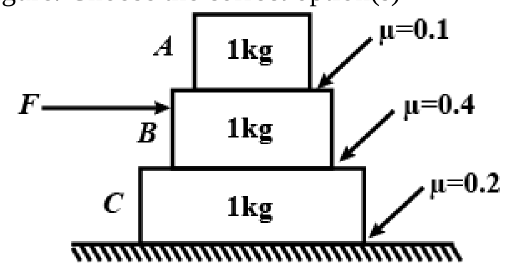
(a) Velocity of platform relative to box after 4 s is 3 m/s.

(b) Velocity of boy relative to platform after 4 s is 2 m/s.

(c) Friction force between boy and platform is 40 N.

(d) Friction force between boy and platform is 50 N.

196. In the given figure, the force is applied on block *B*. The co-efficient of friction for different contact surfaces is as shown in figure. Choose the correct option(s)



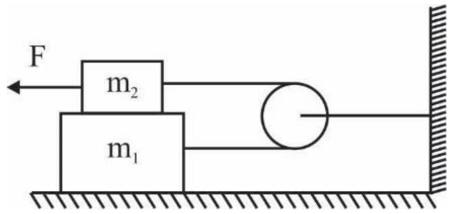
(a) if F = 6 N, there is no motion at any part of the system.

(b) if F > 12 N, there is motion between A and B.

(c) if F > 11 N, there is motion between B and C.

(d) if F < 6 N, there is motion between A and B.

197. Two blocks each of mass 1 kg are placed as shown. They are connected by a string which passes over a smooth massless pulley. There is no friction between m_1 and the ground and the coefficient of friction between m_1 and m_2 is 0.2. A force F is applied to m_2. Which of the following statements is/are correct?



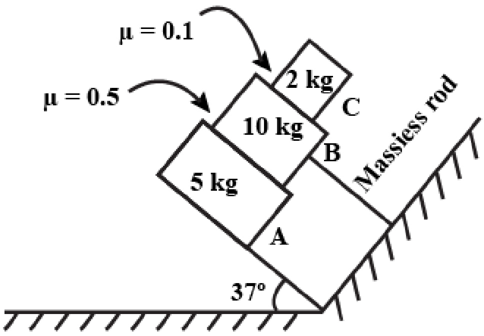
(a) The system will be in equilibrium if $F < 4N$

(b) If $F < 4N$ the tension in the string will be 4N.

(c) If $F < 4N$ the frictional force between the block will be 2N.

(d) If F = 6N the tension in the string will be 3N.

198. In the given figure, the inclined plane is frictionless and co-efficient of friction between the blocks is shown. Then choose the correct option(s)



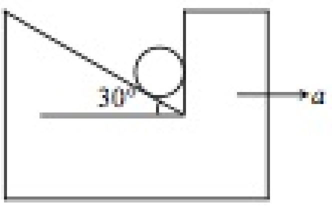
(a) friction force on block *A* is 30 N

(b) friction force on block *C* is 1.6 N

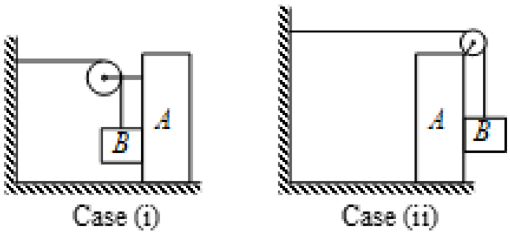
(c) tension in the rod is 91.6 N

(d) block *A* will accelerate down

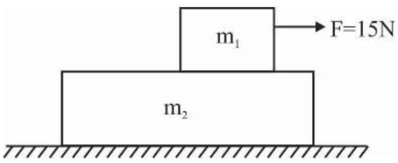
199. A heavy spherical ball is constrained in a frame as shown in figure. The inclined surface is smooth. The maximum acceleration with which the frame can move without causing the ball to leave the frame is $\frac{n}{\sqrt{3}}$. Find value of n.



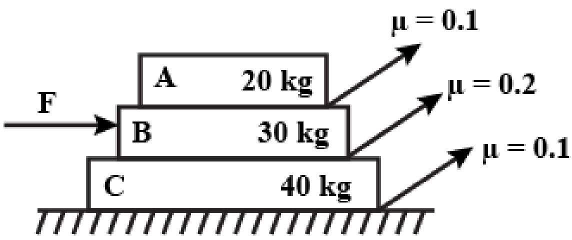
200. A 20 kg block B is suspended from an ideal string attached to a 40 kg block A. The ratio of the acceleration of the block B in cases (i) and (ii) shown in figure immediately after the system is released from rest is $\frac{3n}{2\sqrt{2}}$. Find value of n. (Neglect friction)



201. A slab of mass 10 kg is resting on a frictionless floor with a block of mass 1 kg on its top. The coefficient of friction between them is 0.1. A horizontal force of 15 N is applied to the slab at t = 0. Calculate the distance (in cm) moved by slab when the block has moved a distance of 0.5 m on the slab.

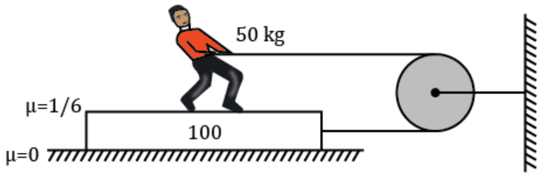


202. A system of masses is shown in the figure with masses & coefficients of friction indicated. Calculate:

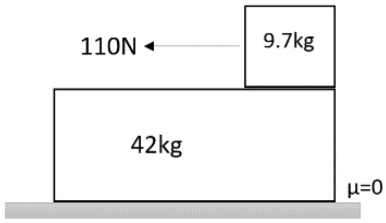


(a) the maximum value of F for which there is no slipping anywhere.
(b) the minimum value of F for which B slides on C.
(c) the minimum value of F for which A slips on B.

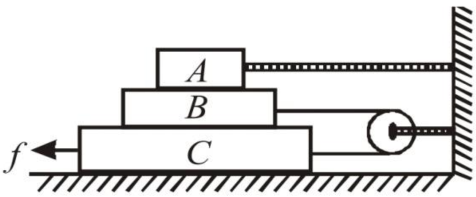
203. A man of mass 50 kg is pulling on a plank of mass 100 kg kept on a smooth floor as shown with force of 100 N. If both man & plank move together, find force of friction acting on man.



204. A 42 kg slab rests on a frictionless floor. A 9.7 kg block rests on the top of the slab as shown in the fig. The coefficient of static friction between the block and the slab is 0.53, while the coefficient of kinetic friction is 0.38. The 9.7 kg block is acted upon by a horizontal force of 110 N. What are the resulting accelerations of?
(a) The block?
(b) The slab?



205. In the diagram shown, the blocks A, B and C weighs, 3kg, 4kg and 5kg respectively. The coefficient of sliding friction between any two surfaces is 0.25. A is held at rest by a massless rigid rod fixed to the wall while B and C are connected by a light flexible cord passing around a frictionless pulley. Find the force F necessary to drag C along the horizontal surface to the left at constant speed. Assume that the arrangement shown in the diagram, B on C and A on B is maintained all through. ($g = 9.8 m/s^2$)

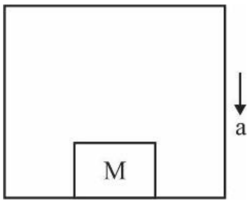


Beginner **Pseudo Force**

206. With what acceleration 'a' should the box in the figure descend so that the block of mass M exerts a force Mg/4 on the floor of the box?

(a) g/4 (b) g/2

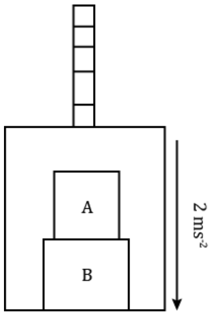
(c) 3g/4 (d) 4g



207. The elevator shown in figure is descending with an acceleration of 2 m/s^2. The mass of the block A = 0.5 kg. The force exerted by the block A on the block B is (g = 10 m/s^2)

(a) 2N (b) 4N

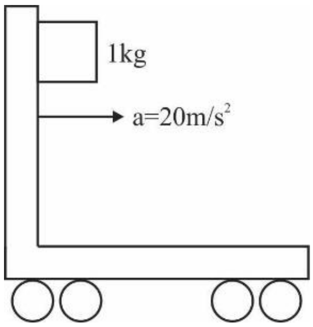
(c) 6N (d) 8N



208. A block of mass 1 kg just remains in equilibrium with the vertical wall of a cart accelerating uniformly with 20 m/s^2 as shown. The co-efficient of friction between block and wall is (g = 10 m/s^2)

(a) 0.1 (b) 0.2

(c) 0.5 (d) 1



209. A man is standing on a weighing machine placed in a lift. When stationary his weight is recorded as 40 kg. If the lift is accelerated upwards with an acceleration of 2m/s^2, then the weight recorded in the machine will be (g = 10 m/s^2)

(a) 32 kg (b) 40 kg

(c) 42 kg (d) 48 kg

210. An elevator weighing 6000 kg is pulled upward by a cable with an acceleration of 5 ms^{-2}. Taking g to be 10 Ms^{-2}, then the tension in the cable is

(a) 6000 N (b) 9000 N

(c) 60000 N (d) 90000 N

211. A 60 kg man stands on a spring balance in a lift. At same instant he finds that the reading on the scale has changed from 60kg to 50 kg for a while and then comes back to the original mark. What is his conclusion?

(a) The lift was in constant motion upwards

(b) The lift was in constant motion downwards

(c) The lift while in motion downward suddenly stopped.

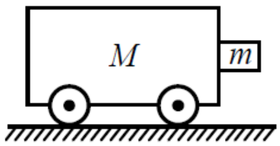
(d) The lift while in motion upward suddenly stopped.

212. A body of mass m is kept stationary on a rough inclined plane of inclination θ. The magnitude of force acting on the body by the inclined plane is

(a) mg (b) mg sin θ

(c) mg cos θ (d) $mg\sqrt{1+\cos^2\theta}$

213. A wagon of mass M has a block of mass m attached to it as shown in the figure. The coefficient of friction between the block and wagon is μ. The minimum acceleration of the wagon so that the block m does not fall is



(a) $\frac{g}{\mu}$ (b) $\frac{\mu}{g}$

(c) μg (d) $\frac{M\mu g}{m}$

214. A body hangs from a spring balance supported from the roof of an elevator.

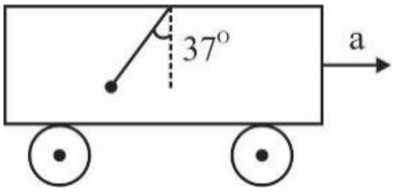
(a) If the elevator has an upward acceleration of 2 m/s^2 and balance reads 240 N, what is the true weight of the body?

(b) Under what circumstances will the balance read 160 N?

(c) What will the balance read if the elevator cable breaks? (Take g=10 m/s^{-2})

215. A child places a picnic basket on the outer rim of merry go round that has a radius of 4.0 m and revolves once in every 24s.What is the minimum co-efficient of static friction for the basket to stay on the merry go round?

216. At what acceleration of the trolley will the string make an angle of 37° with vertical if a small mass is attached to bottom of string.



217. A lift is moving down with acceleration a. A man in the lift drops a ball inside the lift. The acceleration of the ball as observed by the man in the lift and a man standing stationary on the ground are respectively

(a) g, g (b) g – a, g – a
(c) g – a, g (d) a, g

218. A spring balance is attached to the ceiling of a lift. A man hangs his bag on the spring and the spring reads 49 N, when the lift is stationary. If the lift moves downward with an acceleration of 5 m/s^2, the reading of the spring balance will be

(a) 24.5 N (b) 74 N
(c) 15 N (d) 49 N

Expert **Pseudo Force**

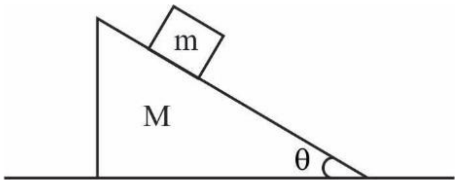
219. A pendulum suspended from the roof of a car that has a constant acceleration a relative to the ground. Find the deflection of the pendulum from the vertical as observed from the ground frame and from the frame attached with the car.

220. In a carnival ride called the rotor, people stand on a ledge inside a large cylinder that rotates about a vertical axis. When it reaches a high enough rotational speed, the ledge drops away. Find the minimum coefficient of friction for the people not to slide down. Take the radius to be 2 m and the period of rotation to be 2 s.

221. A block of mass m = 1 kg rests on a wedge of mass M = 9 kg, which in turn is placed on table as shown in the fig. (all the surfaces are smooth)

(a) What horizontal acceleration 'a' must the wedge have relative to stationary table so that the block remains stationary relative to the wedge?

(b) Find the horizontal force required to maintain this acceleration?



222. A truck is stationary and has a bob suspended by a light string, in a frame attached to the truck. The truck, suddenly moves to the right with an acceleration of a. The pendulum will tilt

(a) to the left and the angle of inclination of the pendulum with the vertical is $\sin^{-1}\left(\frac{g}{a}\right)$

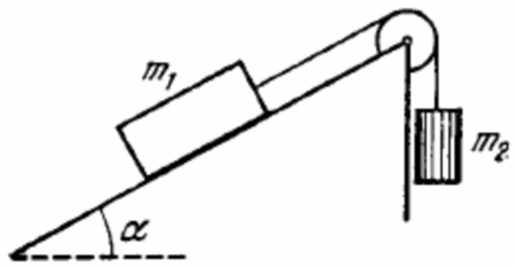
(b) to the left and angle of inclination of the pendulum with the vertical is $\tan^{-1}\left(\frac{a}{g}\right)$

(c) to the left and angle of inclination of the pendulum with the vertical is $\sin^{-1}\left(\frac{a}{g}\right)$

(d) to the left and angle of inclination of the pendulum with the vertical is $\tan^{-1}\left(\frac{g}{a}\right)$

Pro **Pseudo Force**

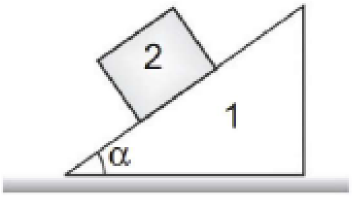
223. The inclined plane of Fig. forms an angle α = 30° with the horizontal. The mass ratio $m_2/m_1 = \eta = 2/3$. The coefficient of friction between the body m1 and the inclined plane is equal to k= 0.10. The masses of the pulley and the threads are negligible. Find the magnitude and the direction of acceleration of the body m_2 when the formerly stationary system of masses starts moving.



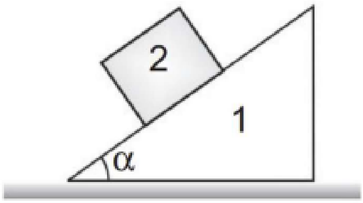
224. A pulley fixed to the ceiling of an elevator car carries a thread whose ends are attached to the loads of masses m_1 and m_2. The car starts going up with an acceleration w_0. Assuming

the masses of the pulley and the thread, as well as the friction, to be negligible find:
(a) The acceleration of the load m1 relative to the elevator shaft and relative to the car;
(b) The force exerted by the pulley on the ceiling of the car.

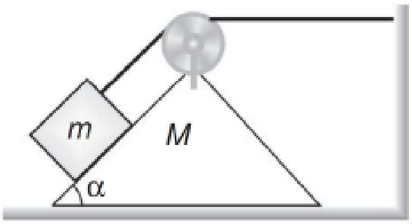
225. Prism 1 with bar 2 of mass m placed on it gets a horizontal acceleration w directed to the left (Fig.). At what maximum value of this acceleration will the bar be still stationary relative to the prism, if the coefficient of friction between them $k < \cot\alpha$?



226. Prism 1 of mass m_1 and with angle α (see Fig.) rests on a horizontal surface. Bar 2 of mass m_2 is placed on the prism. Assuming the friction to be negligible, find the acceleration of the prism.



227. In the arrangement shown in Fig. the masses m of the bar and M of the wedge, as well as the wedge angel α, are known. The masses of the pulley and the thread are negligible. The friction is absent. Find the acceleration of the wedge M.



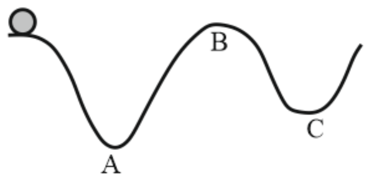
Beginner **Circular Motion**

228. A 500 kg car takes a round turn of radius 50 m with a velocity of 36 km/hr. The centripetal force is
(a) 250 N (b) 750 N
(c) 1000 N (d) 1200 N

229. A ball of mass 0.25 kg attached to the end of a string of length 1.96 m is moving in a horizontal circle. The string will break if the tension is more than 25 N. What is the maximum speed with which the ball can be moved
(a) 14 m/s (b) 3 m/s
(c) 3.2 m/s (d) 5 m/s

230. A stone of mass of 16 kg is attached to a string 144 m long and is whirled in a horizontal circle. The maximum tension the string can withstand is 16 Newton. The maximum velocity of revolution that can be given to the stone without breaking it will be-
(a) 20 ms^{-1} (b) 16 ms^{-1}
(c) 14 ms^{-1} (d) 12 ms^{-1}

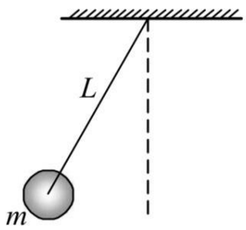
231. A body moves along an uneven surface with constant speed at all points. The normal reaction due to ground on the body is:



(a) maximum at A
(b) maximum at B
(c) minimum at C
(d) the same at A, B and C

232. A particle of mass m is suspended from a ceiling through a string of length L. The particle moves in a horizontal circle of radius r (such a system is called a conical pendulum). Find
(a) the speed of the particle
(b) the tension in the string.

233. A ball of mass (m) 0.5kg is attached to the end of a string having length (L) 0.5m. The wall of rotated on a horizontal circular path about vertical axis. The maximum tension that the string can bear is 324N. The maximum possible value of angular velocity of ball (in radian/s) is



(a) 9 (b) 18
(c) 27 (d) 36

234. A block of mass 10 kg is in contact against the inner wall of a hollow cylindrical drum of radius 1 m. The coefficient of friction between the block and the inner wall of the cylinder is 0.1. The minimum angular velocity needed for the cylinder to keep the block stationary when the cylinder is vertical and rotating about its axis, will be (g = 10 m/s^2)

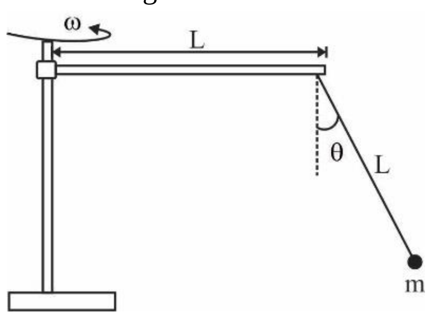
(a) $\frac{10}{2\pi}$ rad/s (b) 10 rad/s

(c) 10π rad/s (d) $\sqrt{10}$ rad/s

235. A plane comes out of a power dive, turning upward in a curve whose center of curvature is 1300 m above the plane. The plane's speed is 260 m/s.
(a) Calculate the upward force of the seat cushion on the 100 kg pilot of the plane.
(b) Calculate the upward force on a 90.0 g sample of blood in the pilot's head.

Expert **Circular Motion**

236. Figure shows a rod of length 20 cm pivoted near an end and which is made to rotate in a horizontal plane with a constant angular speed. A ball of mass m is suspended by a string also of length 20 cm from the other end of the rod. If the angle θ made by the string with the vertical is 30°, find the angular speed of the rotation. Take g = 10 m/s^2.



237. A metal ring of mass m and radius R is placed on smooth horizontal table and is set rotating about its own axis in such a way that each part of the ring moves with a speed v. Tension in the ring is:

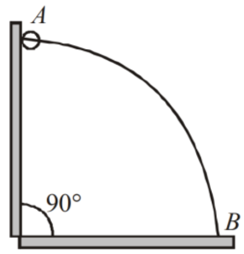
(a) $\frac{mv^2}{R}$ (b) $\frac{mv^2}{2R}$

(c) $\frac{mv^2}{2\pi R}$ (d) None of these

Pro **Circular Motion**

238. A hemispherical bowl of radius R is rotated about its axis of symmetry which is kept vertical. A small block is kept in the bowl at a position where the radius makes an angle **θ** with the vertical. The block rotates with the bowl without any slipping. The friction coefficient between the block and the bowl surface is **μ**. Find the range of the angular speed for which the block will not slip.

239. A wire, which passes through the hole in a small bead, is bent in the form of quarter of a circle. The wire is fixed vertically on ground as shown in the figure. The bead is released from near the top of the wire and it slides along the wire without friction. As the bead moves from A to B, the force it applies on the wire is



(a) Always radially outwards
(b) Always radially inwards
(c) Radially outwards initially and radially inwards later
(d) Radially inwards initially and radially outwards later

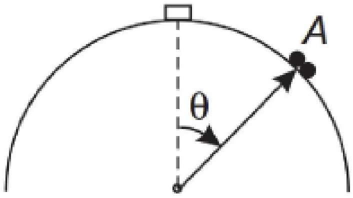
240. A particle of mass m moves along a circle of radius R. Find the modulus of the average vector of the force acting on the particle over the distance equal to a quarter of the circle, if the particle moves
(a) Uniformly with velocity v;
(b) With constant tangential acceleration w_τ, the initial velocity being equal to zero.

241. An aircraft loops the loop of radius R = 500 m with a constant velocity v = 360 km per hour. Find the weight of the flyer of mass m = 70 kg in the lower, upper, and middle points of the loop.

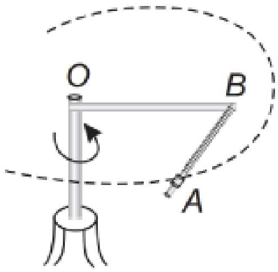
242. A small sphere of mass m suspended by a thread is first taken aside so that the thread forms the right angle with the vertical and then released. Find :
(a) The total acceleration of the sphere and the thread tension as a function of θ, the angle of deflection of the thread from the vertical;
(b) The thread tension at the moment when the vertical component of the sphere's velocity is maximum;
(c) The angle θ between the thread and the vertical at the moment when the total acceleration vector of the sphere is directed horizontally.

243. A ball suspended by a thread swings in a vertical plane so that its acceleration values in the extreme and the lowest position are equal. Find the thread deflection angle in the extreme position.

244. A small body A starts sliding off the top of a smooth sphere of radius R. Find the angle θ (Fig.) corresponding to the point at which the body breaks off the sphere, as well as the break-off velocity of the body.



245. A device (Fig.) consists of a smooth L-shaped rod located in a horizontal plane and a sleeve A of mass m attached by a weight less spring to a point B. The spring stiffness is equal to x. The whole system rotates with a constant angular velocity ω about a vertical axis passing through the point O. Find the elongation of the spring. How is the result affected by the rotation direction?



246. A cyclist rides along the circumference of a circular horizontal plane of radius R, the friction coefficient being dependent only on distance r from the centre O of the plane as $k = k_0 (1 - r/R)$, where k_0 is a constant. Find the radius of the circle with the centre at the point along which the cyclist can ride with the maximum velocity. What is this velocity?

247. A car moves with a constant tangential acceleration $w_\tau = 0.62$ m/s^2 along a horizontal surface circumscribing a circle of radius R = 40 m. The coefficient of sliding friction between the wheels of the car and the surface is k = 0.20. What distance will the car ride without sliding if at the initial moment of time its velocity is equal to zero?

248. A car moves uniformly along a horizontal sine curve $y = a\sin\left(\frac{x}{\alpha}\right)$,where a and α are certain constants. The coefficient of friction between the wheels and the road is equal to k. At what velocity will the car ride without sliding?

249. A chain of mass m forming a circle of radius R is slipped on a smooth round cone with half-angle θ. Find the tension of the chain if it rotates with a constant angular velocity ω about a vertical axis coinciding with the symmetry axis of the cone.

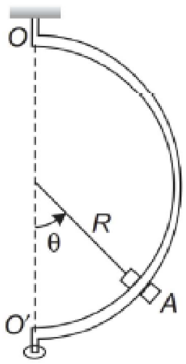
250. A particle of mass m moves along the internal smooth surface of a vertical cylinder of radius R. Find the force with which the particle acts on the cylinder wall if at the initial moment of time its velocity equals v_0 and forms an angle α with the horizontal.

251. Find the magnitude and direction of the force acting on the particle of mass m during its motion in the plane xy according to the law $x = a \sin \omega t$, $y = b \cos \omega t$, where a, b and ω are constants.

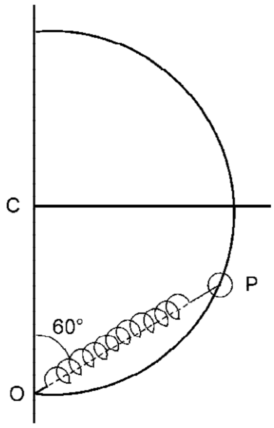
252. A small body is placed on the top of a smooth sphere of radius R. Then the sphere is imparted a constant acceleration w_0 in the horizontal direction and the body begins sliding down. Find:
(a) The velocity of the body relative to the sphere at the moment of break-off;
(b) The angle θ_0 between the vertical and the radius vector drawn from the centre of the sphere to the break-off point; calculate θ_0 for W_0=g.

253. A particle moves in a plane under the action of a force which is always perpendicular to the particle's velocity and depends on a distance to a certain point on the plane as $1/r^n$, where n is constant. At what value of n will the motion of the particle along the circle be steady?

254. A sleeve A can slide freely along a smooth rod bent in the shape of a half-circle of radius R (Fig.). The system is set is rotation with a constant angular velocity ω about a vertical axis OO'. Find the angle θ corresponding to the steady position of the sleeve.



255. A smooth semi-circular wire – track of radius R is fixed in a vertical plane. One end of a massless spring of natural length 3R/4 is attached to the lowest point O of the wire track. A small range of mass m, which can slide on the track, is attached to the other end of the spring. The range is held stationary of point P such that the spring makes an angle of 60° with the vertical. The spring constant K = mg/R. Consider the instant when the range is released, and
(a) draw the free body diagram of the range,
(b) determine the tangential acceleration of the range and the normal
reaction.



Beginner **Banking of Road**

256. A cyclist riding the bicycle at a speed of $14\sqrt{3}$ ms^{-1} takes a turn around a circular road of radius $20\sqrt{3}$ m without skidding. Given g = 9.8 ms^{-2}, What is his inclination to the vertical?
(a) 30° (b) 90°
(c) 45° (d) 60°

257. Consider a circular leveled road of radius 10 m having coefficient of static friction 0.81. Three cars (A, B and C) are travelling with speed 7 m s^{-1}, 8 m s^{-1} and 10 m s^{-1} respectively. Which car will skid when it moves in the circular level road? (g = 10 m s^{-2})

258. A 1200 kg automobile rounds a level curve of radius 200m, on an unbanked road with a velocity of 72 km/hr. What is the minimum coefficient of friction between the tyres and road in order that the automobile may not skid (g= 10m/s^2)?

259. A curve in the road is in the form of an arc of a circle of radius 400 m. At what angle should the surface of the road be laid inclined to the horizontal so that the resultant reaction of the surface acting on a car running at 120 km/h is normal to the surface of the road?

260. What is the angle of banking necessary for a curved road of 50 m radius for safe driving at 54 km/h? If the road is not banked, what is the coefficient of friction necessary between the road surface and tyres for safe driving at this speed?

261. A motor van weighing 4400 kg rounds a level curve of radius 200 m on the unbanked road at 60 km/hr. What should be the minimum value of the coefficient of friction to prevent skidding? At what angle the road should be banked for this velocity?

262. A vehicle enters a circular bend of radius 200 m at 72 km/h. The road surface at the bend is banked at 10°. Is it safe? At what angle should the road surface be ideally banked for safe driving at this speed? If the road is 5m wide, what should be the elevation of the outer edge of the road surface above the inner edge?

263. The radius of curvature of a metre gauge railway line at a place where the train is moving at 36 km/h is 50 m. If there is no side thrust on the rails find the elevation of the outer rail above the inner rail.

264. A metre gauge train is moving at 60 km/hr along a curved road of a radius of curvature 500m at a certain place. Find the elevation of outer rail over the inner rail. so that there is no side pressure on the rail. (g = 9.8 m/s^2)

265. Find the angle of banking of the railway track of radius of curvature 3200 m if there is no side thrust on the rails for a train running at 144 km/h. Find the elevation of the outer rail above the inner one if the distance between the rails is 1.6 m.

Expert **Banking of Road**

266. A car is negotiating a curved road of radius R. The road is banked at angle θ. The coefficient of friction between the tyres of the car and the road is μ_s. The maximum safe velocity on this road is

(a) $\sqrt{gR\left(\frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}\right)}$

(b) $\sqrt{\frac{g}{R}\left(\frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}\right)}$

(c) $\sqrt{\frac{g}{R^2}\left(\frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}\right)}$

(d) $\sqrt{gR^2\left(\frac{\mu_s + \tan\theta}{1 - \mu_s \tan\theta}\right)}$

Beginner Test-I

1. Calculate the force acting on a body which changes the momentum of the body at the rate of $1kg - m/s^2$.

2. A force of 36 dyne is inclined to the horizontal at an angle of 60°. Find the acceleration in a mass of 18 g that moves in a horizontal direction.

3. If force is acting on a moving body perpendicular to the direction of motion, then what will be its effect on the speed and direction of the body?

4. Why are porcelain objects wrapped in paper or straw before packing for transportation?

5. A passenger of mass 72.2 kg is riding in an elevator while standing on a platform scale. What does the scale read when the elevator cab is (i) descending with constant velocity (ii) ascending with constant acceleration, $3.5\,m/s^2$?

6. A person driving a car suddenly applies the brakes on seeing a child on the road ahead. If he is not wearing seat belt, he falls forward and hits his head against the steering wheel. Why?

7. A pebble of mass 0.05 kg is thrown vertically upwards. Give the direction and magnitude of the net force on the pebble.

(i) during its upward motion. (ii) during its downward motion.

(iii) at the highest point where it is momentarily at rest.

Do your answer change if the pebble was thrown at an angle of 45° with the horizontal direction? Ignore air resistance.

8. Ten one-rupee coins are put on top of each other on a table. Each coin has mass m. Give the magnitude and direction of

(i)the force on the 7th coin (counted from the bottom) due to all the coins on its top.

(ii)the force on the 7th coin by the 8 coin, (counted from the bottom)

(iii) the reaction of the 6th coin on the 7th coin. (Counted from the bottom)

9. A girl riding a bicycle along a straight road with a speed of 5 m/s throws a stone of mass 0.5 kg which has a speed of 15 m/s with respect to the ground along her direction of motion. The mass of the girl and bicycle is 50 kg. Does the speed of the bicycle change after the stone is thrown? What is the change in speed, if so?

10. Give the magnitude and direction of the net force acting on a stone of mass 0.1 kg.

(i)Just after it is dropped from the window of a stationary train.

(ii)Just after it is dropped from the window of a train running at a constant velocity of 36 km/h.

(iii)Just after it is dropped from the window of a train accelerating with 1 m/s^2.

(iv)Lying on the floor of a train which is accelerating with 1 m/s^2, the stone being at rest relative to the train. Neglect air resistance throughout.

When any object is thrown from a train, the influence of train on the object becomes zero at the same moment, i.e. there is no effect of acceleration of train on the object.

11. Explain why?

(i)A horse cannot pull a cart and run in empty space.

(ii)Passengers are thrown forward from their seats when a speeding bus stops suddenly.

(iii)It is easier to pull a lawn mower than to push it.

(iv)A cricketer moves his hands backwards while holding a catch.

12. A body is moving in a circular path such that its speed always remains constant. Should there be a force acting on the body?

13. A heavy point mass tied to the end of string is whirled in a horizontal circle of radius 20 cm with a constant angular speed. What is angular speed if the centripetal acceleration is 980 cms^{-2}?

14. The mountain road is generally made winding upwards rather than going straight up. Why?

15. A body placed on a rough inclined plane just begins to slide, when the slope of the plane equal to 1 in 4. Calculate the coefficient of friction.

16. A body of mass 2 kg is being dragged with a uniform velocity of 2 ms^{-1} on a rough horizontal plane. The coefficient of friction between the body and the surface is 0.2. Calculate the amount of heat generated per second. Take $g = 9.8\,ms^{-2}$ and $J = 4.2 Jcal^{-1}$.

17. A train rounds an unbanked circular bend of radius 30 m at a speed of 54 km/h. The mass of the train is $10^6 kg$. What provides the centripetal force required for this purpose, the engine or the rails? What is the angle of banking required to prevent wearing out of the rail?
The centripetal force required by the train to cross the circular bend is provided by the lateral thrust exerted by the outer rails on the wheels. According to Newton's third law of motion, the train also exerts an equal and opposite force on the rails causing its wear and tear.

18. You may have seen in a circus a motorcyclist driving in vertical loops inside a death well (a hollow spherical chamber with holes, so the spectators can watch from outside). Explain clearly, why the motorcyclist does not drop down when he is at the uppermost point, with no support from below. What is the minimum speed required at the uppermost position to perform a vertical loop if the radius of the chamber is 25 m?

19. A disc revolves with a speed of $33\frac{1}{3}\ rev/min$ and has a radius of 15 cm. Two coins are placed at 4 cm and 14 cm away from the centre of the record. If the coefficient of friction between the coins and the record is 0.15, which of the coins will revolve with the record?

20. When a body slides down from rest along a smooth inclined plane making an angle of 45° with the horizontal, it takes time T. When the same body slides down from rest along a rough inclined plane making the same angle and through the same distance, it is seen to take time pT, where p is some number greater than I. Calculate the coefficient of friction between the body and the rough plane.

21. In a rotor, a hollow vertical cylinder rotates about its axis and a person rests against the inner wall. At a particular speed of the rotor, the floor below the person is removed and the person hangs resting against the wall without any floor.
If the radius of the rotor is 2m and the coefficient of static friction between the wall and the person is 0.2.
(i)Find the minimum speed at which the floor may be removed.
(ii)What type of speciality is associated with this question? [take, $g = 10\ m/s^2$]

Beginner Test-II

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1. A constant retarding force of 50 N is applied to a body of mass 20 kg moving initially with a speed of 15 ms^{-1} . How long does the body take to stop?

2. A constant force acting on a body of mass 3.0 kg changes its speed from 2.0 m s^{-1} to 3.5 m s^{-1} in 25 s. The direction of the motion of the body remains unchanged. What is the magnitude and direction of the force?

3. A body of mass 5 kg is acted upon by two perpendicular forces 8 N and 6 N. Give the magnitude and direction of the acceleration of the body.

4. The driver of a three-wheeler moving with a speed of 36 km/h sees a child standing in the middle of the road and brings his vehicle to rest in 4.0 s just in time to save the child. What is the average retarding force on the vehicle? The mass of the three-wheeler is 400 kg and the mass of the driver is 65 kg.

5. A rocket with a lift-off mass 20,000 kg is blasted upwards with an initial acceleration of 5.0 m s^{-2} . Calculate the initial thrust (force) of the blast.

6. A body of mass 0.40 kg moving initially with a constant speed of 10 m $s^{-1}$to the north is subject to a constant force of 8.0 N directed towards the south for 30 s. Take the instant the force is applied to be t = 0, the position of the body at that time to be x = 0, and predict its position at t = –5 s, 25 s, 100 s.

7. A truck starts from rest and accelerates uniformly at 2.0 m s^{-2} . At t = 10 s, a stone is dropped by a person standing on the top of the truck (6 m high from the ground). What are the (a) velocity, and (b) acceleration of the stone at t = 11 s? (Neglect air resistance.)

8. A bob of mass 0.1 kg hung from the ceiling of a room by a string 2 m long is set into oscillation. The speed of the bob at its mean position is 1 m s^{-1} . What is the trajectory of the bob if the string is cut when the bob is (a) at one of its extreme positions, (b) at its mean position?

9. A man of mass 70 kg stands on a weighing scale in a lift which is moving
(a) upwards with a uniform speed of 10 m s^{-1}

(b) downwards with a uniform acceleration of 5 m s^{-2}, c) upwards with a uniform acceleration of 5 m s^{-2} . What would be the readings on the scale in each case? d) What would be the reading if the lift mechanism failed and it hurtled down freely under gravity?

10. Two bodies of masses 10 kg and 20 kg respectively kept on a smooth, horizontal surface are tied to the ends of a light string. A horizontal force F = 600 N is applied to (a) A, (b) B along the direction of string. What is the tension in the string in each case?

11. Two masses 8 kg and 12 kg are connected at the two ends of a light inextensible string that goes over a frictionless pulley. Find the acceleration of the masses, and the tension in the string when the masses are released.

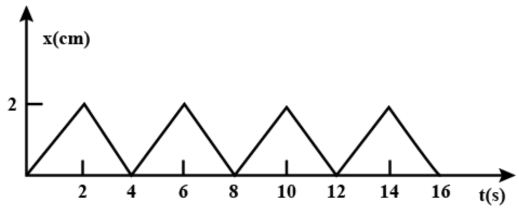
12. Two billiard balls each of mass 0.05 kg moving in opposite directions with speed 6 ms^{-1} collide and rebound with the same speed. What is the impulse imparted to each ball due to the other?

13. A shell of mass 0.020 kg is fired by a gun of mass 100 kg. If the muzzle speed of the shell is 80 m s^{-1} , what is the recoil speed of the gun?

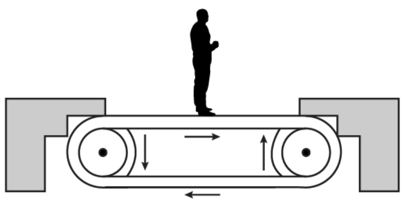
14. A batsman deflects a ball by an angle of 45° without changing its initial speed which is equal to 54 km/h. What is the impulse imparted to the ball? (Mass of the ball is 0.15 kg.)

15. A stone of mass 0.25 kg tied to the end of a string is whirled round in a circle of radius 1.5 m with a speed of 40 rev./min in a horizontal plane. What is the tension in the string? What is the maximum speed with which the stone can be whirled around if the string can withstand a maximum tension of 200 N?

16. Figure shows the position-time graph of a body of mass 0.04 kg. Suggest a suitable physical context for this motion. What is the time between two consecutive impulses received by the body? What is the magnitude of each impulse?



17. Figure shows a man standing stationary with respect to a horizontal conveyor belt that is accelerating with 1 m s^{-2} . What is the net force on the man? If the coefficient of static friction between the man's shoes and the belt is 0.2, up to what acceleration of the belt can the man continue to be stationary relative to the belt? (Mass of the man = 65 kg.)



18. A helicopter of mass 1000 kg rises with a vertical acceleration of 15 m s^{-2}. The crew and the passengers weigh 300 kg. Give the magnitude and direction of the a) force on the floor by the crew and passengers, b) action of the rotor of the helicopter on the surrounding air, c) force on the helicopter due to the surrounding air.

19. A stream of water flowing horizontally with a speed of 15 m s^{-1}gushes out of a tube of cross-sectional area 10^{-2} m^{2} , and hits a vertical wall nearby. What is the force exerted on the wall by the impact of water, assuming it does not rebound?

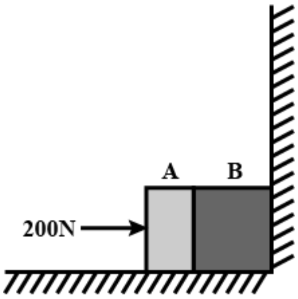
20. An aircraft executes a horizontal loop at a speed of 720 km/h with its wings banked at 15°. What is the radius of the loop?

21. A train runs along an unbanked circular track of radius 30 m at a speed of 54 km/h. The mass of the train is 10^6 kg. What provides the centripetal force required for this purpose – The engine or the rails? What is the angle of banking required to prevent wearing out of the rail?

22. A monkey of mass 40 kg climbs on a rope Fig. which can stand a maximum tension of 600 N. In which of the following cases will the rope break: the monkey
(a) climbs up with an acceleration of 6 m s^{-2}

(b) climbs down with an acceleration of 4 m s^{-2}
(c) climbs up with a uniform speed of 5 m s^{-1}
(d) falls down the rope nearly freely under gravity? (Ignore the mass of the rope).

23. Two bodies A and B of masses 5 kg and 10 kg in contact with each other rest on a table against a rigid wall (Fig.). The coefficient of friction between the bodies and the table is 0.15. A force of 200 N is applied horizontally to A. What are (a) the reaction of the partition (b) the action-reaction forces between A and B? What happens when the wall is removed? Does the answer to (b) change, when the bodies are in motion? Ignore the difference between u_s and μ_k.



24. A block of mass 15 kg is placed on a long trolley. The coefficient of static friction between the block and the trolley is 0.18. The trolley accelerates from rest with 0.5 m s^{-2} for 20 s and then moves with uniform velocity. Discuss the motion of the block as viewed by (a) a stationary observer on the ground, (b) an observer moving with the trolley.

25. A 70 kg man stands in contact against the inner wall of a hollow cylindrical drum of radius 3 m rotating about its vertical axis with 200 rev/min. The coefficient of friction between the wall and his clothing is 0.15. What is the minimum rotational speed of the cylinder to enable the man to remain stuck to the wall (without falling) when the floor is suddenly removed?

Expert Test-I

1. A truck is stationary and has a bob suspended by a light string, in a frame attached to the truck. The truck, suddenly moves to the right with an acceleration of a. The pendulum will tilt

(a) to the left and the angle of inclination of the pendulum with the vertical is $\sin^{-1}\left(\frac{g}{a}\right)$

(b) to the left and angle of inclination of the pendulum with the vertical is $\tan^{-1}\left(\frac{a}{g}\right)$

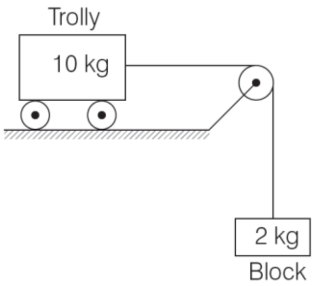
(c) to the left and angle of inclination of the pendulum with the vertical is $\sin^{-1}\left(\frac{a}{g}\right)$

(d) to the left and angle of inclination of the pendulum with the vertical is $\tan^{-1}\left(\frac{g}{a}\right)$

2. A bullet of mass 10 g moving horizontal with a velocity of 400 m/s strikes a wood block of mass 2 kg which is suspended by light inextensible string of length 5 m. As result, the center of gravity of the block found to rise a vertical distance of 10 cm. The speed of the bullet after it emerges of horizontally from the block will be

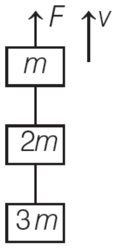
(a) 100 m/s (b) 80 m/s (c) 120 m/s (d) 160 m/s

3. Calculate the acceleration of the block and trolley system shown in the figure. The coefficient of kinetic friction between the trolley and the surface is 0.05. (g =10 m/s^2, mass of the string is negligible and no other friction exists).



(a) 1.25 m/s^2 (b) 1.50 m/s^2 (c) 1.66 m/s^2 (d) 1.00 m/s^2

4. Three blocks with masses m, 2m and 3m are connected by strings, as shown in the figure. After an upward force F is applied on block m, the masses move upward at constant speed v. What is the net force on the block of mass 2m ? (g is the acceleration due to gravity).



(a) Zero (b) 2 mg (c) 3 mg (d) 6 mg

5. The upper half of an inclined plane of inclination θ is perfectly smooth while lower half is rough. A block starting from rest at the top of the plane will again come to rest at the bottom, if the coefficient of friction between the block and lower half of the plane is given by

(a) $\mu = \frac{1}{\tan\theta}$ (b) $\mu = \frac{2}{\tan\theta}$ (c) μ = 2 tan θ (d) u = tan θ

6. A block of mass 10 kg is in contact against the inner wall of a hollow cylindrical drum of radius 1 m. The coefficient of friction between the block and the inner wall of the cylinder is 0.1. The minimum angular velocity needed for the cylinder to keep the block stationary when the cylinder is vertical and rotating about its axis, will be (g = 10 m/s^2)

(a) $\frac{10}{2\pi}$ rad/s (b) 10 rad/s (c) 10π rad/s (d) $\sqrt{10}$ rad/s

7. A uniform circular disc of radius 50 cm at rest is free to turn about an axis which is perpendicular to its plane and passes through its centre. It is subjected to a torque which produces a constant angular acceleration of 2.0 rad s^{-2}. Its net acceleration in ms^{-2} at the end of 2.0 s is approximately

(a) 7.0 (b) 6.0 (c) 3.0 (d) 8.0

8. A particle of mass 10 g moves along a circle of radius 6.4 cm with a constant tangential acceleration. What is the magnitude of this acceleration if the kinetic energy of the particle becomes equal to 8×10^{-4} J by the end of the second revolution after the beginning of the motion?

(a) 0.1 m/s^2 (b) 0.15 m/s^2 (c) 0.18 m/s^2 (d) 0.2 m/s^2

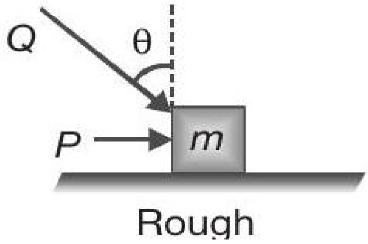
9. A balloon with mass m is descending down with an acceleration a (where, $a < g$). How much mass should be removed from it so that it starts moving up with an acceleration a ?

(a) $\frac{2ma}{g+a}$ (b) $\frac{2ma}{g-a}$ (c) $\frac{ma}{g+a}$ (d) $\frac{ma}{g-a}$

10. A body of mass m rests on a horizontal floor with which it has coefficient of static friction. It is desired to make the body move by applying the minimum possible force F. The magnitude of F is:

(a) μmg (b) $\frac{\sqrt{1+\mu^2}}{\mu}$ (c) $\mu\sqrt{1+\mu^2}mg$ (d) $\frac{\mu mg}{\sqrt{1+\mu^2}}$

11. A block of mass m, lying on a rough horizontal plane, is acted upon by a horizontal force P and another force Q, inclined at an angle θ to the vertical. The block will remain in equilibrium, if the coefficient of friction between it and the surface is:

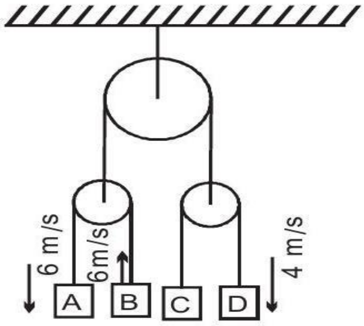


(a) $(P+\text{Qsin }\theta)/(\text{mg}+\text{Qcos }\theta)$ (b) $(P\cos\theta+Q)/(mg-Q\sin\theta)$
(c) $(P+\text{Qcos }\theta)/(\text{mg}+\text{Qsin }\theta)$ (d) $(P\sin\theta\text{Q})/(\text{mg}-\text{Qcos }\theta)$

12. A chain is lying on a rough table with a fraction $1/n$ of its length hanging down from the edge of the table. If it is just on the point of sliding down from the table, then the coefficient of friction between the table and the chain is:

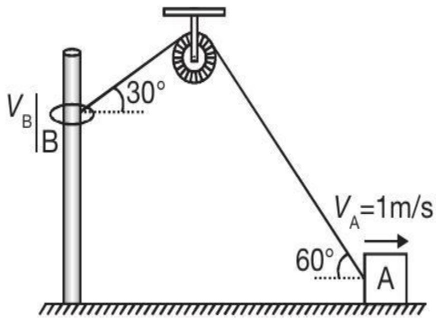
(a) $\frac{1}{n}$ (b) $\frac{1}{(n-1)}$ (c) $\frac{1}{(n+1)}$ (d) $\frac{n-1}{(n+1)}$

13. In the figure shown the velocity of different blocks is shown. The velocity of C is:



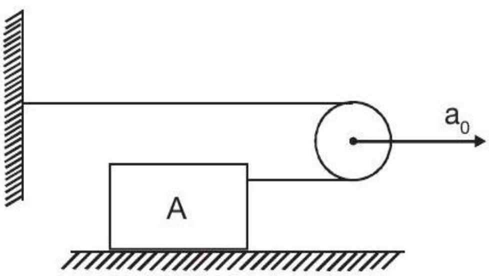
(a) 6 m/s (b) 4 m/s (c) 0 m/s (d) None of these

14. Find velocity of ring $B(V_B)$ at the instant shown. The string is taut and inextensible:



(a) $\frac{1}{2}$ m/s (b) $\frac{\sqrt{3}}{4}$ m/s (c) $\frac{1}{4}$ m/s (d) 1 m/s

15. The pulley is given an acceleration $a_0 = 2\text{ m/s}^2$ starting from rest. A cable is connected to a block A of mass 50 kg as shown. Neglect the mass of the pulley and friction between block and ground. Then the acceleration of block A:



(a) 2 m/s^2 (b) 4 m/s^2 (c) 1 m/s^2 (d) None

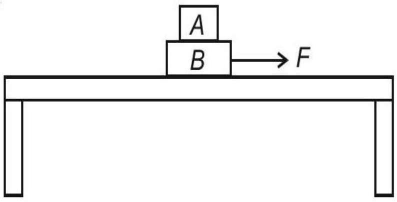
Expert Test-II

1. A ball is thrown upward with an initial velocity V_0 from the surface of the earth. The motion of the ball is affected by a drag force equal to $m\gamma v^2$ (where m is mass of the ball, v is its instantaneous velocity and γ is a constant). Time taken by the ball to rise to its zenith is :

(a) $\frac{1}{\sqrt{\gamma g}}\sin^{-1}\left(\sqrt{\frac{\gamma}{g}}V_0\right)$ (b) $\frac{1}{\sqrt{\gamma g}}\ln\left(1+\sqrt{\frac{\gamma}{g}}V_0\right)$

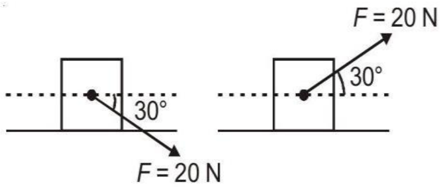
(c) $\frac{1}{\sqrt{\gamma g}}\tan^{-1}\left(\sqrt{\frac{\gamma}{g}}V_0\right)$ (d) $\frac{1}{\sqrt{2\gamma g}}\tan^{-1}\left(\sqrt{\frac{2\gamma}{g}}v_0\right)$

2. Two blocks A and B of masses $m_A = 1\text{ kg}$ and $m_B = 3\text{ kg}$ are kept on the table as shown in figure. The coefficient of friction between A and B is 0.2 and between B and the surface of the table is also 0.2 . The maximum force F that can be applied on B horizontally, so that the block A does not slide over the block B is: [Take $g = 10\text{ m/s}^2$]



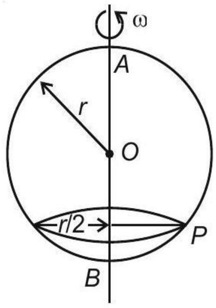
(a) 40 N (b) 12 N (c) 16 N (d) 8 N

3. A block of mass 5 kg is (i) pushed in case (A) and (ii) pulled in case (B), by a force $F = 20\text{ N}$, making an angle of 30° with the horizontal, as shown in the figures. The coefficient of friction between the block and floor is $\mu = 0.2$. The difference between the accelerations of the block, in case (B) and case (A) will be : $(g = 10\text{ ms}^{-2})$



(a) 0.4 ms^{-2} (b) 3.2 ms^{-2} (c) 0 ms^{-2} (d) 0.8 ms^{-2}

4. A smooth wire of length $2\pi r$ is bent into a circle and kept in a vertical plane. A bead can slide smoothly on the wire. When the circle is rotating with angular speed ω about the vertical diameter AB, as shown in figure, the bead is at rest with respect to the circular ring at position P as shown. Then the value of ω^2 is equal to



(a) $\frac{(g\sqrt{3})}{r}$ (b) $\frac{2g}{r}$ (c) $\frac{2g}{(r\sqrt{3})}$ (d) $\frac{\sqrt{3}g}{2r}$

5. A particle of mass m is fixed to one end of a light spring having force constant k and unstretched length I. The other end is fixed. The system is given an angular speed ω about the fixed end of the spring such that it rotates in a circle in gravity free space. Then the stretch in the spring is

(a) $\frac{m/\omega^2}{k-\omega m}$ (b) $\frac{m/\omega^2}{k+m\omega^2}$

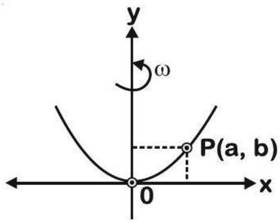
(c) $\frac{m/\omega^2}{k+m\omega}$ (d) $\frac{m/\omega^2}{k-m\omega^2}$

6. A spring mass system (mass m, spring constant k and natural length I) rests in equilibrium on a horizontal disc. The free end of the spring is fixed at the centre of the disc. If the disc together with spring mass system, rotates about it's axis with an angular velocity $\omega, \left(k >> m\omega^2\right)$ the relative change in the length of the spring is best given by the option

(a) $\sqrt{\frac{2}{3}}\left(\frac{m\omega^2}{k}\right)$ (b) $\frac{m\omega^2}{k}$

(c) $\frac{m\omega^2}{3k}$ (d) $\frac{2m\omega^2}{k}$

7. A bead of mass m stays at point $P(a,b)$ on a wire bent in the shape of a parabola $y = 4Cx^2$ and rotating with angular speed ω (see figure). The value of ω is (neglect friction)



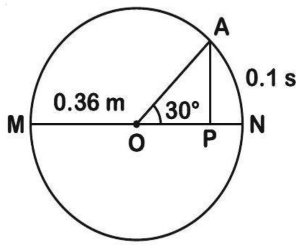
(a) $2\sqrt{2gC}$ (b) $2\sqrt{gC}$ (c) $\sqrt{\frac{2g}{C}}$ (d) $\sqrt{\frac{2gC}{ab}}$

8. A small ball of mass m is thrown upward with velocity u from the ground. The ball experiences a resistive force mkv^2, where v is its speed. The maximum height attained by the ball is

(a) $\frac{1}{2k}\tan^{-1}\frac{ku^2}{g}$ (b) $\frac{1}{k}\ln\left(1+\frac{ku^2}{2g}\right)$

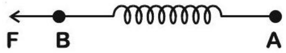
(c) $\frac{1}{2k}\ln\left(1+\frac{ku^2}{g}\right)$ (d) $\frac{1}{k}\tan^{-1}\frac{ku^2}{2g}$

9. The point A moves with a uniform speed along the circumference of a circle of radius 0.36 m and covers 30° in 0.1 s. The perpendicular projection ' P ' from ' A ' on the diameter MN represents the simple harmonic motion of ' P '. The restoration force per unit mass when P touches M will be



(a) 9.87 N (b) 50 N (c) 100 N (d) 0.49 N

10. Two masses A and B, each of mass M are fixed together by a massless spring. A force acts on the mass B as shown in figure. If the mass A starts moving away from mass B with acceleration ' a ', then the acceleration of mass B will be



(a) $\frac{Ma-F}{M}$ (b) $\frac{MF}{F+Ma}$ (c) $\frac{F-Ma}{M}$ (d) $\frac{F+Ma}{M}$

11. A particle of mass M originally at rest is subjected to a force whose direction is constant but magnitude varies with time according to the relation $F=F_0\left[1-\left(\frac{t-T}{T}\right)^2\right]$ Where F_0 and T are constants. The force acts only for the time interval 2T. The velocity v of the particle after time 2 T is :

(a) $\frac{F_0T}{3M}$ (b) $\frac{F_0T}{2M}$

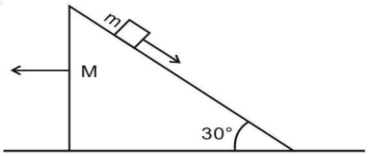
(c) $\frac{2F_0T}{M}$ (d) $\frac{4F_0T}{3M}$

12. A particle of mass m is suspended from a ceiling through a string of length L. The particle moves in a horizontal circle of radius r such that $r=\frac{L}{\sqrt{2}}$. The speed of particle will be:

(a) $2\sqrt{rg}$ (b) $\sqrt{rg}$

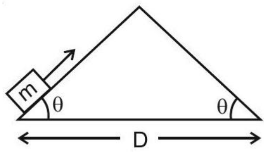
(c) $\sqrt{2rg}$ (d) $\sqrt{\frac{rg}{2}}$

13. A block of mass m slides on the wooden wedge, which in turn slides backward on the horizontal surface. The acceleration of the block with respect to the wedge is: Given $\text{m}=8\text{ kg}, \text{M}=16\text{ kg}$
Assume all the surfaces shown in the figure to be frictionless.

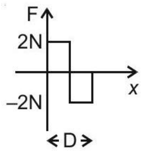


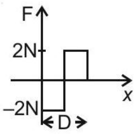
(a) $\frac{2}{3}$ g (b) $\frac{4}{3}$ g (c) $\frac{6}{5}$ g (d) $\frac{3}{5}$ g

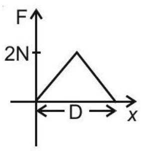
14. An object of mass ' m ' is being moved with a constant velocity under the action of an applied force of 2 N along a frictionless surface with following surface profile.

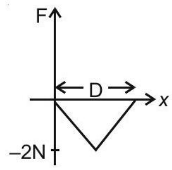


The correct applied force vs distance graph will be:

(a)


(b)


(c)


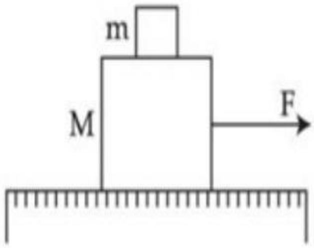
(d)


15. A boy ties a stone of mass 100 g to the end of a 2 m long string and whirls it around in a horizontal plane. The string can withstand the maximum tension of 80 N. If the maximum speed with which the stone can revolve is $\frac{K}{\pi}$ rev. / min. The value of K is (Assume the string is massless and unstretchable)

(a) 400 (b) 300

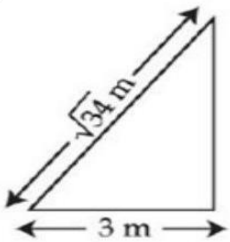
(c) 600 (d) 800

16. A system of two blocks of masses $m = 2\text{ kg}$ and $M = 8\text{ kg}$ is placed on a smooth table as shown in figure. The coefficient of static friction between two blocks is 0.5. The maximum horizontal force F that can be applied to the block of mass M so that the blocks move together will be



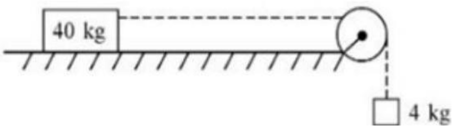
(a) 9.8 N (b) 39.2 N (c) 49 N (d) 78.4 N

17. A $\sqrt{34}\text{ m}$ long ladder weighing 10 kg leans on a frictionless wall. Its feet rest on the floor 3 m away from the wall as shown in the figure. If F_f and F_w are the reaction forces of the floor and the wall, then ratio of F_w / F_f will be: (Use $g = 10\text{ m/s}^2$)



(a) $\frac{6}{\sqrt{110}}$ (b) $\frac{3}{\sqrt{113}}$ (c) $\frac{3}{\sqrt{109}}$ (d) $\frac{2}{\sqrt{109}}$

18. A block of mass 40 kg slides over a surface, when a mass of 4 kg is suspended through an inextensible massless string passing over frictionless pulley as shown below.
The coefficient of kinetic friction between the surface and block is 0.02. The acceleration of block is (Given $g = 10\text{ ms}^{-2}$.)



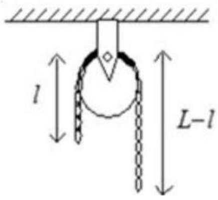
(a) 1 ms^{-2} (b) $1/5\text{ ms}^{-2}$ (c) $4/5\text{ ms}^{-2}$ (d) $8/11\text{ ms}^{-2}$

19. A bag is gently dropped on a conveyor belt moving at a speed of 2 m/s. The coefficient of friction between the conveyor belt and bag is 0.4. Initially the bag slips on the belt before it stops due to friction. The distance travelled by the bag on the belt during slipping motion, is
[Take $g = 10\text{ m/s}^2$]

(a) 2 m (b) 0.5 m

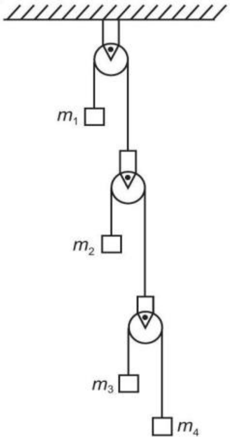
(c) 3.2 m (d) 0.8 ms

20. A uniform metal chain of mass m and length ' L ' passes over a massless and frictionless pully. It is released from rest with a part of its length ' " ' is hanging on one side and rest of its length ' $L-l$ ' is hanging on the other side of the pully. At a certain point of time, when $I=\frac{L}{x}$, the acceleration of the chain is $\frac{g}{2}$. The value of x is



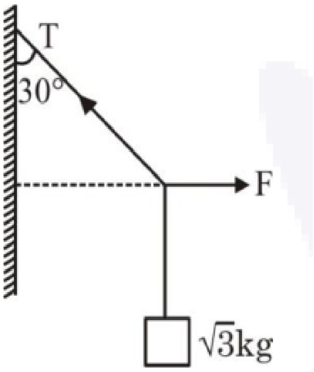
(a) 6
(b) 2
(c) 1.5
(d) 4

21. In the arrangement shown in figure a_1, a_2, a_3 and a_4 are the accelerations of masses m_1, m_2, m_3 and m_4 respectively. Which of the following relation is true for this arrangement?



(a) $4a_1+2a_2+a_3+a_4=0$
(b) $a_1+4a_2+3a_3+a_4=0$
(c) $a_1+4a_2+3a_3+2a_4=0$
(d) $2a_1+2a_2+3a_3+a_4=0$

22. A block of $\sqrt{3}$ kg is attached to a string whose other end is attached to the wall. An unknown force F is applied so that the string makes an angle of 30° with the wall. The tension T is : (Given $\mathrm{g}=10\ \mathrm{ms}^{-2}$)



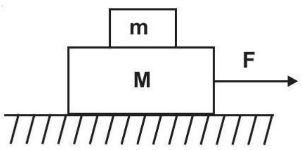
(1) 20 N
(b) 25 N
(3) 10 N
(d) 15 N

23. A block of mass m slides down the plane inclined at angle 30° with an acceleration $\frac{g}{4}$. The value of coefficient of kinetic friction will be :

(a) $\frac{2\sqrt{3}+1}{2}$ (b) $\frac{1}{2\sqrt{3}}$

(c) $\frac{\sqrt{3}}{2}$ (d) $\frac{2\sqrt{3}-1}{2}$

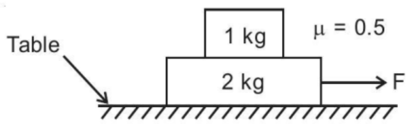
24. Two block ($m = 0.5$ kg and $M = 4.5$ kg) are arranged on a horizontal frictionless table as shown in figure. The coefficient of static friction between the two blocks is $\frac{3}{7}$. Then the maximum horizontal force that can be applied on the larger block so that the blocks move together is N. (Round off to the Nearest Integer) [Take g as $9.8\ ms^{-2}$]



25. A body of mass 1 kg rests on a horizontal floor with which it has a coefficient of static friction $\frac{1}{\sqrt{3}}$. It is desired to make the body move by applying the minimum possible force FN. The value of F will be . (Round off to the Nearest Integer)[Take $g = 10\ ms^{-2}$]

26. A body of mass ' m ' is launched up on a rough inclined plane making an angle of 30° with the horizontal. The coefficient of friction between the body and plane is $\frac{\sqrt{x}}{5}$ if the time of ascent is half of the time of descent. The value of x is

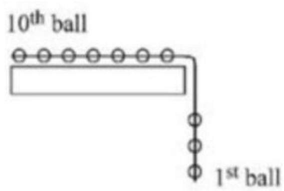
27. The coefficient of static friction between two blocks is 0.5 and the table is smooth. The maximum horizontal force that can be applied to move the blocks together is N. (take $g = 10\ ms^{-2}$)



28. When a body slides down from rest along a smooth inclined plane making an angle of 30° with the horizontal, it takes time T. When the same body slides down from the rest along a rough inclined plane making the same angle and through the same distance, it takes time αT, where α is a constant greater than 1 . The co-efficient of friction between the body and the rough plane is $\frac{1}{\sqrt{x}}\left(\frac{\alpha^2-1}{\alpha^2}\right)$ where $x =$

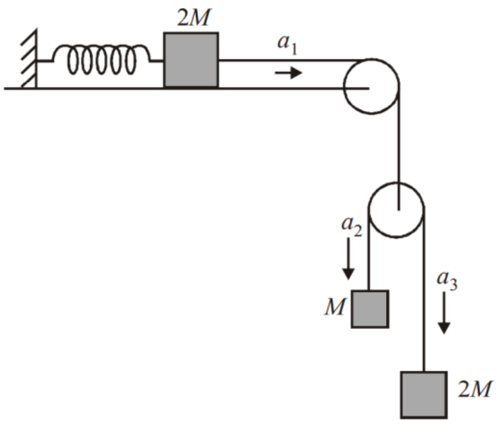
29. A uniform chain of 6 m length is placed on a table such that a part of its length is hanging over the edge of the table. The system is at rest. The co-efficient of static friction between the chain and the surface of the table is 0.5 , the maximum length of the chain hanging from the table is m .

30. A system to 10 balls each of mass 2 kg are connected via massless and unstretchable string. The system is allowed to slip over the edge of a smooth table as shown in figure. Tension on the string between the 7^{th} and 8^{th} ball is N when 6^{th} ball just leaves the table



Pro Test-I

1. A block of mass 2M is attached to a massless spring with spring-constant k. This block is connected to two others blocks of masses M and 2M using two massless pulleys and strings. The acceleration of block are a_1 , a_2 and a_3 as shown in figure. The system is released from rest with the spring in its unstretched state. The maximum extension of the spring is x_0. Which of the following option (s) is/are correct? [g is the acceleration due to gravity. Neglect friction]



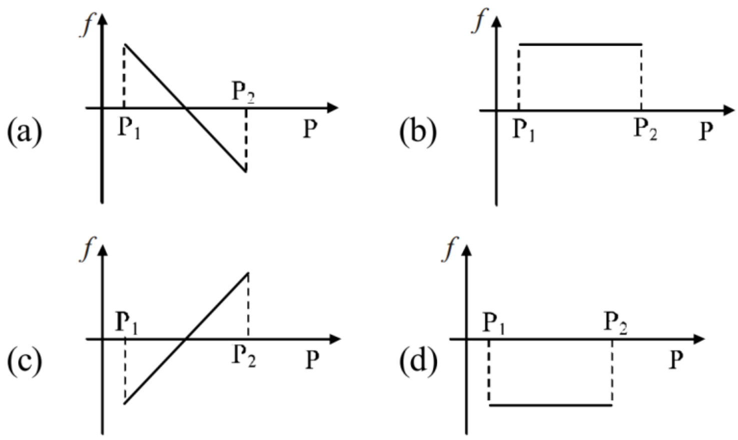
(a) At an extension of $\frac{x_0}{4}$ of the spring, the magnitude of acceleration of the block connected to the spring is $\frac{3g}{10}$

(b) $x_0 = \frac{4Mg}{k}$

(c) When spring achieves an extension of $\frac{x_0}{2}$ for the first time, the speed of the block connected to the spring is $3g\sqrt{\frac{M}{5k}}$

(d) $a_2 - a_1 = a_1 - a_3$

2. A block of mass m is on an inclined plane of angle θ. The coefficient of friction between block and the plane is μ and $\tan\theta > \mu$. The block is held stationary by applying a force P parallel to the plane. The direction of force pointing up the plane is taken to be positive. As P is varied from $P_1 = mg(\sin\theta - \mu\cos\theta)$ to $P_2 = = mg(\sin\theta + \mu\cos\theta)$, the frictional force f versus P graph will look like



3. A block of base 10 cm × 10 cm and height 15cm is kept on an inclined plane. The coefficient of friction between them is $\sqrt{3}$. The inclination $\theta$of this inclined plane from the horizontal plane is gradually increased from 0°. Then

(a) at $\theta = 30°$, the block will start sliding down the plane.

(b) the block will remain at rest on the plane up to certain θ and then it will topple

(c) at $\theta = 60°$, the block will start sliding down the plane and continue to do so at higher angles

(d) at $\theta = 60°$, the block will start sliding down the plane and on further increasing θ, it will topple at certain θ.

4. A block is moving on an inclined plane making an angle 45°with the horizontal and the coefficient of friction is μ. The force required to just push it up the inclined plane is 3times the force required to just prevent it from sliding down. If we define N = 10 μ, then N is

5. A small block of mass of 0.1kg lies on a fixed inclined plane PQ which makes an angle θ with the horizontal. A horizontal force of 1N acts on the block through its centre of mass as shown in figure. The block remains stationary if (take g = 10m/s^2)

(a) $\theta = 45°$

(b) $\theta > 45°$ and a frictional force act on the block towards P.

(c) $\theta > 45°$ and a frictional force act on the block towards Q.

(d) $\theta < 45°$ and a frictional force act on the block towards Q.

Pro Test-II

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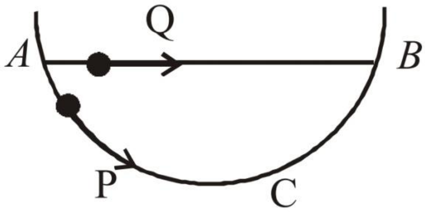
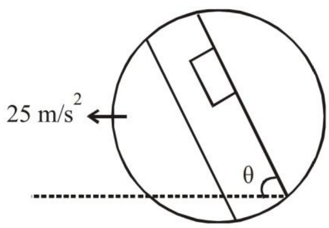
1. A particle P is us sliding down a frictionless hemispherical bowl. It passes the point A at t = 0. At this instant of time the horizontal component of its velocity is v. A bead Q of the same mass as P is ejected from A at t = 0 along the horizontal string AB, with the speed v. Friction between the bead and the string may be neglected let t_P and t_Q be the respective time taken by P and Q to reach the point B. Then:

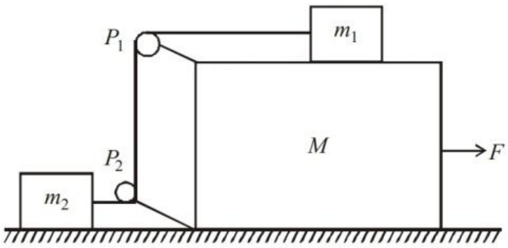


(a) $t_P < t_Q$ (b) $t_P = t_Q$ (c) $t_P > t_Q$ (d) $\frac{t_P}{t_Q} = \frac{length\ of\ arc\ ACB}{lenth\ of\ arc\ AB}$

2. A circular disc with a groove along its diameter is placed horizontally on a rough surface. A block of mass 1kg is placed a shown. The coefficient of friction between the block and all surface of groove and horizontal surface in constant is $\mu = \frac{2}{5}$. The disc has an acceleration of 25m/s^2 towards left. Find the acceleration of the block with respect to disc. Given cosθ $\frac{4}{5}$, sinθ $\frac{3}{5}$.

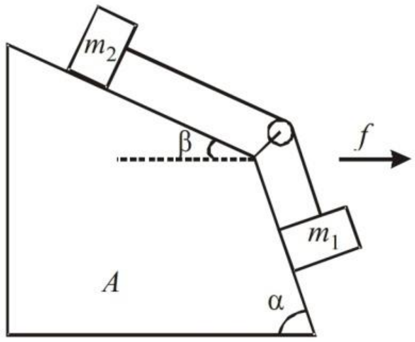


3. In the figure masses m_1 , m_2 and M are 20kg, 5kg and 50kg respectively. The coefficient of friction between M and ground is zero. The coefficient of friction between m_1 and M and the between m_2 and ground is 0.3. The pulleys and the string are massless. The string is perfectly horizontal between P_1 and m_1 and also between P_2 and m_2 the string is perfectly vertical between P_1 and P_2. An external horizontal force F is applied to the mass M. Take g = 10m/s^2



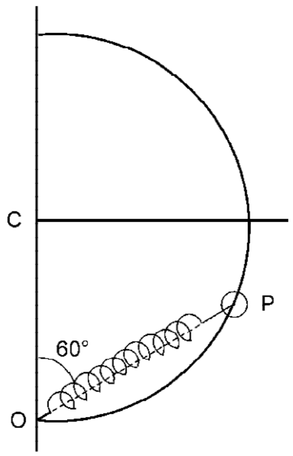
(a) Draw a free body diagram for mass M, clearly showing all the forces.
(b) Let the magnitude of the force of frictional between m_1 and M be f_1 and that between m_2 and ground be f_2 for a particular F it is found that $f_1 = 2f_2$ find f_1 and f_2 , write questions of motion of all the masses . Find F, tension in the string and acceleration of the masses.

4. Two cubes of masses m_1 and m_2 be on two frictionless slope of block A which rests on a horizontal table. The cubes are connected by a string which passes over a pulley as shown in the figure. To what horizontal acceleration



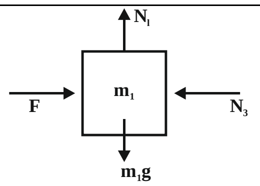
f should the whole system (that is blocks and cubes) be objected so that the cubes do not slid down the plane. What is the tension of string in this situation?

5. A smooth semi-circular wire – track of radius R is fixed in a vertical plane. One end of a massless spring of natural length 3R/4 is attached to the lowest point O of the wire track. A small range of mass m, which can slide on the track, is attached to the other end of the spring. The range is held stationary of point P such that the spring makes an angle of 60° with the vertical. The spring constant K = mg/R. Consider the instant when the range is released, and (1) draw the free body diagram of the range, (2) determine the tangential acceleration of the range and the normal reaction.

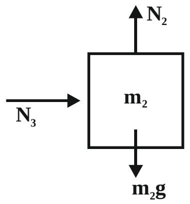


Answer Key

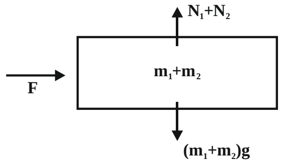
1. (a)



(b)

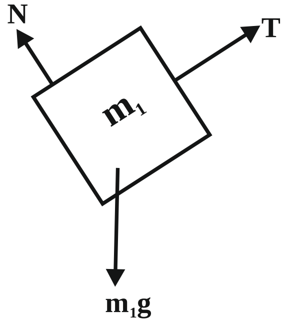


(c)

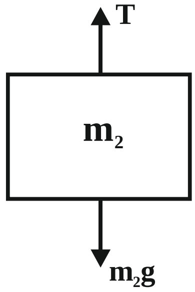


2.

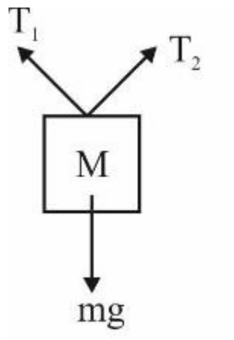
(a)



(b)



3.



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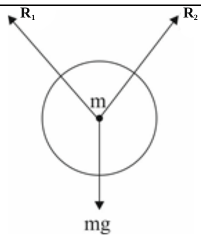

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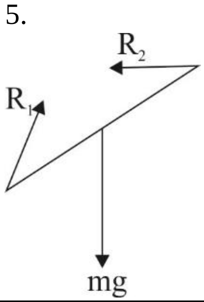

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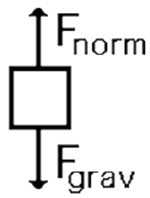

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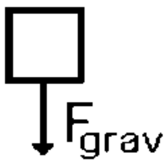
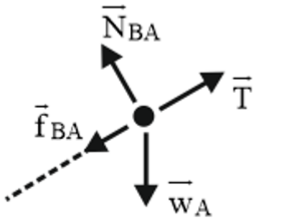


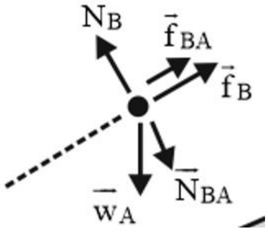
8. (b)

9. (a)

10.

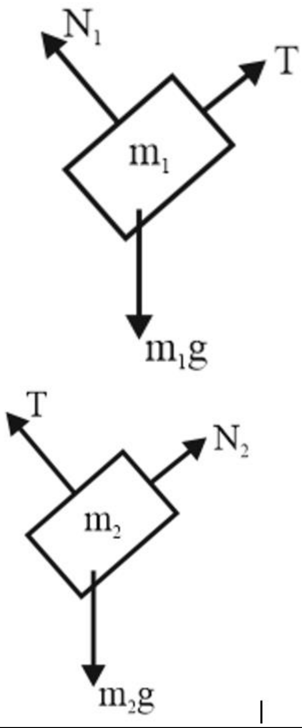


(a)

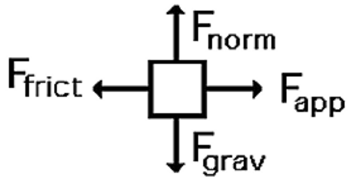


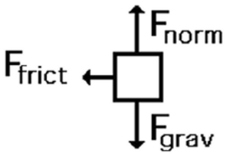
(b)

11.



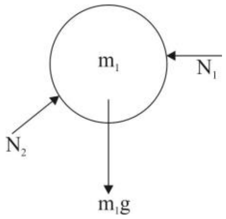
12.



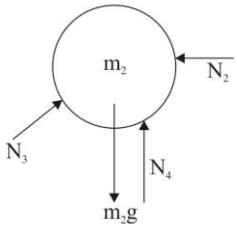


13.

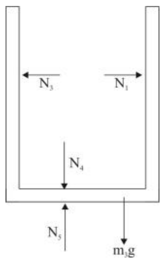
14.



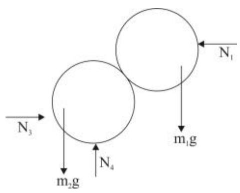
(a)



(b)



(c)



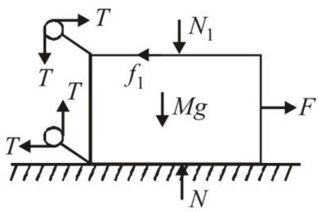
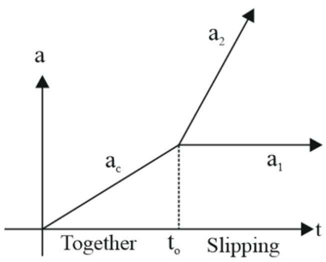
(d)

(e) $(m_1 + m_2 + m_3)g$

15. 1750 N

16. 6250 N	17. 0.25 N, 0 , 0.25 N	18. (b)
19. 1 N	20. 3 N, 9 N, 18 N	21. 51,21
22. 7.5 N	23. (a)(b)	24. (a)
25. (c)	26. (c)	27. $5\sqrt{3}m/s^2$
28. $\frac{g}{10}m/s^2$	29. (a)10 kg m/s (b)100 N	30. (a) $12.5m/s^2$ (b) 137.5 N (c) 112.5 N
31. (a) Yes (b) 235.2 N (c) 823.2N (d) $1.168m/s^2$ (e) 0.584 m (f) $3.322m/s^2$	32. $F\left(1-\frac{x}{L}\right)$	33. (a) 70 N (b) 35 N
34. (c)	35. (a)	36. (d)
37. (b)	38. (d)	39. (b)
40. (d)	41. (c)	42. (d)
43. (a)	44. (a)	45. (a)
46. (a) $10(\sin 37° - 0.5\cos 37°)$ (b) 40 N (c) 25 N (d) 20 N	47. (a) 1.568 (b) 85 (c) 13.3 (d) 25.5	48. (b)
49. (d)	50. (b)	51. (a)
52. (d)	53. 5	54. (b)
55. 24 N	56. (b)	57. t = 2 s
58. (b)	59. $\frac{2m\omega}{g+\omega}$	60. $a=\frac{(m_0-km_1-km_2)}{m_0+m_1+m_2}g$, $\frac{(k+1)m_0m_2g}{m_0+m_1+m_2}$
61. (a) $F=\frac{m_1m_2\cos\alpha(k_1-k_2)g}{m_1+m_2}$ (b) $\tan\alpha>\frac{k_1m_1+k_2m_2}{m_1+m_2}$	62. $k=\left(\frac{\eta^2-1}{\eta^2+1}\right)\tan\alpha$	63. (a) $m_2g>m_1g\sin\alpha+km_1g\cos\alpha$ (b) $\frac{m_2}{m_1}<\sin\alpha-k\cos\alpha$ (c) $\sin\alpha+k\cos\alpha$
64. $\frac{g(\eta-\sin\alpha-k\cos\alpha)}{1+\eta}$	65. $\tan 2\alpha=-\frac{1}{k}$ $t=\sqrt{\frac{2\ell}{ag(\sin\alpha-k\cos\alpha)\cos\alpha}}$	66. $\frac{mg(\sin\alpha+k\cos\alpha)}{\sqrt{k^2+1}}$
67. (a) $\frac{mg^2\cos\alpha}{2a\sin^2\alpha}$ (b) $\frac{m^2g^3\cos\alpha}{6a^2\sin^3\alpha}$	68. $\sqrt{\frac{2g\sin\alpha}{3a}}$	69. $\sqrt{\frac{2\ell}{kg+3w}}$
70. $\frac{v_0}{1+\cos\phi}$	71. (b)	72. $\frac{2Ma}{g+a}$
73. (a),(b),(c),(d)	74. $\sqrt{F-L}m/s$	75. 4
76. 0.3	77. 10(x)/2	78. $g\frac{[\pi+4]}{2\pi}$
79. 306 N, $4.7m/s^2$	80. $\frac{1}{\sqrt{e}+1}$	81. $\frac{v_0}{\sqrt{1+\frac{kv_0^2}{mg}}}$
82. (d)	83. (a)	84. (a)
85. $\frac{h(v_0-v)}{v_0v\ell n\frac{v_0}{v}}$	86. $\frac{2\tan\alpha}{a}$, $\sqrt{\frac{g}{a}\sin\alpha\tan\alpha}$	87. $\frac{a}{m}\frac{(t-t_0)^3}{6}$

88. $\frac{v_0}{\sqrt{1+\frac{kv_0^2}{mg}}}$	89. (a) $\frac{\vec{a}\tau^3}{6}$ (b) $\frac{\vec{a}}{m}\frac{\tau^4}{12}$	90. $\frac{\vec{F}_0}{m\omega}\left(t-\frac{\sin\omega t}{\omega}\right)$
91. $\frac{F_0}{m}\int_0^t \cos\omega t\ dt$, $2\frac{F_0}{m\omega^2}$	92. (a) $t\to\infty$ (b) $\frac{mv_0}{r}$ (c) $\frac{v_0(\eta-1)}{\ell n\eta\ \eta}$	93. (a) $\frac{F}{m\omega}.2\left\|\sin\omega\frac{t}{2}\right\|$ (b) $\frac{4F}{\pi m\omega}$
94. $\frac{gR}{\ell}\left(1-\cos\frac{\ell}{R}\right)$	95. 30 N	96. (a)
97. (a)	98. (b)	99. (c)
100. $T_1=\frac{60}{\sqrt{3}+1}$, $T_2=\frac{60}{\sqrt{3}+1}\left(\frac{\sqrt{3}}{\sqrt{2}}\right)$ T_3 = 30 N, T_4 = 20 N	101. $\sec^2\theta$	102. (c)
103. $mg\sec\theta$	104. (a) (c) (d)	105. (c)
106. $\frac{\mu mg}{(\sin\theta-\mu\cos\theta)}$	107. $\tan^{-1}\left(\frac{1}{3\sqrt{3}}\right)$	108. $\frac{25}{3}m/s$
109. 2.5 m/s	110. $\frac{20}{3}m/s$	111. (b)
112. (a)	113. (b)	114. (c)
115. (d)	116. 8 m/s	117. 8 m/s
118. $10m/s^2$	119. 1 m/s	120. (a)
121. (c)	122. (b)	123. $2a_1-a_2+a_3=0$
124. (b)	125. (b)	126. (d)
127. (c)	128. $5ms^{-1}$	129. 3 s
130. (a) $\frac{8g}{3}$ (b) $\frac{20g}{11}N$	131. (c)	132. 5 N
133. (c)	134. (b)	135. (c)
136. $\frac{8}{13}g$ *downward*	137. (d)	138. (b)
139. $\frac{v_C}{2}$, $\frac{a_C}{2}$	140. 35 kg	141. $\frac{10}{3}$
142. $\frac{g}{1+\frac{m_1}{4}\left(\frac{1}{m_2}+\frac{1}{m_3}\right)}$	143. (a) $a_1=6.66m/s^2$ $a_2=3.33m/s^2$, T = 6.66 N (b) $a_1=\frac{70}{11}m/s^2$ $a_2=\frac{30}{11}m/s^2$ $a_3=\frac{50}{11}m/s^2$ $T=\frac{80}{11}N$	144. $\frac{2g(2\eta-\sin\alpha)}{(4\eta+1)}$

145. $\frac{4m_1m_2+m_0(m_1-m_2)}{4m_1m_2+m_0(m_1+m_2)}g$	146. $\frac{2\ell Mm}{(M+m)t^2}$	147. $\sqrt{\frac{2\ell(\eta+4)}{3(2-\eta)g}}$
148. $\frac{6\eta h}{\eta+4}$	149. $k=\frac{1}{k}\ell n\eta_0$, $a=g\frac{(\eta-\eta_0)}{(\eta+\eta_0)}$	150. 1/7 m/s^2
151. (d)	152. $\frac{g}{3}$	153. $\frac{M_1+M}{\cos\theta-1}$
154. $\frac{2g}{7}$	155. (a)	156. (a)
157. (c)	158. (c)	159. (a)
160. (1) 4.2 kg (2) 9.8 N	161. $v_2=v_1\tan\theta$	162. $\frac{40}{3}m/s$
163. $\frac{20}{\sqrt{3}}m/s$	164. $\frac{100}{3}$	165. 5 N, $\frac{16}{31}kg$
166. $-v_2\hat{i}-\frac{4}{3}(v_1-v_2)$	167. (d)	168. (c)
169.  (a) (b) f_1 = 30N, f_2 = 15N a = $\frac{3}{5}$ m/s^2, T = 18N, F = 60N	170. $\frac{g}{1+\eta\cot^2\alpha}$, $\frac{g}{\tan\alpha+\eta\cot\alpha}$	171. $\frac{\sqrt{2}g}{2+k+\frac{M}{m}}$
172. $\frac{g(1-k)}{(1+k)}$	173. $\frac{7}{3}ms^{-2}$	174. 125 N
175. $\frac{72}{7}ms^{-2}$	176. $\frac{23}{7}ms^{-2}$	177. $\frac{2}{3}ms^{-2}$
178. $2ms^{-2}$	179. (a) 3.25 N (b) 1 N	180. (c)
181. (d)	182. 3	183. (a)
184. (a)	185. (a)	186. (a),(b),(c)
187. (a),(b),(c)	188. (c)	189. (b)
190. (a)	191. $a_1=\frac{km_2g}{m_1}$, $a_2=\frac{a}{m_2}t-kg$  	192. (b)
193. (c)	194. (b)(d)	195. (a)(d)
196. (a),(b),(c),(d)	197. (a),(c),(d)	198. (a),(b),(c)
199. 10	200. 1	201. 175 cm
202. (a) 176.4 N (b) 117.6 N	203. 100/3 N	204. (a) $7.6\ m/s^2$ (b) $0.86\ m/s^2$

(c) 176.4 N		
205. 71.05 N	206. (c)	207. (b)
208. (c)	209. (d)	210. (d)
211. (d)	212. (a)	213. (a)
214. (a) 20.34 kg (b) $-1.93 m/s^2$ (c) 0	215. 0.025	216. 63 s^{-2}
217. (c)	218. (a)	219. $\tan^{-1}\left(\frac{a}{g}\right)$
220. 0.5	221. (a) $7.5ms^2$ (b) $(M+m)g\tan\theta$	222. (b)
223. $\vec{a}=\frac{(\eta-\sin\alpha-k\cos\alpha)\vec{g}}{1+\eta}=0.05\vec{g}$	224. (a) $\frac{(m_1-m_2)\vec{g}+2m_2\vec{w}_0}{m_1+m_2}$ (b) $\frac{4m_1m_2}{m_1+m_2}(\vec{g}-\vec{w}_0)$	225. $g\left(\frac{1+k\cot\alpha}{\cot\alpha-k}\right)$
226. $\frac{g\sin\alpha\cos\alpha}{\frac{M}{m}+\sin^2\alpha}$	227. $\frac{g\sin\alpha\cos\alpha}{\frac{M}{m}+\sin^2\alpha}$	228. (c)
229. (a)	230. (d)	231. (a)
232. (a) $\sqrt{rg\tan\theta}$ (b) $\frac{mgL}{(L^2-r^2)^{1/2}}$	233. (d)	234. (b)
235. (a) 6180 (b) 5.56 N	236. 4.4 $radians/\sec$	237. (c)
238. $\left[\frac{g(\sin\theta+\mu\cos\theta)}{r\sin\theta(\cos\theta-\mu\sin\theta)}\right]^{1/2}$	239. (d)	240. (a) $\lvert\vec{F}_{avg}\rvert=\frac{2\sqrt{2}mv^2}{\pi R}$ (b) $\lvert\vec{F}_{avg}\rvert=m\omega_\tau$
241. $mg+\frac{mv^2}{R}$, $\frac{mv^2}{R}-mg$, $\frac{mv^2}{R}$	242. (a) $g\sqrt{3\cos^2\theta+1}$ (b) $\sqrt{3}mg$ (c) 0	243. 53°
244. $\cos\theta=\frac{2}{3}, v=\sqrt{\frac{2Rg}{3}}$	245. $\frac{m\omega^2}{k-m\omega^2}$	246. $\sqrt{\frac{k_0gR}{4}}$
247. $\frac{R}{2at}\sqrt{(k^2g^2-a_t^2)}$	248. $\sqrt{\frac{kg\alpha^2}{a}}$	249. $\left[\frac{\omega^2R}{g}+\cot\theta\right]\frac{mg}{2\pi}$
250. $\frac{m(v\cos\alpha)^2}{R}$	251. $\vec{F}=-m\omega^2(x\hat{i}+y\hat{j})$ $\lvert\vec{F}\rvert=m\omega^2\sqrt{x^2+y^2}$	252. $v_0=\sqrt{\frac{2Rg}{3}}$ $\cos\theta=\frac{2+\eta\sqrt{s+9\eta^2}}{3(1+\eta^2)}$ where $\eta=\frac{\omega_0}{g}, \theta_0=17^0$
253. $-\frac{mv_0^2}{r_0^2}(1-n)x$	254. 0 if $g>\omega^2R$ $\cos^{-1}\left(\frac{g}{\omega^2R}\right)$ if $g<\omega^2R$	255. $a_t=\frac{5\sqrt{3}}{8}g$, $N=\frac{3mg}{8}$
256. (d)	257. Car C	258. 0.2

259. $\tan^{-1}\left(\frac{5}{18}\right)$	260. 24°42' , 0.4592	261. 0.1418 , 8°4'
262. 11°32’ , 1m	263. 20 cm	264. 3°15' , 5.67 cm
265. 8 cm	266. (a)	

Answer Key- Beginner Test-I

1. 1N	2. 1 cm/s^2
3. No change in speed, but change in direction is possible. Forces acting on a body in circular motion is an example.	4. Porcelain objects are wrapped in paper or straw before packing to reduce the chances of damage during transportation. During transportation sudden jerks or even fall can take place. Forces are created at the point of collision and the force takes longer time to reach the porcelain objects through paper or straw for same change in momentum as $F = \Delta p/\Delta t$ and therefore a lesser force acts on object.
5. (i) 707.56 N (ii) 938.6 N	6. When a person driving a car suddenly applies the brakes, the lower part of the body slows down with the car while upper part of the body continues to move forward due to inertia of motion. If driver is not wearing seat belt, then he falls forward and his head hits against the steering wheel.
7. (i) 0.50 N (vertically downward) (ii) 0.50 N (vertically downward) (iii) 0.05 N (vertically downward)	8. (i) 3 mg N (downward) (ii) 3 mg N (downward) (iii) $-4mg$ N (Vertically upward)
9. 0.1 m/s	10. (i) 1.0 N (vertically downward)
11. (i) When a horse is trying to pull a cart, he pushes the ground backward at an angle from the horizontal. According to Newton's third law of motion the ground also apply equal reaction force on the feet of the horse in opposite direction. The vertical component of reaction balances the weight of the horse and horizontal component is responsible for motion of the cart. In empty space, there is no reaction force; therefore, a horse cannot pull a cart. (ii)When bus is moving, the passengers sitting in it are also in motion and moving with the speed of the bus. When bus stops suddenly then lower part of the body of passengers which is in contact with the bus slows down with the bus but upper part of the bodies of the passengers continues to remain in motion in initial direction due to its inertia of motion and hence is thrown forward.	12.When a body is moving along a circular path, speed always remains constant and a centripetal force is acting on the body.
13. 7 rad/s	14. When we go up a mountain, the opposing force of friction $F = \mu R = \mu mg\cos\theta$. Where θ is angle of slope with horizontal? To avoid skidding, F should be large. $\therefore \cos\theta$ Should be large and hence, θ must be small. Therefore, mountain roads are generally made winding upwards. The road straight up would have large slope.

15. 0.258	16. 1.87 cal
17. 37.4°	18. 15.65 m/s
19. Coin A	20. $\left(1-\frac{1}{p^2}\right)$
21. (i) 10ms (ii) Specialty is that without the floor an object a body may be 0 align with a vertical wall provided, it is set to be in circular motion (horizontal) with properly required speed.	

Answer Key- Beginner Test-II

1. 6s	2. 0.18N
3. 2 m/s^2, at an angle of 37° with a force of 8 N	4. -1162.5 N
5. 3 × 10^5 N	6. Refer Solution
7. (a) 22.36 (b) 10	8. (a) Vertically downward Parabolic path (b) Parabolic path
9. (a) 700 N (b) 350 N (c) 1050 N (d) 0 N	10. 400N, 200N
11. 2 m/s^2 , 96N	12. –0.6 kg m/s
13. 0.016m/s	14. 4.16 kg m/s
15. 6.57 N , 34m/s	16. 0.08 × 10^{-2} kg m/s
17. 2m/s^2	18. (a) 7500 N downward (b) 32500N downward (c) 32500 N upward
19. 2250 N	20. 14.92 km
21. 36.87°	22. (a)
23. (a) 192.5 N acting leftward (b) 133.3 N, acting opposite to the direction of motion	24. (a) for an observer on the ground, the block will appear to be at rest. (b) the trolley will appear to be at rest for the observer moving with the trolley.
25. 4.71 $rads^{-1}$	

Answer Key- Expert Test-I

1. (b)	2. (c)
3. (a)	4. (a)
5. (c)	6. (b)
7. (d)	8. (a)
9. (a)	10. (d)
11. (a)	12. (b)
13. (b)	14. (d)
15. (b)	

Answer Key- Expert Test-II

1. (c)	2. (c)
3. (d)	4. (c)
5. (d)	6. (b)
7. (a)	8. (c)
9. (a)	10. (d)
11. (d)	12. (b)
13. (a)	14. (a)
15. (c)	16. (c)
17. (c)	18. (d)
19. (b)	20. (d)
21. (a)	22. (a)
23. (b)	24. 21N
25. 5	26. 3
27. 15	28. 3
29. 2	30. 36N

Answer Key- Pro Test-I

1. (d)	2. (a)
3. (b)	4. 5
5. (a, c)	

Answer Key- Pro Test-II

1. (a)	2. $10 m/s^2$
3. (a)	4. $\frac{m_1 m_2[cos\beta sin\alpha - sin\beta cos\alpha]g}{(m_1 cos\alpha\ m_2 cos\beta)}$
5. $\frac{3mg}{8}$	

Energy

Chapter Summary

Work

The work *W* is said to be done if the force produces displacement. ***It*** is also defined as the *dot product of force and its displacement* as given by equation

$$W = \vec{\mathbf{F}}.\vec{\mathbf{s}}$$

$$W = F\,s\,\cos\theta$$

where θ is the angle between $\vec{\mathbf{F}}$ and $\vec{\mathbf{s}}$

If the force is variable and as a function of x, then the work done via path A to B is given by

$$W_{A\to B} = \int_A^B \vec{\mathrm{F}}.\overrightarrow{\mathrm{dx}} = \int_A^B \left(F\cos\theta\right)\,dx$$

If the force is variable and as a function of x, then the work done via path A to B is given by

$$W_{A\to B} = \int_A^B \vec{\mathrm{F}}.\vec{v}\,dt$$

In *general*, Area under F vs x graph gives the work done.

Area (work) above the *x – axis* is taken as positive, and negative if below x-axis.

Work is a *scalar* quantity and its *SI* unit is the *joule* (J)

$$1\,J = 1\text{ N-m} = 10^7\text{ erg}$$

Positive, Negative & Zero Work

Work done by a force be positive or negative depending on the angle θ between the force and displacement. If the angle θ is acute $(\theta < 90°)$, then the work done is positive and if the angle θ is obtuse $(\theta > 90°)$, the component of force is antiparallel to the displacement and the work done by force is negative. If the angle θ is 0 between force and displacement, then the work done by force will be zero.

Energy:

Capacity to do work is called energy.

It is a scalar quantity. Its Unit is Joule (J).

Kinetic Energy

Energy of the body due to its motion.

$$KE = \frac{1}{2}mv^2$$

Where, m is the mass, v is the velocity

Potential Energy

Energy of the body due to the relative positions of two or more interacting particles.

Gravitational Potential Energy

Energy of a body associated with Earth.

$$U = mgh$$

Spring potential energy

Energy of a body associated with Spring.

$$U = \frac{1}{2}kx^2$$

Work Done by Conservative Forces

Work done by conservative forces doesn't depends on the path, ie. Independent of path taken

$$W_C = -\Delta U = U_i - U_f$$

Work Energy Theorem

Work done by all forces equals to change in Kinetic Energy of the body. It is given by

$$W_{net} = \Delta K = K_f - K_i$$

$$W_N + W_T + W_f + W_g + ... = \Delta K = K_f - K_i$$

Conservation of Mechanical Energy

If only conservative forces are acting on a body, then *the total mechanical energy of the system is conserved.*

$$K_i + U_i = K_f + U_f$$

Relation between Energy and Force

$$\vec{\mathbf{F}} = -\vec{\nabla}U$$

Where, U=f(x, y, z) is the Potential Energy

And $\vec{\nabla}$ is the Differential Operator

$$\vec{\nabla} = \frac{\partial}{\partial x}\hat{i} + \frac{\partial}{\partial y}j + \frac{\partial}{\partial z}k$$

POWER

Power is defined *as the rate at which work is done.* If an amount of work ΔW is done in a time interval Δt, then the average power is defined to be

$$P_{av} = \frac{Total\,Work}{Total\,time} = \frac{\int P dt}{\int dt}$$

where, P is the instantaneous power

$$P = \frac{dW}{dt} = \vec{F}\bullet\vec{v} = Fv\cos\theta$$

The *SI* unit of power is J/s (Watt)

$$1Watt = 1\;J/s$$

Horsepower (hp) is another unit of power

$$1\;hp = 746\,Watts$$

Centre of Mass

When we consider a system of particles, or a body (no matter how irregular its shape is), centre of mass is a point where the entire mass is assumed to be concentrated at that point. This point is called centre of mass of the body or the system.

Centre of Mass of Discrete Bodies

$$\vec{r}_{com} = \frac{m_1\vec{r}_1 + m_2\vec{r}_2 + ... + m_n\vec{r}_n}{m_1 + m_2 + ... + m_n}$$

$$\vec{r}_{cm} = \frac{\sum_{i=1}^{n} m_i\vec{r}_1}{\sum_{i=1}^{n} m_i}$$

where, $\vec{r}_i = x_i\hat{i} + y_i\,j + z_i\,k$

and $\vec{r}_{com} = x_{com}\hat{i} + y_{com}\;j + z_{com}\,k$

And in Cartesian co-ordinates of the COM will be

$$x_{com} = \frac{m_1x_1 + m_2x_2 + m_3x_3 + ...m_nx_n}{m_1 + m_2 + ...m_n}$$

$$\text{or }\; x_{com} = \frac{\sum_{i=1}^{n} m_ix_i}{\sum_{i=1}^{n} m_i}$$

$$\text{Similarly, }\; y_{com} = \frac{m_1y_1 + m_2y_2 + m_3y_3 + ...m_ny_n}{m_1 + m_2 + ...m_n}$$

$$\text{or, }\; y_{cm} = \frac{\sum_{i=1}^{n} m_iy_i}{\sum_{i=1}^{n} m_i}$$

Centre of Mass of Discrete Bodies

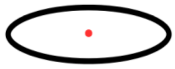
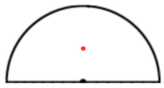
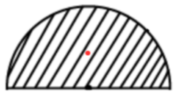
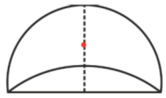
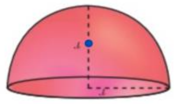
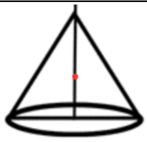
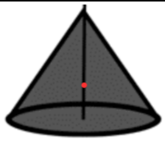
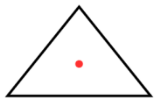
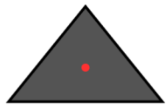
$$\vec{r}_{COM} = \frac{1}{M}\int \vec{r}\,dm$$

In component from this equation can be written as Suppose x, y and z are the coordinates of small elements of mass dm, we have

$$x_{com} = \frac{\int xdm}{\int dm} = \frac{\int xdm}{M},$$

$$y_{com} = \frac{\int ydm}{\int dm} = \frac{\int ydm}{M};$$

Centre of Mass of Some Common Objects

SN	Body	Diagram	COM
1.	Uniform Rod		(0,0)
2.	Uniform Ring		(0,0)
3.	Semi-Circular Ring		$\left(0, \frac{2R}{\pi}\right)$
4.	Semi-Circular Disc		$\left(0, \frac{4R}{3\pi}\right)$
5.	Hollow hemisphere		$\left(0, \frac{R}{2}\right)$
6.	Solid hemisphere		$\left(0, \frac{3R}{8}\right)$
7.	Hollow Cone		$\left(0, \frac{h}{3}\right)$
8.	Solid Cone		$\left(0, \frac{h}{4}\right)$
9.	Triangular Wire		$\left(0, \frac{h}{3}\right)$
10.	Triangular Disc		$\left(0, \frac{h}{3}\right)$

Velocity of Centre of Mass

Let us consider the motion of a system of n particles of individual masses $m_1, m_2, m_3 ...... m_n$ and the total mass M. Then, we have,

$$\Rightarrow \vec{v}_{com} = \frac{m_1\vec{v}_1 + m_2\vec{v}_2 + ...m_n\vec{v}_n}{M}$$

$$\text{or, }\; \vec{v}_{com} = \frac{\sum_{i=1}^{n} m_i\vec{v}_i}{M}$$

Acceleration of Centre of Mass

$$a_{com} = \frac{m_1\vec{a}_1 + m_2\vec{a}_2 + ... + m_n\vec{a}_n}{M}$$

$$= \frac{\sum m_i a_i}{M}$$

Linear momentum (p)

It is the product of mass and velocity.

If m is the mass and $\vec{v}$ its velocity, then the linear momentum is given by

$$\vec{p} = m\vec{v}$$

Its SI unit is kg m/s

Momentum is a vector in the direction of the velocity.

Impulse (I)

Impulse is defined as change in linear momentum.

$$\vec{I} = \int \vec{F} dt = m(\vec{v} - \vec{u})$$

Also, Area under F versus t graph gives impulse.

Conservation of Linear Momentum

If no external forces acts on a system or body, then

$$\text{As } \frac{d\vec{p}}{dt} = 0 \Rightarrow \overrightarrow{\Delta p} = \text{constant} \Rightarrow \vec{p}_i = \vec{p}_f$$

Also, for **x-direction**

If $\sum \vec{F}_x = 0$ then, $\sum \vec{p}_{i\, in\, x-direction} = \sum \vec{p}_{f\, in\, x-direction}$

And, for **y-direction**

If $\sum \vec{F}_y = 0$ then, $\sum \vec{p}_{i\, in\, y-direction} = \sum \vec{p}_{f\, in\, y-direction}$

Elastic and Inelastic Collisions

When there is a collision between two bodies, they get slightly deformed momentarily. If the bodies are perfectly elastic, then can recover their original shapes and sizes and rebound without any loss of kinetic energy.

On the other hand, if the bodies are perfectly inelastic, both the bodies stick together after collision and move together with a common velocity with some loss of kinetic energy.

Coefficient of Restitution

It is defined as the ratio of degree of reformation upon degree of deformation.

$$e = \frac{\text{Degree of reformation}}{\text{Degree of deformation}}$$

It is also defined as the ratio of relative velocity of separation after collision to the relative velocity of approach before collision along the common normal.

$$e = \frac{\text{velocity of separation (after collision)}}{\text{velocity of approach (before collision)}}$$

Variable Mass System

$$F_{th} = u\frac{dm}{dt}$$

Where, u is the relative velocity of elemental mass

$\frac{dm}{dt}$ is the rate at which the mass is increasing or decreasing.

$$\vec{F}_{ext} + \vec{F}_{th} = M\vec{a}$$

Beginner **Calculation of Work**

1. A block of mass 5.0 kg slides down an incline of inclination 30° and length 10 m. Find the work done by theforce of gravity.

2. A body moves a distance of 10 *m* along a straight line under the action of a force of 5 *N*. If the work done is25 *joules*, the angle which the force makes with the direction of motion of the body is

(a) 0° (b) 30°
(c) 60° (d) 90°

3. A block of mass 250g slides down an incline of inclination 37° with a uniform speed. Find the work doneagainst the friction as the block slides through 1.0 m.

4. A 250 g block slides on a rough horizontal table. Find the work done by the frictional force in bringing the block to rest if it is initially moving at a speed of 40 cm/s. If the friction coefficient between the table and the block is 0.1, how far does the block move before coming to rest?

5. A force of 5 *N* acts on a 15 *kg* body initially at rest. The work done by the force during the first second of motion of the body is

(a) 5 *J* (b) $\frac{5}{6}J$
(c) 6 *J* (d) 75 *J*

6. A particle moves from a point $\vec{r_1} = (2)\vec{\imath} + (3)\vec{\jmath}\ m$ to another point $\vec{r_2} = (3)\vec{\imath} + (2)\vec{\jmath}\,m$ during which acertain force $\vec{F} = (5)\vec{\imath} + (5)\vec{\jmath}$ N acts on it. Find the work done by the force on the particle during the displacement.

7. A force $\boldsymbol{F} = (5\hat{\boldsymbol{i}} + 3\hat{\boldsymbol{j}})$ *Newton* is applied over a particle which displaces it from its origin to the point $\boldsymbol{r} = (2\hat{\boldsymbol{i}} - 1\hat{\boldsymbol{j}})$ *metres*. The work done on the particle is

(a) – 7 *joules* (b) + 13 *joules*
(c) + 7 *joules* (d) + 11 *joules*

8. A particle moves from position $\vec{r}_1 = 3\hat{i} + 2\hat{j} - 6\hat{k}$ to position $\vec{r}_2 = 14\hat{i} + 13\hat{j} + 9\hat{k}$ under the action of force $4\hat{i} + \hat{j} + 3\hat{k}\, N$. The work done will be

(a) 100 *J* (b) 50 *J*
(c) 200 *J* (d) 75 *J*

9. A body is constrained to move along z-axis of the co-ordinate system is being applied by a constant force $\vec{F} = \left(2\hat{i} + 3j + 4k\right)$. Find the work done by this force in moving the body over a distance of 5m along z-axis.

(a) 30 J (b) 20 J
(c) 40 J (d) 61 J

10. A force F = (10 + 0.50 *x*) acts on a particle in the *x* direction, where F is in Newton and *x* in meter. Find the work done by this force during a displacement from *x*=0 to *x*= *2.0 m.*

11. A particle of mass *m* moves on a straight line with its velocity varying with the distance travelled according to the equation, $v = a\sqrt{x}$, where *a* is a constant. Find the total work done by all the forces during a displacement from *x* = *0* to *x* = *d.*

12. A position dependent force $F = 7 - 2x + 3x^2$ Newton acts on a small body of mass 2 *kg* and displaces it from $x = 0$ to $x = 5m$. The work done in *joules* is

(a) 70 (b) 270
(c) 35 (d) 135

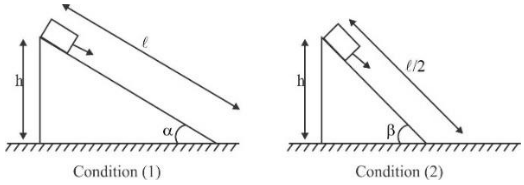
13. A bucket tied to a string is lowered at a constant acceleration of g/2. If the mass of the bucket is M and is lowered by a distance d, the work done by the string will be (assume the string to be mass less)

(a) 1/2 Mg d (b) – 3/2 Mgd
(c) – 2/3Mgd (d) 2/3 Mgd

14. Work done by kinetic friction on an object:

(a) may be positive
(b) must be negative
(c) must be zero
(d) none of these

15. Find the ratio of work done by gravity on the block under the two conditions. Assume μ = 0 between block and plane.



(a) 1 : 2 (b) 2 : 1
(c) 1 : 1 (d) α : β

16. A load of mass m = 3000kg is lifted by a string with an acceleration a = 2 m/s^2 . Find work done during the first one and a half second from the beginning of motion.

17. A body of mass 6 *kg* is under a force which causes displacement in it given by $S = \frac{t^2}{4}$ *metres* where *t* is time. The work done by the force in 2 seconds is

(a) 12 *J* (b) 9 *J*
(c) 6 *J* (d) 3 *J*

18. A body of mass 3 *kg* is under a force, which causes a displacement in it is given by $S = \frac{t^3}{3}$ (in *m*). Find the work done by the force in first 2 seconds.

(a) 2 *J* (b)3.8 *J*
(c) 5.2 *J* (d) 24 *J*

19. A force acts on a 30 *gm* particle in such a way that the position of the particle as a function of time is given by $x = 3t - 4t^2 + t^3$, where *x* is in *metres* and *t* is in seconds. The work done during the first 4 seconds is

(a) 5.28 *J* (b) 450 *mJ*
(c) 490 *mJ* (d) 530 *mJ*

20. A body is acted upon by a force which is inversely proportional to the distance covered. The work done will be proportional to:

(a)s (b) s^2
(c) √s (d) None of the above

21. A force $F = \left(3\times\hat{i} + 4j\right)$ Newton (where x is in meters) acts on a particle which moves from a position (2m,3m) to (3m, 0m). Then the work done is

(a) 7.5J (b) –12J
(c) –4.5 J (d) +4.5 J

22. A body which is constrained to move along

Y-direction is acted upon by a force $\vec{F} = (-2\hat{j} + 15\hat{j} + 6\hat{k})N$. The work done by this force in displacing the body by 10m along Y-axis is-

(a) 190 J (b) 160 J
(c) 150 J (d) 20 J

23. A block of mass M is kept on a platform which is accelerating upward from rest with a constant acceleration, during the time interval from t = 0 to t = t_0. Find

(a) the work done by gravity,
(b) the work done by normal reaction.

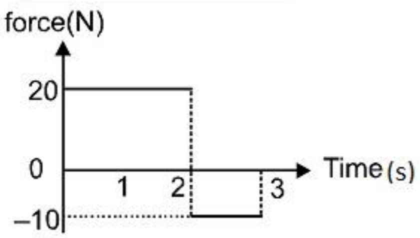
25. A bucket tied to a string is lowered at a constant acceleration of g/4. If the mass of the bucket is M and is lowered by a distance d, the work done by the string will be (assume the string to be mass less)

(a) 1/4 Mg d (b) – 3/4 Mgd
(c) – 4/3Mgd (d) 4/3 Mgd

26. Work done by static friction on an object:

(a) may be positive
(b) must be negative
(c) must be zero
(d) none of these

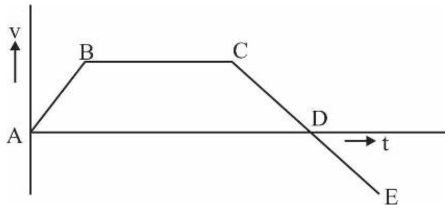
27. Starting at rest, a 5 kg object is acted upon by only one force as indicated in figure. Find the total work done by the force.



(a) 180 J (b) 60 J
(c) 150 J (d) 90 J

28. The plot of velocity versus time is shown in the figure, A varying force acts on the body. The correct statement(s) among the following is(are)

(a) In moving from A to B, work done on the body is negative
(b) In moving from B to C, no work is done on the body
(c) In moving from C to D, work done by the force on the body is positive.
(d) In moving from D to E, work done by force on the body is positive.



29. A particle of mass 100g is thrown vertically upwards with a speed of 5 m/s. The work done by the force of gravity during the time the particle goes up is

(a) – 0.5J (b) – 1.25 J
(c) 1.25 J (d) 0.5 J

Expert **Calculation of Work**

30. When a rubber-band is stretched by a distance x, it exerts restoring force of magnitude F = ax + bx^2 where a and b are constants. The work done in stretching the unscratched rubber-band by L is:

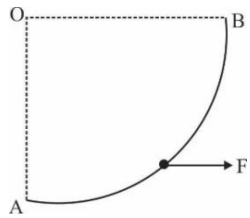
(a) $aL^2 + bL^3$ (b) $\frac{1}{2}(aL^2 + bL^3)$

(c) $\frac{aL^2}{2} + \frac{bL^3}{3}$ (d) $\frac{1}{2}\left(\frac{aL^2}{2} + \frac{bL^3}{3}\right)$

31. A box weighing 2000 N is to be slowly slid through 20 m on a straight track having friction coefficient 0.2 with the box. (a) Find the work done by the person pulling the box with a chain at an angle θ with the horizontal. (b) Find the work when the person has chosen a value of θ which ensures him the minimum magnitude of the force.

32. A block of weight 100 N is slowly slid up on a smooth incline of inclination 37° by a person. Calculate the work done by the person in moving the block through a distance of 2.0 m, if the driving force is (a) parallel to the incline and (b) in the horizontal direction.

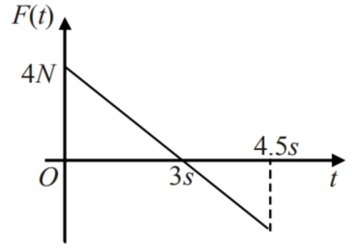
33. The figure shows a smooth circular path of radius R in the vertical plane which subtends an angle $\frac{\pi}{2}$ at O. A block of mass m is taken from position A to B under the action of a constant horizontal force F.



(a) Find the work done by this force.

(b) In part (a), if the block is being pulled by a force F of constant magnitude which is always tangential to the surface, find the work done by the force F between A and B.

34. A block of mass 2kg is free to move along the x-axis. It is at rest and from t = 0 onwards it is the subjected to a time dependent force F(t) in the x-direction. The force F(t) varies with t as shown in the figure. The kinetic energy of the block after 4.5seconds is



(a) 4.50J (b) 7.5J
(c) 5.06J (d) 14.06J

Pro **Calculation of Work**

35. The displacement x of a particle moving in one dimension under the action of a constant force is related to time 't' by equation $t=\sqrt{x}+3$, where x is in meter and t in sec. Calculate:

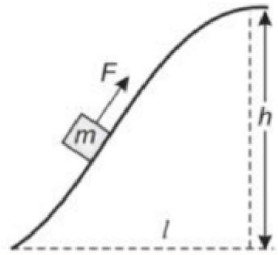
(a) the displacement of the particle when its velocity is zero.

(b) the work done by the force in the first 6 sec.

36. A particle has shifted along some trajectory in the plane xy from point 1 whose radius vector r_1 = i + 2j to point 2 with the radius vector r_2 =2i -3j. During that time the particle experienced the action of certain forces, one of which being F = 3i + 4j. Find the work performed by the force F. (Here r_1, r_2 and fare given in SI units).

37. A locomotive of mass m starts moving so that its velocity varies according to the law $v=a\sqrt{s}$, where a is a constant, and s is the distance covered. Find the total work performed by all the forces which are acting on the locomotive during the first t seconds after the beginning of motion.

38. A body of mass m was slowly hauled up the hill (Fig.) by a force F which at each point was directed along a tangent to the trajectory. Find the work performed by this force, if the height of the hill is h, the length of its base l, and the coefficient of friction k.

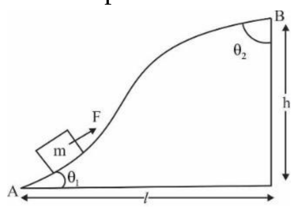


39. A disc of mass m = 50 g slides with the zero initial velocity down an inclined plane set at an angel $\alpha=30°$ to the horizontal; having traversed the distance l=50cm along the horizontal plane, the disc stops. Find the work performed by the friction forces over the whole distance, assuming the friction coefficient k = 0.15 for both inclined and horizontal planes.

40. A chain of mass m =0.80 kg and length l = 1.5 m rests on a rough-surfaced table so that one of its ends hangs over the edge. The chain starts sliding off the table all by itself provided the overhanging part equals $\eta=\frac{1}{3}$ of the chain length. What will be the total work performed by the friction forces?

41. A small body of mass m = 0.10 kg moves in the reference frame rotating about a stationary axis with a constant angular velocity $\omega=5.0\text{rads}^{-1}$. What work does the centrifugal force of inertia perform during the transfer of this body along an arbitrary path from point 1 to 2 which are located at the distances r_1 = 30 cm and r_2 = 50 cm from the rotation axis?

42. A block of mass m is slowly carried on a inclined plane by a force F which always acts along the tangent to the plane. If the co-efficient of friction between the block and the inclined plane be μ, then work done by force of friction while carrying block from bottom of the plane to the top will be:



(a) Dependent on the actual shape of the path between point A and B.

(b) will have a total positive value.

(c) will not change if force F is not applied along the tangent to the plane always.

(d) Independent of the actual shape of the path between points A and B.

43. A 500 kg elevator cab is descending with speed v_o = 4 m/s when the winch system that lowers it begins to slip, allowing it to fall with a constant acceleration a = g/5, During its fall through a distance 12 m, the total work done on the elevator cab is (Take g = 10 m/s^2)

(a) 60 kJ (b) –40 kJ
(c) 12 kJ (d) 100 kJ

44. A force $\vec{F} = -k(x\hat{\imath} + y\hat{\jmath})$, where k is a positive constant, acts on a particle moving in the x-y plane. Starting from the origin, the particle is taken along the positive x-axis to the point (a,0) and then parallel to the y-axis to the point(a, a).

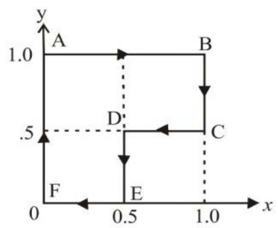
(a) work done by the force in moving particle along x-axis is $-\frac{1}{2}ka^2$

(b) work done by the force in moving particle along x-axis is $-ka^2$

(c) work done by the force in moving particle along y-axis is $-\frac{1}{2}ka^2$

(d) Total work done by the force for overall motion is $-ka^2$

45. A particle is moved along a path AB-BC-CD-DE-EF-FA, as shown in figure, in presence of a forced $\vec{F} = (\alpha y\hat{\imath} + 2\alpha x\hat{\jmath})$N, where x and y are in meter and α = -1 Nm^{-1}. The work done on the particle by this force $\vec{F}$ will be______ joule



Beginner **Energy**

46. A spring of force constant 10 *N*/*m* has an initial stretch 0.20 *m*. In changing the stretch to 0.25 *m*, the increase in potential energy is about

(a) 0.1 *joule* (b) 0.2 *joule*
(c) 0.3 *joule* (d) 0.5 *joule*

47. The potential energy of a certain spring when stretched through a distance '*S*' is 10 *joule*. The amount of work (in joule) that must be done on this spring to stretch it through an additional distance '*S*' will be

(a) 30 (b) 40
(c) 10 (d) 20

48. A spring 40 *mm* long is stretched by the application of a force. If 10 *N* force required to stretch the spring through 1 *mm*, then work done in stretching the spring through 40 *mm* is

(a) 84 *J* (b) 68 *J*
(c) 23 *J* (d) 8 *J*

49. When a 1.0*kg* mass hangs attached to a spring of length 50 *cm*, the spring stretches by 2 *cm*. The mass is pulled down until the length of the spring becomes 60 *cm*. What is the amount of elastic energy stored in the spring in this condition, Take *g* = 10 m/s^2

(a) 1.5 *Joule* (b)2.0*Joule*
(c) 2.5 *Joule* (d) 3.0 *Joule*

50. A body of mass 5kg initially at rest, is subjected to a force of 40N. Find the kinetic energy acquired by the body at the end of 5 seconds

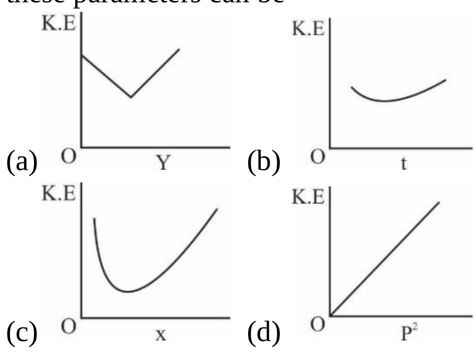
(a) 4000 J (b) 6000 J
(c) 6249 J (d) 6145 N

51. A spring of spring constant 5 x 10^3 N/m is stretched initially by 5cm from the unscratched position. Then the work required to stretch it further by another 5 cm is

(a) 12.50 N-m (b) 18.75 N-m
(c) 25.00 N-m (d) 6.25 N-m

Expert **Energy**

52. A heavy particle is projected up from a point at an angle with the horizontal. At any instant 't', if p = linear momentum, y = vertical displacement, x = horizontal displacement, then the kinetic energy of the particle plotted against these parameters can be



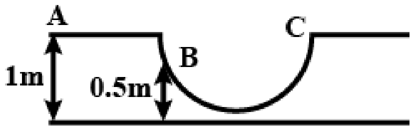
53. A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement x is proportional to

(a) x (b) e^x
(c) x^2 (d) $\log e^x$

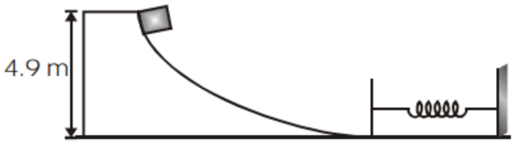
Beginner **Work & Energy**

54. A body of mass m is dropped from *a* height H reaches ground with *a* speed of $1.2\sqrt{gH}$. Calculate the work done by air Friction.

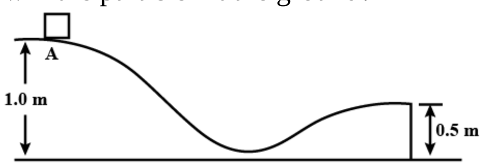
55. A particle is placed at the point A of a frictionless track ABC as shown in figure. It is pushed slightly towards right. Find its speed when it reaches the point B. Take g = 10 m/s^2.



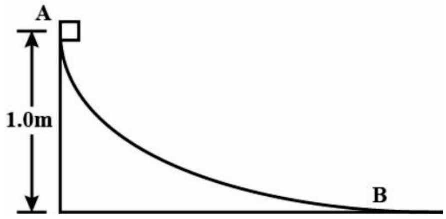
56. Figure shows a smooth curved track terminating in a smooth horizontal part. A spring of spring constant 400N/m is attached at one end to a wedge fixed rigidly with the horizontal part. A 40 g mass is released from rest at a height of 4.9 m on the curved track. Find the maximum compression of the spring.



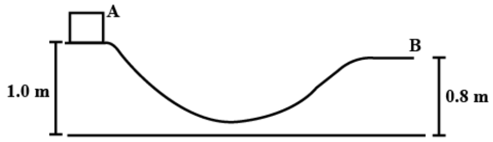
57. Figure shows a particle sliding on a frictionless track which terminates in a straight horizontal section. If the particle starts slipping from the point A, how far away from the track will the particle hit the ground?



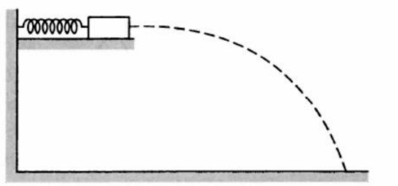
58. A block weighing 10 N travels down a smooth curved track *AB* joined to a rough horizontal surface. The rough surface has a friction coefficient of 0.20 with the block. If the block starts slipping on the track from a point 1.0 0m above the horizontal surface, how far will it move on the rough surface?



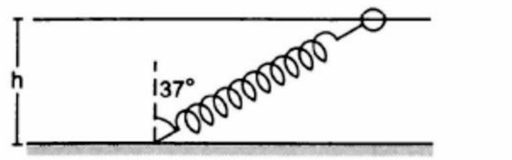
59. A block of mass 1 kg is placed at the point A of a rough track shown in figure. If slightly pushed towards right, it stops at the point B of the track. Calculate the work done by the frictional force on the block during its transit from A to B.



60. A small block of mass 100 g is pressed against a horizontal spring fixed at one end to compress the spring through 5.0 cm. The spring constant is 100 N/m. When released, the block moves horizontally till it leaves the spring. Where will it hit the ground 2 m below the spring?



61. One end of a spring of natural length *h* and spring constant *k* is fixed at the ground and the other is fitted with a smooth ring of mass *m* which is allowed to slide on a horizontal rod fixed at a height *h*. Initially, the spring makes an angle of 37° with the vertical when the system is released from rest. Find the speed of the ring when the spring becomes vertical.



62. If the kinetic energy of a body is directly proportional to time t, the magnitude of the force acting on the body is:

(a) directly proportional to $\sqrt{t}$

(b) inversely proportional to $\sqrt{t}$