

JEE (Main) PHYSICS SOLVED PAPER

2023
10th April Shift 2

Section A

Q. 1. Given below are two statements:

Statement I : Rotation of the earth shows effect on the value of acceleration due to gravity 'g'.

Statement II : The effect of rotation of the earth on the value of 'g' at the equator is minimum and that at the pole is maximum.

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

- (1) Both Statement I and Statement II are true
 (2) Both Statement I and Statement II are false
 (3) Statement I is false but statement II is true
 (4) Statement I is true but statement II is false.

Q. 2. The ratio of intensities at two points P and Q on the screen in a Young's double slit experiment where phase difference between two waves of same amplitude are $\frac{\pi}{3}$ and $\frac{\pi}{2}$, respectively are:

- (1) 3 : 2 (2) 3 : 1 (3) 2 : 3 (4) 1 : 3

Q. 3. The time period of a satellite, revolving above earth's surface at a height equal to R will be: (Given $g = \pi^2 \text{ m/s}^2$, R = radius of earth)

- (1) $\sqrt{32R}$ (2) $\sqrt{4R}$ (3) $\sqrt{2R}$ (4) $\sqrt{8R}$

Q. 4. In a metallic conductor, under the effect of applied electric field, the free electrons of the conductor:

- (1) Move with the uniform velocity throughout from lower potential to higher potential
 (2) Move in the curved paths from lower potential to higher potential
 (3) Move in the straight line paths in the same direction
 (4) Drift from higher potential to lower potential.

Q. 5. A message signal of frequency 3 kHz is used to modulate a carrier signal of frequency 1.5 MHz. The bandwidth of the amplitude modulated wave is:

- (1) 6 kHz (2) 3 kHz (3) 6 MHz (4) 3 MHz

Q. 6. In an experiment with vernier calipers of least count 0.1 mm, when two jaws are joined together the zero of vernier scale lies right to the zero of the main scale and 6th division of vernier scale coincides with the main scale division. While measuring the diameter of a spherical bob, the zero of vernier scale lies in between 3.2 cm and 3.3 cm marks, and 4th division of vernier scale coincides with the main scale division. The diameter of bob is measured as:

- (1) 3.25 cm (2) 3.22 cm
 (3) 3.18 cm (4) 3.26 cm

Q. 7. Two projectiles are projected at 30° and 60° with the horizontal with the same speed. The ratio of the maximum height attained by the two projectiles respectively is:

- (1) $2:\sqrt{3}$ (2) $1:\sqrt{3}$ (3) $\sqrt{3}:1$ (4) $1:3$

Q. 8. Given below are two statements : one is labelled as Assertion A and the other is labelled as Reason R.

Assertion A: An electric fan continues to rotate for some time after the current is switched off.

Reason R: Fan continues to rotate due to inertia of motion.

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

- (1) A is not correct but R is correct
 (2) Both A and R are correct and R is the correct explanation of A
 (3) Both A and R are correct but R is NOT the correct explanation of A
 (4) A is correct but R is not correct

Q. 9. The distance between two plates of a capacitor is d and its capacitance is C_1 , when air is the medium between the plates. If a metal sheet of thickness $\frac{2d}{3}$ and of the same area as plate is

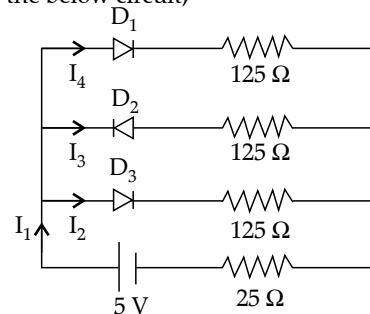
introduced between the plates, the capacitance of the capacitor becomes C_2 . The ratio $\frac{C_2}{C_1}$ is:

- (1) 4 : 1 (2) 3 : 1 (3) 2 : 1 (4) 1 : 1

Q. 10. The amplitude of magnetic field in an electromagnetic wave propagating along y -axis is 6.0×10^{-7} T. The maximum value of electric field in the electromagnetic wave is:

- (1) $2 \times 10^{15} \text{ V m}^{-1}$ (2) $2 \times 10^{14} \text{ V m}^{-1}$
 (3) $6.0 \times 10^{-7} \text{ V m}^{-1}$ (4) 180 V m^{-1}

Q. 11. If each diode has a forward bias resistance of 25 Ω in the below circuit,



Which of the following options is correct:

- (1) $\frac{I_1}{I_2} = 2$ (2) $\frac{I_2}{I_3} = 1$ (3) $\frac{I_3}{I_4} = 1$ (4) $\frac{I_1}{I_2} = 1$

Q. 12. A gas mixture consists of 2 moles of oxygen and 4 moles of neon at temperature T . Neglecting all vibrational modes, the total internal energy of the system will be:

- (1) $4RT$ (2) $11RT$ (3) $8RT$ (4) $16RT$

Q. 13. For a periodic motion represented by the equation $y = \sin \omega t + \cos \omega t$ the amplitude of the motion is:

- (1) 0.5 (2) 1 (3) 2 (4) $\sqrt{2}$

Q. 14. A person travels x distance with velocity v_1 and then x distance with velocity v_2 in the same direction. The average velocity of the person is v , then the relation between v , v_1 and v_2 will be:

- (1) $v = v_1 + v_2$ (2) $\frac{1}{v} = \frac{1}{v_1} + \frac{1}{v_2}$

- (3) $\frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$ (4) $v = \frac{v_1 + v_2}{2}$

Q. 15. The half life of a radioactive substance is T . The time taken, for disintegrating $\frac{7}{8}$ th part of its original mass will be:

- (1) T (2) $2T$ (3) $3T$ (4) $8T$

Q. 16. A gas is compressed adiabatically, which one of the following statement is NOT true.

- (1) There is no change in the internal energy
 (2) The temperature of the gas increases.
 (3) The change in the internal energy is equal to the work done on the gas
 (4) There is no heat supplied to the system

Q. 17. Given below are two statements:

Statement I: For diamagnetic substance, $-1 \leq X < 0$, where, X is the magnetic susceptibility.

Statement II: Diamagnetic substances when placed in an external magnetic field, tend to move from stronger to weaker part of the field.

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

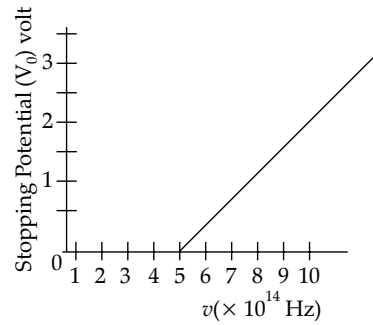
- (1) Both Statement I and Statement II are false
 (2) Statement I is incorrect but Statement II is true
 (3) Both Statement I and Statement II are true
 (4) Statement I is correct but Statement II is false

Q. 18. Young's moduli of the material of wires A and B are in the ratio of 1 : 4, while its area of cross sections are in the ratio of 1 : 3. If the same amount of load is applied to both the wires, the amount of elongation produced in the wires A and B will be in the ratio of:

(Assume length of wires A and B are same)

- (1) 12 : 1 (2) 1 : 36 (3) 1 : 12 (4) 36 : 1

Q. 19. The variation of stopping potential (V_0) as a function of the frequency (ν) of the incident light for a metal is shown in figure. The work function of the surface is:



- (1) 2.07 eV (2) 18.6 eV
 (3) 2.98 eV (4) 1.36 eV

Q. 20. A bar magnet is released from rest along the axis of a very long vertical copper tube. After some time the magnet will

- (1) Oscillate inside the tube
 (2) Move down with an acceleration greater than g
 (3) Move down with almost constant speed
 (4) Move down with an acceleration equal to g

Section B

Q. 21. If 917 \AA be the lowest wavelength of Lyman series then the lowest wavelength of Balmer series will be _____ \AA .

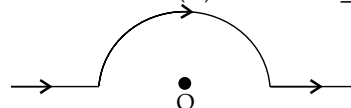
Q. 22. A square loop of side 2.0 cm is placed inside a long solenoid that has 50 turns per centimetre and carries a sinusoidally varying current of amplitude 2.5 A and angular frequency 700 rad s^{-1} . The central axes of the loop and solenoid coincide. The amplitude of the emf induced in the loop is $x \times 10^{-4} \text{ V}$. The value of x is _____.

(Take, $\pi = \frac{22}{7}$)

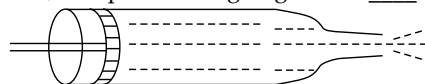
Q. 23. A rectangular parallelepiped is measured as $1 \text{ cm} \times 1 \text{ cm} \times 100 \text{ cm}$. If its specific resistance is $3 \times 10^{-7} \Omega \text{ m}$, then the resistance between its two opposite rectangular faces will be _____ $\times 10^{-7} \Omega$.

Q. 24. A force of $-P \hat{k}$ acts on the origin of the coordinate system. The torque about the point $(2, -3)$ is $P(a\hat{i} + b\hat{j})$. The ratio of $\frac{a}{b}$ is $\frac{x}{2}$. The value of x is:

Q. 25. A straight wire carrying a current of 14 A is bent into a semicircular arc of radius 2.2 cm as shown in the figure. The magnetic field produced by the current at the centre (O) of the arc is _____ $\times 10^{-4} \text{ T}$

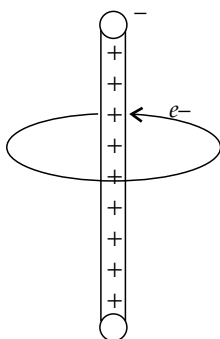


Q. 26. Figure below shows a liquid being pushed out of the tube by a piston having area of cross section 2.0 cm^2 . The area of cross section at the outlet is 10 mm^2 . If the piston is pushed at a speed of 4 cm s^{-1} , the speed of outgoing fluid is _____ cm s^{-1}



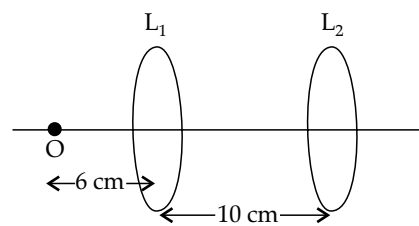
Q. 27. A rectangular block of mass 5 kg attached to a horizontal spiral spring executes simple harmonic motion of amplitude 1 m and time period 3.14 s. The maximum force exerted by spring on block is _____ N.

Q. 28. An electron revolves around an infinite cylindrical wire having uniform linear charge density $2 \times 10^{-8} \text{ C m}^{-1}$ in circular path under the influence of attractive electrostatic field as shown in the figure. The velocity of electron with which it is revolving is _____ $\times 10^6 \text{ m s}^{-1}$. Given mass of electron = $9 \times 10^{-31} \text{ kg}$



Q. 29. A point object, 'O' is placed in front of two thin symmetrical coaxial convex lenses L_1 and L_2 with focal length 24 cm and 9 cm respectively. The

distance between two lenses is 10 cm and the object is placed 6 cm away from lens L_1 as shown in the figure. The distance between the object and the image formed by the system of two lenses is _____ cm.



Q. 30. If the maximum load carried by an elevator is 1400 kg (600 kg-Passengers + 800 kg - elevator), which is moving up with a uniform speed of 3 m s^{-1} and the frictional force acting on it is 2000 N, then the maximum power used by the motor is _____ kW ($g = 10 \text{ m s}^{-2}$)

Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	(4)	Variation of g	Gravitation
2	(1)	YDSE	Wave optics
3	(1)	Orbital velocity of satellite	Gravitation
4	(2)	Drift velocity	Electric current
5	(1)	Modulation	Communication system
6	(3)	Vernier callipers	Units & Dimension
7	(4)	Projectile motion	Motion in a plane
8	(2)	Newton's first law	Newton's laws of motion
9	(2)	Parallel plate capacitor	Electrostatics
10	(4)	Transverse nature of electromagnetic waves	Electromagnetic waves
11	(1)	Diode	Semiconductors
12	(2)	Law of equipartition of energy	Kinetic theory of gases
13	(4)	Equation of SHM	Waves
14	(3)	Average velocity	Motion in straight line
15	(3)	Half life	Nuclear physics
16	(1)	Adiabatic change	Thermodynamics
17	(3)	Magnetic substances	Magnetism
18	(1)	Hook's law	Properties of solid
19	(1)	Photoelectric effect	Dual nature of matter and radiation
20	(3)	Len's law	Electromagnetic induction
21	[3668]	Energy levels	Atoms
22	[44]	Induced emf	Electromagnetic induction
23	[3]	Resistance	Electric current
24	[3]	Cross product of vectors	Vector
25	[2]	Bio-Savart's law	Magnetic effect of current
26	[80]	Continuity equation	Fluid mechanics
27	[20]	SHM	Waves
28	[8]	Coulomb's law	Electrostatics
29	[34]	Refraction through lenses	Ray optics
30	[48]	Power	Work, Energy and Power

SOLUTIONS

Section A

1. **Option (4) is correct.**

The effect of rotation of earth on the value of acceleration due to gravity is $g' = g - \omega^2 R \cos^2 \theta$ where, θ is the latitude of the place considered

At the equator, $\theta = 0^\circ, g' = g - \omega^2 R$

$$\Delta g = g - g' = \omega^2 R \text{ (Maximum)}$$

At the poles $\theta = 90^\circ, g' = g$

$$\Delta g = g - g' = 0 \text{ (Minimum)}$$

Thus there is maximum change in the value of g at the equator and minimum (no) change at the poles.

2. **Option (1) is correct.**

$$I = 4a^2 \cos^2 \frac{\phi}{2} \text{ since } a_1 = a_2 = a$$

For $\phi = \frac{\pi}{3}, I_1 = 4a^2 \cos^2 \left(\frac{\pi}{6} \right) = 4a^2 \left(\frac{3}{4} \right)$

For $\phi = \frac{\pi}{2}, I_2 = 4a^2 \cos^2 \left(\frac{\pi}{4} \right) = 4a^2 \left(\frac{1}{2} \right)$

$$\frac{I_1}{I_2} = \frac{3}{2}$$

3. **Option (1) is correct.**

$$T = \frac{2\pi(R+h)^{3/2}}{R\sqrt{g}}$$

At $h = R, T = \frac{2\pi(2R)^{3/2}}{R\sqrt{g}}$

Given, $g = \pi^2$

$\therefore T = \frac{2}{R} \times 2\sqrt{2} R^{3/2}$

$$= 4\sqrt{2} \sqrt{R} = \sqrt{32R}$$

4. **Option (2) is correct.**

In the presence of electric field, the free electrons may deviate from their straight line paths, when they collide with other electrons. Their paths are nearly parabolic between two successive collisions. Moreover, electrons being negatively charged, move from low to high potential.

5. **Option (1) is correct.**

Bandwidth of amplitude modulated (AM) signal is given by $2f_m$ where, f_m is the frequency of the baseband (modulating) signal.

$$BW = 2f_m = 2 \times 3 = 6 \text{ kHz}$$

6. **Option (3) is correct.**

For the given vernier callipers, least count

$$\text{L.C.} = 0.01 \text{ cm}$$

It has a positive zero error = $6 \times 0.01 = 0.06 \text{ cm}$

The measured value of the diameter is

$$d = 3.2 + (4 \times 0.01) - 0.06 \\ = 3.2 - 0.02 = 3.18 \text{ cm}$$

7. **Option (4) is correct.**

$$H = \frac{u^2 \sin^2 \theta}{2g}$$

$$\frac{H_1}{H_2} = \frac{\sin^2 30}{\sin^2 60} = \frac{1}{4} \times \frac{4}{3} = \frac{1}{3}$$

8. **Option (2) is correct.**

Inertia of the rotating fan continues to maintain its motion even after switching it off in accordance with Newton's first law. Fan finally stops due to air resistance.

9. **Option (2) is correct.**

$$C_1 = \frac{\epsilon_0 A}{d}$$

$$C_2 = \frac{\epsilon_0 A}{d-t}$$

where, t = thickness of the metal sheet

Given, $t = \frac{2d}{3}, C_2 = 3 \frac{\epsilon_0 A}{d} = 3C_1$

$$\frac{C_2}{C_1} = 3 : 1$$

10. **Option (4) is correct.**

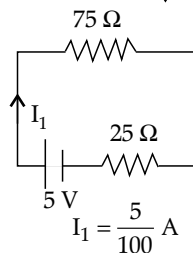
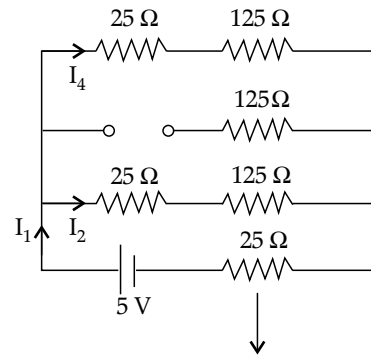
Given: $B_0 = 6 \times 10^{-7} \text{ T}$

$$E_0 = CB_0$$

$$3 \times 10^8 \times 6 \times 10^{-7} = 180 \text{ V m}^{-1}$$

11. **Option (1) is correct.**

For the given circuit, D_1 and D_3 are forward biased and D_2 is reverse biased. D_2 acts as an open. The equivalent circuit can be drawn as:



$$I_1 = \frac{5}{100} \text{ A}$$

$$I_2 = I_4 = \frac{I_1}{2} = \frac{5}{200} \text{ A}$$

Hence $\frac{I_1}{I_2} = 2$

12. Option (2) is correct.

$$\text{Internal energy per mole of a gas} = \frac{1}{2} f RT$$

where, f = degrees of freedom

$$f_{O_2} \text{ (diatomic)} = 5 \text{ (3 translational + 2 rotational)}$$

$$f_{N_e} \text{ (Monoatomic)} = 3 \text{ (translational)}$$

Total internal energy of the mixture

$$\begin{aligned} U &= n_1 \left[\frac{1}{2} f_{O_2} RT \right] + n_2 \left[\frac{1}{2} f_{N_e} RT \right] \\ &= 2 \left[\frac{1}{2} \times 5RT \right] + 4 \left[\frac{1}{2} \times 3RT \right] \\ &= 5RT + 6RT = 11RT \end{aligned}$$

13. Option (4) is correct.

For $y = a \sin \omega t + b \cos \omega t$
the amplitude of the motion

$$R = \sqrt{a^2 + b^2}$$

Here, $a = b = 1$

Hence, $R = \sqrt{2}$

14. Option (3) is correct.

$$\text{Average velocity} = \frac{\text{total displacement}}{\text{total time}}$$

$$v = \frac{x + x}{\frac{x}{v_1} + \frac{x}{v_2}} = \frac{2v_1 v_2}{v_2 + v_1}$$

$$\text{or } \frac{2}{v} = \frac{1}{v_1} + \frac{1}{v_2}$$

15. Option (3) is correct.

If $\frac{7}{8}$ th part of the original mass decays then $\frac{1}{8}$ th

$$\text{part remains } N = N_0 \left(\frac{1}{2} \right)^n$$

where, n = number of half lives

$$\frac{N}{N_0} = \frac{1}{8} = \frac{1}{2^3} = \left(\frac{1}{2} \right)^n$$

$$\rightarrow n = 3$$

time taken, $t = 3 T$

16. Option (1) is correct.

For an adiabatic process, $\Delta Q = 0$

Hence $\Delta U + \Delta W = 0$ (1st law of thermodynamics)

$$\Delta U = -\Delta W$$

$$TV^{\gamma-1} = \text{const}$$

If volume decreases (compression), Temperature increases.

17. Option (3) is correct.

From theory of diamagnetic materials, both statements are true.

18. Option (1) is correct.

$$\text{Elongation, } \Delta l = \frac{Fl}{YA}$$

$$\frac{\Delta l_1}{\Delta l_2} = \frac{F_1 l_1 Y_2 A_2}{F_2 l_2 Y_1 A_1}$$

$$F_1 = F_2 = W$$

$$l_1 = l_2 = l$$

$$\therefore \frac{\Delta l_1}{\Delta l_2} = \frac{4}{1} \times \frac{3}{1} = 12:1$$

19. Option (1) is correct.

For Einstein's photoelectric equation,

$$h\nu = h\nu_0 + eV_0$$

Work function $\phi = h\nu_0$

ν_0 = threshold frequency

$$V_0 = \frac{h\nu}{e} - \frac{h\nu_0}{e}$$

At $V_0 = 0, \nu = \nu_0 = 5 \times 10^{14}$ Hz

$$\therefore \phi = h\nu_0$$

$$= \frac{h\nu_0}{e} eV$$

$$= \frac{6.625 \times 10^{-34} \times 5 \times 10^{14}}{1.6 \times 10^{-19}}$$

$$\approx 2.07 eV$$

20. Option (3) is correct.

As the magnet moves inside the copper tube, the magnetic flux changes inducing current loops on the walls of the tube. These oppose the fall of the magnet according to Lenz's law. Hence the acceleration of the magnet reduces ($< g$).

Section B

21. The correct answer is (3668).

Series limit is the lowest wavelength

For Lyman series,

$$\frac{1}{917} = RZ^2 \left(\frac{1}{1^2} - \frac{1}{\infty} \right)$$

For Balmer series,

$$\frac{1}{\lambda} = RZ^2 \left(\frac{1}{2^2} - \frac{1}{\infty} \right)$$

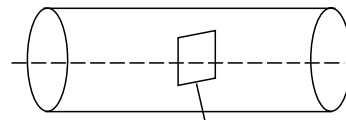
Dividing, we get

$$\frac{\lambda}{917} = 4$$

$$\lambda = 4 \times 917 = 3668 \text{ \AA}$$

22. The correct answer is (44).

Solenoid



Square loop

Amplitude of the induced emf in the square loop

$$= NB_0 A \omega$$

Here, $N = 1$

$$B = \mu_0 n i = \mu_0 n i_0 \sin \omega t$$

$$= 4\pi \times 10^{-7} \times 50 \times 10^2 \times 2.5 \sin 700t$$

$$= 50\pi \times 10^{-4} \sin 700t$$

$$B_0 = 5\pi \times 10^{-3} \text{ T}$$

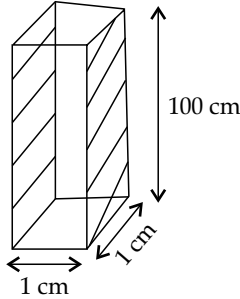
$$A = 4 \times 10^{-4} \text{ m}^2$$

$$\omega = 700 \text{ rad s}^{-1}$$

$$\begin{aligned}
 e_0 &= NB_0Aw \\
 &= 5\pi \times 10^{-3} \times 4 \times 10^{-4} \times 700 \\
 &= 5 \times \frac{22}{7} \times 28 \times 10^{-5} \\
 &= 44 \times 10^{-4} \text{ V} \\
 &= x \times 10^{-4} \text{ V}
 \end{aligned}$$

on comparing, $x = 44$

23. The correct answer is (3).



Resistance between the opposite (shaded) faces

$$\begin{aligned}
 &= \rho \frac{l}{A} = \frac{3 \times 10^{-7} \times 10^{-2}}{100 \times 10^{-4}} \\
 &= 3 \times 10^{-7} \Omega
 \end{aligned}$$

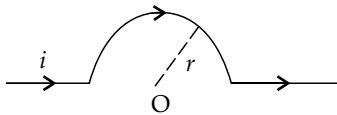
24. The correct answer is (3).

$$\begin{aligned}
 \text{Torque} &= \vec{r} \times \vec{F} \\
 \vec{r} &= -2\hat{i} + 3\hat{j} \\
 \vec{F} &= -P\hat{k} \\
 \vec{J} &= \vec{r} \times \vec{F} = (-2\hat{i} + 3\hat{j}) \times (-P\hat{k}) \\
 &= 2P(-\hat{j}) - 3P\hat{i} = P[-3\hat{i} - 2\hat{j}] \\
 &= P[a\hat{i} + b\hat{j}]
 \end{aligned}$$

On comparing, we get $a = -3$ and $b = -2$

$$\frac{a}{b} = \frac{3}{2} = \frac{x}{2} \Rightarrow x = 3$$

25. The correct answer is (2).



B_0 due to straight wires is zero as O lies on the extension of the two wires.

$$\begin{aligned}
 B_0 (\text{due to semicircular arc}) &= \frac{\mu_0 i}{4r} \\
 &= \frac{\pi \times 10^{-7} \times 14}{2.2 \times 10^{-2}} = \frac{22}{7} \times 14 \times 10^{-5} \\
 &= 2 \times 10^{-4} \text{ T}
 \end{aligned}$$

26. The correct answer is (80).

From equation of continuity

$$\begin{aligned}
 A_1 v_1 &= A_2 v_2 \\
 2 \times 4 &= 10 \times 10^{-2} v_2 \\
 v_2 &= 80 \text{ cm s}^{-1}
 \end{aligned}$$

27. The correct answer is (20).

$$T = 2\pi \sqrt{\frac{m}{K}} \Rightarrow 3.14 = 2(3.14) \sqrt{\frac{5}{K}}$$

$$\frac{5}{k} = \frac{1}{4}$$

$$k = 20 \text{ N m}^{-1}$$

$$\begin{aligned}
 \text{Maximum force} &= kA \\
 &= 20 \times 1 = 20 \text{ N}
 \end{aligned}$$

28. The correct answer is (8).

For circular motion, centripetal force is provided by attractive central electrostatic force

$$\begin{aligned}
 \frac{\lambda e}{2\pi\epsilon_0 r} &= \frac{mv^2}{r} \Rightarrow v = \sqrt{\frac{2ke\lambda}{m}} \\
 &= \sqrt{\frac{2 \times 10^{-8} \times 1.6 \times 10^{-19} \times 2 \times 9 \times 10^9}{9 \times 10^{-31}}} \\
 &= \sqrt{\frac{2 \times 16 \times 18}{9} \times 10^{12}} = 8 \times 10^6
 \end{aligned}$$

29. The correct answer is (34).

For the first lens (L_1)

$$\begin{aligned}
 u_1 &= -6 \text{ cm} \\
 v_1 &= ? \\
 f_1 &= 24 \text{ cm}
 \end{aligned}$$

Applying lens formula,

$$\frac{1}{v_1} - \frac{1}{-6} = \frac{1}{24}$$

$$v_1 = -8 \text{ cm (on the left of } L_1)$$

For the second lens (L_2)

$$\begin{aligned}
 u_2 &= -18 \text{ cm} \\
 v_2 &= ? \\
 f_2 &= 9 \text{ cm}
 \end{aligned}$$

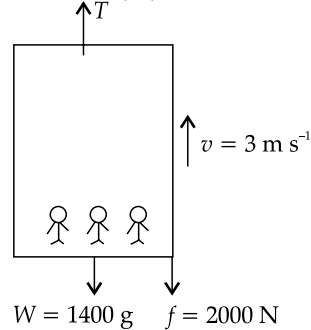
Applying lens formula,

$$\frac{1}{v_2} - \frac{1}{-18} = \frac{1}{9}$$

$$v_2 = 18 \text{ cm (on the right of } L_2)$$

\therefore distance between the object and the final image is $6 + 10 + 18 = 34 \text{ cm}$.

30. The correct answer is (48).



Since elevator is moving up with a constant speed

$$\begin{aligned}
 \Sigma F &= 0 \\
 T &= W + f = 16000 \text{ N}
 \end{aligned}$$

$$\begin{aligned}
 \text{Power used} \quad P &= Tv = 16000 \times 3 = 48000 \text{ W} \\
 &= 48 \text{ kW}
 \end{aligned}$$