

PHYSICS for you



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Competition Edge

NEET Solved Paper 2017	21
WB JEE Solved Paper 2017	31
Olympiad Problems	42
Kerala PET Solved Paper 2017	48
Physics Musing Solution Set 46	61
Karnataka CET Solved Paper 2017	63
Physics Musing Problem Set 47	80

Class 11

Exam Prep	8
MPP-2	17
Brain Map	46

Class 12

Brain Map	47
Ace Your Way CBSE : Series 1	71
MPP-2	82

CONTENTS

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EXAM PREP 2018

CLASS
XI



Useful for Medical/Engg. Entrance Exams

CHAPTERWISE MCQs FOR PRACTICE

UNITS AND MEASUREMENT

- One nautical mile is equal to 6080 feet. 18 nautical mile per hour is equal to
 (a) 1.46 m s^{-1} (b) 9.26 m s^{-1}
 (c) 4.28 m s^{-1} (d) 7.36 m s^{-1}
- A physical quantity z , depends upon two other physical quantities x and y , as follows $z = ax^2y^{1/2}$ where, a is a constant. In an experiment, the quantity x is determined by measuring z and y , and using the above expression. If the percentage error in the measurement of z and y are 10% and 12% respectively, then the percentage error in the determined value of x is
 (a) 2% (b) 8%
 (c) 15% (d) without the value of the constant a , the percentage error cannot be calculated
- A student writes four different expressions for the displacement y in a periodic motion as a function of time t , a as amplitude, T as time period. Which of the following can be correct?
 (a) $y = aT \sin \frac{2\pi t}{T}$ (b) $y = \frac{a}{T} \sin t$
 (c) $y = \frac{a}{T} \sin \frac{t}{a}$
 (d) $y = \frac{a}{\sqrt{2}} \left[\sin \frac{2\pi t}{T} + \cos \frac{2\pi t}{T} \right]$
- The frequency ν of an oscillating drop may depend upon radius r of the drop, density ρ of the liquid and surface tension S of the liquid. An expression for ν dimensionally is
 (a) $\nu = k \sqrt{\frac{S}{\rho r^2}}$ (b) $\nu = k \sqrt{\frac{S}{\rho r^3}}$
 (c) $\nu = k \sqrt{\frac{S}{\rho r}}$ (d) $\nu = k \sqrt{\rho r S}$
- In the formula $X = 3YZ^2$, X and Z have dimensions of capacitance and magnetic induction, respectively. The dimensions of Y is (Q denotes charge)
 (a) $[M^{-3} L^{-1} T^3 Q^4]$ (b) $[M^{-3} L^{-2} T^4 Q^4]$
 (c) $[M^{-2} L^{-2} T^4 Q^4]$ (d) $[M^{-3} L^{-2} T^4 Q]$
- If voltage, $V = (100 \pm 5) \text{ V}$ and current, $I = (10 \pm 0.2) \text{ A}$, the percentage error in resistance R is
 (a) 5.2% (b) 25%
 (c) 7% (d) 10%
- In an experiment, the period of oscillation of a simple pendulum was observed to be 2.63 s, 2.56 s, 2.42 s, 2.71 s and 2.80 s. The mean absolute error is
 (a) 0.11 s (b) 0.12 s
 (c) 0.13 s (d) 0.14 s
- The mass of a box measured by a grocer's balance is 2.3 kg. Two gold pieces of masses 20.15 g and 20.17 g are added to the box. What is the total mass of the box and the difference in the masses of the pieces to correct significant figures
 (a) 2.34 kg, 0 g (b) 2.3 kg, 0.02 g
 (c) 2.34 kg, 0.02 g (d) 2.3 kg, 0 g
- The unit of length is 5 cm, unit of mass is 100 g, and unit of time is 0.01 s. In a system of measurement, how many newton will the unit of force contains?
 (a) 5×10^5 (b) 5×10^{-5}
 (c) 50 (d) 10

10. Which one of the following is not correct?

- (a) Dimensional formula of thermal conductivity (K) is $[M^1L^1T^{-3}K^{-1}]$.
 (b) Dimensional formula of potential (V) is $[M^1L^2T^3A^{-1}]$.
 (c) Dimensional formula of permeability of free space (μ_0) is $[M^1L^1T^{-2}A^{-2}]$.
 (d) Dimensional formula of RC is $[M^0L^0T^1]$.

11. Which of the following product of e, h, μ, G (where μ is the permeability) be taken so that the dimensions of the product are same as that of the speed of light?

- (a) $he^{-2}\mu^{-1}G^0$ (b) $h^2eG^0\mu$
 (c) $h^0e^2G^{-1}m$ (d) $hGe^{-2}m^0$

12. 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 $1''$ (s) of arc from opposite ends of a baseline equal to the distance from the earth to the sun. The order of magnitude of parsec in terms of m is

- (a) 16 (b) 20 (c) 14 (d) 23

13. Suppose a quantity y can be dimensionally represented in terms of M, L and T, that is $[y] = [M^a L^b T^c]$ then M

- (a) may be represented in terms of L, T and y if $a = 0$
 (b) may be represented in terms of L, T and y if $a \neq 0$
 (c) can always be dimensionally represented in terms of L, T and y
 (d) can never be dimensionally represented in terms of L, T and y .

14. The equation of state of a gas is given by

$$\left(P + \frac{a}{V^3}\right)(V - b^2) = cT, \text{ where } P, V, T \text{ are pressure,}$$

volume and temperature respectively and a, b, c are constants. The dimensions of a and b are respectively

- (a) $[ML^8T^{-2}]$ and $[L^{3/2}]$
 (b) $[ML^5T^{-2}]$ and $[L^3]$
 (c) $[ML^5T^{-2}]$ and $[L^6]$
 (d) $[ML^6T^{-2}]$ and $[L^{3/2}]$

15. A new system of units is proposed in which unit of mass is α kg, unit of length is β m and unit of time is γ s. What will be value of 5 J in this new system?

- (a) $5\alpha\beta^2\gamma^{-2}$ (b) $5\alpha^{-1}\beta^{-2}\gamma^2$
 (c) $5\alpha^{-2}\beta^{-1}\gamma^{-2}$ (d) $5\alpha^{-1}\beta^2\gamma^2$

MOTION IN A STRAIGHT LINE

16. A point moves with uniform acceleration and v_1, v_2 and v_3 denote the average velocities in the three successive intervals of time t_1, t_2 and t_3 . Which of the following relations is correct?

- (a) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 + t_3)$
 (b) $(v_1 - v_2) : (v_2 - v_3) = (t_1 + t_2) : (t_2 + t_3)$
 (c) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_1 - t_3)$
 (d) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 - t_3)$

17. A particle moves along x -axis and its displacement at any time is given by $x(t) = 2t^3 - 3t^2 + 4t$ in SI units. The velocity of the particle when its acceleration is zero, is

- (a) 2.5 m s^{-1} (b) 3.5 m s^{-1}
 (c) 4.5 m s^{-1} (d) 8.5 m s^{-1}

18. A rocket is fired vertically from the ground with a resultant vertical acceleration of 10 m s^{-2} . The fuel is finished in 1 min and it continues to move up. What is the maximum height reached?

- (a) 42.3 km (b) 48.4 km
 (c) 36.4 km (d) 25.6 km

19. A particle moves along a straight line such that its position x at any time t is $x = 6t^2 - t^3$ where x is in m and t is in s. Then

- (a) at $t = 0$ acceleration is 12 m s^{-2} .
 (b) $x - t$ curve has maxima at 4 s.
 (c) both (a) and (b) are wrong.
 (d) both (a) and (b) are correct.

20. A particle starts from rest and has an acceleration of 2 m s^{-2} for 10 s. After that, the particle travels for 30 s with constant speed and then undergoes a retardation of 4 m s^{-2} and comes back to rest. The total distance covered by the particle is

- (a) 650 m (b) 700 m
 (c) 750 m (d) 800 m

21. A body starts from rest with an acceleration of 2 m s^{-2} . After 5 s, the direction of acceleration reverses again for 5 s. The displacement is

- (a) 0 m (b) 50 m (c) 55 m (d) 500 m

22. A parachutist jump first freely from an aeroplane for 10 s and then his parachute opens out. Now he descends with a net retardation of 2.5 m s^{-2} . If he bails out of the plane at a height of 2495 m and $g = 10 \text{ m s}^{-2}$, his velocity on reaching the ground will be

- (a) 5 m s^{-1} (b) 10 m s^{-1}
 (c) 15 m s^{-1} (d) 20 m s^{-1}

23. A car A is travelling on a straight level road with a speed of 60 km h^{-1} . It is followed by another car B which is moving with a speed of 70 km h^{-1} . When the distance between them is 2.5 km , the car B is given a deceleration of 20 km h^{-2} . After what distance will the car B catch up with car A?

- (a) 28.4 km (b) 36.4 km
(c) 22.6 km (d) 32.5 km

24. A body travelling with uniform acceleration crosses two points A and B with velocities 20 m s^{-1} and 30 m s^{-1} respectively. The speed of the body at the midpoint of A and B is nearest to

- (a) 25.5 m s^{-1} (b) 25 m s^{-1}
(c) 24 m s^{-1} (d) $10\sqrt{6} \text{ m s}^{-1}$

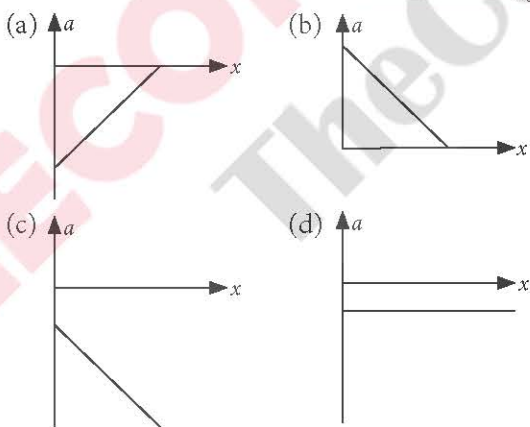
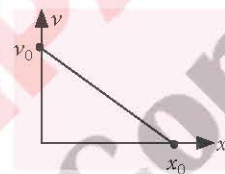
25. A car moving on a straight road covers $(1/3)^{\text{rd}}$ of the distance with 25 km h^{-1} and rest with 75 km h^{-1} . The average speed is

- (a) 25 km h^{-1} (b) 45 km h^{-1}
(c) 55 km h^{-1} (d) 75 km h^{-1}

26. A body starts from rest and travels a distance s with uniform acceleration, then moves uniformly a distance $2s$ and finally comes to rest after moving further $5s$ under uniform retardation. The ratio of the average velocity to maximum velocity is

- (a) $\frac{2}{5}$ (b) $\frac{3}{5}$ (c) $\frac{4}{7}$ (d) $\frac{5}{7}$

27. The velocity-displacement graph of a particle moving along a straight line is shown. The most suitable acceleration-displacement graph will be



28. From a building two balls A and B are thrown such that A is thrown upwards and B downwards with the same speed (both vertically). If v_A and v_B are their respective velocities on reaching the ground then,

- (a) $v_B > v_A$ (b) $v_A = v_B$
(c) $v_A > v_B$
(d) their velocities depend on their masses

29. A man runs at a speed of 4.0 m s^{-1} to overtake a standing bus. When he is 6.0 m behind the door of the bus (at $t = 0$), the bus moves forward and continues with a constant acceleration of 1.2 m s^{-2} . The man shall reach the door at time t equal to
(a) 5.2 s (b) 4.3 s (c) 2.3 s
(d) the man shall never gain the door

30. A train 100 m long travelling at 40 m s^{-1} starts overtaking another train 200 m long travelling at 30 m s^{-1} . The time taken by the train to pass the second train completely is
(a) 30 s (b) 40 s (c) 50 s (d) 60 s

SOLUTIONS

1. (b): Given : One nautical mile = 6080 feet

$$n_1 u_1 = n_2 u_2 \quad \text{or} \quad 18 \left(\frac{\text{nautical mile}}{\text{hour}} \right) = n_2 \frac{\text{m}}{\text{s}}$$

$$\therefore n_2 = 18 \times \frac{6080 \text{ ft}}{60 \times 60} = \frac{18 \times 6080 \times 12 \times 2.54 \times 10^{-2} \text{ m}}{60 \times 60 \text{ s}} = 9.26 \text{ ms}^{-1}$$

2. (b): Given : $z = ax^2 y^{1/2}$

$$\therefore x^2 = \frac{z}{ay^{1/2}} \quad \text{or} \quad x = \frac{z^{1/2}}{a^{1/2} y^{1/4}} \quad \text{where } a \text{ is a constant.}$$

Relative error in x is

$$\frac{\Delta x}{x} = \frac{1}{2} \frac{\Delta z}{z} + \frac{1}{4} \frac{\Delta y}{y}$$

Percentage error in x is

$$\begin{aligned} \frac{\Delta x}{x} \times 100 &= \left(\frac{1}{2} \frac{\Delta z}{z} + \frac{1}{4} \frac{\Delta y}{y} \right) \times 100 \\ &= \frac{1}{2} \times 10\% + \frac{1}{4} \times 12\% \\ &= 5\% + 3\% = 8\% \end{aligned}$$

3. (d)

MPP-2 CLASS XII ANSWER KEY

- | | | | | |
|------------|------------|------------|---------|---------------|
| 1. (b) | 2. (c) | 3. (b) | 4. (a) | 5. (c) |
| 6. (a) | 7. (d) | 8. (c) | 9. (b) | 10. (a) |
| 11. (b) | 12. (b) | 13. (c) | 14. (a) | 15. (b) |
| 16. (a) | 17. (c) | 18. (a) | 19. (d) | 20. (a, b, d) |
| 21. (b, d) | 22. (b, c) | 23. (a, d) | 24. (2) | 25. (4) |
| 26. (2) | 27. (c) | 28. (b) | 29. (a) | 30. (a) |

4. (b): Let $v = k r^a \rho^b S^c$... (i)
where k = a dimensionless constant.

Dimensions of various quantities are

$$[v] = [T^{-1}], [r] = [L], [\rho] = [ML^{-3}], [S] = [MT^{-2}]$$

Substituting these dimensions in eqn (i), we get

$$[T^{-1}] = [L]^a [ML^{-3}]^b [MT^{-2}]^c$$

$$\text{or } [M^0 L^0 T^{-1}] = [M^{b+c} L^{a-3b} T^{-2c}]$$

Equating the powers of M, L and T on both sides,

$$b + c = 0, a - 3b = 0, -2c = -1$$

On solving these equations, we get

$$a = -\frac{3}{2}, b = -\frac{1}{2}, c = \frac{1}{2}$$

$$\therefore v = k r^{-3/2} \rho^{-1/2} S^{1/2} = k \sqrt{\frac{S}{\rho r^3}}$$

5. (b): The given formula is, $X = 3YZ^2$

$$Y = \left[\frac{X}{Z^2} \right] = \left[\frac{\text{Capacitance}}{(\text{Magnetic induction})^2} \right]$$

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

Hence, the correct answer is (b).

6. (c): Given : Voltage, $V = (100 \pm 5) V$
Current, $I = (10 \pm 0.2) A$

According to Ohm's law, $V = IR$ or $R = \frac{V}{I}$

Relative error in R is

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

Percentage error in resistance R is

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

$$= \frac{5}{100} \times 100 + \frac{0.2}{10} \times 100 = 7\%$$

7. (a): The mean period of oscillation of the pendulum is

$$T_{\text{mean}} = \frac{\sum_{i=1}^n T_i}{n} = \frac{(2.63 + 2.56 + 2.42 + 2.71 + 2.80)}{5} \text{ s}$$

$$= \frac{13.12}{5} \text{ s} = 2.624 \text{ s} = 2.62 \text{ s}$$

(Rounded off to two decimal places)

The absolute errors in the measurement are

$$\Delta T_1 = 2.62 \text{ s} - 2.63 \text{ s} = -0.01 \text{ s}$$

$$\Delta T_2 = 2.62 \text{ s} - 2.56 \text{ s} = 0.06 \text{ s}$$

$$\Delta T_3 = 2.62 \text{ s} - 2.42 \text{ s} = 0.20 \text{ s}$$

$$\Delta T_4 = 2.62 \text{ s} - 2.71 \text{ s} = -0.09 \text{ s}$$

$$\Delta T_5 = 2.62 \text{ s} - 2.80 \text{ s} = -0.18 \text{ s}$$

Mean absolute error is

$$\Delta T_{\text{mean}} = \frac{\sum_{i=1}^n |\Delta T_i|}{n}$$

$$= \frac{(0.01 + 0.06 + 0.20 + 0.09 + 0.18)}{5} = \frac{0.54}{5} \text{ s} = 0.11 \text{ s}$$

8. (b): Total mass = 2.3 kg + 0.02015 kg + 0.02017 kg
= 2.34032 kg = 2.3 kg

Difference of mass of the gold pieces

$$= 20.17 \text{ g} - 20.15 \text{ g} = 0.02 \text{ g}$$

9. (c) 10. (b)

11. (a): Here $v = e^a h^b \mu^c G^d$. Taking the dimensions,
 $[M^0 L T^{-1} A^0] = [AT^{-1}]^a [ML^2 T^{-1}]^b [MLT^{-2} A^{-2}]^c [M^{-1} L^3 T^{-2}]^d$
There will be four simultaneous equations by equating the dimensions of M, L, T and A. These are $a - 2c = 0$, $a - b - 2c - 2d = -1$, $b + c - d = 0$ and $2b + c + 3d = 1$.

Solving for a , b , c and d , we get

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

$$\text{Thus, } v = h e^{-2} \mu^{-1} G^0$$

12. (a): One parsec is the distance at which an arc of length 1 AU makes an angle of 1 second of an arc.

$$\text{As } \theta(\text{rad}) = \frac{\text{Arc}}{\text{Radius}} = \frac{l}{r} \quad \therefore r = \frac{l}{\theta}$$

$$\text{Here } l = 1 \text{ AU} = 1.496 \times 10^{11} \text{ m}$$

$$\theta = 1 \text{ s of arc} = \frac{\pi}{60 \times 60 \times 180} \text{ rad} = 4.85 \times 10^{-6} \text{ rad}$$

$$\therefore 1 \text{ parsec} = r = \frac{1.496 \times 10^{11}}{4.85 \times 10^{-6}} = 3.08 \times 10^{16} \text{ m}$$

Order of magnitude of parsec = 16.

13. (b): $M = L^{-\frac{b}{a}} T^{-\frac{c}{a}} Y^{\frac{1}{a}}$ if $a \neq 0$.

14. (a): Given, $\left(P + \frac{a}{V^3} \right) (V - b^2) = cT$

Dimension of $\frac{a}{V^3}$ = dimensions of P

\therefore Dimensions of a = dimensions of PV^3

$$[a] = \left[\frac{F}{A} V^3 \right] \quad \left(\because P = \frac{F}{A} \right)$$

$$= \frac{[MLT^{-2}]}{[L^2]} \times [L^3]^3 = [ML^8 T^2]$$

Dimensions of b^2 = dimensions of V

$$\therefore [b] = [V]^{1/2} = [L^3]^{1/2} \text{ or } [b] = [L^{3/2}]$$

15. (b): Joule is a unit of energy.

SI	New system
$n_1 = 5$	$n_2 = ?$
$M_1 = 1 \text{ kg}$	$M_2 = \alpha \text{ kg}$
$L_1 = 1 \text{ m}$	$L_2 = \beta \text{ m}$
$T_1 = 1 \text{ s}$	$T_2 = \gamma \text{ s}$

Dimensional formula of energy is $[ML^2T^{-2}]$.

Comparing with $[M^aL^bT^c]$, we get

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

$$\begin{aligned} \text{As } n_2 &= n_1 \left(\frac{M_1}{M_2} \right)^a \left(\frac{L_1}{L_2} \right)^b \left(\frac{T_1}{T_2} \right)^c \\ &= 5 \left(\frac{1 \text{ kg}}{\alpha \text{ kg}} \right)^1 \left(\frac{1 \text{ m}}{\beta \text{ m}} \right)^2 \left(\frac{1 \text{ s}}{\gamma \text{ s}} \right)^{-2} = \frac{5\gamma^2}{\alpha\beta^2} = 5\alpha^{-1}\beta^{-2}\gamma^2 \end{aligned}$$

16. (b): Suppose u be the initial velocity.

$$\text{Velocity after time } t_1 : v_{11} = u + at_1$$

$$\text{Velocity after time } t_1 + t_2 : v_{22} = u + a(t_1 + t_2)$$

$$\text{Velocity after time } t_1 + t_2 + t_3 :$$

$$v_{33} = u + a(t_1 + t_2 + t_3)$$

$$\text{Now, } v_1 = \frac{u + v_{11}}{2} = \frac{u + u + at_1}{2} = u + \frac{1}{2}at_1$$

$$v_2 = \frac{v_{11} + v_{22}}{2} = u + at_1 + \frac{1}{2}at_2$$

$$v_3 = \frac{v_{22} + v_{33}}{2} = u + at_1 + at_2 + \frac{1}{2}at_3$$

$$\text{So } v_1 - v_2 = -\frac{1}{2}a(t_1 + t_2)$$

$$v_2 - v_3 = -\frac{1}{2}a(t_2 + t_3)$$

$$(v_1 - v_2) : (v_2 - v_3) = (t_1 + t_2) : (t_2 + t_3)$$

17. (a)

18. (c): Height covered in 1 min,

$$s_1 = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 10 \times (60)^2 = 18000 \text{ m}$$

Velocity attained after 1 min,

$$v = u + at = 0 + 10 \times 60 = 600 \text{ m s}^{-1}$$

After the fuel is finished, $u = 600 \text{ m s}^{-1}$, $v = 0$

$$v^2 - u^2 = 2gs_2$$

$$\text{or } 0 - (600)^2 = 2 \times (-9.8) \times s_2$$

$$\text{or } s_2 = \frac{(600)^2}{2 \times 9.8} = 18367.3 \text{ m}$$

Maximum height reached

$$= s_1 + s_2 = 36367.3 \text{ m} \approx 36.4 \text{ km}$$

19. (d): Given, $x = 6t^2 - t^3 \therefore \frac{dx}{dt} = 12t - 3t^2$

For maximum or minimum

$$\frac{dx}{dt} = 0 \Rightarrow 12t - 3t^2 = 0 \text{ or } t = 4 \text{ s}$$

Again differentiating, we get $\frac{d^2x}{dt^2} = 12 - 6t$

$$\text{At } t = 4 \text{ s, } \frac{d^2x}{dt^2} = 12 - 6(4) = -12$$

Since $\frac{d^2x}{dt^2}$ is negative, hence $t = 4 \text{ s}$ gives the maximum value for $x-t$ curve.

$$\text{Acceleration, } a = \frac{d^2x}{dt^2} = 12 - 6t, \text{ At } t = 0, a = 12 \text{ m s}^{-2}$$

20. (c): Given, $u = 0$, $a = 2 \text{ m s}^{-2}$, $t = 10 \text{ s}$.

$$\therefore s_1 = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 2 \times (10)^2 = 100 \text{ m}$$

$$v = u + at = 0 + 10 \times 2 = 20 \text{ m s}^{-1}$$

For motion with constant speed: $t = 30 \text{ s}$

$$s_2 = vt = 20 \times 30 = 600 \text{ m}$$

For motion with retardation:

$$u = 20 \text{ m s}^{-1}, a = 4 \text{ m s}^{-2}, v = 0$$

$$\text{As } v^2 - u^2 = 2as_3$$

$$\therefore 0 - 20^2 = 2(-4) \times s_3$$

$$s_3 = 50 \text{ m}$$

Total distance covered

$$s = s_1 + s_2 + s_3 = 100 + 600 + 50 = 750 \text{ m}$$

21. (a)

22. (a): The velocity v acquired by the parachutist after 10 s is

$$v = u + gt = 0 + 10 \times 10 = 100 \text{ m s}^{-1}$$

$$\text{Then, } s_1 = ut + \frac{1}{2}gt^2 = 0 + \frac{1}{2} \times 10 \times 10^2 = 500 \text{ m}$$

The distance travelled by the parachutist under retardation is

$$s_2 = 2495 - 500 = 1995 \text{ m}$$

Let v_g be the velocity on reaching the ground. Then

$$v_g^2 - v^2 = 2as_2$$

$$\text{or } v_g^2 - (100)^2 = 2 \times (-2.5) \times 1995 \text{ or } v_g = 5 \text{ m s}^{-1}$$

23. (d): Relative velocity of car B w.r.t. A

$$= 70 - 60 = 10 \text{ km h}^{-1}$$

\therefore For car B,

$$u = 10 \text{ km h}^{-1}, s = 2.5 \text{ km}, a = -20 \text{ km h}^{-2}$$

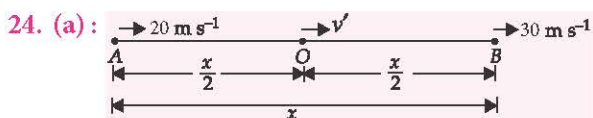
$$\text{As } s = ut + \frac{1}{2}at^2$$

$$\therefore 2.5 = 10t - \frac{1}{2} \times 20 \times t^2 \text{ or } t = 0.5 \text{ h}$$

Actual distance travelled by car B during this time,

$$s = ut + \frac{1}{2}at^2 = 70 \times 0.5 - \frac{1}{2} \times 20 \times (0.5)^2$$

$$= 35 - 2.5 = 32.5 \text{ km}$$



Let x be the distance between two points A and B and O is the midpoint of AB . Let a be the uniform acceleration of the body and v' be velocity of the body at point O .

Using $v^2 - u^2 = 2as$

According to given problem

$$(v')^2 - (20)^2 = 2a \frac{x}{2} \quad \dots(i)$$

$$\text{and } (30)^2 - (v')^2 = 2a \frac{x}{2} \quad \dots(ii)$$

Equating eqns (i) and (ii), we get

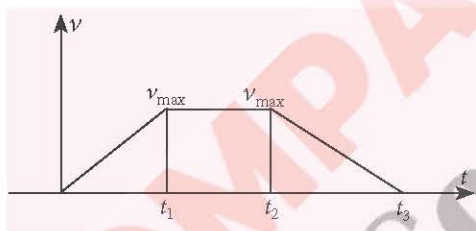
$$(v')^2 - (20)^2 = (30)^2 - (v')^2 \quad \text{or } 2(v')^2 = (30)^2 + (20)^2$$

$$v' = \sqrt{\frac{(30)^2 + (20)^2}{2}} = \sqrt{\frac{900 + 400}{2}} = 25.5 \text{ m s}^{-1}$$

25. (b)

26. (c): Graphically, the area of $v-t$ curve represents displacement:

$$s = \frac{1}{2} v_{\max} t_1 \quad \text{or } t_1 = \frac{2s}{v_{\max}}$$



$$2s = v_{\max} t_2 \quad \text{or } t_2 = \frac{2s}{v_{\max}}; 5s = \frac{1}{2} v_{\max} t_3 \quad \text{or } t_3 = \frac{10s}{v_{\max}}$$

$$v_{\text{av}} = \frac{\text{Total displacement}}{\text{Total time}} = \frac{s + 2s + 5s}{\frac{2s}{v_{\max}} + \frac{2s}{v_{\max}} + \frac{10s}{v_{\max}}}$$

$$\frac{v_{\text{av}}}{v_{\max}} = \frac{8s}{14s} = \frac{4}{7}$$

27. (a): From the given velocity-displacement graph,

$$\text{Slope} = -\frac{v_0}{x_0}, \text{ intercept on } y\text{-axis} = v_0$$

Thus the equation for this graph is

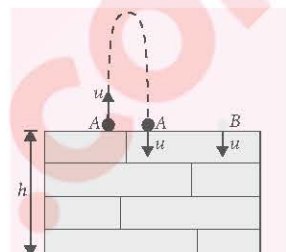
$$v = -\frac{v_0}{x_0} \cdot x + v_0 \quad \therefore \frac{dv}{dt} = -\frac{v_0}{x_0} \frac{dx}{dt}$$

$$\text{or } a = -\frac{v_0}{x_0} \cdot v = -\frac{v_0}{x_0} \left(-\frac{v_0}{x_0} x + v_0 \right)$$

$$\text{or } a = -\frac{v_0^2}{x_0^2} \cdot x - \frac{v_0^2}{x_0^2}$$

Clearly, the $a-x$ graph must have a positive slope (v_0^2/x_0^2) and negative intercept ($-v_0^2/x_0^2$) on y -axis.

28. (b): Let the ball A is thrown vertically upwards with speed u and ball B is thrown vertically downwards with the same speed u . After reaching the highest point, A comes back to its point of projection with the same speed u in the downward direction.



If h be height of the building, then velocity of A on reaching the ground is

$$v_A^2 = u^2 + 2gh \quad \text{or } v_A = \sqrt{u^2 + 2gh} \quad \dots(i)$$

and that of B on reaching the ground is

$$v_B^2 = u^2 + 2gh \quad \text{or } v_B = \sqrt{u^2 + 2gh} \quad \dots(ii)$$

From eqns. (i) and (ii), we get $v_A = v_B$

29. (c): At $t = 0$, let the man's position be the origin.

$$\therefore x_{0m} = 0$$

The bus door is then at $x_{b0} = 6.0 \text{ m}$.

The equation of motion for the man is

$$x_m = x_{m0} + v_{m0}t + \frac{1}{2} a_m t^2$$

Here, $x_{0m} = 0$, $v_{0m} = 4.0 \text{ m s}^{-1}$, $a_m = 0$

$$\therefore x_m = 4t \quad \dots(i)$$

The equation of motion for the bus is

$$x_b = x_{b0} + v_{b0}t + \frac{1}{2} a_b t^2$$

Here, $x_{0b} = 6.0 \text{ m}$, $v_{0b} = 0$, $a_b = 1.2 \text{ m s}^{-2}$

$$\therefore x_b = 6 + \frac{1}{2} (1.2)t^2 \quad \text{or } x_b = 6 + 0.6t^2 \quad \dots(ii)$$

When the man catches the bus, $x_m = x_b$

$$\therefore 4t = 6 + 0.6t^2 \quad \text{Using eqn. (i) and (ii)}$$

$$\text{or } 0.6t^2 - 4t + 6 = 0; 3t^2 - 20t + 30 = 0$$

$$\therefore t = \frac{20 \pm \sqrt{400 - 360}}{6} = \frac{10 \pm \sqrt{10}}{3} = 2.3 \text{ s}, 4.4 \text{ s}$$

30. (a): Relative velocity of overtaking = $40 - 30 = 10 \text{ m s}^{-1}$.

Total relative distance covered with this relative velocity during overtaking = $100 + 200 = 300 \text{ m}$

So time taken = $300/10 = 30 \text{ s}$. ◆◆

MPP-2 MONTHLY Practice Problems

Class XI



This specially designed column enables students to self analyse their extent of understanding of specified chapters. Give yourself four marks for correct answer and deduct one mark for wrong answer. Self check table given at the end will help you to check your readiness.

Kinematics

Total Marks : 120

Time Taken : 60 min

NEET / AIIMS

Only One Option Correct Type

- A parachutist after bailing out, falls 50 m without friction. When parachute opens, it decelerates at 2 m s^{-2} . He reaches the ground with a speed of 3 m s^{-1} . At what height did he bail out?
(a) 111 m (b) 293 m
(c) 182 m (d) 91 m
- A person travelling eastward with a speed of 3 km h^{-1} finds that wind seems to blow from north. On doubling his speed, the wind appears to flow from north-east. Find the magnitude of the actual velocity of the wind.
(a) 4 km h^{-1} (b) $2\sqrt{3} \text{ km h}^{-1}$
(c) 3 km h^{-1} (d) $3\sqrt{2} \text{ km h}^{-1}$
- What is the resultant of three coplanar forces 300 N at 0° , 400 N at 30° and 400 N at 150° ?
(a) 400 N, 45° (b) 500 N, 50°
(c) 500 N, 53° (d) 550 N, 60°
- 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) $\frac{v}{2}\sqrt{1+2\cos^2\theta}$ (b) $\frac{v}{2}\sqrt{1+\cos^2\theta}$
(c) $\frac{v}{2}\sqrt{1+3\cos^2\theta}$ (d) $v \cos \theta$
- A body dropped from top of a tower falls through 40 m during the last two seconds of its fall. The height of the tower (in m) is [Take $g = 10 \text{ m s}^{-2}$]
(a) 60 m (b) 45 m
(c) 80 m (d) 50 m
- A stone with weight W is thrown vertically upwards into air from ground level with initial velocity v_0 . If a constant force f due to air drag acts on the stone throughout flight, the speed of the stone just before impact with the ground is
(a) $v_0 \left(\frac{W-f}{W+f} \right)^{1/2}$ (b) $v_0 \left(\frac{W+f}{W-f} \right)^{1/2}$
(c) $v_0 \left(\frac{W-f}{W} \right)^{1/2}$ (d) $v_0 \left(\frac{W+f}{f} \right)^{1/2}$
- A projectile can have the same range R for two angles of projection. If T_1 and T_2 be the time of flights in the two cases, then the product of the two time of flights is directly proportional to
(a) $1/R^2$ (b) $1/R$
(c) R (d) R^2
- At a height 0.4 m from the ground, the velocity of a projectile in vector form is $\vec{v} = (6\hat{i} + 2\hat{j}) \text{ m s}^{-1}$. The angle of projection is
(a) 45° (b) 60°
(c) 30° (d) $\tan^{-1}(3/4)$
- A threaded rod with 12 turns per cm and diameter 1.18 cm is mounted horizontally. A bar with a threaded hole to match the rod is screwed onto the rod. The bar spins at the rate of 216 rpm. How long will it take for the bar to move 1.50 cm along the rod?
(a) 3 s (b) 5 s
(c) 7 s (d) 4 s

10. A cannon on a level plain is aimed at an angle θ above the horizontal and a shell is fired with a muzzle velocity v_0 towards a cliff at a distance R away. The height from the bottom at which the shell strikes the side walls of the cliff is

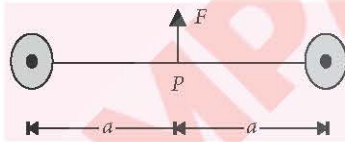
(a) $R \sin \theta - \frac{gR^2}{2v_0^2 \sin^2 \theta}$

(b) $R \cos \theta - \frac{gR^2}{2v_0^2 \cos^2 \theta}$

(c) $R \tan \theta - \frac{gR^2}{2v_0^2 \cos^2 \theta}$

(d) $R \tan \theta - \frac{gR^2}{2v_0^2 \sin^2 \theta}$

11. 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 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 at the surfaces. The magnitude of acceleration, when the separation between them becomes $2x$ is



(a) $\frac{Fa}{2m\sqrt{a^2 - x^2}}$

(b) $\frac{Fx}{2m\sqrt{a^2 - x^2}}$

(c) $\frac{Fx}{\sqrt{2ma}}$

(d) $\frac{F\sqrt{a^2 - x^2}}{2mx}$

12. Two trains take 3 s to pass one another when going in the opposite direction but only 2.5 s if the speed of one is increased by 50%. The time one would take to pass the other when going in the same direction at their original speeds is

(a) 10 s

(b) 12 s

(c) 15 s

(d) 18 s

Assertion & Reason Type

Directions : In the following questions, a statement of assertion is followed by a statement of reason. Mark the correct choice as :

- (a) If both assertion and reason are true and reason is the correct explanation of assertion.
- (b) If both assertion and reason are true but reason is not the correct explanation of assertion.
- (c) If assertion is true but reason is false.
- (d) If both assertion and reason are false.

13. **Assertion :** The time of flight of a body becomes n times the original value if its speed is made n times.
Reason : This is due to the range of the projectile which becomes n times.

14. **Assertion :** When the displacement of a body is directly proportional to the square of the time. Then the body is moving with uniform acceleration.
Reason : The slope of velocity-time graph with time axis gives acceleration.

15. **Assertion :** If dot product and cross product of \vec{P} and \vec{Q} are zero, it implies that one of the vector \vec{P} and \vec{Q} must be null vector.
Reason : A null vector is a vector of zero magnitude.

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JEE MAIN / JEE ADVANCED

Only One Option Correct Type

16. A ball rolls from the edge of the top step of a staircase with horizontal speed 5 m s^{-1} . Each step is of 2 m high and 1 m width. The ball hits
 (a) 10^{th} step (b) 5^{th} step
 (c) 2^{nd} step (d) 3^{rd} step
17. A policeman moving on a highway with a speed of 30 km h^{-1} fires a bullet at 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^{-1} , with what speed does the bullet hit the thief's car?
 (a) 120 m s^{-1} (b) 90 m s^{-1}
 (c) 125 m s^{-1} (d) 105 m s^{-1}
18. The speed of a projectile when it is at its greatest height is $\sqrt{2/5}$ times its speed at half the maximum height. The angle of projection is
 (a) 30° (b) 60°
 (c) 45° (d) $\tan^{-1}(3/4)$
19. A particle is projected horizontally with a speed v_0 from the top of a plane inclined at an angle θ with the horizontal. How far from the point of projection will the particle strike the plane?
 (a) $\frac{2v_0^2 g \sec \theta}{\tan \theta}$ (b) $\frac{2v_0^2 g \tan \theta}{\sec \theta}$
 (c) $\frac{2v_0^2 \tan \theta \sec \theta}{g}$ (d) $\frac{2v_0^2 g}{\tan \theta}$

More than One Options Correct Type

20. A train is passing through a platform of length 50 m with uniform velocity. It takes 15 s to cross the platform and 5 s to cross a man standing on the platform. Mark the correct option(s).
 (a) The length of train is 25 m
 (b) The length of train is 50 m
 (c) The speed of train is 10 m s^{-1}
 (d) The speed of train is 5 m s^{-1}
21. If a particle is projected with speed 20 m s^{-1} making angle 37° with horizontal. At $t = \frac{10}{3} \text{ s}$, (Take $\cos \theta = 4/5$)
 (a) the velocity of the particle is horizontally directed
 (b) the velocity is perpendicular to initial velocity

- (c) the magnitude of velocity is $\frac{80}{3} \text{ m s}^{-1}$
 (d) the magnitude of velocity is 16 m s^{-1}

22. Two cities A and B are connected by a regular bus service with buses plying in either direction every T seconds. The speed of each bus is uniform and equal to v_b . A cyclist cycles from A to B with a uniform speed of v_c . A bus goes past the cyclist in T_1 seconds in the direction A to B and every T_2 seconds in the direction B to A . Then
 (a) $T_1 = \frac{v_b T}{v_b + v_c}$ (b) $T_2 = \frac{v_b T}{v_b - v_c}$
 (c) $T_1 = \frac{v_b T}{v_b - v_c}$ (d) $T_2 = \frac{v_b T}{v_b + v_c}$
23. The coordinates of a particle moving in a plane given by $x = a \cos pt$ and $y = b \sin pt$ where $a, b (< a)$ and p are positive constants of appropriate dimensions. Then,

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1	P											5	M								6	F	A	R	A	D	6	R
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- (a) the path of the particle is an ellipse
- (b) the velocity and acceleration of the particle are normal to each other at $t = \pi/2p$
- (c) the acceleration of the particle is always directed towards a fixed point
- (d) the distance travelled by the particle in time interval $t = 0$ to $t = \pi/2p$ is a

Integer Answer Type

24. A 200 m long train starts from rest at $t = 0$ with constant acceleration 4 cm s^{-2} . The head light of its engine is switched ON at $t = 60$ s and its tail light is switched ON at $t = 120$ s. The distance between these two events for an observer standing on platform is $(2)^n$ m. Find the value of n .
25. A stone is dropped from certain height which can reach the ground in 5 s. If the stone is stopped after 3 s of its fall and then allowed to fall again. Find the time taken (in second) by the stone to reach the ground for the remaining distance.
26. A particle is moving in a circle of radius R with constant speed. The time period (T) is 1 s. In a time $t = T/6$, if the difference between average speed and average velocity of the particle is 2 m s^{-1} , the radius of the circle (in m) is

Comprehension Type

To a stationary man, rain appears to be falling at his back at an angle 30° with the vertical. As he starts moving forward with a speed of 0.5 m s^{-1} , he finds that the rain is falling vertically.

27. The speed of rain with respect to the stationary man is
- (a) 0.5 m s^{-1}
 - (b) 1.0 m s^{-1}
 - (c) $0.5\sqrt{3} \text{ m s}^{-1}$
 - (d) 0.43 m s^{-1}
28. The speed of rain with respect to the moving man is
- (a) 0.5 m s^{-1}
 - (b) 1.0 m s^{-1}
 - (c) $0.5\sqrt{3} \text{ m s}^{-1}$
 - (d) 0.45 m s^{-1}

Matrix Match Type

29. A ball is projected from the ground with velocity v such that its range is maximum.

Column-I

Column-II

- | | |
|--|---------------------------|
| (A) Velocity at half of the maximum height | (P) $\frac{\sqrt{3}v}{2}$ |
| (B) Velocity at the maximum height | (Q) $\frac{v}{\sqrt{2}}$ |
| (C) Change in its velocity when it returns to the ground | (R) $v\sqrt{2}$ |
| (D) Average velocity when it reaches the maximum height | (S) $\frac{v}{2}\sqrt{5}$ |

- | A | B | C | D |
|-------|---|---|---|
| (a) P | S | Q | R |
| (b) P | Q | R | S |
| (c) P | S | R | Q |
| (d) R | P | S | Q |

30. A balloon rises up with constant net acceleration of 10 m s^{-2} from the ground. After 2 s a particle drops from the balloon. After further 2 s match the following.

(Take $g = 10 \text{ m s}^{-2}$).

Column-I

Column-II

- | | |
|------------------------------------|-----------------|
| (A) Height of particle from ground | (P) Zero |
| (B) Speed of particle | (Q) 10 SI units |
| (C) Height of the balloon | (R) 40 SI units |
| (D) Acceleration of particle | (S) 80 SI units |
- | A | B | C | D |
|-------|---|---|---|
| (a) R | P | S | Q |
| (b) S | P | R | Q |
| (c) P | S | Q | R |
| (d) P | Q | R | S |

Keys are published in this issue. Search now! ☺

SELF CHECK

No. of questions attempted
 No. of questions correct
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Check your score! If your score is

- > 90% **EXCELLENT WORK !** You are well prepared to take the challenge of final exam.
- 90-75% **GOOD WORK !** You can score good in the final exam.
- 74-60% **SATISFACTORY !** You need to score more next time.
- < 60% **NOT SATISFACTORY!** Revise thoroughly and strengthen your concepts.

NEET

SOLVED PAPER 2017

Hurray!!

We are happy to inform our readers that out of the 45 questions asked in NEET 2017, more than 60% questions were either exactly same or of similar type from the **MTG Books**.

Hurray!!

Here, the references of few are given :

Exact Questions

Exam Q. No.	MTG Book	Q. No.	P. No.	Exam Q. No.	MTG Book	Q. No.	P. No.
14	NEET Guide	6	734	36	NEET Guide	59	181
16	NCERT Fingertips	6	43	41	29 Years NEET-AIPMT	5	95
33	MTG Excel	25	462	42	NCERT Fingertips	56	301
34	NEET Champion	16	248				

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2	NEET Guide	194	620	22	29 Years NEET-AIPMT	29	219
6	NEET Champion	76	305	23	NEET Guide	14	213
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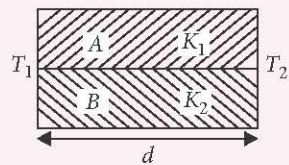
and more such questions

- A spring of force constant k is cut into lengths of ratio 1 : 2 : 3. They are connected in series and the new force constant is k' . Then they are connected in parallel and force constant is k'' . Then $k' : k''$ is
(a) 1 : 9 (b) 1 : 11 (c) 1 : 14 (d) 1 : 6
- The ratio of resolving powers of an optical microscope for two wavelengths $\lambda_1 = 4000 \text{ \AA}$ and $\lambda_2 = 6000 \text{ \AA}$ is
(a) 9 : 4 (b) 3 : 2 (c) 16 : 81 (d) 8 : 27
- The two nearest harmonics of a tube closed at one end and open at other end are 220 Hz and 260 Hz. What is the fundamental frequency of the system?
(a) 20 Hz (b) 30 Hz
(c) 40 Hz (d) 10 Hz
- Consider a drop of rain water having mass 1 g falling from a height of 1 km. It hits the ground with a speed of 50 m s^{-1} . Take 'g' constant with a value 10 m s^{-2} . The work done by the (i) gravitational force and the (ii) resistive force of air is
(a) (i) 1.25 J (ii) -8.25 J
(b) (i) 100 J (ii) 8.75 J
(c) (i) 10 J (ii) -8.75 J
(d) (i) -10 J (ii) -8.25 J

5. A physical quantity of the dimensions of length that can be formed out of c , G and $\frac{e^2}{4\pi\epsilon_0}$ is [c is velocity of light, G is universal constant of gravitation and e is charge]

(a) $c^2 \left[G \frac{e^2}{4\pi\epsilon_0} \right]^{1/2}$ (b) $\frac{1}{c^2} \left[\frac{e^2}{G 4\pi\epsilon_0} \right]^{1/2}$
 (c) $\frac{1}{c} G \frac{e^2}{4\pi\epsilon_0}$ (d) $\frac{1}{c^2} \left[G \frac{e^2}{4\pi\epsilon_0} \right]^{1/2}$

6. Two rods A and B of different materials are welded together as shown in figure. Their thermal conductivities are K_1 and K_2 . The thermal conductivity of the composite rod will be



(a) $\frac{3(K_1 + K_2)}{2}$ (b) $K_1 + K_2$
 (c) $2(K_1 + K_2)$ (d) $\frac{K_1 + K_2}{2}$

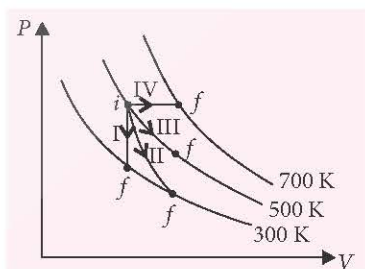
7. A capacitor is charged by a battery. The battery is removed and another identical uncharged capacitor is connected in parallel. The total electrostatic energy of resulting system

- (a) decreases by a factor of 2
 (b) remains the same
 (c) increases by a factor of 2
 (d) increases by a factor of 4

8. In a common emitter transistor amplifier the audio signal voltage across the collector is 3 V. The resistance of collector is 3 k Ω . If current gain is 100 and the base resistance is 2 k Ω , the voltage and power gain of the amplifier is

- (a) 15 and 200 (b) 150 and 15000
 (c) 20 and 2000 (d) 200 and 1000

9. Thermodynamic processes are indicated in the following diagram.



Match the following

Column-1

- P. Process I
 Q. Process II
 R. Process III
 S. Process IV

Column-2

- A. Adiabatic
 B. Isobaric
 C. Isochoric
 D. Isothermal

- (a) P \rightarrow C, Q \rightarrow A, R \rightarrow D, S \rightarrow B
 (b) P \rightarrow C, Q \rightarrow D, R \rightarrow B, S \rightarrow A
 (c) P \rightarrow D, Q \rightarrow B, R \rightarrow A, S \rightarrow C
 (d) P \rightarrow A, Q \rightarrow C, R \rightarrow D, S \rightarrow B

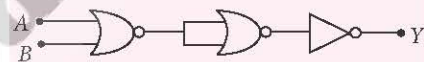
10. Suppose the charge of a proton and an electron differ slightly. One of them is $-e$, the other is $(e + \Delta e)$. If the net of electrostatic force and gravitational force between two hydrogen atoms placed at a distance d (much greater than atomic size) apart is zero, then Δe is of the order of [Given mass of hydrogen $m_h = 1.67 \times 10^{-27}$ kg]

- (a) 10^{-23} C (b) 10^{-37} C
 (c) 10^{-47} C (d) 10^{-20} C

11. The resistance of a wire is 'R' ohm. If it is melted and stretched to 'n' times its original length, its new resistance will be

- (a) R/n (b) n^2R (c) R/n^2 (d) nR

12. The given electrical network is equivalent to

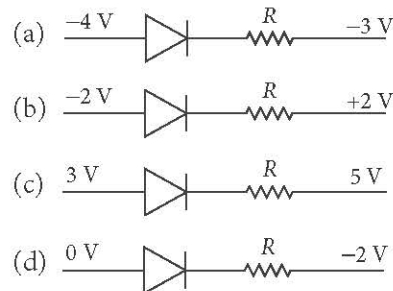


- (a) OR gate (b) NOR gate
 (c) NOT gate (d) AND gate

13. The de-Broglie wavelength of a neutron in thermal equilibrium with heavy water at a temperature T (kelvin) and mass m , is

(a) $\frac{h}{\sqrt{3mkT}}$ (b) $\frac{2h}{\sqrt{3mkT}}$
 (c) $\frac{2h}{\sqrt{mkT}}$ (d) $\frac{h}{\sqrt{mkT}}$

14. Which one of the following represents forward bias diode?



15. A long solenoid of diameter 0.1 m has 2×10^4 turns per meter. At the centre of the solenoid, a coil of 100 turns and radius 0.01 m is placed with its axis coinciding with the solenoid axis. The current in the solenoid reduces at a constant rate to 0 A from 4 A in 0.05 s. If the resistance of the coil is $10 \pi^2 \Omega$, the total charge flowing through the coil during this time is

- (a) $16 \mu\text{C}$ (b) $32 \mu\text{C}$
(c) $16 \pi \mu\text{C}$ (d) $32 \pi \mu\text{C}$

16. 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) $\frac{t_1 t_2}{t_2 - t_1}$ (b) $\frac{t_1 t_2}{t_2 + t_1}$ (c) $t_1 - t_2$ (d) $\frac{t_1 + t_2}{2}$

17. Young's double slit experiment is first performed in air and then in a medium other than air. It is found that 8th bright fringe in the medium lies where 5th dark fringe lies in air. The refractive index of the medium is nearly

- (a) 1.59 (b) 1.69 (c) 1.78 (d) 1.25

18. A beam of light from a source L is incident normally on a plane mirror fixed at a certain distance x from the source. The beam is reflected back as a spot on a scale placed just above the source L . When the mirror is rotated through a small angle θ , the spot of the light is found to move through a distance y on the scale. The angle θ is given by

- (a) $\frac{y}{x}$ (b) $\frac{x}{2y}$ (c) $\frac{x}{y}$ (d) $\frac{y}{2x}$

19. If θ_1 and θ_2 be the apparent angles of dip observed in two vertical planes at right angles to each other, then the true angle of dip θ is given by

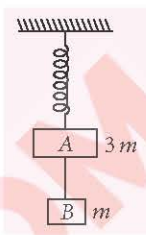
- (a) $\tan^2 \theta = \tan^2 \theta_1 + \tan^2 \theta_2$
(b) $\cot^2 \theta = \cot^2 \theta_1 - \cot^2 \theta_2$
(c) $\tan^2 \theta = \tan^2 \theta_1 - \tan^2 \theta_2$
(d) $\cot^2 \theta = \cot^2 \theta_1 + \cot^2 \theta_2$

20. Two cars moving in opposite directions approach each other with speed of 22 m s^{-1} and 16.5 m s^{-1} respectively. The driver of the first car blows a horn having a frequency 400 Hz . The frequency heard by the driver of the second car is

[velocity of sound is 340 m s^{-1}]

- (a) 361 Hz (b) 411 Hz (c) 448 Hz (d) 350 Hz

21. Two blocks A and B of masses $3m$ and m respectively are connected by a massless and inextensible string. The whole system is suspended by a massless spring as shown in figure. The magnitudes of acceleration of A and B immediately after the string is cut, are respectively



- (a) $\frac{g}{3}, g$ (b) g, g (c) $\frac{g}{3}, \frac{g}{3}$ (d) $g, \frac{g}{3}$

22. A thin prism having refracting angle 10° is made of glass of refractive index 1.42. This prism is combined with another thin prism of glass of refractive index 1.7. This combination produces dispersion without deviation. The refracting angle of second prism should be

- (a) 6° (b) 8° (c) 10° (d) 4°

23. The acceleration due to gravity at a height 1 km above the earth is the same as at a depth d below the surface of earth. Then

- (a) $d = 1 \text{ km}$ (b) $d = \frac{3}{2} \text{ km}$
(c) $d = 2 \text{ km}$ (d) $d = \frac{1}{2} \text{ km}$

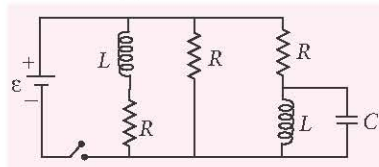
24. A potentiometer is an accurate and versatile device to make electrical measurements of EMF because the method involves

- (a) potential gradients
(b) a condition of no current flow through the galvanometer
(c) a combination of cells, galvanometer and resistances
(d) cells

25. A spherical black body with a radius of 12 cm radiates 450 watt power at 500 K. If the radius were halved and the temperature doubled, the power radiated in watt would be

- (a) 450 (b) 1000 (c) 1800 (d) 225

26. Figure shows a circuit that contains three identical resistors with resistance $R = 9.0 \Omega$ each, two identical inductors with inductance $L = 2.0 \text{ mH}$ each, and an ideal battery with emf $\varepsilon = 18 \text{ V}$. The current i through the battery just after the switch closed is

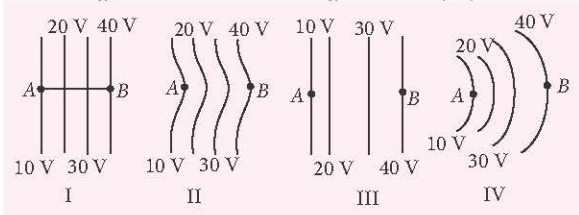


- (a) 0.2 A (b) 2 A
(c) 0 ampere (d) 2 mA

27. Radioactive material 'A' has decay constant ' 8λ ' and material 'B' has decay constant ' λ '. Initially they have same number of nuclei. After what time, the ratio of number of nuclei of material 'B' to that 'A' will be $\frac{1}{e}$?

- (a) $\frac{1}{7\lambda}$ (b) $\frac{1}{8\lambda}$ (c) $\frac{1}{9\lambda}$ (d) $\frac{1}{\lambda}$

28. The diagrams below show regions of equipotentials.



A positive charge is moved from A to B in each diagram.

- (a) In all the four cases the work done is the same.
(b) Minimum work is required to move q in figure (I).
(c) Maximum work is required to move q in figure (II).
(d) Maximum work is required to move q in figure (III).
29. Two astronauts are floating in gravitational free space after having lost contact with their spaceship. The two will
(a) move towards each other.
(b) move away from each other.
(c) will become stationary.
(d) keep floating at the same distance between them.
30. 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 metres and t in seconds. The acceleration of the particle at $t = 2$ s is
(a) 5 m s^{-2} (b) -4 m s^{-2}
(c) -8 m s^{-2} (d) 0
31. One end of string of length l is connected to a particle of mass ' m ' and the other end is connected to a small peg on a smooth horizontal table. If the particle moves in circle with speed ' v ', the net force on the particle (directed towards centre) will be (T represents the tension in the string)

- (a) $T + \frac{mv^2}{l}$ (b) $T - \frac{mv^2}{l}$
(c) zero (d) T

32. A particle executes linear simple harmonic motion with an amplitude of 3 cm. When the particle is at 2 cm from the mean position, the magnitude of its velocity is equal to that of its acceleration. Then its time period in seconds is

- (a) $\frac{\sqrt{5}}{2\pi}$ (b) $\frac{4\pi}{\sqrt{5}}$ (c) $\frac{2\pi}{\sqrt{3}}$ (d) $\frac{\sqrt{5}}{\pi}$

33. Two polaroids P_1 and P_2 are placed with their axis perpendicular to each other. Unpolarised light I_0 is incident on P_1 . A third polaroid P_3 is kept in between P_1 and P_2 such that its axis makes an angle 45° with that of P_1 . The intensity of transmitted light through P_2 is

- (a) $\frac{I_0}{4}$ (b) $\frac{I_0}{8}$ (c) $\frac{I_0}{16}$ (d) $\frac{I_0}{2}$

34. The bulk modulus of a spherical object is ' B '. If it is subjected to uniform pressure ' p ', the fractional decrease in radius is

- (a) $\frac{B}{3p}$ (b) $\frac{3p}{B}$ (c) $\frac{p}{3B}$ (d) $\frac{p}{B}$

35. In an electromagnetic wave in free space the root mean square value of the electric field is $E_{\text{rms}} = 6 \text{ V m}^{-1}$. The peak value of the magnetic field is

- (a) $2.83 \times 10^{-8} \text{ T}$ (b) $0.70 \times 10^{-8} \text{ T}$
(c) $4.23 \times 10^{-8} \text{ T}$ (d) $1.41 \times 10^{-8} \text{ T}$

36. A rope is wound around a hollow cylinder of mass 3 kg and radius 40 cm. What is the angular acceleration of the cylinder if the rope is pulled with a force of 30 N?

- (a) 0.25 rad s^{-2} (b) 25 rad s^{-2}
(c) 5 m s^{-2} (d) 25 m s^{-2}

37. Two discs of same moment of inertia rotating about their regular axis passing through centre and perpendicular to the plane of disc with angular velocities ω_1 and ω_2 . They are brought into contact face to face coinciding the axis of rotation. The expression for loss of energy during this process is

- (a) $\frac{1}{4}I(\omega_1 - \omega_2)^2$ (b) $I(\omega_1 - \omega_2)^2$
(c) $\frac{1}{8}I(\omega_1 - \omega_2)^2$ (d) $\frac{1}{2}I(\omega_1 + \omega_2)^2$

38. The photoelectric threshold wavelength of silver is $3250 \times 10^{-10} \text{ m}$. The velocity of the electron

ejected from a silver surface by ultraviolet light of wavelength 2536×10^{-10} m is

[Given $h = 4.14 \times 10^{-15}$ eV s and $c = 3 \times 10^8$ m s $^{-1}$]

- (a) $\approx 0.6 \times 10^6$ m s $^{-1}$ (b) $\approx 61 \times 10^3$ m s $^{-1}$
 (c) $\approx 0.3 \times 10^6$ m s $^{-1}$ (d) $\approx 6 \times 10^5$ m s $^{-1}$

39. A 250-turn rectangular coil of length 2.1 cm and width 1.25 cm carries a current of 85 μ A and subjected to a magnetic field of strength 0.85 T. Work done for rotating the coil by 180° against the torque is

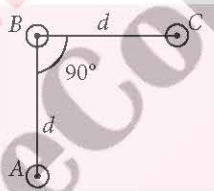
- (a) 4.55 μ J (b) 2.3 μ J
 (c) 1.15 μ J (d) 9.1 μ J

40. The ratio of wavelengths of the last line of Balmer series and the last line of Lyman series is
 (a) 1 (b) 4 (c) 0.5 (d) 2

41. A Carnot engine having an efficiency of $\frac{1}{10}$ as heat engine, is used as a refrigerator. If the work done on the system is 10 J, the amount of energy absorbed from the reservoir at lower temperature is
 (a) 90 J (b) 99 J (c) 100 J (d) 1 J

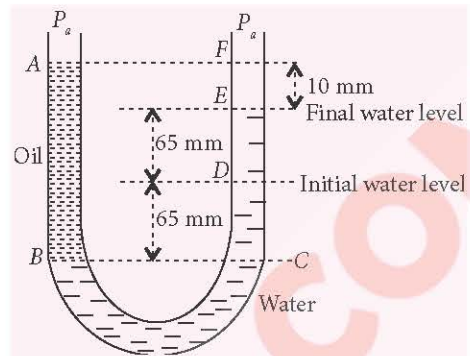
42. A gas mixture consists of 2 moles of O $_2$ and 4 moles of Ar at temperature T . Neglecting all vibrational modes, the total internal energy of the system is
 (a) 15 RT (b) 9 RT
 (c) 11 RT (d) 4 RT

43. An arrangement of three parallel straight wires placed perpendicular to plane of paper carrying same current I along the same direction as shown in figure. Magnitude of force per unit length on the middle wire 'B' is given by



- (a) $\frac{2\mu_0 I^2}{\pi d}$ (b) $\frac{\sqrt{2}\mu_0 I^2}{\pi d}$ (c) $\frac{\mu_0 I^2}{\sqrt{2}\pi d}$ (d) $\frac{\mu_0 I^2}{2\pi d}$

44. A U tube with both ends open to the atmosphere, is partially filled with water. Oil, which is immiscible with water, is poured into one side until it stands at a distance of 10 mm above the water level on the other side. Meanwhile the water rises by 65 mm from its original level (see diagram). The density of the oil is



- (a) 425 kg m $^{-3}$ (b) 800 kg m $^{-3}$
 (c) 928 kg m $^{-3}$ (d) 650 kg m $^{-3}$

45. Which of the following statements are correct?

- (1) Centre of mass of a body always coincides with the centre of gravity of the body.
 (2) Centre of mass of a body is the point at which the total gravitational torque on the body is zero.
 (3) A couple on a body produces both translational and rotational motion in a body.
 (4) Mechanical advantage greater than one means that small effort can be used to lift a large load.
 (a) (1) and (2) (b) (2) and (3)
 (c) (3) and (4) (d) (2) and (4)

SOLUTIONS

1. (b): Let us assume, the length of spring be l . When we cut the spring into ratio of length 1 : 2 : 3, we get three springs of lengths $\frac{l}{6}$, $\frac{2l}{6}$ and $\frac{3l}{6}$ with force constant,

$$\therefore k_1 = \frac{kl}{l_1} = \frac{kl}{l/6} = 6k; k_2 = \frac{kl}{l_2} = \frac{kl}{2l/6} = 3k$$

$$k_3 = \frac{kl}{l_3} = \frac{kl}{3l/6} = 2k$$

When connected in series,

$$\frac{1}{k'} = \frac{1}{6k} + \frac{1}{3k} + \frac{1}{2k} = \frac{1+2+3}{6k} = \frac{1}{k}$$

$$\therefore k' = k$$

When connected in parallel, $k'' = 6k + 3k + 2k = 11k$

$$\frac{k'}{k''} = \frac{k}{11k} = \frac{1}{11}$$

2. (b): The resolving power of an optical microscope,

$$RP = \frac{2\mu \sin \theta}{\lambda}; \therefore \frac{RP_1}{RP_2} = \frac{6000}{4000} = \frac{3}{2}$$

3. (a): Nearest harmonics of an organ pipe closed at one end is differ by twice of its fundamental frequency.

$$\therefore 260 - 220 = 2\nu, \quad \nu = 20 \text{ Hz}$$

4. (c): Here, $m = 1 \text{ g} = 10^{-3} \text{ kg}$, $h = 1 \text{ km} = 1000 \text{ m}$,
 $v = 50 \text{ m s}^{-1}$, $g = 10 \text{ m s}^{-2}$.

(i) The work done by the gravitational force
 $= mgh = 10^{-3} \times 10 \times 1000 = 10 \text{ J}$

(ii) The total work done by gravitational force and the resistive force of air is equal to change in kinetic energy of rain drop.

$$\therefore W_g + W_r = \frac{1}{2}mv^2 - 0$$

$$10 + W_r = \frac{1}{2} \times 10^{-3} \times 50 \times 50 \quad \text{or} \quad W_r = -8.75 \text{ J}$$

5. (d): Dimensions of

$$\frac{e^2}{4\pi\epsilon_0} = [F \times d^2] = [\text{ML}^3\text{T}^{-2}]$$

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

Dimensions of $c = [\text{LT}^{-1}]$

$$l \propto \left(\frac{e^2}{4\pi\epsilon_0} \right)^p G^q c^r$$

$$\therefore [L] = [\text{ML}^3\text{T}^{-2}]^p [\text{M}^{-1}\text{L}^3\text{T}^{-2}]^q [\text{LT}^{-1}]^r$$

On comparing both sides and solving, we get

$$p = \frac{1}{2}, \quad q = \frac{1}{2} \quad \text{and} \quad r = -2$$

$$\therefore [l] = \frac{1}{c^2} \left[\frac{Ge^2}{4\pi\epsilon_0} \right]^{1/2}$$

6. (d): Equivalent thermal conductivity of the composite rod in parallel combination will be,

$$K = \frac{K_1 A_1 + K_2 A_2}{A_1 + A_2} = \frac{K_1 + K_2}{2}$$

7. (a): When the capacitor is charged by a battery of potential V , then energy stored in the capacitor,

$$U_i = \frac{1}{2} CV^2 \quad \dots(i)$$

When the battery is removed and another identical uncharged capacitor is connected in parallel

Common potential,

$$V' = \frac{CV}{C+C} = \frac{V}{2}$$

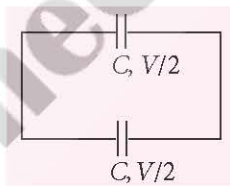
\therefore Then the energy stored in the capacitor,

$$U_f = \frac{1}{2} (2C) \left(\frac{V}{2} \right)^2 = \frac{1}{4} CV^2 \quad \dots(ii)$$

\therefore From eqns. (i) and (ii)

$$U_f = \frac{U_i}{2}$$

that means the total electrostatic energy of resulting system will decrease by a factor of 2.



8. (b): Given: $V_i = 3 \text{ V}$, $R_C = 3 \text{ k}\Omega$, $R_B = 2 \text{ k}\Omega$,
 $\beta = 100$

Voltage gain of the CE amplifier,

$$A_V = -\beta_{ac} \left(\frac{R_C}{R_B} \right) = -100 \left(\frac{3}{2} \right) = -150$$

Power gain, $A_p = \beta \times A_V = 100 \times (-150) = -15000$

Negative sign represents that output voltage is in opposite phase with the input voltage.

9. (a): In process I, volume is constant

\therefore Process I \rightarrow Isochoric; P \rightarrow C

As slope of curve II is more than the slope of curve III.

Process II \rightarrow Adiabatic and Process III \rightarrow Isothermal

\therefore Q \rightarrow A, R \rightarrow D

In process IV, pressure is constant

Process IV \rightarrow Isobaric; S \rightarrow B

10. (b): A hydrogen atom consists of an electron and a proton.

\therefore Charge on one hydrogen atom

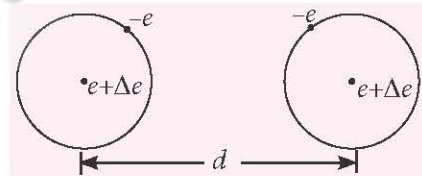
$$= q_e + q_p = -e + (e + \Delta e) = \Delta e$$

Since a hydrogen atom carries a net charge Δe ,

\therefore Electrostatic force,

$$F_e = \frac{1}{4\pi\epsilon_0} \frac{(\Delta e)^2}{d^2} \quad \dots(i)$$

will act between two hydrogen atoms.



The gravitational force between two hydrogen atoms is given as

$$F_g = \frac{G m_h m_h}{d^2} \quad \dots(ii)$$

Since, the net force on the system is zero, $F_e = F_g$

Using eqns. (i) and (ii), we get

$$\frac{(\Delta e)^2}{4\pi\epsilon_0 d^2} = \frac{G m_h^2}{d^2}$$

$$(\Delta e)^2 = 4\pi\epsilon_0 G m_h^2$$

$$= 6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2 / (9 \times 10^9)$$

$$\Delta e \approx 10^{-37} \text{ C}$$

11. (b): The resistance of a wire of length l and area A and resistivity ρ is given as $R = \rho l/a$

Given, $l' = nl$

As the volume of the wire remains constant

$$\therefore A'l' = Al; A' = \frac{Al}{l'} = \frac{Al}{nl} = \frac{A}{n}$$

$$\therefore R' = \frac{\rho l'}{A'} = \frac{n^2 \rho l}{A} = n^2 R$$

12. (b)

13. (a): Kinetic energy of a neutron in thermal equilibrium with heavy water at a temperature T is given as

$$K = \frac{3}{2} kT \quad \dots(i)$$

Also momentum (p) is, $p = \sqrt{2mK}$

From eqn. (i)

$$p = \sqrt{2m \cdot \frac{3}{2} kT} = \sqrt{3mkT}$$

Required de-Broglie wavelength is given as

$$\lambda = \frac{h}{p} = \frac{h}{\sqrt{3mkT}}$$

14. (d): A diode is said to be forward biased if p -side is at higher potential than n -side of p - n junction.

15. (b): Given $n = 2 \times 10^4$; $I = 4$ A

Initially $I = 0$ A

$$\therefore B_i = 0 \text{ or } \phi_i = 0$$

Finally, the magnetic field at the centre of the solenoid is given as

$$B_f = \mu_0 nI = 4\pi \times 10^{-7} \times 2 \times 10^4 \times 4 = 32\pi \times 10^{-3} \text{ T}$$

Final magnetic flux through the coil is given as

$$\phi_f = NBA = 100 \times 32\pi \times 10^{-3} \times \pi \times (0.01)^2$$

$$\phi_f = 32\pi^2 \times 10^{-5} \text{ Tm}^2$$

$$\text{Induced charge, } q = \frac{|\Delta\phi|}{R} = \frac{|\phi_f - \phi_i|}{R} = \frac{32\pi^2 \times 10^{-5}}{10\pi^2} \\ = 32 \times 10^{-6} \text{ C} = 32 \mu\text{C}$$

16. (b): Let v_1 is the velocity of Preeti on stationary escalator and d is the distance travelled by her

$$\therefore v_1 = d/t_1$$

Again, let v_2 is the velocity of escalator

$$\therefore v_2 = d/t_2$$

\therefore Net velocity of Preeti on moving escalator with respect to the ground

$$v = v_1 + v_2 = \frac{d}{t_1} + \frac{d}{t_2} = d \left(\frac{t_1 + t_2}{t_1 t_2} \right)$$

The time taken by her to walk up on the moving escalator will be

$$t = \frac{d}{v} = \frac{d}{d \left(\frac{t_1 + t_2}{t_1 t_2} \right)} = \frac{t_1 t_2}{t_1 + t_2}$$

17. (c): Position of 8th bright fringe in medium,

$$x = \frac{8\lambda_m D}{d}$$

Position of 5th dark fringe in air,

$$x' = \left(5 - \frac{1}{2} \right) \lambda_{\text{air}} D = \frac{4.5 \lambda_{\text{air}} D}{d}$$

Given $x = x'$

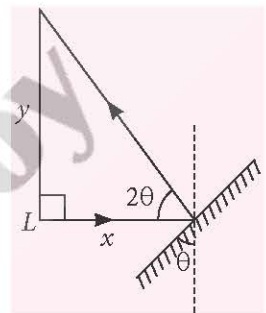
$$\therefore \frac{8\lambda_m D}{d} = \frac{4.5\lambda_{\text{air}} D}{d} \\ \mu_m = \frac{\lambda_{\text{air}}}{\lambda_m} = \frac{8}{4.5} \approx 1.78$$

18. (d): When mirror is rotated by θ angle reflected ray will be rotated by 2θ .

For small angle θ ,

$$\tan 2\theta \approx 2\theta = \frac{y}{x}$$

$$\therefore \theta = \frac{y}{2x}$$



19. (d): Let B_H and B_V be the horizontal and vertical components of earth's magnetic field \vec{B} . Since θ is the angle of dip

$$\therefore \tan \theta = \frac{B_V}{B_H} \text{ or } \cot \theta = \frac{B_H}{B_V} \quad \dots(i)$$

Suppose planes 1 and 2 are two mutually perpendicular planes and respectively make angles θ and $90^\circ - \theta$ with the magnetic meridian. The vertical components of earth's magnetic field remain same in the two planes but the effective horizontal components in the planes will be

$$B_1 = B_H \cos \theta$$

$$\text{and } B_2 = B_H \sin \theta$$

The angles of dip θ_1

and θ_2 in the two

planes are given by

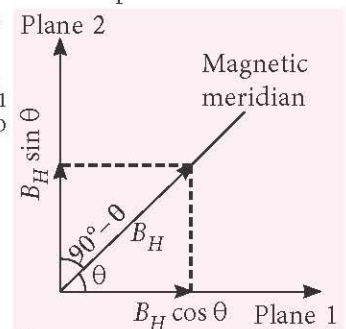
$$\tan \theta_1 = \frac{B_V}{B_1}$$

$$\tan \theta_1 = \frac{B_V}{B_H \cos \theta}$$

$$\text{or } \cot \theta_1 = \frac{B_H \cos \theta}{B_V} \quad \dots(ii)$$

Similarly,

$$\cot \theta_2 = \frac{B_H \sin \theta}{B_V} \quad \dots(iii)$$



From eqns. (ii) and (iii)

$$\cot^2 \theta_1 + \cot^2 \theta_2 = \frac{B_H^2}{B_V^2} (\cos^2 \theta + \sin^2 \theta) = \frac{B_H^2}{B_V^2}$$

$$\therefore \cot^2 \theta_1 + \cot^2 \theta_2 = \cot^2 \theta \quad [\text{from eqn. (i)}]$$

20. (c) : The required frequency of sound heard by the driver of second car is given as

$$v' = v \left(\frac{v + v_o}{v - v_s} \right)$$

where v = velocity of sound

v_o = velocity of observer, i.e., second car

v_s = velocity of source i.e., first car

$$v' = 400 \left(\frac{340 + 16.5}{340 - 22} \right) = 400 \left(\frac{356.5}{318} \right) \approx 448 \text{ Hz}$$

21. (a) : Before the string is cut

$$kx = T + 3mg \quad \dots(i)$$

$$T = mg \quad \dots(ii)$$

From eqns. (i) and (ii)

$$kx = 4mg$$

Just after the string is cut $T = 0$

$$a_A = \frac{kx - 3mg}{3m}$$

$$a_A = \frac{4mg - 3mg}{3m}$$

$$= \frac{mg}{3m} = \frac{g}{3}$$

and also $a_B = g$

22. (a) : The condition for dispersion without deviation is given as $(\mu - 1)A = (\mu' - 1)A'$

Given $\mu = 1.42$, $A = 10^\circ$, $\mu' = 1.7$, $A' = ?$

$$\therefore (1.42 - 1) \times 10 = (1.7 - 1)A'$$

$$(0.42) \times 10 = 0.7 \times A'$$

$$\text{or, } A' = \frac{0.42 \times 10}{0.7} = 6^\circ$$

23. (c) : The acceleration due to gravity at a height h is given as $g_h = g(1 - 2h/R_e)$

where R_e is radius of earth.

The acceleration due to gravity at a depth d is given as $g_d = g(1 - d/R_e)$

Given, $g_h = g_d$

$$\therefore g \left(1 - \frac{2h}{R_e} \right) = g \left(1 - \frac{d}{R_e} \right)$$

$$\therefore d = 2h = 2 \times 1 = 2 \text{ km} \quad (\because h = 1 \text{ km})$$

24. (b) : A potentiometer is an accurate and versatile device to make electrical measurements of emf because the method involves a condition of no current flow through the galvanometer, the device can be used to measure potential difference, internal resistance of a cell and compare emf's of two sources.

25. (c) : According to Stefan-Boltzman law, rate of energy radiated by a black body is given as

$$E = \sigma AT^4 = \sigma 4\pi R^2 T^4$$

Given $E_1 = 450 \text{ W}$, $T_1 = 500 \text{ K}$, $R_1 = 12 \text{ cm}$

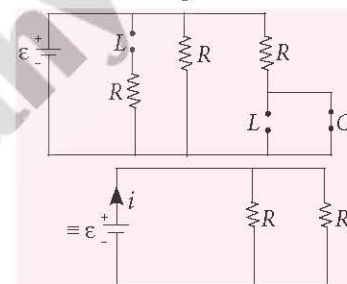
$$R_2 = \frac{R_1}{2}, \quad T_2 = 2T_1, \quad E_2 = ?$$

$$\frac{E_2}{E_1} = \frac{\sigma 4\pi R_2^2 T_2^4}{\sigma 4\pi R_1^2 T_1^4} = \left(\frac{R_2}{R_1} \right)^2 \left(\frac{T_2}{T_1} \right)^4 = \frac{1}{4} \times 16 = 4$$

$$E_2 = E_1 \times 4 = 450 \times 4 = 1800 \text{ W}$$

26. (*) : At time, $t = 0$ i.e., when switch is closed, inductor in the circuit provides very high resistance (open circuit) while capacitor starts charging with maximum current (low resistance).

Equivalent circuit of the given circuit



Current drawn from battery,

$$i = \frac{\varepsilon}{(R/2)} = \frac{2\varepsilon}{R} = \frac{2 \times 18}{9} = 4 \text{ A}$$

*None of the given options is correct.

27. (*) : The number of radioactive nuclei 'N' at any time t is given as $N(t) = N_0 e^{-\lambda t}$ where N_0 is number of radioactive nuclei in the sample at some arbitrary time $t = 0$ and λ is the radioactive decay constant.

Given: $\lambda_A = 8\lambda$, $\lambda_B = \lambda$, $N_{0A} = N_{0B} = N_0$

$$\therefore \frac{N_B}{N_A} = \frac{e^{-\lambda t}}{e^{-8\lambda t}} \Rightarrow \frac{1}{e} = e^{-\lambda t} e^{8\lambda t} = e^{7\lambda t}$$

$$\Rightarrow -1 = 7\lambda t \text{ or } t = \frac{-1}{7\lambda}$$

Negative value of time is not possible.

So given ratio in question should be $\frac{N_B}{N_A} = e$.

*Question is not properly framed.

28. (a): Work done is given as $W = q\Delta V$
In all the four cases the potential difference from A to B is same.

\therefore In all the four cases the work done is same.

29. (a): Since two astronauts are floating in gravitational free space. The only force acting on the two astronauts is the gravitational pull of their masses,

$$F = \frac{Gm_1m_2}{r^2},$$

which is attractive in nature.

Hence they move towards each other.

30. (b): $x = 5t - 2t^2, \quad y = 10t$

$$\frac{dx}{dt} = 5 - 4t, \quad \frac{dy}{dt} = 10$$

$$\therefore v_x = 5 - 4t, \quad v_y = 10$$

$$\frac{dv_x}{dt} = -4, \quad \frac{dv_y}{dt} = 0$$

$$\therefore a_x = -4, \quad a_y = 0$$

Acceleration, $\vec{a} = a_x \hat{i} + a_y \hat{j} = -4\hat{i}$

\therefore The acceleration of the particle at $t = 2$ s is -4 m s^{-2} .

31. (d): Centripetal force (mv^2/l) is provided by tension so net force on the particle will be equal to tension T .

32. (b): Given, $A = 3$ cm, $x = 2$ cm
The velocity of a particle in simple harmonic motion is given as

$$v = \omega \sqrt{A^2 - x^2}$$

and magnitude of its acceleration is

$$a = \omega^2 x$$

Given, $|v| = |a|$

$$\therefore \omega \sqrt{A^2 - x^2} = \omega^2 x$$

$$\omega x = \sqrt{A^2 - x^2} \quad \text{or} \quad \omega^2 x^2 = A^2 - x^2$$

$$\omega^2 = \frac{A^2 - x^2}{x^2} = \frac{9 - 4}{4} = \frac{5}{4}$$

$$\omega = \frac{\sqrt{5}}{2}$$

$$\text{Time period, } T = \frac{2\pi}{\omega} = 2\pi \cdot \frac{2}{\sqrt{5}} = \frac{4\pi}{\sqrt{5}} \text{ s}$$

33. (b): The intensity of transmitted light through P_1 ,

$$I_1 = \frac{I_0}{2}$$

The intensity of transmitted light through P_3 ,

$$I_2 = I_1 \cos^2 45^\circ = \frac{I_0}{2} \left(\frac{1}{\sqrt{2}} \right)^2 = \frac{I_0}{2} \cdot \frac{1}{2} = \frac{I_0}{4}$$

Angle between polaroids P_3 and $P_2 = (90^\circ - 45^\circ) = 45^\circ$

\therefore Intensity of transmitted light through P_2 ,

$$I_3 = I_2 \cos^2 45^\circ = \frac{I_0}{4} \left(\frac{1}{\sqrt{2}} \right)^2 = \frac{I_0}{8}$$

34. (c): Bulk modulus B is given as

$$B = \frac{-pV}{\Delta V} \quad \dots(i)$$

The volume of a spherical object of radius r is given as

$$V = \frac{4}{3}\pi r^3, \quad \Delta V = \frac{4}{3}\pi(3r^2)\Delta r \quad \therefore \frac{V}{\Delta V} = \frac{r}{3\Delta r}$$

Put this value in eqn. (i), we get

$$B = -\frac{pr}{3\Delta r}$$

Fractional decrease in radius is, $-\frac{\Delta r}{r} = \frac{p}{3B}$.

35. (a)

36. (b): $m = 3$ kg, $r = 40$ cm = 40×10^{-2} m, $F = 30$ N

Moment of inertia of hollow cylinder about its axis
 $= mr^2 = 3 \text{ kg} \times (0.4)^2 \text{ m}^2 = 0.48 \text{ kg m}^2$

The torque is given by,

$$\tau = I\alpha$$

where I = moment of inertia,

α = angular acceleration

In the given case, $\tau = rF$, as the force is acting perpendicularly to the radial vector.

$$\therefore \alpha = \frac{\tau}{I} = \frac{Fr}{mr^2} = \frac{F}{mr} = \frac{30}{3 \times 40 \times 10^{-2}} = \frac{30 \times 100}{3 \times 40}$$

$$\alpha = 25 \text{ rad s}^{-2}$$

37. (a): Initial angular momentum = $I\omega_1 + I\omega_2$

Let ω be angular speed of the combined system.

Final angular momentum = $2I\omega$

\therefore According to conservation of angular momentum

$$I\omega_1 + I\omega_2 = 2I\omega \quad \text{or} \quad \omega = \frac{\omega_1 + \omega_2}{2}$$

Initial rotational kinetic energy

$$E_i = \frac{1}{2}I(\omega_1^2 + \omega_2^2)$$

Final rotational kinetic energy

$$E_f = \frac{1}{2}(2I)\omega^2 = \frac{1}{2}(2I)\left(\frac{\omega_1 + \omega_2}{2}\right)^2 = \frac{1}{4}I(\omega_1 + \omega_2)^2$$

\therefore Loss of energy $\Delta E = E_i - E_f$

$$= \frac{1}{2}I(\omega_1^2 + \omega_2^2) - \frac{1}{4}I(\omega_1^2 + \omega_2^2 + 2\omega_1\omega_2)$$

$$= \frac{1}{4}I[\omega_1^2 + \omega_2^2 - 2\omega_1\omega_2] = \frac{1}{4}I(\omega_1 - \omega_2)^2$$