1

Physical World, Units and Measurements

Numerical

Q.1 The diameter of a spherical bob is measured using a vernier callipers. 9 divisions of the main scale, in the vernier callipers, are equal to 10 divisions of vernier scale. One main scale division is 1 mm. The main scale reading is 10 mm and 8^{th} division of vernier scale was found to coincide exactly with one of the main scale division If the given vernier callipers has positive zero error of 0.04 cm, then the radius of the bob is __________ ×× 10^{-2} cm.

31st Aug Evening Shift 2021

Q.2 The acceleration due to gravity is found upto an accuracy of 4% on a planet. The energy supplied to a simple pendulum to known mass 'm' to undertake oscillations of time period T is being estimated. If time period is measured to an accuracy of 3%, the accuracy to which E is known as ....%

31st Aug Evening Shift 2021

Q.3 A 16 Ω wire is bend to form a square loop. A 9V supply having internal resistance of 1Ω is connected across one of its sides. The potential drop across the diagonals of the square loop is ______________ ×× 10^{-1} V

25th July Evening Shift 2021

Q.4 Student A and student B used two screw gauges of equal pitch and 100 equal circular divisions to measure the radius of a given wire. The actual value of the

radius of the wire is 0.322 cm. The absolute value of the difference between the final circular scale readings observed by the students A and B is ____________.
[Figure shows position of reference 'O' when jaws of screw gauge are closed]

Given pitch = 0.1 cm.

25th July Morning Shift 2021

Q.5 Three students S_1, S_2 and S_3 perform an experiment for determining the acceleration due to gravity (g) using a simple pendulum. They use different lengths of pendulum and record time for different number of oscillations. The observations are as shown in the table.

Student No.	Length of Pendulum (cm)	No. of oscillations (n)	Total time for n oscillations	Time period (s)
1	64.0	8	128.0	16.0
2	64.0	4	64.0	16.0
3	20.0	4	36.0	9.0

(Least count of length = 0.1 cm and Least count for time = 0.1 s)
If E_1, E_2 and E_3 are the percentage errors in 'g' for students 1, 2 and 3 respectively, then the minimum percentage error is obtained by student no. ____________.

22th July Evening Shift 2021

Q.6 The radius of a sphere is measured to be (7.50 ±± 0.85) cm. Suppose the percentage error in its volume is x.
The value of x, to the nearest x, is ________.

18th Mar Evening Shift 2021

Q.7

The resistance R = $\frac{V}{I}$, where V = (50 $\pm$ 2)V and I = (20 $\pm$ 0.2)A. The percentage error in R is 'x'%. The value of 'x' to the nearest integer is __________.

16th Mar Morning Shift 2021

Numerical Answer Key

1. Ans. (52)
2. Ans. (14)
3. Ans. (45)
4. Ans. (13)
5. Ans. (1)
6. Ans. (34)
7. Ans. (5)

Numerical Explanation

Ans. 1

9 MSD = 10 VSD

9 $\times$ 1 mm = 10 VSD

$\therefore$ 1 VSD = 0.9 mm

LC = 1 MSD $-$ 1 VSD = 0.1 mm

Reading = MSR + VSR $\times$ LC

10 + 8 $\times$ 0.1 = 10.8 mm

Actual reading = 10.8 $-$ 0.4 = 10.4 mm

radius = $\frac{d}{2} = \frac{10.4}{2}$ = 5.2 mm

= 52 $\times$ 10^{-2} cm

Ans 2.

$$T = 2\pi\sqrt{\frac{l}{g}} \Rightarrow l = \frac{T^2 g}{4\pi^2}$$

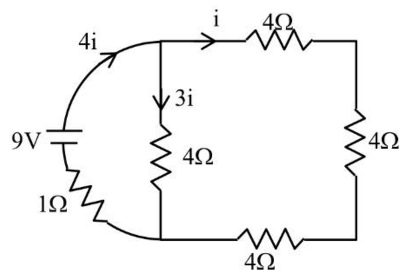
$$E = mgl\frac{\theta^2}{2} = mg^2\frac{T^2\theta^2}{8\pi^2}$$

$$\frac{dE}{E} = 2\left(\frac{dg}{g} + \frac{dT}{T}\right)$$

$$= (4 + 3) = 14\%$$

Ans 3.

Here assume current as



By KVL in outer loop

$9 - 12i - 4i = 0$

$16i = 9$

$8i = \frac{9}{2} = 4.5$

$= 45 \times 10^{-1}$

Ans 4.

For (A)

Reading = MSR + CSR + Error

0.322 = 0.300 + CSR + 5 ×× LC

0.322 = 0.300 + CSR + 0.005

CSR = 0.017

For (B)

Reading = MSR + CSR + Error

0.322 = 0.200 + CSR + 0.092

CSR = 0.030

Difference = 0.030 −− 0.017 = 0.013 cm

Division on circular scale = $\frac{0.013}{0.001} = 13$

Ans 5.

$$T = \frac{t}{n} = 2\pi\sqrt{\frac{l}{g}}$$

$$\Rightarrow g = \frac{4\pi^2 l}{T^2}$$

$$\Rightarrow \frac{\Delta g}{g} \times 100 = \frac{\Delta l}{l} \times 100 + 2\frac{\Delta T}{T} \times 100$$

$$= \left(\frac{\Delta l}{l} + \frac{2\Delta T}{T}\right) 100\%$$

$$E_1 = \frac{20}{64}\%$$

$$E_2 = \frac{30}{64}\%$$

$$E_3 = \frac{19}{18}\%$$

Ans 6.

Given, radius of sphere = (7.50 $\pm$ 0.85) cm

$\therefore$ r = 7.50 and dr = 0.85

We know, volume of a sphere $v = \frac{4}{3}\pi r^3$

taking log both sides, we get

$$\ln v = \ln \frac{4\pi}{3} + 3 \ln r$$

Differentiating both sides,

$$\frac{dv}{v} = 0 + 3\frac{dr}{r}$$

$\therefore$ Fractional error in volume $\frac{dv}{v} = 3\frac{dr}{r}$

$\therefore$ % error in volume,

$\frac{dv}{v} \times 100 = 3\frac{dr}{r} \times 100$

$= 3 \times \frac{0.85}{7.50} \times 100$

= 34%

Ans 7.

$R = \frac{V}{I}$

$\frac{\Delta R}{R} \times 100 = \frac{\Delta V}{V} \times 100 + \frac{\Delta I}{I} \times 100$

% error in $R = \frac{2}{50} \times 100 + \frac{0.2}{20} \times 100$

% error in R = 4 + 1

$\therefore$ % error in R = 5%

MCQ (Single Correct Answer)

Q.1. A student determined Young's Modulus of elasticity using the formula $Y = \frac{MgL^3}{4bd^3\delta}$. The value of g is taken to be 9.8 m/s^2, without any significant error, his observation are as following.

Physical Quantity	Least count of the Equipment used for measurement	Observed value
Mass (M)	1 g	2 kg

Physical Quantity	Least count of the Equipment used for measurement	Observed value
Length of bar (L)	1 mm	1 m
Breadth of bar (b)	0.1 mm	4 cm
Thickness of bar (d)	0.01 mm	0.4 cm
Depression (δδ)	0.01 mm	5 mm

Then the fractional error in the measurement of Y is :

A 0.0083

B 0.0155

C 0.155

D 0.083

1st Sep Evening Shift 2021

Q.2 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 $[FTV^{-1}]$

C $[FT^2 V]$

D $[FVT^{-1}]$

31st Aug Evening Shift 2021

Q.3 Which of the following equations is dimensionally incorrect?
Where t = time, h = height, s = surface tension, θ= angle, ρ = density, a, r = radius, g = acceleration due to gravity, v = volume, p = pressure, W = work done, T = torque, ∈∈ = permittivity, E = electric field, J = current density, L = length.

A $v = \frac{\pi p a^4}{8\eta L}$

B $h = \frac{2s\cos\theta}{\rho r g}$

C $J = \in \frac{\partial E}{\partial t}$

D $W = \Gamma\theta$

31st Aug Morning Shift 2021

Q.4 Match List - I with List - II.

	List - I		List - II
(a)	Torque	(i)	MLT^{-1}
(b)	Impulse	(ii)	MT^{-2}
(c)	Tension	(iii)	ML^2T^{-2}
(d)	Surface Tension	(iv)	MLT^{-2}

Choose the most appropriate answer from the option given below :

A (a)-(iii), (b)-(i), (c)-(iv), (d)-(ii)

B (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)

C (a)-(i), (b)-(iii), (c)-(iv), (d)-(ii)

D (a)-(iii), (b)-(iv), (c)-(i), (d)-(ii)

31st Aug Morning Shift 2021

Q.5 An object is placed at the focus of concave lens having focal length f. What is the magnification and distance of the image from the optical centre of the lens?

A) 1, ∞

B) Very high, ∞

C) $\frac{1}{2}, \frac{f}{2}$

D) $\frac{1}{4}, \frac{f}{4}$

31st Aug Morning Shift 2021

Q.6 If force (F), length (L) and time (T) are taken as the fundamental quantities. Then what will be the dimension of density :

A) $[FL^{-4}T^2]$

B) $[FL^{-3}T^2]$

C) $[FL^{-5}T^2]$

D) $[FL^{-3}T^3]$

27st Aug Evening Shift 2021

Q.7 Match List - I with List - II.

	List - I		List - II
(a)	R_H (Rydberg constant)	(i)	$kg m^{-1} s^{-1}$
(b)	h (Planck's constant)	(ii)	$kg m^2 s^{-1}$
(c)	μ_B (Magnetic field energy density)	(iii)	m^{-1}
(d)	η (coefficient of viscocity)	(iv)	$kg m^{-1} s^{-2}$

Choose the most appropriate answer from the options given below :

A (a)-(ii), (b)-(iii), (c)-(iv), (d)-(i)

B (a)-(iii), (b)-(ii), (c)-(iv), (d)-(i)

C (a)-(iv), (b)-(ii), (c)-(i), (d)-(iii)

D (a)-(iii), (b)-(ii), (c)-(i), (d)-(iv)

27st Aug Evening Shift 2021

Q.8 If E and H represents the intensity of electric field and magnetising field respectively, then the unit of E/H will be :

A ohm

B mho

C joule

D newton

27st Aug Morning Shift 2021

Q.9 Which of the following is not a dimensionless quantity?

(A) Relative magnetic permeability (μ_r)

(B) Power factor

(C) Permeability of free space (μ_0)

(D) Quality factor

27st Aug Morning Shift 2021

Q.10 If the length of the pendulum in pendulum clock increases by 0.1%, then the error in time per day is :

(A) 86.4 s

(B) 4.32 s

(C) 43.2 s

(D) 8.64 s

26st Aug Evening Shift 2021

Q.11 Match List - I with List – II

List-I		List-II	
(a)	Magnetic Induction	(i)	$ML^2T^{-2}A^{-1}$
(b)	Magnetic Flux	(ii)	$M^0L^{-1}A$
(c)	Magnetic Permeability	(iii)	$MT^{-2}A^{-1}$
(d)	Magnetization	(iv)	$MLT^{-2}A^{-2}$

Choose the most appropriate answer from the options given below :

A (a)-(ii), (b)-(iv), (c)-(i), (d)-(iii)

B (a)-(ii), (b)-(i), (c)-(iv), (d)-(iii)

C (a)-(iii), (b)-(ii), (c)-(iv), (d)-(i)

D (a)-(iii), (b)-(i), (c)-(iv), (d)-(ii)

26st Aug Evening Shift 2021

Q.12 If E, L, M and G denote the quantities as energy, angular momentum, mass and constant of gravitation respectively, then the dimensions of P in the formula $P = EL^2M^{-5}G^{-2}$ are :

A $[M^0 L^1 T^0]$

B $[M^{-1} L^{-1} T^2]$

C $[M^1 L^1 T^{-2}]$

D $[M^0 L^0 T^0]$

26st Aug Morning Shift 2021

Q.13 In a Screw Gauge, fifth division of the circular scale coincides with the reference line when the ratchet is closed. There are 50 divisions on the circular scale, and the main scale moves by 0.5 mm on a complete rotation. For a particular observation the reading on the main scale is 5 mm and the 20th division of the circular scale coincides with reference line. Calculate the true reading.

A 5.00 mm

B 5.25 mm

C 5.15 mm

D 5.20 mm

26st Aug Evening Shift 2021

Q.15

A physical quantity 'y' is represented by the formula $y = m^2 r^{-4} g^x l^{-\frac{3}{2}}$

If the percentage errors found in y, m, r, l and g are 18, 1, 0.5, 4 and p respectively, then find the value of x and p.

(A) 5 and ± 2

(B) 4 and ± 3

(C) $\frac{16}{3}$ and $\pm\frac{3}{2}$

(D) 8 and $\pm$ 2

27st July Evening Shift 2021

Q.16 The vernier scale used for measurement has a positive zero error of 0.2 mm. If while taking a measurement it was noted that '0' on the vernier scale lies between 8.5 cm and 8.6 cm, vernier coincidence is 6, then the correct value of measurement is _________ cm. (least count = 0.01 cm)

(A) 8.58 cm

(B) 8.54 cm

(C) 8.56 cm

(D) 8.36 cm

17th March Morning Shift 2021

Q.17 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 cm) and length 1m (measured using a scale of least count = 1 mm), a weight of mass 1 kg (measured using a scale of least count = 1 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 0.14%

B 9%

C 1.4%

D 0.9%

16th March Evening Shift 2021

Q.18 One main scale division of a vernier callipers is 'a' cm and n^{th} division of the vernier scale coincide with $(n - 1)^{th}$ division of the main scale. The least count of the callipers in mm is :

A $\frac{10a}{n}$

B $\frac{10na}{(n-1)}$

C $\left(\frac{n-1}{10n}\right)a$

D $\frac{10a}{(n-1)}$

16th March Morning Shift 2021

Q.19 If 'C' and 'V' represent capacity and voltage respectively then what are the dimensions of λλ where C/V = λ ?

A $[M^{-3}L^{-4}I^{3}T^{7}]$

B $[M^{-2}L^{-3}I^{2}T^{6}]$

C $[M^{-2}L^{-4}I^{3}T^{7}]$

D $[M^{-1}L^{-3}I^{-2}T^{-7}]$

26th Feb Evening Shift 2021

Q.20 In a typical combustion engine the workdone 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 $[M^{0}LT^{0}]$

B $[MLT^{-1}]$

C $[MLT^{-2}]$

D $[M^{2}LT^{-2}]$

26th Feb Morning Shift 2021

Q.20 If e is the electronic charge, c is the speed of light in free space and h is Planck's constant, the

quantity $\frac{1}{4\pi\varepsilon_0}\frac{|e|^2}{hc}$ has dimensions of :

A $[MLT^{-1}]$

B $[MLT^{0}]$

C $[M^{0}L^{0}T^{0}]$

D $[LC^{-1}]$

25th Feb Evening Shift 2021

Q.21 Match List - I with List - II :

	List I		List II
(a)	h (Planck's constant)	(i)	$[MLT^{-1}]$
(b)	E (kinetic energy)	(ii)	$[ML^{2}T^{-1}]$
(c)	V (electric potential)	(iii)	$[ML^{2}T^{-2}]$
(d)	P (linear momentum)	(iv)	$[ML^{2}I^{-1}T^{-3}]$

Choose the correct answer from the options given below :

A (a) $\rightarrow$ (ii), (b) $\rightarrow$ (iii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (i)

B (a) $\rightarrow$ (i), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (iii)

C (a) $\rightarrow$ (iii), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (i)

D (a) $\rightarrow$ (iii), (b) $\rightarrow$ (iv), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (i)

25th Feb Morning Shift 2021

Q.22 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%

24th Feb Evening Shift 2021

Q.23 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. αα and ββ are constants. Then the dimensions of ββ will be:

(A) $[M^0LT^0]$

(B) $[ML^2T^{-2}]$

(C) $[MLT^{-2}]$

(D) $[M^2LT^2]$

24th Feb Morning Shift 2021

MCQ Answer Key

1. Ans. (B)	**10. Ans.** (c)	**19. Ans.** (a)
2. Ans. (B)	**11. Ans.** (d)	**20. Ans.** (c)

3. **Ans.** (a)
4. **Ans.** (a)
5. **Ans.** (c)
6. **Ans.** (a)
7. **Ans.** (B)
8. **Ans.** (a)
9. **Ans.** (c)
12. **Ans.** (d)
13. **Ans.** (c)
14. **Ans.** (c)
15. **Ans.** (b)
16. **Ans.** (c)
17. **Ans.** (a)
18. **Ans.** (c)
21. **Ans.** (a)
22. **Ans.** (c)
23. **Ans.** (c)

MCQ Explanation

Ans 1.

$$y = \frac{MgL^3}{4bd^3\delta}$$

$$\frac{\Delta y}{y} = \frac{\Delta M}{M} + \frac{3\Delta L}{L} + \frac{\Delta b}{b} + \frac{3\Delta d}{d} + \frac{\Delta \delta}{\delta}$$

$$\frac{\Delta y}{y} = \frac{10^{-3}}{2} + \frac{3\times10^{-3}}{1} + \frac{10^{-2}}{4} + \frac{3\times10^{-2}}{4} + \frac{10^{-2}}{5}$$

$$= 10^{-3}[0.5 + 3 + 2.5 + 7.5 + 2] = 0.0155$$

Ans 2.

$[M] = K[F]^a [T]^b [V]^c$

$[M^1] = [M^1L^1T^{-2}]^a [T^1]^b [L^1T^{-1}]^c$

$a = 1, b = 1, c = -1$

$\therefore [M] = [FTV^{-1}]$

Ans 3.

(a) $\frac{\pi p a^4}{8\eta L} = \frac{dv}{dt}$ = Volumetric flow rate (Poiseuille's law)

(b) $h\rho g = \frac{2s}{r}\cos\theta$

(c) $\varepsilon \times \frac{1}{4\pi\varepsilon_0}\frac{a}{r^2} \times \frac{1}{\varepsilon} = \frac{q}{t} \times \frac{1}{r^2}$

$= \frac{1}{L^2} = IL^{-2}$

LHS

$T = \frac{I}{A} = IL^{-2}$

(d) W = $\tau\theta$

Ans 4.

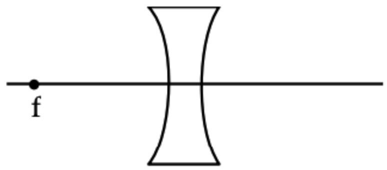
torque $\tau \rightarrow ML^2T^{-2}$ (iii)

Impulse I $\Rightarrow MLT^{-1}$ (i)

Tension force $\Rightarrow MLT^{-2}$ (iv)

Surface tension $\Rightarrow MT^{-2}$ (ii)

Ans 5.



U = –f

$\frac{1}{V} - \frac{1}{U} = \frac{1}{-f} \Rightarrow \frac{1}{V} = -\frac{2}{f}$

$V = \frac{-f}{2}$

$m = \frac{V}{U} = \frac{1}{2}$

distance = $\frac{f}{2}$

Ans 6.

Density = $[F^aL^bT^c]$

$[ML^{-3}] = [M^aL^{a+b}T^{-2a}L^bT^c]$

$[M^1L^{-3}] = [M^aL^{a+b}T^{-2a+c}]$

$a = 1 \quad ; \quad a + b = -3 \quad ; \quad -2a + c = 0$

$1 + b = -3 \qquad c = 2a$

$b = -4 \qquad c = 2$

So, density = $[F^1L^{-4}T^2]$

Ans 7.

SI unit of Rydberg const. = m^{-1}

SI unit of Plank's const. = kg m^2s^{-1}

SI unit of Magnetic field energy density = kg $m^{-1}s^{-2}$

SI unit of coeff. of viscosity = kg $m^{-1}s^{-1}$

Ans 8.

Unit of $\frac{E}{H}$ is $\frac{volt/metre}{Ampere/metre} = \frac{volt}{Ampere} = ohm$

Ans 9.

$[\mu_r]$ = 1 as $\mu_r = \frac{\mu}{\mu_m}$

[power factor (cos ϕ)] = 1

$\mu_0 = \frac{B_0}{H}$ (unit = NA^{-2}) : Not dimensionless

$[\mu_0] = [MLT^{-2}A^{-2}]$

quality factor $(Q) = \frac{Energy\ stored}{Energy\ dissipated\ per\ cycle}$

So Q is unitless & dimensionless.

Ans 10.

$$T = 2\pi\sqrt{\frac{l}{g}}$$

$$\frac{\Delta T}{T} = \frac{1}{2}\frac{\Delta l}{l}$$

$$\Delta T = \frac{1}{2} \times \frac{0.1}{100} \times 24 \times 3600$$

$$\Delta T = 43.2$$

Ans 11.

(a) Magnetic Induction = $MT^{-2}A^{-1}$

(b) Magnetic Flux = $ML^{2}T^{-2}A^{-1}$

(c) Magnetic Permeability = $MLT^{-2}A^{-2}$

(d) Magnetization = $M^{0}L^{-1}A$

Ans 12.

E = $ML^{2}T^{-2}$

L = $ML^{2}T^{-1}$

m = M

G = $M^{-1}L^{+3}T^{-2}$

P = $\frac{EL^2}{M^5G^2}$

[P] = $\frac{(ML^2T^{-2})(M^2L^4T^{-2})}{M^5(M^{-2}L^6T^{-4})} = M^0L^0T^0$

Ans 13.

Least count (L. C.) = $\frac{0.5}{50}$

True reading = $5+\frac{0.5}{50}\times 20-\frac{0.5}{50}\times 5$

$=5+\frac{0.5}{50}(15)=5.15$ mm

Ans 14.

$\frac{\Delta y}{y}=\frac{2\Delta m}{m}+\frac{4\Delta r}{r}+\frac{x\Delta g}{g}+\frac{3}{2}\frac{\Delta l}{l}$

$18=2(1)+4(0.5)+xp+\frac{3}{2}(4)$

$\Rightarrow$ 8 = xp

By checking from options.

$x=\frac{16}{3}, p=\pm\frac{3}{2}$

Ans 15.

Reading = MSR + VSD $\times$ LC $-$ zero error

Reading = 8.5 + $\frac{(0.1)\times 6}{10}-\frac{0.2}{10}=8.54$ cm

Ans 16.

$\frac{\Delta Y}{Y}=\left(\frac{\Delta m}{m}\right)+\left(\frac{\Delta g}{g}\right)+\left(\frac{\Delta A}{A}\right)+\left(\frac{\Delta l}{l}\right)+\left(\frac{\Delta L}{L}\right)$

$=\left(\frac{1g}{1kg}\right)+0+2\left(\frac{\Delta r}{r}\right)+\left(\frac{\Delta l}{l}\right)+\left(\frac{\Delta L}{L}\right)$

$=\left(\frac{1g}{1kg}\right)+2\left(\frac{0.001cm}{0.2cm}\right)+\left(\frac{0.001cm}{0.5cm}\right)+\left(\frac{0.001m}{1m}\right)$

$=\left(\frac{1}{1000}\right)+2\left(\frac{1\times 10}{2\times 10^{3}}\right)+\left(\frac{1}{5}\times\frac{10^{2}}{10^{3}}\right)+\left(\frac{1}{10^{3}}\right)$

$= \frac{1}{1000} + \frac{1}{100} + \frac{2}{10^3} + \frac{1}{10^3}$

$= \frac{1+10+2+1}{1000} = \frac{14}{1000} \times 100\%$

$= 1.4\%$

Ans 17.

n VSD = (n – 1) MSD

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

L.C. = 1 MSD – 1 VSD

= 1 MSD – $\left(\frac{n-1}{n}\right)$MSD

= 1 MSD – 1 MSD + $\frac{MSD}{n}$

= $\frac{MSD}{n}$

= $\frac{a}{n}$ cm

= $\frac{10a}{n}$ mm

Ans 18.

$\lambda = \frac{C}{V} = \frac{Q/V}{V} = \frac{Q}{V^2}$

$V = \frac{work}{Q}$

$\lambda = \frac{Q^3}{(work)^2} = \frac{(It)^3}{(F.s)^2}$

$= \frac{[I^3T^3]}{[ML^2T^{-2}]^2} = [M^{-2}L^{-4}I^3T^7]$

Ans 19.

kT has dimension of energy

$\frac{\beta x^2}{kT}$ is dimensionless

$[\beta][L^2] = [ML^2T^{-2}]$

$[\beta] = [MT^{-2}]$

$\alpha^2\beta$ has dimensions of work

$[\alpha^2][MT^{-2}] = [ML^2T^{-2}]$

$[\alpha] = [M^0LT^0]$

Ans 20.

Given

e = electronic charge

c = speed of light in free space

h = Planck's constant

We know, E = $\frac{hc}{\lambda}$

and $F = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{d^2} \Rightarrow \frac{q^2}{4\pi\varepsilon_0} = Fd^2$

$\frac{1}{4\pi\varepsilon_0}\frac{e^2}{hc}$

= $\frac{Fd^2}{E\lambda}$

= $\frac{Fd.d}{E\lambda}$

= $\frac{d}{\lambda}$

$=$ dimensionless

$= [M^0L^0T^0]$

Ans 21.

Kinetic Energy,

$\frac{1}{2}mv^2 = [ML^2T^{-2}]$

Momentum,

$mv = [MLT^{-1}]$

Plank constant :

$E = h\gamma$

$\Rightarrow ML^2T^{-2} = h \times \frac{1}{T}$

$\Rightarrow h = [ML^2T^{-1}]$

Also, $E = qV$

$\Rightarrow V = \frac{[ML^2T^{-2}]}{[C]} = [ML^2T^{-2}C^{-1}]$

Ans 22.

Given, $T = 2\pi\sqrt{\frac{L}{g}}$ .... (i)

where, time period, T = 1.95 s

Length of string, l = 1 m

Acceleration due to gravity = g

Error in time period, ΔT = 0.01 s = 10^{-2} s

Error in length, ΔL = 1 mm = 1 $\times$ 10^{-3} m

Squaring Eq. (i) on both sides, we get

$T^2 = 4\pi^2\frac{L}{g}$

$\Rightarrow g = 4\pi^2\frac{L}{T^2}$

$\Rightarrow \frac{\Delta g}{g} = \frac{\Delta L}{L} + \frac{2\Delta T}{T} = \frac{10^{-3}}{1} + \frac{2\times10^{-2}}{1.95}$

Ans 23.

where, k is Boltzmann constant,

T is temperature and x is displacement.

$\therefore \left[\frac{x^2}{\alpha kT}\right] = [M^0L^0T^0] \Rightarrow [\alpha] = \frac{[x^2]}{[k][T]}$

$\Rightarrow [\alpha] = \frac{[L^2]}{[k][T]}$ ..... (i)

Since, dimensions of k are

$[k] = [M^1L^2T^{-2}K^{-1}]$ ...... (ii)

Dimensions of temperature are

$[T] = [K]$ ..... (iii)

Substituting Eqs. (ii) and (iii) in Eq. (i), we get

$[\alpha] = \frac{[L^2]}{[M^1L^2T^{-2}K^{-1}][K]}$

$[\alpha] = [M^{-1}T^2]$

According to dimensional analysis,

$[W] = [\alpha\beta^2]$

$\Rightarrow [\beta^2] = \frac{[W]}{[\alpha]}$

$\Rightarrow [\beta^2] = \frac{M^1L^2T^{-2}]}{[M^{-1}T^2]} = [M^2L^2T^{-4}]$

$\Rightarrow [\beta] = [MLT^{-2}]$

MCQ (Single Correct Answer)

Q.1 Statement I:

Two forces $\left(\vec{P}+\vec{Q}\right)$ and $\left(\vec{P}-\vec{Q}\right)$ where $\vec{P}\perp\vec{Q}$, hen act at an angle θ$_1$ to each other, the magnitude of their resultant is $\sqrt{3(P^2+Q^2)}$, when they act at an angle θθ$_2$, the magnitude of their resultant becomes $\sqrt{2(P^2+Q^2)}$. This is possible only when θ1<θ2

Statement II:

In the situation given above.

$\theta_1 = 60^\circ$ and $\theta_2 = 90^\circ$
In the light of the above statements, choose the most appropriate answer from the options given below :-

A. Statement I is false but Statement II is true

B. Both Statement I and Statement II are true

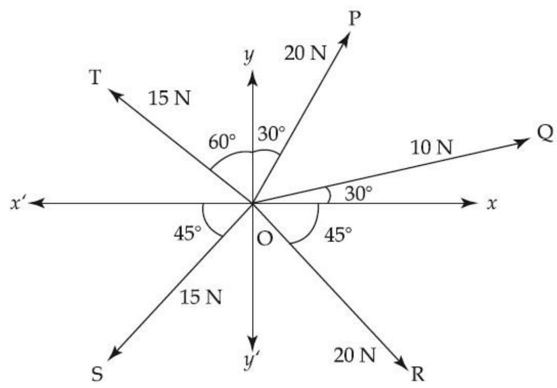
C. Statement I is true but Statement II is false

D. Both Statement I and Statement II are false.

31st Aug Evening Shift 2021

Q.2 The resultant of these forces $\overrightarrow{OP}, \overrightarrow{OQ}, \overrightarrow{OR}, \overrightarrow{OS}$ and $\overrightarrow{OT}$ is approximately .... N.

[Take $\sqrt{3} = 1.7$, $\sqrt{2} = 1.4$ Given $\hat{i}$ and $\hat{j}$ unit vectors along x, y axis]



A $9.25\hat{i} + 5\hat{j}$

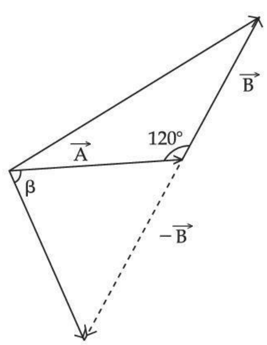
B $3\hat{i} + 15\hat{j}$

C $2.5\hat{i} - 14.5\hat{j}$

D $-1.5\hat{i} - 15.5\hat{j}$

27th Aug Morning Shift 2021

Q.3 The angle between vector $\left(\vec{A}\right)$ and $\left(\vec{A} - \vec{B}\right)$ is :



A $\tan^{-1}\left(\frac{-\frac{B}{2}}{A - B\frac{\sqrt{3}}{2}}\right)$

B $\tan^{-1}\left(\frac{A}{0.7B}\right)$

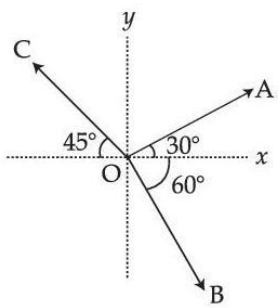
C $\tan^{-1}\left(\frac{\sqrt{3}B}{2A-B}\right)$

D $\tan^{-1}\left(\frac{B\cos\theta}{A-B\sin\theta}\right)$

26th Aug Evening Shift 2021

Q.4 The magnitude of vectors $\overrightarrow{OA}$, $\overrightarrow{OB}$ and $\overrightarrow{OC}$ in the given figure are equal. The direction of

$\overrightarrow{OA}+\overrightarrow{OB}-\overrightarrow{OC}$ with x-axis will be :



A $\tan^{-1}\frac{(1-\sqrt{3}-\sqrt{2})}{(1+\sqrt{3}+\sqrt{2})}$

B $\tan^{-1}\frac{(\sqrt{3}-1+\sqrt{2})}{(1+\sqrt{3}-\sqrt{2})}$

C $\tan^{-1}\frac{(\sqrt{3}-1+\sqrt{2})}{(1-\sqrt{3}+\sqrt{2})}$

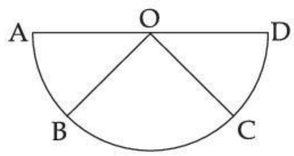
D $\tan^{-1}\frac{(1+\sqrt{3}-\sqrt{2})}{(1-\sqrt{3}-\sqrt{2})}$

26th Aug Morning Shift 2021

Q.5 Assertion A: If A, B, C, D are four points on a semi-circular are with centre at 'O' such that

$\left|\overrightarrow{AB}\right|=\left|\overrightarrow{BC}\right|=\left|\overrightarrow{CD}\right|$, then $\overrightarrow{AB}+\overrightarrow{AC}+\overrightarrow{AD}=4\overrightarrow{AO}+\overrightarrow{OB}+\overrightarrow{OC}$

Reason R: Polygon law of vector addition yields $\overrightarrow{AB}+\overrightarrow{BC}+\overrightarrow{CD}+\overrightarrow{AD}=2\overrightarrow{AO}$



In the light of the above statements, choose the most appropriate answer from the options given below :

(A) A is correct but R is not correct.

(B) A is not correct but R is correct.

(C) Both A and R are correct and R is the correct explanation of A.

(D) Both A and R are correct but R is not the correct explanation of A.

27th July Morning Shift 2021

Q.6

Two vectors $\vec{X}$ and $\vec{Y}$ have equal magnitude. The magnitude of ($\vec{X} - \vec{Y}$) is n times the magnitude of ($\vec{X} + \vec{Y}$). The angle between $\vec{X}$ and $\vec{Y}$ is :

(A) $\cos^{-1}\left(\frac{-n^2-1}{n^2-1}\right)$

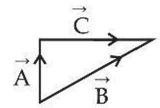
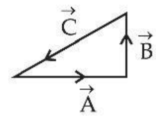
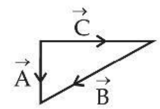
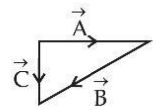
(B) $\cos^{-1}\left(\frac{n^2-1}{-n^2-1}\right)$

(C) $\cos^{-1}\left(\frac{n^2+1}{-n^2-1}\right)$

(D) $\cos^{-1}\left(\frac{n^2+1}{n^2-1}\right)$

25th July Evening Shift 2021

Q.7 Match List - I with List – II

List I	List II
(a) $\vec{C} - \vec{A} - \vec{B} = 0$	(i) 
(b) $\vec{A} - \vec{C} - \vec{B} = 0$	(ii) 
(c) $\vec{B} - \vec{A} - \vec{C} = 0$	(iii) 
(d) $\vec{A} + \vec{B} = -\vec{C}$	(iv) 

Choose the correct answer from the options given below:

A (a) $\rightarrow$ (iv), (b) $\rightarrow$ (i), (c) $\rightarrow$ (iii), (d) $\rightarrow$ (ii)

B (a) $\rightarrow$ (iv), (b) $\rightarrow$ (iii), (c) $\rightarrow$ (i), (d) $\rightarrow$ (ii)

C (a) $\rightarrow$ (iii), (b) $\rightarrow$ (ii), (c) $\rightarrow$ (iv), (d) $\rightarrow$ (i)

D (a) $\rightarrow$ (i), (b) $\rightarrow$ (iv), (c) $\rightarrow$ (ii), (d) $\rightarrow$ (iii)

25th July Evening Shift 2021

Q.8 What will be the projection of vector $\overrightarrow{A} = \hat{i} + \hat{j} + \hat{k}$ on vector $\overrightarrow{B} = \hat{i} + \hat{j}$?

A $\sqrt{2}(\hat{i} + \hat{j} + \hat{k})$

B $(\hat{i} + \hat{j})$

C $\sqrt{2}(\hat{i} + \hat{j})$

D $2(\hat{i} + \hat{j} + \hat{k})$

22th July Evening Shift 2021

Q.9

Two vectors $\vec{P}$ and $\vec{Q}$ have equal magnitudes. If the magnitude of $\vec{P}+\vec{Q}$ is n times the magnitude of $\vec{P}-\vec{Q}$, then angle between $\vec{P}$ and $\vec{Q}$ is :

A $\sin^{-1}\left(\frac{n-1}{n+1}\right)$

B $\cos^{-1}\left(\frac{n-1}{n+1}\right)$

C $\sin^{-1}\left(\frac{n^2-1}{n^2+1}\right)$

D $\cos^{-1}\left(\frac{n^2-1}{n^2+1}\right)$

20th July Evening Shift 2021

Q.10

If $\vec{A}$ and $\vec{B}$ are two vectors satisfying the relation $\vec{A}\,.\,\vec{B}$ = $\left|\vec{A}\times\vec{B}\right|$. Then the value of $\left|\vec{A}-\vec{B}\right|$ will be :

A $\sqrt{A^2+B^2+\sqrt{2}AB}$

B $\sqrt{A^2+B^2}$

C $\sqrt{A^2+B^2-\sqrt{2}AB}$

D $\sqrt{A^2+B^2+2AB}$

20th July Morning Shift 2021

MCQ Answer Key

1. Ans. (b)
2. Ans. (A)
3. Ans. (c)
4. Ans. (A)
5. Ans. (d)
6. Ans. (b)
7. Ans. (b)
8. Ans. (b)
9. Ans. (d)
10. Ans. (c)

MCQ Explanation

Ans 1.

$\vec{A} = \vec{P} + \vec{Q}$

$\vec{B} = \vec{P} - \vec{Q}$

$\vec{P} \perp \vec{Q}$

$\left|\vec{A}\right| = \left|\vec{B}\right| = \sqrt{2(P^2 + Q^2)(1 + \cos\theta)}$

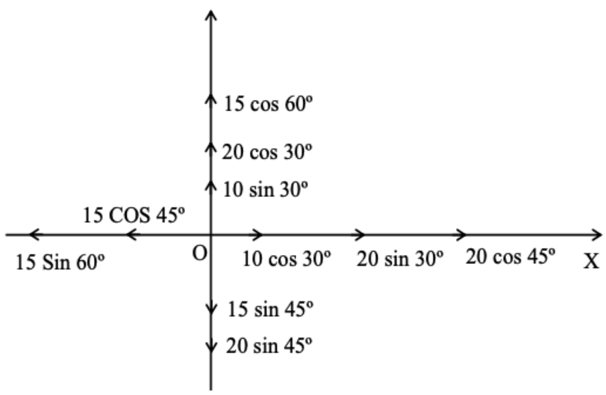
For $\left|\vec{A} + \vec{B}\right| = \sqrt{3(P^2 + Q^2)}$

$\theta_1 = 60^\circ$

For $\left|\overrightarrow{A} + \overrightarrow{B}\right| = \sqrt{2(P^2 + Q^2)}$

$\theta_2 = 90^\circ$

Ans 2.



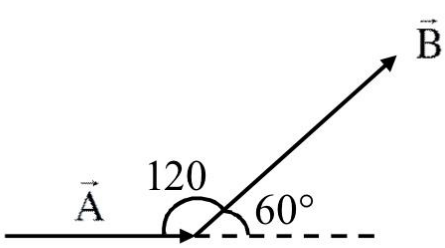
$$\overrightarrow{F_x} = \left(10 \times \frac{\sqrt{3}}{2} + 20\left(\frac{1}{2}\right) + 20\left(\frac{1}{\sqrt{2}}\right) - 15\left(\frac{1}{\sqrt{2}}\right) - 15\left(\frac{\sqrt{3}}{2}\right)\right)\hat{i}$$

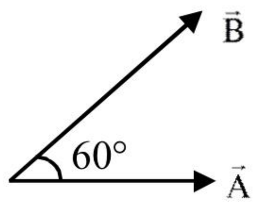
$$= 9.25\hat{i}$$

$$\overrightarrow{F_y} = \left(15\left(\frac{1}{2}\right) + 20\left(\frac{\sqrt{3}}{2}\right) + 10\left(\frac{1}{2}\right) - 15\left(\frac{1}{\sqrt{2}}\right) - 20\left(\frac{1}{\sqrt{2}}\right)\right)\hat{j}$$

$$= 5\hat{j}$$

Ans 3.





Angle between $\vec{A}$ and $\vec{B}$, θ = 60°

Angle between $\vec{A}$ and -$\vec{B}$, θ = 120°

If angle between $\vec{A}$ and $\vec{A} - \vec{B}$ is α

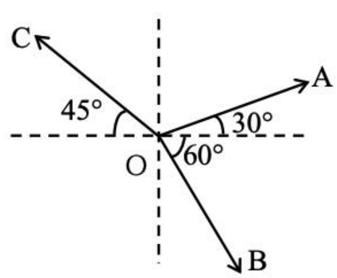
then $\tan\alpha = \frac{\left|-\vec{B}\right|\sin\theta}{\vec{A}+\left|-\vec{B}\right|\cos\theta}$

= $\frac{B\sin 120^\circ}{A+B\cos 120^\circ}$

=$\frac{B\frac{\sqrt{3}}{2}}{A-\frac{B}{2}}$

$\Rightarrow \tan\alpha = \frac{\sqrt{3}B}{2A-B}$

Ans 4.



Let magnitude be equal to λ

$\overrightarrow{OA} = \lambda\left[\cos 30^\circ\hat{i} + \sin 30\hat{j}\right] = \lambda\left[\frac{\sqrt{3}}{2}\hat{i} + \frac{1}{2}\hat{j}\right]$

$$\overrightarrow{OB} = \lambda\left[\cos 60^{\circ}\hat{i} - \sin 60\hat{j}\right] = \lambda\left[\frac{1}{2}\hat{i} - \frac{\sqrt{3}}{2}\hat{j}\right]$$

$$\overrightarrow{OC} = \lambda\left[\cos 45^{\circ}(-\hat{i}) + \sin 45\hat{j}\right] = \lambda\left[-\frac{1}{\sqrt{2}}\hat{i} + \frac{1}{\sqrt{2}}\hat{j}\right]$$

$$\therefore \overrightarrow{OA} + \overrightarrow{OB} - \overrightarrow{OC}$$

$$= \lambda\left[\left(\frac{\sqrt{3}+1}{2} + \frac{1}{\sqrt{2}}\right)\hat{i} + \left(\frac{1}{2} - \frac{\sqrt{3}}{2} - \frac{1}{\sqrt{2}}\right)\hat{j}\right]$$

∴ Angle with x-axis

$$\tan^{-1}\left[\frac{\frac{1}{2} - \frac{\sqrt{3}}{2} - \frac{1}{\sqrt{2}}}{\frac{\sqrt{3}}{2} + \frac{1}{2} + \frac{1}{\sqrt{2}}}\right] = \tan^{-1}\left[\frac{\sqrt{2} - \sqrt{6} - 2}{\sqrt{6} + \sqrt{2} + 2}\right]$$

$$= \tan^{-1}\left[\frac{1 - \sqrt{3} - \sqrt{2}}{\sqrt{3} + 1 + \sqrt{2}}\right]$$

Hence option (a).

Ans 5. Polygon law is applicable in both but the equation given in the reason is not useful in explaining the assertion.

Ans 6. Given X = Y

$$\sqrt{X^2 + Y^2 - 2 \times Y\cos\theta}$$

$$= n\sqrt{X^2 + Y^2 + 2 \times Y\cos\theta}$$

Square both sides

$$2X^2(1 - \cos\theta) = n^2.2X^2(1 + \cos\theta)$$

$$1 - \cos\theta = n^2 + n^2\cos\theta$$

$$\cos\theta = \frac{1-n^2}{1+n^2}$$

$$\theta = \cos^{-1}\left[\frac{n^2-1}{-n^2-1}\right]$$

Ans 7.

(a) $\vec{C} = \vec{A} + \vec{B}$

Option (iv)

(b) $\vec{A} = \vec{B} + \vec{C} = \vec{C} + \vec{B}$

Option (iii)

(c) $\vec{B} = \vec{A} + \vec{C}$

Option (i)

(d) $\vec{A} + \vec{B} + \vec{C} = 0$

Option (ii)

Ans 8.

Projection = $\frac{\vec{A}.\vec{B}}{\left|\vec{B}\right|}(\widehat{B})$

$= \frac{(\hat{i}+\hat{j}+\hat{k}).(\hat{i}+\hat{j})}{\sqrt{2}} \frac{(\hat{i}+\hat{j})}{\sqrt{2}}$

$= \frac{2}{\sqrt{2}} \times \frac{(\hat{i}+\hat{j})}{2}$

$= (\hat{i} + \hat{j})$

Ans 9.

$\left|\vec{P}\right| = \left|\vec{Q}\right| = x$ ..... (i)

$\left|\vec{P} + \vec{Q}\right| = n\left|\vec{P} - \vec{Q}\right|$

$P^2 + Q^2 + 2PQ\cos\theta = n^2(P^2 + Q^2 - 2PQ\cos\theta)$

Using (i) in above equation

$$\cos\theta = \frac{n^2-1}{1+n^2}$$

$$\theta = \cos^{-1}\left(\frac{n^2-1}{n^2+1}\right)$$

Ans 10.

Given, $\vec{A} \cdot \vec{B} = \left|\vec{A} \times \vec{B}\right|$ ..... (i)

Also, we know that

$\vec{A} \cdot \vec{B} = \left|\vec{A}\right|\left|\vec{B}\right| \cos\theta$ .... (ii)

and $\vec{A} \times \vec{B} = \left|\vec{A}\right|\left|\vec{B}\right| \sin\theta$ ..... (iii)

From Eqs. (i), (ii) and (iii), we get

$$\left|\vec{A}\right|\left|\vec{B}\right| \cos\theta = \left|\vec{A}\right|\left|\vec{B}\right| \sin\theta$$

$$\Rightarrow \cos\theta = \sin\theta \Rightarrow \frac{\sin\theta}{\cos\theta} = 1$$

$$\Rightarrow \tan\theta = 1$$

$$\Rightarrow \tan\theta = \tan 45^\circ \Rightarrow \theta = 45^\circ$$

$$\therefore \left|\vec{A} - \vec{B}\right| = \sqrt{A^2 + B^2 - 2\left|\vec{A}\right|\left|\vec{B}\right|\cos\theta}$$

$$= \sqrt{A^2 + B^2 - 2\left|\vec{A}\right|\left|\vec{B}\right|\cos(45^\circ)}$$

$$= \sqrt{A^2 + B^2 - \sqrt{2}AB}$$

TOPIC 1 Unit of Physical Quantities

1. The density of a material in SI unit is 128 kg m^{-3}. In certain units in which the unit of length is 25 cm and the unit of mass is 50 g, the numerical value of density of the material is: **[10 Jan. 2019 I]**
   (a) 40 (b) 16 (c) 640 (d) 410

2. A metal sample carrying a current along X-axis with density J_x is subjected to a magnetic field B_z (along z-axis). The electric field E_y developed along Y-axis is directly proportional to J_x as well as B_z. The constant of proportionality has SI unit **[Online April 25, 2013]**
   (a) $\frac{m^2}{A}$ (b) $\frac{m^3}{As}$ (c) $\frac{m^2}{As}$ (d) $\frac{As}{m^3}$

TOPIC 2 Dimensions of Physical Quantities

3. The quantities $x = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}$, $y = \frac{E}{B}$ and $z = \frac{1}{CR}$ are defined where C-capacitance, R-Resistance, l-length, E-Electric field, B-magnetic field and ε_0, μ_0, - free space permittivity and permeability respectively. Then : **[Sep. 05, 2020 (II)]**
   (a) x, y and z have the same dimension.
   (b) Only x and z have the same dimension.
   (c) Only x and y have the same dimension.
   (d) Only y and z have the same dimension.

4. Dimensional formula for thermal conductivity is (here K denotes the temperature : **[Sep. 04, 2020 (I)]**
   (a) $MLT^{-2}K$ (b) $MLT^{-2}K^{-2}$
   (c) $MLT^{-3}K$ (d) $MLT^{-3}K^{-1}$

5. A quantity x is given by (IFv^2/WL^4) 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 : **[Sep. 04, 2020 (II)]**
   (a) planck's constant (b) force constant
   (c) energy density (d) coefficient of viscosity

6. Amount of solar energy received on the earth's surface per unit area per unit time is defined a solar constant. Dimension of solar constant is : **[Sep. 03, 2020 (II)]**
   (a) ML^2T^{-2} (b) ML^0T^{-3}
   (c) $M^2L^0T^{-1}$ (d) MLT^{-2}

7. If speed V, area A and force F are chosen as fundamental units, then the dimension of Young's modulus will be : **[Sep. 02, 2020 (I)]**
   (a) FA^2V^{-1} (b) FA^2V^{-3}
   (c) FA^2V^{-2} (d) $FA^{-1}V^0$

8. If momentum (P), area (A) and time (T) are taken to be the fundamental quantities then the dimensional formula for energy is : **[Sep. 02, 2020 (II)]**
   (a) $[P^2AT^{-2}]$ (b) $[PA^{-1}T^{-2}]$
   (c) $[PA^{1/2}T^{-1}]$ (d) $[P^{1/2}AT^{-1}]$

9. Which of the following combinations has the dimension of electrical resistance ($\in_0$ is the permittivity of vacuum and μ_0 is the permeability of vacuum)? **[12 April 2019 I]**
   (a) $\sqrt{\frac{\mu_0}{\varepsilon_0}}$ (b) $\frac{\mu_0}{\varepsilon_0}$ (c) $\sqrt{\frac{\varepsilon_0}{\mu_0}}$ (d) $\frac{\varepsilon_0}{\mu_0}$

10. 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 ? **[10 April 2019 II]**
    (a) $[M^{-3}L^{-2}T^8A^4]$ (b) $[M^{-1}L^{-2}T^4A^2]$
    (c) $[M^{-2}L^0T^{-4}A^{-2}]$ (d) $[M^{-2}L^{-2}T^6A^3]$

11. In SI units, the dimensions of $\sqrt{\frac{\in_0}{\mu_0}}$ is: **[8 April 2019 I]**
    (a) $A^{-1}TML^3$ (b) $AT^2M^{-1}L^{-1}$
    (c) $AT^{-3}ML^{3/2}$ (d) $A^2T^3M^{-1}L^{-2}$

12. Let l, r, c and v represent inductance, resistance, capacitance and voltage, respectively. The dimension of $\frac{\ell}{rcv}$ in SI units will be : **[12 Jan. 2019 II]**
    (a) $[LA^{-2}]$ (b) $[A^{-1}]$
    (c) $[LTA]$ (d) $[LT^2]$

13. 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 dimensions of β is: **[11 Jan. 2019 I]**

(a) $M^0L^2T^{-4}$ (b) M^2LT^{-4}
(c) MLT^{-2} (d) $M^2L^2T^{-2}$

14. If speed (V), acceleration (A) and force (F) are considered as fundamental units, the dimension of Young's modulus will be : **[11 Jan. 2019 II]**

(a) $V^{-2}A^2F^{-2}$ (b) $V^{-2}A^2F^2$
(c) $V^{-4}A^{-2}F$ (d) $V^{-4}A^2F$

15. A quantity f is given by $f = \sqrt{\frac{hc^5}{G}}$ where c is speed of light, G universal gravitational constant and h is the Planck's constant. Dimension of f is that of : **[9 Jan. 2019 I]**

(a) area (b) energy
(c) momentum (d) volume

16. Expression for time in terms of G (universal gravitational constant), h (Planck's constant) and c (speed of light) is proportional to: **[9 Jan. 2019 II]**

(a) $\sqrt{\frac{hc^5}{G}}$ (b) $\sqrt{\frac{c^3}{Gh}}$
(c) $\sqrt{\frac{Gh}{c^5}}$ (d) $\sqrt{\frac{Gh}{c^3}}$

17. The dimensions of stopping potential V_0 in photoelectric effect in units of Planck's constant 'h', speed of light 'c' and Gravitational constant 'G' and ampere A is: **[8 Jan. 2019 I]**

(a) $h^{1/3}G^{2/3}c^{1/3}A^{-1}$ (b) $h^{2/3}c^{5/3}G^{1/3}A^{-1}$
(c) $h^{-2/3}e^{-1/3}G^{4/3}A^{-1}$ (d) $h^2G^{3/2}C^{1/3}A^{-1}$

18. The dimensions of $\frac{B^2}{2\mu_0}$, where B is magnetic field and μ_0 is the magnetic permeability of vacuum, is: **[8 Jan. 2019 II]**

(a) MLT^{-2} (b) ML^2T^{-1}
(c) ML^2T^{-2} (d) $ML^{-1}T^{-2}$

19. The characteristic distance at which quantum gravitational effects are significant, the Planck length, can be determined from a suitable combination of the fundamental physical constants G, h and c. Which of the following correctly gives the Planck length? **[Online April 15, 2018]**

(a) G^2hc (b) $\left(\frac{Gh}{c^3}\right)^{\frac{1}{2}}$ (c) $G^{\frac{1}{2}}h^2c$ (d) Gh^2c^3

20. Time (T), velocity (C) and angular momentum (h) are chosen as fundamental quantities instead of mass, length and time. In terms of these, the dimensions of mass would be : **[Online April 8, 2017]**

(a) $[M]=[T^{-1}C^{-2}h]$ (b) $[M]=[T^{-1}C^2h]$
(c) $[M]=[T^{-1}C^{-2}h^{-1}]$ (d) $[M]=[TC^{-2}h]$

21. A, B, C and D are four different physical quantities having different dimensions. None of them is dimensionless. But we know that the equation AD = C ln (BD) holds true. Then which of the combination is not a meaningful quantity? **[Online April 10, 2016]**

(a) $\frac{C}{BD} - \frac{AD^2}{C}$ (b) $A^2 - B^2C^2$
(c) $\frac{A}{B} - C$ (d) $\frac{(A - C)}{D}$

22. In the following 'I' refers to current and other symbols have their usual meaning, Choose the option that corresponds to the dimensions of electrical conductivity : **[Online April 9, 2016]**

(a) $M^{-1}L^{-3}T^3I$ (b) $M^{-1}L^{-3}T^3I^2$
(c) $M^{-1}L^3T^3I$ (d) $ML^{-3}T^{-3}I^2$

23. If electronic charge e, electron mass m, speed of light in vacuum c and Planck's constant h are taken as fundamental quantities, the permeability of vacuum μ_0 can be expressed in units of : **[Online April 11, 2015]**

(a) $\left(\frac{h}{me^2}\right)$ (b) $\left(\frac{hc}{me^2}\right)$
(c) $\left(\frac{h}{ce^2}\right)$ (d) $\left(\frac{mc^2}{he^2}\right)$

24. If the capacitance of a nanocapacitor is measured in terms of a unit 'u' made by combining the electric charge 'e', Bohr radius 'a_0', Planck's constant 'h' and speed of light 'c' then: **[Online April 10, 2015]**

(a) $u = \frac{e^2h}{a_0}$ (b) $u = \frac{hc}{e^2a_0}$
(c) $u = \frac{e^2c}{ha_0}$ (d) $u = \frac{e^2a_0}{hc}$

25. From the following combinations of physical constants (expressed through their usual symbols) the only combination, that would have the same value in different systems of units, is: **[Online April 12, 2014]**

(a) $\frac{ch}{2\pi\varepsilon_o^2}$

(b) $\frac{e^2}{2\pi\varepsilon_o Gm_e^2}$ (m_e = mass of electron)

(c) $\frac{\mu_o\varepsilon_o}{c^2}\frac{G}{he^2}$

(d) $\frac{2\pi\sqrt{\mu_o\varepsilon_o}}{ce^2}\frac{h}{G}$

26. In terms of resistance R and time T, the dimensions of ratio $\frac{\mu}{\varepsilon}$ of the permeability μ and permittivity ε is: **[Online April 11, 2014]**

(a) $[RT^{-2}]$ (b) $[R^2T^{-1}]$ (c) $[R^2]$ (d) $[R^2T^2]$

27. Let $[\in_0]$ denote the dimensional formula of the permittivity of vacuum. If M = mass, L = length, T = time and A = electric current, then: **[2013]**

(a) $\in_0 = [M^{-1} L^{-3} T^2 A]$ (b) $\in_0 = [M^{-1} L^{-3} T^4 A^2]$

(c) $\in_0 = [M^1 L^2 T^1 A^2]$ (d) $\in_0 = [M^1 L^2 T^1 A]$

28. If the time period t of the oscillation of a drop of liquid of density d, radius r, vibrating under surface tension s is given by the formula $t = \sqrt{r^{2b} s^c d^{a/2}}$. It is observed that the time period is directly proportional to $\sqrt{\frac{d}{s}}$. The value of b should therefore be : **[Online April 23, 2013]**

(a) $\frac{3}{4}$ (b) $\sqrt{3}$

(c) $\frac{3}{2}$ (d) $\frac{2}{3}$

29. The dimensions of angular momentum, latent heat and capacitance are, respectively. **[Online April 22, 2013]**

(a) $ML^2T^1A^2$, L^2T^{-2}, $M^{-1}L^{-2}T^2$

(b) ML^2T^{-2}, L^2T^2, $M^{-1}L^{-2}T^4A^2$

(c) ML^2T^{-1}, L^2T^{-2}, ML^2TA^2

(d) ML^2T^{-1}, L^2T^{-2}, $M^{-1}L^{-2}T^4A^2$

30. Given that K = energy, V = velocity, T = time. If they are chosen as the fundamental units, then what is dimensional formula for surface tension? **[Online May 7, 2012]**

(a) $[KV^{-2}T^{-2}]$ (b) $[K^2V^2T^{-2}]$

(c) $[K^2V^{-2}T^{-2}]$ (d) $[KV^2T^2]$

31. The dimensions of magnetic field in M, L, T and C (coulomb) is given as **[2008]**

(a) $[MLT^{-1} C^{-1}]$ (b) $[MT^2 C^{-2}]$

(c) $[MT^{-1} C^{-1}]$ (d) $[MT^{-2} C^{-1}]$

32. Which of the following units denotes the dimension $\frac{ML^2}{Q^2}$, where Q denotes the electric charge? **[2006]**

(a) Wb/m^2 (b) Henry (H)

(c) H/m^2 (d) Weber (Wb)

33. Out of the following pair, which one does NOT have identical dimensions ? **[2005]**

(a) Impulse and momentum

(b) Angular momentum and planck's constant

(c) Work and torque

(d) Moment of inertia and moment of a force

34. Which one of the following represents the correct dimensions of the coefficient of viscosity? **[2004]**

(a) $[ML^{-1}T^{-1}]$ (b) $[MLT^{-1}]$

(c) $[ML^{-1}T^{-2}]$ (d) $[ML^{-2}T^{-2}]$

35. Dimensions of $\frac{1}{\mu_0\varepsilon_0}$, where symbols have their usual meaning, are **[2003]**

(a) $[L^{-1}T]$ (b) $[L^{-2}T^2]$

(c) $[L^2T^{-2}]$ (d) $[LT^{-1}]$

36. The physical quantities not having same dimensions are **[2003]**

(a) torque and work

(b) momentum and planck's constant

(c) stress and young's modulus

(d) speed and $(\mu_0\varepsilon_0)^{-1/2}$

37. Identify the pair whose dimensions are equal **[2002]**

(a) torque and work (b) stress and energy

(c) force and stress (d) force and work

TOPIC 3 Errors in Measurements

38. 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 : **[Sep. 06, 2020 (I)]**

(a) Negative, 2 μm (b) Positive, 10 μm

(c) Positive, 0.1 mm (d) Positive, 0.1 μm

39. The density of a solid metal sphere is determined by measuring its mass and its diameter. The maximum error in the density of the sphere is $\left(\frac{x}{100}\right)$%. If the relative errors in measuring the mass and the diameter are 6.0% and 1.5% respectively, the value of x is ______. **[NA Sep. 06, 2020 (I)]**

40. 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 reading 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 : **[Sep. 06, 2020 (II)]**

(a) (5.5375 ± 0.0739) mm (b) (5.5375 ± 0.0740) mm

(c) (5.538 ± 0.074) mm (d) (5.54 ± 0.07) mm

41. A physical quantity z depends on four observables a, b, c and d, as $z = \frac{a^2 b^{\frac{2}{3}}}{\sqrt{c} d^3}$. 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 : **[Sep. 05, 2020 (I)]**

(a) 12.25% (b) 16.5%
(c) 13.5% (d) 14.5%

42. 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 : **[Sep. 03, 2020 (I)]**
(a) 2.121 cm (b) 2.124 cm
(c) 2.125 cm (d) 2.123 cm

43. 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 betwen 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) **[Sep. 02, 2020 (I)]**
(a) 3.2 cm (b) 3.21 cm
(c) 3.07 cm (d) 2.99 cm

44. If the screw on a screw-gauge is given six rotations, it moves by 3 mm on the main scale. If there are 50 divisions on the circular scale the least count of the screw gauge is: **[9 Jan. 2020 I]**
(a) 0.001 cm (b) 0.02 mm
(c) 0.01 cm (d) 0.001 mm

45. For the four sets of three measured physical quantities as given below. Which of the following options is correct? **[9 Jan. 2020 II]**
(A) $A_1 = 24.36, B_1 = 0.0724, C_1 = 256.2$
(B) $A_2 = 24.44, B_2 = 16.082, C_2 = 240.2$
(C) $A_3 = 25.2, B_3 = 19.2812, C_3 = 236.183$
(D) $A_4 = 25, B_4 = 236.191, C_4 = 19.5$
(a) $A_4 + B_4 + C_4 < A_1 + B_1 + C_1 < A_3 + B_3 + C_3 < A_2 + B_2 + C_2$
(b) $A_1 + B_1 + C_1 = A_2 + B_2 + C_2 = A_3 + B_3 + C_3 = A_4 + B_4 + C_4$
(c) $A_4 + B_4 + C_4 < A_1 + B_1 + C_1 = A_2 + B_2 + C_2 = A_3 + B_3 + C_3$
(d) $A_1 + B_1 + C_1 < A_3 + B_3 + C_3 < A_2 + B_2 + C_2 < A_4 + B_4 + C_4$

46. 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 cm and a stop watch with 1 s resolution measures the time taken for 40 oscillations to be 50 s. The accuracy in g is: **[8 Jan. 2020 II]**
(a) 5.40% (b) 3.40%
(c) 4.40% (d) 2.40%

47. In the density measurement of a cube, the mass and edge length are measured as (10.00 ± 0.10) kg and (0.10 ± 0.01) m, respectively. The error in the measurement of density is: **[9 April 2019 I]**
(a) 0.01 kg/m^3 (b) 0.10 kg/m^3
(c) 0.013 kg/m^3 (d) 0.07 kg/m^3

48. The area of a square is 5.29 cm^2. The area of 7 such squares taking into account the significant figures is: **[9 April 2019 II]**
(a) 37cm^2 (b) 37.030 cm^2
(c) 37.03 cm^2 (d) 37.0 cm^2

49. 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 s. The length of pendulum is measured by using a meter scale of least count 1 mm and the value obtained is 55.0 cm. The percentage error in the determination of g is close to : **[8 April 2019 II]**
(a) 0.7% (b) 0.2% (c) 3.5% (d) 6.8%

50. 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 5 μm diameter of a wire is: **[12 Jan. 2019 I]**
(a) 50 (b) 200 (c) 100 (d) 500

51. 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? **[10 Jan. 2019 II]**
(a) 4264 ± 81 cm^3 (b) 4264.4 ± 81.0 cm^3
(c) 4260 ± 80 cm^3 (d) 4300 ± 80 cm^3

52. The pitch and the number of divisions, on the circular scale for a given screw gauge are 0.5 mm and 100 respectively. When the screw gauge is fully tightened without any object, the zero of its circular scale lies 3 division below the mean line.
The readings of the main scale and the circular scale, for a thin sheet, are 5.5 mm and 48 respectively, the thickness of the sheet is: **[9 Jan. 2019 II]**
(a) 5.755 mm (b) 5.950 mm
(c) 5.725 mm (d) 5.740 mm

53. The density of a material in the shape of a cube is determined by measuring three sides of the cube and its mass. If the relative errors in measuring the mass and length are respectively 1.5% and 1%, the maximum error in determining the density is: **[2018]**
(a) 2.5% (b) 3.5% (c) 4.5% (d) 6%

54. The percentage errors in quantities P, Q, R and S are 0.5%, 1%, 3% and 1.5% respectively in the measurement of a physical quantity $A = \frac{P^3Q^2}{\sqrt{RS}}$.
The maximum percentage error in the value of A will be **[Online April 16, 2018]**
(a) 8.5% (b) 6.0%
(c) 7.5% (d) 6.5%

55. The relative uncertainty in the period of a satellite orbiting around the earth is 10^{-2}. If the relative uncertainty in the radius of the orbit is negligible, the relative uncertainty in the mass of the earth is **[Online April 16, 2018]**
(a) 3×10^{-2} (b) 10^{-2}
(c) 2×10^{-2} (d) 6×10^{-2}

56. The relative error in the determination of the surface area of a sphere is α. Then the relative error in the determination of its volume is **[Online April 15, 2018]**

(a) $\frac{2}{3}\alpha$ (b) $\frac{2}{3}\alpha$ (c) $\frac{3}{2}\alpha$ (d) α

57. In a screw gauge, 5 complete rotations of the screw cause it to move a linear distance of 0.25 cm. There are 100 circular scale divisions. The thickness of a wire measured by this screw gauge gives a reading of 4 main scale divisions and 30 circular scale divisions. Assuming negligible zero error, the thickness of the wire is: **[Online April 15, 2018]**

(a) 0.0430 cm (b) 0.3150 cm
(c) 0.4300 cm (d) 0.2150 cm

58. The following observations were taken for determining surface tensiton T of water by capillary method :
Diameter of capilary, $D = 1.25 \times 10^{-2}$ m
rise of water, $h = 1.45 \times 10^{-2}$ m
Using $g = 9.80$ m/s^2 and the simplified relation
$T = \frac{rhg}{2} \times 10^3$ N/m, the possible error in surface tension is closest to : **[2017]**

(a) 2.4% (b) 10% (c) 0.15% (d) 1.5%

59. A physical quantity P is described by the relation
$P = a^{1/2} b^2 c^3 d^{-4}$
If the relative errors in the measurement of *a, b, c* and *d* respectively, are 2%, 1%, 3% and 5%, then the relative error in P will be : **[Online April 9, 2017]**

(a) 8% (b) 12% (c) 32% (d) 25%

60. 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 wen the two jaws of the screw gauge are brought in contact, the 45th 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 25th division coincides with the main scale line? **[2016]**

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

61. A student measures the time period of 100 oscillations of a simple pendulum four times. The data set is 90 s, 91 s, 95 s, and 92 s. If the minimum division in the measuring clock is 1 s, then the reported mean time should be: **[2016]**

(a) 92 ± 1.8 s (b) 92 ± 3s
(c) 92 ± 1.5 s (d) 92 ± 5.0 s

62. 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 : **[2015]**

(a) 1% (b) 5% (c) 2% (d) 3%

63. Diameter of a steel ball is measured using a Vernier callipers which has divisions of 0.1 cm on its main scale (MS) and 10 divisions of its vernier scale (VS) match 9 divisions on the main scale. Three such measurements for a ball are given as: **[Online April 10, 2015]**

S.No.	MS(cm)	VS divisions
1.	0.5	8
2.	0.5	4
3.	0.5	6

If the zero error is – 0.03 cm, then mean corrected diameter is:

(a) 0.52 cm (b) 0.59 cm
(c) 0.56 cm (d) 0.53 cm

64. The current voltage relation of a diode is given by $I = \left(e^{1000V/T} - 1\right)$ mA, where the applied voltage V is in volts and the temperature T is in degree kelvin. If a student makes an error measuring ± 0.01 V while measuring the current of 5 mA at 300 K, what will be the error in the value of current in mA? **[2014]**

(a) 0.2 mA (b) 0.02 mA (c) 0.5 mA (d) 0.05 mA

65. A student measured the length of a rod and wrote it as 3.50 cm. Which instrument did he use to measure it? **[2014]**

(a) A meter scale.
(b) A vernier calliper where the 10 divisions in vernier scale matches with 9 division 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.

66. Match List - I (Event) with List-II (Order of the time interval for happening of the event) and select the correct option from the options given below the lists: **[Online April 19, 2014]**

List - I		List - II	
(1)	Rotation period of earth	(i)	10^5 s
(2)	Revolution period of earth	(ii)	10^7 s
(3)	Period of light wave	(iii)	10^{-15} s
(4)	Period of sound wave	(iv)	10^{-3} s

(a) (1)-(i), (2)-(ii), (3)-(iii), (4)-(iv)
(b) (1)-(ii), (2)-(i), (3)-(iv), (4)-(iii)
(c) (1)-(i), (2)-(ii), (3)-(iv), (4)-(iii)
(d) (1)-(ii), (2)-(i), (3)-(iii), (4)-(iv)

67. In the experiment of calibration of voltmeter, a standard cell of e.m.f. 1.1 volt is balanced against 440 cm of potential wire. The potential difference across the ends of resistance is found to balance against 220 cm of the wire. The corresponding reading of voltmeter is 0.5 volt. The error in the reading of volmeter will be: **[Online April 12, 2014]**

(a) – 0. 15 volt (b) 0.15 volt
(c) 0.5 volt (d) – 0.05 volt

68. An experiment is performed to obtain the value of acceleration due to gravity g by using a simple pendulum of length L. In this experiment time for 100 oscillations is measured by using a watch of 1 second least count and the value is 90.0 seconds. The length L is measured by using a meter scale of least count 1 mm and the value is 20.0 cm. The error in the determination of g would be: **[Online April 9, 2014]**

(a) 1.7% (b) 2.7% (c) 4.4% (d) 2.27%

69. Resistance of a given wire is obtained by measuring the current flowing in it and the voltage difference applied across it. If the percentage errors in the measurement of the current and the voltage difference are 3% each, then error in the value of resistance of the wire is **[2012]**

(a) 6% (b) zero (c) 1% (d) 3%

70. A spectrometer gives the following reading when used to measure the angle of a prism.
Main scale reading : 58.5 degree
Vernier scale reading : 09 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 is **[2012]**

(a) 58.59 degree (b) 58.77 degree
(c) 58.65 degree (d) 59 degree

71. N divisions on the main scale of a vernier calliper coincide with $(N+1)$ divisions of the vernier scale. If each division of main scale is 'a' units, then the least count of the instrument is **[Online May 19, 2012]**

(a) a (b) $\frac{a}{N}$
(c) $\frac{N}{N+1}\times a$ (d) $\frac{a}{N+1}$

72. A student measured the diameter of a wire using a screw gauge with the least count 0.001 cm and listed the measurements. The measured value should be recorded as **[Online May 12, 2012]**

(a) 5.3200 cm (b) 5.3 cm
(c) 5.32 cm (d) 5.320 cm

73. 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 1mm on main scale corresponds to 100 divisions of the circular scale. The diameter of wire from the above data is **[2011]**

(a) 0.052 cm (b) 0.026 cm
(c) 0.005 cm (d) 0.52 cm

74. The respective number of significant figures for the numbers 23.023, 0.0003 and 2.1×10^{-3} are **[2010]**

(a) 5, 1, 2 (b) 5, 1, 5
(c) 5, 5, 2 (d) 4, 4, 2

75. In an experiment the angles are required to be measured using an instrument, 29 divisions of the main scale exactly coincide with the 30 divisions of the vernier scale. If the smallest division of the main scale is half- a degree (= 0.5°), then the least count of the instrument is: **[2009]**

(a) half minute (b) one degree
(c) half degree (d) one minute

76. 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 **[2008]**

(a) 17.6 kg ms^{-1} (b) 17.565 kg ms^{-1}
(c) 17.56 kg ms^{-1} (d) 17.57 kg ms^{-1}

77. 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 **[2008]**

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

Hints & Solutions

1. **(a)** Density of material in SI unit,

$= \frac{128 kg}{m^3}$

Density of material in new system

$= \frac{128(50 g)(20)}{(25 cm)^3 (4)^3} = \frac{128}{64}(20) = 40$ units

2. **(b)** According to question

$E_y \propto J_x B_Z$

∴ Constant of proportionality

$K = \frac{E_y}{B_Z J_x} = \frac{C}{J_x} = \frac{m^3}{As}$

[As $\frac{E}{B} = C$ (speed of light) and $J = \frac{I}{Area}$]

3. **(a)** We know that

Speed of light, $c = \frac{1}{\sqrt{\mu_0 \varepsilon_0}} = x$

Also, $c = \frac{E}{B} = y$

Time constant, $\tau = Rc = t$

$\therefore z = \frac{l}{Rc} = \frac{l}{t} = \text{Speed}$

Thus, x, y, z will have the same dimension of speed.

4. **(d)** From formula, $\frac{dQ}{dt} = kA\frac{dT}{dx}$

$\Rightarrow k = \frac{\left(\frac{dQ}{dt}\right)}{A\left(\frac{dT}{dx}\right)}$

$[k] = \frac{[ML^2T^{-3}]}{[L^2][KL^{-1}]} = [MLT^{-3}K^{-1}]$

5. **(c)** Dimension of Force $F = M^1L^1T^{-2}$

Dimension of velocity $V = L^1T^{-1}$

Dimension of work $= M^1L^2T^{-2}$

Dimension of length = L

Moment of inertia $= ML^2$

$\therefore x = \frac{IFv^2}{WL^4}$

$= \frac{(M^1L^2)(M^1L^1T^{-2})(L^1T^{-2})^2}{(M^1L^2T^{-2})(L^4)}$

$= \frac{M^1L^{-2}T^{-2}}{L^3} = M^1L^{-1}T^{-2}$ = Energy density

6. **(b)** Solar constant $= \frac{\text{Energy}}{\text{Time Area}}$

Dimension of Energy, $E = ML^2T^{-2}$

Dimension of Time = T

Dimension of Area = L^2

∴ Dimension of Solar constant

$= \frac{M^1L^2T^{-2}}{TL^2} = M^1L^0T^{-3}$.

7. **(d)** Young's modulus, $Y = \frac{\text{stress}}{\text{strain}}$

$\Rightarrow Y = \frac{F}{A} \Big/ \frac{\Delta \ell}{\ell_0} = FA^{-1}V^0$

8. **(c)** Energy, $E \propto A^a T^b P^c$

or, $E = kA^a T^b P^c$ ...(i)

where k is a dimensionless constant and a, b and c are the exponents.

Dimension of momentum, $P = M^1L^1T^{-1}$

Dimension of area, $A = L^2$

Dimension of time, $T = T^1$

Putting these value in equation (i), we get

$M^1L^2T^{-2} = M^c L^{2a+c} T^{b-c}$

by comparison

$c = 1$

$2a + c = 2$

$b - c = -2$

$c = 1$, $a = 1/2$, $b = -1$

$\therefore E = A^{1/2}T^{-1}P^1$

9. **(a)** $\sqrt{\frac{\mu_0}{\varepsilon_0}} = \sqrt{\frac{\mu_0^2}{\varepsilon_0 \mu_0}} = \mu_0 c$ $\left(\frac{1}{\sqrt{\mu_0 \varepsilon_0}} = c\right)$

$\mu_0 c \rightarrow MLT^{-2}A^{-2} \times LT^{-1}$

$ML^2T^{-3}A^{-2}$

Dimensions of resistance

10. **(a)** $X = 5YZ^2$

$\Rightarrow Y \propto \frac{X}{Z^2}$ ...(i)

$X = \text{Capacitance} = \frac{Q}{V} = \frac{Q^2}{W} = \frac{[A^2T^2]}{[ML^2T^{-2}]}$

$X = [M^{-1}L^{-2}T^4A^2]$

$Z = B = \frac{F}{IL}$ $[\because F = ILB]$

$Z = [MT^{-2}A^{-1}]$

$Y = \frac{[M^{-1}L^{-2}T^4A^2]}{[MT^{-2}A^{-1}]^2}$

$Y = [M^{-3}L^{-2}T^8A^4]$ (Using (i))

11. (d) $\left[\sqrt{\frac{\varepsilon_0}{\mu_0}}\right] = \sqrt{\frac{\varepsilon_0^2}{\mu_0\varepsilon_0}} = \left[\frac{\varepsilon_0}{\sqrt{\mu_0\varepsilon_0}}\right] = \varepsilon_0 C[LT^{-1}]\times[\varepsilon_0]$

$\left[\because \frac{1}{\sqrt{\mu_0\varepsilon_0}} = C\right]$

$\because F = \frac{q^2}{4\pi\varepsilon_0 r^2}$

$\Rightarrow [\varepsilon_0] = \frac{[AT]^2}{[MLT^{-2}]\times[L^2]} = [A^2M^{-1}L^{-3}T^4]$

$\therefore \left[\sqrt{\frac{\varepsilon_0}{\mu_0}}\right] = [LT^{-1}]\times[A^2M^{-1}L^{-3}T^4]$

$= [M^{-1}L^{-2}T^3A^2]$

12. (b) As we know,

$\left[\frac{\ell}{r}\right] = [T]$ and $[cv] = [AT]$

$\therefore \left[\frac{\ell}{rcv}\right] = \left[\frac{T}{AT}\right] = [A^{-1}]$

13. (b) Force of interaction between two atoms,

$F = \alpha\beta e^{\left(\frac{-x^2}{\alpha kT}\right)}$

Since exponential terms are dimensionless

$\therefore \left[\frac{x^2}{\alpha kT}\right] = M^0L^0T^0$

$\Rightarrow \frac{L^2}{[\alpha]ML^2T^{-2}} = M^0L^0T^0$

$\Rightarrow [\alpha] = M^{-1}T^2$

$[F] = [\alpha][\beta]$

$MLT^{-2} = M^{-1}T^2[\beta]$

$\Rightarrow [\beta] = M^2LT^{-4}$

14. (d) Let $[Y] = [V]^a[F]^b[A]^c$

$[ML^{-1}T^{-2}] = [LT^{-1}]^a[MLT^{-2}]^b[LT^{-2}]^c$

$[ML^{-1}T^{-2}] = [M^bL^{a+b+c}T^{-a-2b-2c}]$

Comparing power both side of similar terms we get,

$b = 1, a + b + c = -1, -a - 2b - 2c = -2$

solving above equations we get:

$a = -4, b = 1, c = 2$

so $[Y] = [V^{-4}FA^2] = [V^{-4}A^2F]$

15. (b) Dimension of $[h] = [ML^2T^{-1}]$

$[C] = [LT^{-1}]$

$[G] = [M^{-1}L^3T^{-2}]$

Hence dimension of

$\left[\sqrt{\frac{hC^5}{G}}\right] = \frac{[ML^2T^{-1}]\cdot[L^5T^{-5}]}{[M^{-1}L^3T^{-2}]}$

$= [ML^2T^{-2}] = \text{energy}$

16. (c) Let $t \propto G^x h^y C^z$

Dimensions of $G = [M^{-1}L^3T^{-2}]$,

$h = [ML^2T^{-1}]$ and $C = [LT^{-1}]$

$[T] = [M^{-1}L^3T^{-2}]^x[ML^2T^{-1}]^y[LT^{-1}]^z$

$[M^0L^0T^1] = [M^{-x+y}L^{3x+2y+z}T^{-2x-y-z}]$

By comparing the powers of M, L, T both the sides

$-x + y = 0 \Rightarrow x = y$

$3x + 2y + z = 0 \Rightarrow 5x + z = 0$ ..... (i)

$-2x - y - z = 1$ $\Rightarrow 3x + z = -1$ ..... (ii)

Solving eqns. (i) and (ii),

$x = y = \frac{1}{2}, z = -\frac{5}{2}$ $\therefore t \propto \sqrt{\frac{Gh}{C^5}}$

17. (None)

Stopping potential $(V_0) \propto h^x I^y G^Z C^r$

Here, h = Planck's constant $= [ML^2T^{-1}]$

I = current = $[A]$

G = Gravitational constant = $[M^{-1}L^3T^{-2}]$

and c = speed of light = $[LT^{-1}]$

V_0 = potential= $[ML^2T^{-3}A^{-1}]$

$\therefore [ML^2T^{-3}A^{-1}] = [ML^2T^{-1}]^x[A]^y[M^{-1}L^3T^{-2}]^z[LT^{-1}]r$

$M^{x-z}; L^{2x+3z+r}; T^{-x-2z-r}; A^y$

Comparing dimension of M, L, T, A, we get

$y = -1, x = 0, z = -1, r = 5$

$\therefore V_0 \propto h^0 I^{-1} G^{-1} C^5$

18. (d) The quantity $\frac{B^2}{2\mu_0}$ is the energy density of magnetic field.

$\Rightarrow \left[\frac{B^2}{2\mu_0}\right] = \frac{\text{Energy}}{Volume} = \frac{\text{Force} \times \text{displacement}}{(\text{displacement})^3}$

$= \left[\frac{ML^2T^{-2}}{L^3}\right] = ML^{-1}T^{-2}$

19. **(b)** Plank length is a unit of length, $l_p = 1.616229 \times 10^{-35}$ m

$$l_p = \sqrt{\frac{hG}{c^3}}$$

20. **(a)** Let mass, related as $M \propto T^x C^y h^z$

$M^1L^0T^0 = (T')^x (L^1T^{-1})^y (M^1L^2T^{-1})^z$

$M^1L^0T^0 = M^z L^{y+2z} + T^{x-y-z}$

$z = 1$

$y + 2z = 0$ $\quad$ $x - y - z = 0$

$y = -2$ $\quad$ $x + 2 - 1 = 0$

$x = -1$

$M = [T^{-1} C^{-2} h^1]$

21. **(d)** Dimension of A ≠ dimension of (C)

Hence A – C is not possible.

22. **(b)** We know that resistivity

$$\rho = \frac{RA}{\ell}$$

$$\text{Conductivity} = \frac{1}{\text{resistivity}} = \frac{\ell}{RA}$$

$$= \frac{\ell I}{VA} \quad (\because V = RI)$$

$$= \frac{[L][I]}{\left[\frac{[ML^2T^{-2}]}{[I][T]}\right] \times [L^2]} \quad \because V = \frac{W}{q} = \frac{W}{it}$$

$$= [M^{-1}L^{-3}T^3][I^2] = [M^{-1}L^{-3}T^3I^2]$$

23. **(c)** Let μ_0 related with e, m, c and h as follows.

$\mu_0 = ke^a m^b c^c h^d$

$$[MLT^{-2}A^{-2}] = [AT]^a [M]^b [LT^{-1}]^c [ML^2T^{-1}]^d$$

$= [M^{b+d} L^{c+2d} T^{a-c-d} A^a]$

On comparing both sides we get

$a = -2$ ...(i)

$b + d = 1$ ...(ii)

$c + 2d = 1$ ...(iii)

$a - c - d = -2$ ...(iv)

By equation (i), (ii), (iii) & (iv) we get,

$a = -2,\ b = 0,\ c = -1,\ d = 1$

$$\therefore [\mu_0] = \left[\frac{h}{ce^2}\right]$$

24. **(d)** Let unit 'u' related with e, a_0, h and c as follows.

$[u] = [e]^a [a_0]^b [h]^c [C]^d$

Using dimensional method,

$[M^{-1}L^{-2}T^{+4}A^{+2}] = [A^1T^1]^a [L]^b [ML2T^{-1}]^c [LT^{-1}]^d$

$[M^{-1}L^{-2}T^{+4}A^{+2}] = [M^c L^{b+2c+d} T^{a-c-d} A^a]$

$a = 2,\ b = 1,\ c = -1,\ d = -1$

$$\therefore \quad u = \frac{e^2 a_0}{hc}$$

25. **(b)** The dimensional formulae of

$e = \left[M^0L^0T^1A^1\right]$

$\varepsilon_0 = \left[M^{-1}L^3T^4A^2\right]$

$G = \left[M^{-1}L^3T^{-2}\right]$ and $m_e = \left[M^1L^0T^0\right]$

Now, $\dfrac{e^2}{2\pi\varepsilon_0 G m_e^2}$

$$= \frac{\left[M^0L^0T^1A^1\right]^2}{2\pi\left[M^{-1}L^{-3}T^4A^2\right]\left[M^{-1}L^3T^{-2}\right]\left[M^1L^0T^0\right]^2}$$

$$= \frac{\left[T^2A^2\right]}{2\pi\left[M^{-1-1+2}L^{-3+3}T^{4-2}A^2\right]}$$

$$= \frac{\left[T^2A^2\right]}{2\pi\left[M^0L^0T^2A^2\right]} = \frac{1}{2\pi}$$

$\because \dfrac{1}{2\pi}$ is dimensionless thus the combination $\dfrac{e^2}{2\pi\varepsilon_0 G m_e^2}$ would have the same value in different systems of units.

26. **(c)** Dimensions of $\mu = [MLT^{-2}A^{-2}]$

Dimensions of $\in = [M^{-1}L^{-3}T^4A^2]$

Dimensions of $R = [ML^2T^{-3}A^{-2}]$

$$\therefore \quad \frac{\text{Dimensions of } \mu}{\text{Dimensions of } \in} = \frac{[MLT^{-2}A^{-2}]}{[M^{-1}L^{-3}T^4A^2]}$$

$= [M^2L^4T^{-6}A^{-4}] = [R^2]$

27. **(b)** As we know, $F = \dfrac{1}{4\pi\varepsilon_0}\dfrac{q_1q_2}{R^2}$

$$\Rightarrow \varepsilon_0 = \frac{q_1q_2}{4\pi FR^2}$$

Hence, $\varepsilon_0 = \dfrac{C^2}{N.m^2} = \dfrac{[AT]^2}{[MLT^{-2}][L^2]}$

$= [M^{-1} L^{-3} T^4 A^2]$

28. **(c)**

29. **(d)** Angular momentum $= m \times v \times r = ML^2 T^{-1}$

Latent heat $L = \dfrac{Q}{m} = \dfrac{ML^2T^{-2}}{M} = L^2T^{-2}$

Capacitance $C = \dfrac{\text{Charge}}{\text{P.d.}} = M^{-1}L^{-2}T^4A^2$

30. **(a)** Surface tension, $T = \dfrac{F}{\ell} = \dfrac{F}{\ell}.\dfrac{\ell}{\ell}.\dfrac{T^2}{T^2}$

(As, $F.\ell = K$ (energy); $\dfrac{T^2}{\ell^2} = V^{-2}$)

Therefore, surface tension $= [KV^{-2}T^{-2}]$

31. **(c)** Magnitude of Lorentz formula $F = qvB \sin\theta$

$$B = \frac{F}{qv} = \frac{MLT^{-2}}{C \times LT^{-1}} = [MT^{-1}C^{-1}]$$

32. **(b)** Mutual inductance $= \frac{\phi}{I} = \frac{BA}{I}$

$[\text{Henry}] = \frac{[MT^{-1}Q^{-1}L^2]}{[QT^{-1}]} = ML^2Q^{-2}$

33. **(d)** Moment of Inertia, $I = MR^2$

$[I] = [ML^2]$

Moment of force, $\vec{\tau} = \vec{r} \times \vec{F}$

$\vec{\tau} = [L][MLT^{-2}] = [ML^2T^{-2}]$

34. **(a)** According to, Stokes law,

$F = 6\pi\eta rv \Rightarrow \eta = \frac{F}{6\pi r v}$

$\eta = \frac{[MLT^{-2}]}{[L][LT^{-1}]} \Rightarrow \eta = [ML^{-1}T^{-1}]$

35. **(c)** As we know, the velocity of light in free space is given by

$c = \frac{1}{\sqrt{\mu_o\varepsilon_o}} \quad \therefore \frac{1}{\mu_0\varepsilon_0} = e^2 = Z_1^2T^2$

$\frac{1}{\mu_o\varepsilon_o} = C^2[\text{m/s}]^2$

$= [LT^{-1}]^2$

$= [M^0L^2T^{-2}]$

36. **(b)** Momentum, $= mv = [MLT^{-1}]$

Planck's constant,

$h = \frac{E}{v} = \frac{[ML^2T^{-2}]}{[T^{-1}]} = [ML^2T^{-1}]$

37. **(a)** Work $W = \vec{F}\cdot\vec{s} = Fs\cos\theta$

$\because \vec{A}\cdot\vec{B} = AB\cos\theta$

$= [MLT^{-2}][L] = [ML^2T^{-2}]$;

Torque, $\vec{\tau} = \vec{r} \times \vec{F} \Rightarrow \tau = rF\sin\theta$

$\because \vec{A}\times\vec{B} = AB\sin\theta$

$= [L][MLT^{-2}] = [ML^2T^{-2}]$

38. **(b)** Given : No. of division on circular scale of screw gauge = 50

Pitch = 0.5 mm

Least count of screw gauge

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

$= \frac{0.5}{50}\text{mm} = 1\times10^5 \text{ m} = 10\ \mu\text{m}$

And nature of zero error is positive.

39. **(1050)**

Density, $\rho = \frac{M}{V} = \frac{M}{\frac{4}{3}\pi\left(\frac{D}{2}\right)^3} \Rightarrow \rho = \frac{6}{\pi}MD^{-3}$

$\therefore \%\left(\frac{\Delta\rho}{\rho}\right) = \frac{\Delta m}{m} + 3\left(\frac{\Delta D}{D}\right) = 6 + 3\times1.5 = 10.5\%$

$\%\left(\frac{\Delta\rho}{\rho}\right) = \frac{1050}{100}\% = \left(\frac{x}{100}\right)\%$

$\therefore x = 1050.00$

40. **(d)** Average diameter, $d_{av} = 5.5375$ mm

Deviation of data, $\Delta d = 0.07395$ mm

As the measured data are upto two digits after decimal, therefore answer should be in two digits after decimal.

$\therefore d = (5.54 \pm 0.07)$ mm

41. **(d)** Given : $Z = \frac{a^2b^{2/3}}{\sqrt{c}d^3}$

Percentage error in Z,

$= \frac{\Delta Z}{Z} = \frac{2\Delta a}{a} + \frac{2}{3}\frac{\Delta b}{b} + \frac{1}{2}\frac{\Delta c}{c} + \frac{3\Delta d}{d}$

$= 2\times2 + \frac{2}{3}\times1.5 + \frac{1}{2}\times4 + 3\times2.5 = 14.5\%$.

42. **(a)** Thickness = M.S. Reading + Circular Scale Reading (L.C.)

Here LC $= \frac{\text{Pitch}}{\text{Circular scale division}} = \frac{0.1}{50} = 0.002$ cm per division

So, correct measurement is measurement of integral multiple of L.C.

43. **(c)** L.C. of vernier callipers = 1 MSD – 1 VSD

$= \left(1 - \frac{9}{10}\right)\times1 = 0.1 \text{ mm} = 0.01 \text{ cm}$

Here 7th 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.

Zero error = 7 × 0.1 = 0.7 mm = 0.07 cm.

Length of the cylinder = measured value – zero error

= (3.1 + 4 × 0.01) – 0.07 = 3.07 cm.

44. **(d)** When screw on a screw-gauge is given six rotations, it moves by 3mm on the main scale

$\therefore \quad \text{Pitch} = \frac{3}{6} = 0.5\text{mm}$

$\therefore \quad \text{Least count L.C.} = \frac{\text{Pitch}}{CSD} = \frac{0.5\text{mm}}{50}$

$= \frac{1}{100}\text{mm} = 0.01mm = 0.001\text{cm}$

45. **(None)**

$D_1 = A_1 + B_1 + C_1 = 24.36 + 0.0724 + 256.2 = 280.6$

$D_2 = A_2 + B_2 + C_2 = 24.44 + 16.082 + 240.2 = 280.7$

$D_3 = A_3 + B_3 + C_3 = 25.2 + 19.2812 + 236.183 = 280.7$

$D_4 = A_4 + B_4 + C_4 = 25 + 236.191 + 19.5 = 281$
None of the option matches.

46. (c) Given, Length of simple pendulum, $l = 25.0$ cm
Time of 40 oscillation, $T = 50s$
Time period of pendulum

$$T = 2\pi\sqrt{\frac{\ell}{g}}$$

$$\Rightarrow T^2 = \frac{4\pi^2\ell}{g} \Rightarrow g = \frac{4\pi^2\ell}{T^2}$$

$$\Rightarrow \text{Fractional error in g} = \frac{\Delta g}{g} = \frac{\Delta l}{l} + \frac{2\Delta T}{T}$$

$$\Rightarrow \frac{\Delta g}{g} = \left(\frac{0.1}{25.0}\right) + 2\left(\frac{1}{50}\right) = 0.044$$

$$\therefore \text{Percentage error in } g = \frac{\Delta g}{g} \times 100 = 4.4\%$$

47. (Bonus) $\delta = \frac{M}{V} = \frac{M}{l^3} = Ml^{-3}$

$$\frac{\Delta\delta}{\delta} = \frac{\Delta M}{M} + 3\frac{\Delta l}{l} = \frac{0.10}{10.00} + 3\left(\frac{0.01}{0.10}\right) = 0.31 \text{ kg/m}^3$$

48. (d) $A = 7 \times 5.29 = 37.03 \text{ cm}^2$
The result should have three significant figures, so $A = 37.0 \text{ cm}^2$

49. (d) We have

$$T = 2\pi\sqrt{\frac{\ell}{g}} \text{ or } g = 4\pi^2\frac{\ell}{T^2}$$

$$\frac{\Delta g}{g} \times 100 = \frac{\Delta R}{Q} \times 100 + 2\frac{\Delta T}{T} \times 100$$

$$= \frac{0.1}{55} \times 100 + 2\left(\frac{1}{30}\right) \times 100$$

$= 0.18 + 6.67 = 6.8\%$

50. (b) Least count of main scale of screw gauge = 1 mm
Least count of screw gauge

$$= \frac{\text{Pitch}}{\text{Number of division on circular scale}}$$

$$5 \times 10^{-6} = \frac{10^{-3}}{N}$$

$\Rightarrow N = 200$

51. (c)

52. (c) Least count of screw gauge,

$$LC = \frac{\text{Pitch}}{\text{No. of division}}$$

$= 0.5 \times 10^{-3} = 0.5 \times 10^{-2}$ mm + ve error $= 3 \times 0.5 \times 10^{-2}$ mm
$= 1.5 \times 10^{-2}$ mm $= 0.015$ mm
Reading = MSR + CSR – (+ve error)
$= 5.5 \text{ mm} + (48 \times 0.5 \times 10^{-2}) - 0.015$
$= 5.5 + 0.24 - 0.015 = 5.725$ mm

53. (c) $= 1.5\% + 3(1\%) = 4.5\%$

54. (d) Maximum percentage error in A
$= 3(\%\text{ error in P}) + 2(\%\text{ error in Q}) + \frac{1}{2}(\%\text{ error in R}) + 1(\%\text{ error in S})$

$$= 3 \times 0.5 + 2 \times 1 + \frac{1}{2} \times 3 + 1 \times 1.5$$

$= 1.5 + 2 + 1.5 + 1.5 = 6.5\%$

55. (c) From Kepler's law, time period of a satellite,

$$T = 2\pi\sqrt{\frac{r^3}{Gm}} \qquad T^2 = \frac{4\pi^2}{GM}r^3$$

Relative uncertainty in the mass of the earth

$$\left|\frac{\Delta M}{M}\right| = 2\frac{\Delta T}{T} = 2 \times 10^{-2}$$

($\because$ 4π & G constant and relative uncertainty in radius $\frac{\Delta r}{r}$ negligible)

56. (c) Relative error in Surface area, $\frac{\Delta s}{s} = 2 \times \frac{\Delta r}{r} = \alpha$ and relative error in volume, $\frac{\Delta v}{v} = 3 \times \frac{\Delta r}{r}$

$\therefore$ Relative error in volume w.r.t. relative error in area,

$$\frac{\Delta v}{v} = \frac{3}{2}\alpha$$

57. (d) Least count $= \frac{\text{Value of 1 part on main scale}}{\text{Number of parts on vernier scale}}$

$$= \frac{0.25}{5 \times 100} \text{ cm} = 5 \times 10^{-4} \text{ cm}$$

Reading $= 4 \times 0.05 \text{ cm} + 30 \times 5 \times 10^{-4}$ cm
$= (0.2 + 0.0150)$ cm $= 0.2150$ cm (Thickness of wire)

58. (d) Surface tension, $T = \frac{rhg}{2} \times 10^3$
Relative error in surface tension,

$$\frac{\Delta T}{T} = \frac{\Delta r}{r} + \frac{\Delta h}{h} + 0 \quad (\because \text{ g, 2 \& } 10^3 \text{ are constant})$$

Percentage error

$$100 \times \frac{\Delta T}{T} = \left(\frac{10^{-2} \times 0.01}{1.25 \times 10^{-2}} + \frac{10^{-2} \times 0.01}{1.45 \times 10^{-2}}\right)100$$

$= (0.8 + 0.689)$
$= (1.489) = 1.489\% \cong 1.5\%$

59. (c) Given, $P = a^{1/2} b^2 c^2 d^{-4}$,
Maximum relative error,

$$\frac{\Delta P}{P} = \frac{1}{2}\frac{\Delta a}{a} + 2\frac{\Delta b}{b} + 3\frac{\Delta c}{c} + 4\frac{\Delta d}{d}$$

$$= \frac{1}{2} \times 2 + 2 \times 1 + 3 \times 3 + 4 \times 5 = 32\%$$

60. (d) L.C. $= \frac{0.5}{50} = 0.01$ mm
Zero error $= 5 \times 0.01 = 0.05$ mm (Negative)
Reading $= (0.5 + 25 \times 0.01) + 0.05 = 0.80$ mm

61. **(c)** $\Delta T = \frac{|\Delta T_1| + |\Delta T_2| + |\Delta T_3| + |\Delta T_4|}{4}$

$= \frac{2+1+3+0}{4} = 1.5$

As the resolution of measuring clock is 1.5 therefore the mean time should be 92 ± 1.5

62. **(d)** As, $g = 4\pi^2 \frac{L}{T^2}$

So, $\frac{\Delta g}{g} \times 100 = \frac{\Delta L}{L} \times 100 + 2\frac{\Delta T}{T} \times 100$

$= \frac{0.1}{20} \times 100 + 2 \times \frac{1}{90} \times 100 = 2.72 \simeq 3\%$

63. **(b)** Least count $= \frac{0.1}{10} = 0.01$ cm

$d_1 = 0.5 + 8 \times 0.01 + 0.03 = 0.61$ cm
$d_2 = 0.5 + 4 \times 0.01 + 0.03 = 0.57$ cm
$d_3 = 0.5 + 6 \times 0.01 + 0.03 = 0.59$ cm

Mean diameter $= \frac{0.61 + 0.57 + 0.59}{3}$

$= 0.59$ cm

64. **(a)** The current voltage relation of diode is

$I = (e^{1000\,V/T} - 1)$ mA (given)

When, $I = 5mA, e^{1000\,V/T} = 6mA$

Also, $dI = (e^{1000\,V/T}) \times \frac{1000}{T}$

Error = ± 0.01 (By exponential function)

$= (6\,mA) \times \frac{1000}{300} \times (0.01) = 0.2$ mA

65. **(b)** Measured length of rod = 3.50 cm

For Vernier Scale with 1 Main Scale Division = 1 mm

9 Main Scale Division = 10 Vernier Scale Division,

Least count = 1 MSD – 1 VSD = 0.1 mm

66. **(a)** Rotation period of earth is about 24 hrs $\simeq 10^5$ s

Revolution period of earth is about 365 days $\simeq 10^7$ s

Speed of light wave $C = 3 \times 10^8$ m/s

Wavelength of visible light of spectrum

$\lambda = 4000 - 7800$ Å

$C = f\lambda \left(\text{and } T = \frac{1}{f}\right)$

Therefore period of light wave is 10^{-15} s (approx)

67. **(d)** In a voltmeter

$V \propto l$

$V = kl$

Now, it is given E = 1.1 volt for $l_1 = 440$ cm

and V = 0.5 volt for $l_2 = 220$ cm

Let the error in reading of voltmeter be ΔV then,

$1.1 = 400$ K and $(0.5 - \Delta V) = 220$ K.

$\Rightarrow \frac{1.1}{440} = \frac{0.5 - \Delta V}{220}$

$\therefore \Delta V = -0.05$ volt

68. **(b)** According to the question.

$t = (90 \pm 1)$ or, $\frac{\Delta t}{t} = \frac{1}{90}$

$l = (20 \pm 0.1)$ or, $\frac{\Delta l}{l} = \frac{0.1}{20}$

$\frac{\Delta g}{g}\% = ?$

As we know,

$t = 2\pi\sqrt{\frac{l}{g}} \Rightarrow g = \frac{4\pi^2 l}{t^2}$

or, $\frac{\Delta g}{g} = \pm\left(\frac{\Delta l}{l} + 2\frac{\Delta t}{t}\right) = \left(\frac{0.1}{20} + 2 \times \frac{1}{90}\right) = 0.027$

$\therefore \frac{\Delta g}{g}\% = 2.7\%$

69. **(a)** According to ohm's law, V = IR

$R = \frac{V}{I}$

$\therefore$ Percentage error $= \frac{\text{Absolute error}}{\text{Measurement}} \times 10^2$

where, $\frac{\Delta V}{V} \times 100 = \frac{\Delta I}{I} \times 100 = 3\%$

then, $\frac{\Delta R}{R} \times 100 = \frac{\Delta V}{V} \times 10^2 + \frac{\Delta I}{I} \times 10^2$

$= 3\% + 3\% = 6\%$

70. **(c)** $\because$ Reading of Vernier = Main scale reading + Vernier scale reading × least count.

Main scale reading = 58.5

Vernier scale reading = 09 division

least count of Vernier = 0.5°/30

Thus, $R = 58.5° + 9 \times \frac{0.5°}{30}$

$R = 58.65°$

71. **(d)** No. of divisions on main scale = N

No. of divisions on vernier scale = $N + 1$

size of main scale division = a

Let size of vernier scale division be b

then we have

$aN = b(N+1) \Rightarrow b = \frac{aN}{N+1}$

Least count is $a - b = a - \frac{aN}{N+1}$

$= a\left[\frac{N+1-N}{N+1}\right] = \frac{a}{N+1}$

72. **(d)** The least count (L.C.) of a screw guage is the smallest length which can be measured accurately with it.

As least count is 0.001 cm $= \frac{1}{1000}$ cm

Hence measured value should be recorded upto 3 decimal places i.e., 5.320 cm

73. **(a)** Least count, L.C. = $\frac{1}{100}$ mm

Diameter of wire = $MSR + CSR \times L.C.$

$\because$ 1 mm = 0.1 cm

$= 0 + \frac{1}{100} \times 52 = 0.52\text{ mm} = 0.052\text{ cm}$

74. **(a)** Number of significant figures in 23.023 = 5

Number of significant figures in 0.0003 = 1

Number of significant figures in $2.1 \times 10^{-3} = 2$

So, the radiation belongs to X-rays part of the spectrum.

75. **(d)** 30 Divisions of V.S. coincide with 29 divisions of M.S.

$\therefore$ 1 V.S.D = $\frac{29}{30}$ MSD

L.C. = 1 MSD – 1VSD

= 1 MSD $- \frac{29}{30}$ MSD

$= \frac{1}{30}$ MSD

$= \frac{1}{30} \times 0.5° = 1$ minute.

76. **(a)** Momentum, $p = m \times v$

Given, mass of a body = 3.513 kg speed of body

= (3.513) × (5.00) = 17.565 kg m/s

= 17.6 (Rounding off to get three significant figures)

77. **(d)** Least count of screw gauge = 0.01 mm

$\because \frac{0.5}{50}$ mm

Reading = [M.S.R. + C.S.R. × L.C.] – (zero error)

= [3 + 35 × 0.01] – (–0.03) = 3.38 mm