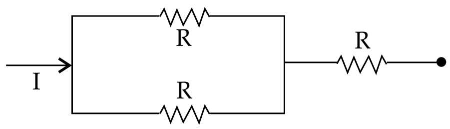
JEE (Main) PHYSICS SOLVED PAPER

2023
13^{th} April Shift 1

Section A

Q. 1. Different combination of 3 resistors of equal resistance R are shown in the figures. The increasing order for power dissipation is:

(a)



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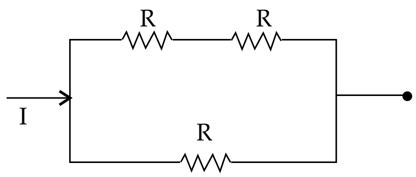

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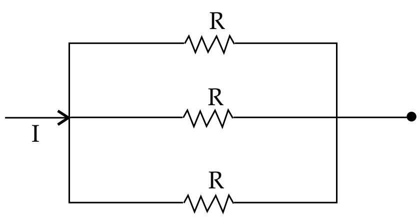

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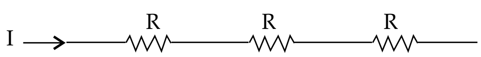
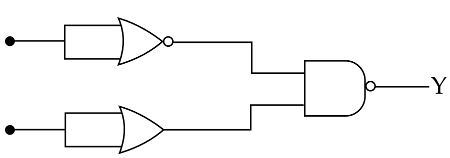
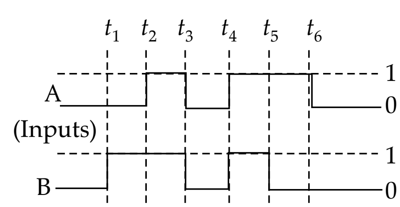


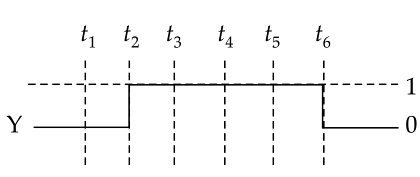
(1) $P_C < P_B < P_A < P_D$ **(2)** $P_C < P_D < P_A < P_B$
(3) $P_B < P_C < P_D < P_A$ **(4)** $P_A < P_B < P_C < P_D$

Q. 2. For the following circuit and given inputs A and B, chose the correct option for output 'Y'





(1)



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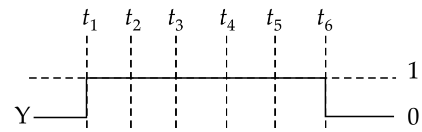

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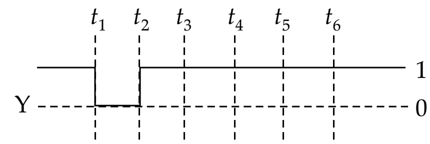

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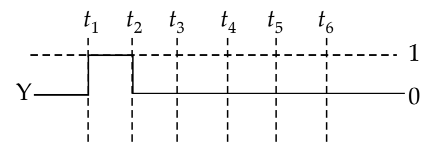


Q. 3. A bullet of 10 g leaves the barrel of gun with a velocity of 600 m s^{-1}. If the barrel of gun is 50 cm long and mass of gun is 3 kg, then value of impulse supplied to the gun will be:

(1) 12 N s **(2)** 6 N s **(3)** 3 N s **(4)** 36 N s

Q. 4. Which of the following Maxwell's equation is valid for time varying conditions but not valid for static conditions:

(1) $\oint \vec{D}.\vec{dA} = Q$ **(2)** $\oint \vec{E}.\vec{dl} = -\frac{\partial \phi_B}{\partial t}$

(3) $\oint \vec{E}.\vec{dl} = 0$ **(4)** $\oint \vec{B}.\vec{dl} = \mu_0 I$

Q. 5. Match List – I with List – II

List – I (Layer of atmosphere)	List – II (Approximate height over earth's surface)
(A) F1 - Layer	(I) 10 km
(B) D - Layer	(II) 170 - 190 km
(C) Troposphere	(III) 100 km
(D) E - layer	(IV 65 - 75 km

Choose the correct answer from the options given below:
(1) A – II, B – I, C – IV, D – III
(2) A – II, B – IV, C – III, D – I
(3) A – II, B – IV, C – I, D – III
(4) A – III, B – IV, C – I, D – II

Q. 6. The r.m.s. speed of oxygen molecule in a vessel at particular temperature is $\left(1+\frac{5}{x}\right)^{1/2} \nu$, where ν is the average speed of the molecule. The value of x will be: $\left(\text{Take } \pi = \frac{22}{7}\right)$

(1) 28 **(2)** 27 **(3)** 8 **(4)** 4

Q. 7. The ratio of powers of two motors is $\frac{3\sqrt{x}}{\sqrt{x}+1}$, that are capable of raising 300 kg water in 5 minutes and 50 kg water in 2 minutes respectively from a well of 100 m deep. The value of x will be

(1) 16 **(2)** 2 **(3)** 4 **(4)** 2.4

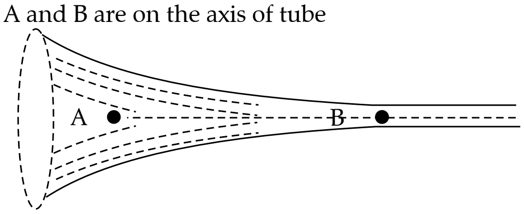
Q. 8. Two trains 'A' and 'B' of length 'l' and '$4l$' are travelling into a tunnel of length 'L' in parallel tracks from opposite directions with velocities 108 km/h and 72 km/h, respectively. If train 'A' takes 35s less time than train 'B' to cross the tunnel then, length 'L' of tunnel is: (Given $L = 60l$)

(1) 2700 m **(2)** 1800 m **(3)** 1200 m **(4)** 900 m

Q. 9. Two bodies are having kinetic energies in the ratio 16 : 9. If they have same linear momentum, the ratio of their masses respectively is:

(1) 16 : 9 **(2)** 4 : 3 **(3)** 9 : 16 **(4)** 3 : 4

Q. 10. The figure shows a liquid of given density flowing steadily in horizontal tube of varying cross-section. Cross sectional areas at A is 1.5 cm^2, and B is 25 mm^2, if the speed of liquid at B is 60 cm then ($P_A - P_B$) is:
(Given P_A and P_B are liquid pressures at A and B points)
Density ρ = 1000 kg m^{-3}
A and B are on the axis of tube

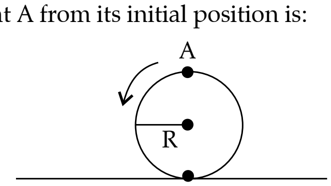


(1) 175 Pa **(2)** 36 Pa **(3)** 27 Pa **(4)** 135 Pa

Q. 11. $^{238}_{92}A \rightarrow ^{234}_{90}B + ^{4}_{2}D + Q$
In the given nuclear reaction, the approximate amount of energy released will be:
[Given, mass of $^{238}_{92}A$ = 238.05079 × 931.5 Me V/C^2,
mass of $^{234}_{90}B$ = 234.04363 × 931.5 MeV/C^2,
mass of $^{4}_{2}D$ = 4.00260 × 931.5 MeV/C^2]

(1) 4.25 Me V **(2)** 5.9 Me V
(3) 3.82 Me V **(4)** 2.12 Me V

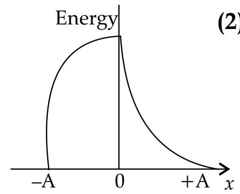
Q. 12. A disc is rolling without slipping on a surface. The radius of the disc is R. At t = 0, the top most point on the disc is A as shown in figure. When the disc completes half of its rotation, the displacement of point A from its initial position is:



(1) $2R\sqrt{(1+4\pi^2)}$ **(2)** $R\sqrt{(\pi^2+4)}$

(3) 2R **(4)** $R\sqrt{(\pi^2+1)}$

Q. 13. Which graph represents the difference between total energy and potential energy of a particle executing SHM *vs.* its distance from mean position?

(1)


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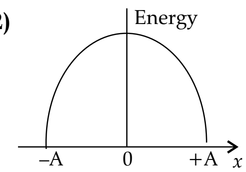

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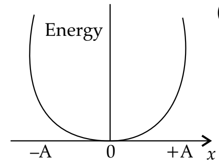

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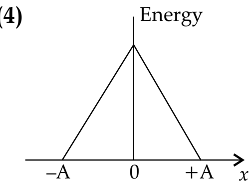


Q. 14. Two charges each of magnitude 0.01 C and separated by a distance of 0.4 mm constitute an electric dipole. If the dipole is placed in an uniform electric field '$\vec{E}$' of 10 dyne C^{-1} making 30° angle with $\vec{E}$, the magnitude of torque acting on dipole is:

(1) 1.5×10^{-9} N m **(2)** 2.0×10^{-10} N m
(3) 1.0×10^{-8} N m **(4)** 4.0×10^{-10} N m

Q. 15. Under isothermal condition, the pressure of a gas is given by $P = aV^{-3}$, where a is a constant and V is the volume of the gas. The bulk modulus at constant temperature is equal to

(1) $\frac{P}{2}$ **(2)** 2P **(3)** P **(4)** 3P

Q. 16. A planet having mass 9 Me and radius 4Re, where Me and Re are mass and radius of earth respectively, has escape velocity in km given by: (Given escape velocity on earth s^{-1} $V_e = 11.2 \times 10^3$ m s^{-1})

(1) 11.2 **(2)** 67.2 **(3)** 33.6 **(4)** 16.8

Q. 17. A body of mass (5 ± 0.5) kg is moving with a velocity of (20 ± 0.4) m s^{-1}. Its kinetic energy will be:

(1) (1000 ± 140) J **(2)** (500 ± 140) J
(3) (500 ± 0.14) J **(4)** (1000 ± 0.14) J

Q. 18. The difference between threshold wavelengths for two metal surfaces A and B having work function, ϕ_A = 9 e V and ϕ_B = 4.5 e V in n m is: {Given, hc = 1242 e V n m}

(1) 276 **(2)** 264 **(3)** 540 **(4)** 138

Q. 19. The source of time varying magnetic field may be:
(A) A permanent magnet
(B) An electric field changing linearly with time
(C) Direct current
(D) A decelerating charge particle
(E) An antenna fed with a digital signal
Choose the correct answer from the options given below:

(1) (B) and (D) only **(2)** (C) and (E) only
(3) (D) only **(4)** (A) only

Q. 20. A vessel of depth 'd' is half filled with oil of refractive index n_1 and the other half is filled with water of refractive index n_2. The apparent depth of this vessel when viewed from above will be:

(1) $\dfrac{d(n_1+n_2)}{2n_1n_2}$ (2) $\dfrac{dn_1n_2}{(n_1+n_2)}$

(3) $\dfrac{dn_1n_2}{2(n_1+n_2)}$ (4) $\dfrac{2d(n_1+n_2)}{n_1n_2}$

Section B

Q. 21. When a resistance of 5 Ω is shunted with a moving coil galvanometer, it shows a full scale deflection for a current of 250 mA. However when 1050 Ω resistance is connected with it in series, it gives full scale deflection for 25 volt. The resistance of galvanometer is __________ Ω.

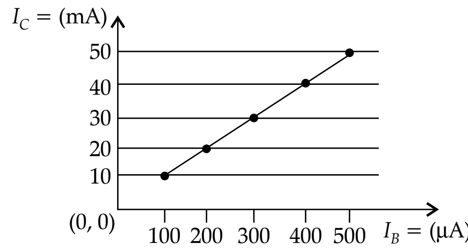
Q. 22. The radius of 2nd orbit of He^+ of Bohr's model is r_1 and that of fourth orbit of Be^{3+} is represented as r_2. Now the ratio $\dfrac{r_2}{r_1}$ is $x : 1$. The value of x is __________.

Q. 23. A solid sphere is rolling on a horizontal plane without slipping. If the ratio of angular momentum about axis of rotation of the sphere to the total energy of moving sphere is $\pi : 22$, the value of its angular speed will be rad s^{-1}.

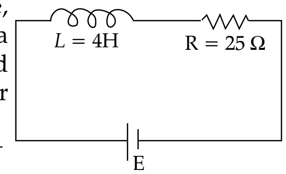
Q. 24. A fish rising vertically upward with a uniform velocity of 8 m s^{-1}, observes that a bird is diving vertically downward towards the fish with the velocity of 12 m s^{-1}. If the refractive index of water is $\dfrac{4}{3}$, then the actual velocity of the diving bird to pick the fish, will be ______________m s^{-1}.

Q. 25. The elastic potential energy stored in a steel wire of length 20 m stretched through 2 cm is 80 J. The cross sectional area of the wire is ___________ mm^2.
(Given, $y = 2.0 \times 10^{11}$ N m^{-2})

Q. 26. From the given transfer characteristic of a transistor in CE configuration, the value of power gain of this configuration is 10^x, for RB = 10 kΩ, R_C = 1 k Ω. The value of x is ______________.



Q. 27. In the given figure, an inductor and a resistor are connected in series with a batter of emf E volt. $\dfrac{E^a}{2b}$ Js^{-1} represents the maximum rate at which the energy is stored in the magnetic field (inductor). The numerical value of $\dfrac{b}{a}$ will be _____



Q. 28. A potential V_0 is applied across a uniform wire of resistance R. The power dissipation is P_1. The wire is then cut into two equal halves and a potential of V_0 is applied across the length of each half. The total power dissipation across two wires is P_2. The ratio $P_2 : P_1$ is $\sqrt{x} : 1$. The value of x is _______________.

Q. 29. At a given point of time the value of displacement of a simple harmonic oscillator is given as $y = A \cos(30°)$. If amplitude is 40 cm and kinetic energy at that time is 200 J, the value of force constant is 1.0×10^x N m^{-1}. The value of x is ______.

Q. 30. A thin infinite sheet charge and an infinite line charge of respective charge densities $+\sigma$ and $+\lambda$ are placed parallel at 5 m distance from each other. Points 'P' and 'Q' are at $\dfrac{3}{\pi}$ m and $\dfrac{4}{\pi}$ m perpendicular distances from line charge towards sheet charge, respectively. 'E_P' and 'E_Q' are the magnitudes of resultant electric field intensities at point 'P' and 'Q' respectively. If $\dfrac{E_P}{E_Q} = \dfrac{4}{a}$ for $2|\sigma| = |\lambda|$, then the value of a is ___________.

Answer Key

Q. No.	Answer	Topic Name	Chapter Name
1	(1)	Power of electric circuit	Electric current
2	(3)	Logic gates	Semiconductors
3	(2)	Momentum conservation principle	Newton's laws of motion
4	(2)	Mawell's equation	Magnetism and Matter
5	(3)	Layers of atmosphere	Communication system
6	(1)	Speed of gas molecules	Kinetic theory of gases
7	(1)	Power	Work, Energy and Power
8	(2)	Uniform velocity	Motion in a straight line

9	**(3)**	Kinetic energy	Work, Energy and Power
10	**(1)**	Bernoulli's equation	Properties of fluid
11	**(1)**	Mass energy equivalence	Nuclei
12	**(2)**	Displacement	Motion in one dimension
13	**(2)**	Kinetic and potential energies	Oscillation and waves
14	**(2)**	Electric dipole in electric field	Electrostatics
15	**(4)**	Thermodynamic processes	Thermodynamics
16	**(4)**	Escape velocity	Gravitation
17	**(1)**	Percentage error	Units & Dimensions
18	**(4)**	Work function	Photoelectric effect
19	**(3)**	Transverse nature of EM wave	Electromagnetic waves
20	**(1)**	Refraction	Ray optics
21	**[50]**	Moving coil galvanometer	Magnetic effect of current and Magnetism
22	**[2]**	Bohr's Model	Atoms
23	**[4]**	Kinetic energy	Rotational Motion
24	**[3]**	Refraction	Ray optics
25	**[40]**	Energy stored in stretched wire	Properties of solid
26	**[3]**	Transistor	Semiconductors
27	**[25]**	RL circuit	AC current
28	**[16]**	Power of electric circuit	Electric current
29	**[4]**	Kinetic and Potential energies	Oscillation and Waves
30	**[6]**	Electric field	Electrostatics

SOLUTIONS

Section A

1. Option (1) is correct.

(A) $R_1 = \frac{R}{2} + R = \frac{3R}{2}$, $\quad P_1 = I^2 R_1 = I^2\left(\frac{3R}{2}\right)$

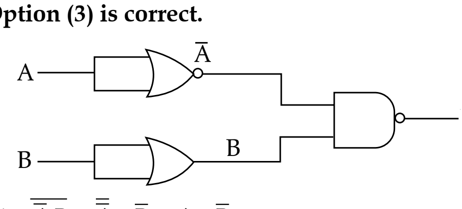
(B) $R_2 = \frac{2R}{3}$, $\quad P_2 = I^2 R_2 = I^2\left(\frac{2R}{3}\right)$

(C) $R_3 = \frac{R}{3}$, $\quad P_3 = I^2 R_3 = I^2\left(\frac{R}{3}\right)$

(D) $R_4 = 3R$, $\quad P_4 = I^2 R_4 = I^2(3R)$

from above, increasing order of power dissipation is $P_C < P_B < P_A < P_D$

2. Option (3) is correct.



$Y = \overline{\overline{A}.B} = \overline{\overline{A}} + \overline{B} = A + \overline{B}$

	A	B	$\overline{B}$	$A+\overline{B}$
$0 - t_1$	0	0	1	1
$t_1 - t_2$	0	1	0	0
$t_2 - t_3$	1	1	0	1
$t_3 - t_4$	0	0	1	1
$t_4 - t_5$	1	1	0	1
$t_5 - t_6$	1	0	1	1
$t_6 - t$	0	0	1	1

3. Option (2) is correct.

Impulse = change in momentum

$|\vec{J}| = |\Delta\vec{p}| = mv - 0$

$= \frac{10}{1000} \times 600 - 0 = 6 \text{ (N s)}$

4. Option (2) is correct.

For static conditions $\oint \vec{E}.d\vec{l} = 0$

For time varying conditions, $\oint \vec{E}.d\vec{l} = -\frac{\partial \phi_B}{\partial t}$

Which is Faraday's law of electromagnetism.

5. Option (3) is correct.

In the increasing order of heights, various layers of atmosphere can be arranged as:
Troposphere < D-layer < E layer < F1 layer.

6. Option (1) is correct.

$$v_{rms} = \sqrt{\frac{3RT}{M}} \text{ and } v_{av} = \sqrt{\frac{8RT}{\pi M}} = v$$

$$\Rightarrow \quad \sqrt{\frac{RT}{M}} = \sqrt{\frac{\pi}{8}}\, v$$

$$\therefore \quad v_{rms} = \sqrt{3} \times \sqrt{\frac{\pi}{8}}\, v$$

$$v_{rms} = \sqrt{\frac{3\pi}{8}}\, v = \sqrt{1 + \frac{5}{x}}\, v$$

$$\Rightarrow \quad \frac{3\pi}{8} - 1 = \frac{5}{x} \Rightarrow \frac{3}{8} \times \frac{22}{7} - 1 = \frac{5}{x}$$

$$\Rightarrow \quad \frac{66}{56} - 1 = \frac{5}{x} \Rightarrow \frac{10}{56} = \frac{5}{x}$$

$$\Rightarrow \quad x = 28$$

7. Option (1) is correct.

$$P = \frac{W}{t} = \frac{mgh}{t} \Rightarrow \frac{P_1}{P_2} = \frac{m_1}{m_2} \times \frac{t_2}{t_1}$$

$$\frac{3\sqrt{x}}{\sqrt{x}+1} = \frac{300}{50} \times \frac{2}{5} = \frac{12}{5}$$

Squaring, we get

$$\frac{9x}{x+1+2\sqrt{x}} = \frac{144}{25}$$

$$25x = 16x + 16 + 32\sqrt{x}$$

$$9x - 32\sqrt{x} - 16 = 0 \quad \text{Let } \sqrt{x} = p$$

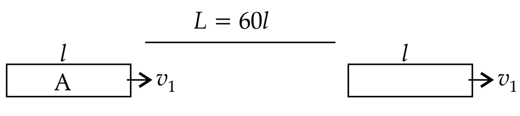
$$9p^2 - 32p - 16 = 0$$

$$p = \frac{32 + \sqrt{1024 + 576}}{18} \Rightarrow p = \frac{32 + \sqrt{1600}}{18} = \frac{72}{18}$$

$$p = 4 = \sqrt{x}$$

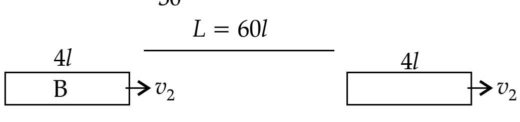
$$\therefore \quad x = 16$$

8. Option (2) is correct.



$$t_1 = \frac{61l}{v_1} \Rightarrow v_1 = 108 \text{ km h}^{-1} = 108 \times \frac{5}{18} = 30 \text{ m s}^{-1}$$

$$t_1 = \frac{61l}{30} \text{ s}$$



$$t_2 = \frac{64l}{v_2} \Rightarrow v_2 = 72 \text{ km/h} = 72 \times \frac{5}{18} = 20 \text{ m/s}$$

$$t_2 = \frac{64l}{20}$$

Given $\quad t_1 = t_2 - 35 \Rightarrow \frac{61l}{30} = \frac{64l}{20} - 35$

On solving, $\quad l = 30$ m

Length of the tunnel, $L = 60l = 1800$ m

9. Option (3) is correct.

$$\text{KE} = \frac{p^2}{2m} \Rightarrow \text{KE} \propto \frac{1}{m} \Rightarrow \frac{m_1}{m_2} = \frac{\text{KE}_2}{\text{KE}_1} = \left(\frac{16}{9}\right)^{-1}$$

$$\frac{m_1}{m_2} = \frac{9}{16}$$

10. Option (1) is correct.

From Bernouilli's theorem

$$p_A + \frac{1}{2}\rho v^2{}_A = p_B + \frac{1}{2}\rho v^2{}_B$$

$$p_A - p_B = \frac{1}{2}\rho\left(v^2{}_B - v^2{}_A\right)$$

From equation of continuity,

$$A_A v_A = A_B v_B$$

$$1.5 \times v_A = 0.25 \times 60$$

$$v_A = 10 \text{ cm s}^{-1}$$

$$\therefore \quad p_A - p_B = \frac{1}{2} \times 1000(3600 - 100) \times 10^{-4} = 175 \text{ Pa}$$

11. Option (1) is correct.

Q value of the given nuclear reaction

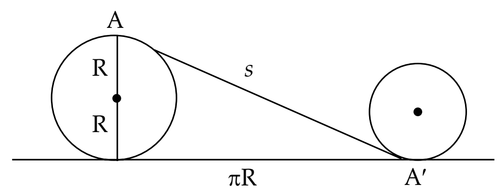
$$= \left[\sum m_{reactants} - \sum m_{products}\right] \times C^2 \text{ J}$$

$$= \underbrace{\left[\sum m_{reactants} - \sum m_{products}\right]}_{\text{In a.m.u.}} \times 931.5 \text{ Me V}$$

$= [238.05079 - 234.04363 - 4.00260] \times 931.5$

$= 4.25$ Me V

12. Option (2) is correct.



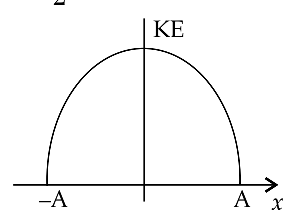
Displacement of point A after half rotation

$$= \sqrt{4R^2 + \pi^2 R^2} = R\sqrt{4 + \pi^2}$$

13. Option (2) is correct.

KE of a particle in SHM is given by

$$\text{KE} = \frac{1}{2}K(A^2 - x^2)$$



At $x = \pm A$, KE = 0 (Minimum)

At $x = 0$, KE $= \frac{1}{2}KA^2$ (Maximum)

14. Option (2) is correct.

Torque on a dipole in a uniform electric field is given by $\tau = pE\sin\theta$

$p = ql = 0.01 \times 0.4 \times 10^{-3} = 4 \times 10^{-6}$ cm

$\tau = 4 \times 10^{-6} \times 10 \times 10^{-5} \times \sin 30^\circ = 2 \times 10^{-10}$ N m

15. Option (4) is correct.

Given process, $PV^3 = a =$ constant

Differentiating on both sides, we get

$V^3 \Delta P + P\,[3V^2 \Delta V] = 0$

$$B = \frac{-\Delta P}{\frac{\Delta V}{V}} = 3P$$

16. Option (4) is correct.

Escape velocity, $V_e = \sqrt{\frac{2GM}{R}}$

For the planet, $M' = 9M$ and $R' = 4R$

$$V_e' = \sqrt{\frac{2G(9M)}{4R}} = \frac{3}{2}V_e = \frac{3}{2}\times 11.2$$
$$= 16.8 \text{ km s}^{-1}$$

17. Option (1) is correct.

$$K = \frac{1}{2}mv^2 \Rightarrow \frac{\Delta K}{K} = \frac{\Delta m}{m} + \frac{2\Delta v}{v}$$

Given $m = (5 \pm 0.5)$ kg

$v = (20 \pm 0.4)$ m s^{-1}

$$K = \frac{1}{2}mv^2 = \frac{1}{2}\times 5 \times 400 = 1000 \text{ J}$$

$$\frac{\Delta K}{1000} = \frac{0.5}{5} + 2\left(\frac{0.4}{20}\right) = (0.1 + 0.04)$$

$$\Delta K = 1000\,(0.14) = 140 \text{ J} \Rightarrow K = (1000 \pm 140) \text{ J}$$

18. Option (4) is correct.

From Einstein's photoelectric equation

$$\frac{hc}{\lambda} = \phi + KE_{max}$$

$$\phi = \text{work function} = \frac{hc}{\lambda_0}\text{J} = \frac{hc}{\lambda_0 e}(\text{eV})$$

$$9 = \frac{1242}{\lambda_{01}(\text{n m})}$$

$$\Rightarrow \lambda_{01} = \frac{1242}{9} \Rightarrow 4.5 = \frac{1242}{\lambda_{02}(\text{n m})} \Rightarrow \lambda_{02} = \frac{1242}{4.5}$$

$$\lambda_{02} - \lambda_{01} = 1242\left(\frac{1}{4.5} - \frac{1}{9}\right)\text{ n m} = 1242 \times \frac{1}{9} = 138 \text{ n m}$$

19. Option (3) is correct.

From Maxwell's equation for EM waves,

$$\oint \vec{B}.\overline{dl} = \mu_0 i + \mu_0 \epsilon_0 \frac{d\phi_E}{dt} \Rightarrow \frac{d\phi_E}{dt} = A\frac{dE}{dt}$$

If E is a linear function in time, $\frac{dE}{dt}$ = constant

As accelerated or decelerated charged particle creates an oscillating electric and magnetic field (EM wave).

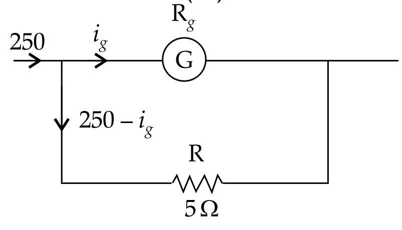
20. Option (1) is correct.

$$\text{Apparent depth} = \frac{\text{Actual depth}}{n}$$

$$= \frac{d}{2}\left(\frac{1}{n_1} + \frac{1}{n_2}\right) = \frac{d(n_1 + n_2)}{2n_1 n_2}$$

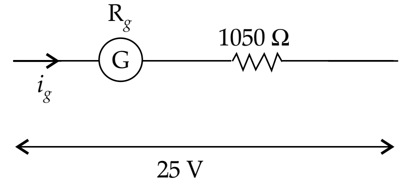
Section B

21. The correct answer is (50).



Let R_g be the resistance of the galvanometer from the figure above

$$R_g i_g = 5(250 - i_g) \Rightarrow i_g = \frac{1250}{5 + R_g}\text{ m A}$$



$$25 = i_g(R_g + 1050)$$

$$25 = \left(\frac{1250}{5 + R_g}\right)(R_g + 1050) \times 10^{-3}$$

$$125 + 25R_g = [1250R_g + 1250 \times 1050] \times 10^{-3}$$
$$= 1.25R_g + 1250 \times 1.05$$
$$= 1.25R_g + 1312.50$$
$$23.75R_g = 1187.50$$

$$R_g = \frac{1187.50}{23.75} = 50\ \Omega$$

22. The correct answer is (2).

According to Bohr's theory,

$$r_n \propto \frac{n^2}{Z} \Rightarrow \frac{r_2}{r_1} = \frac{n_2^2}{n_1^2}\times\frac{Z_1}{Z_2} = \frac{(4)^2}{(2)^2}\times\frac{2}{4}$$

Since $Z_1 = Z_{He} = 2 \Rightarrow Z_2 = Z_{Be} = 4 \Rightarrow \frac{r_2}{r_1} = 2$

23. The correct answer is (4).

Angular momentum,

$$|\vec{L}| = I\omega = \frac{2}{5}MR^2\left(\frac{v}{R}\right) = \frac{2}{5}MvR$$

$$\text{Total energy} = \frac{1}{2}Mv^2\left(1 + \frac{k^2}{R^2}\right)$$

$$\frac{k^2}{R^2} = \frac{2}{5} \text{ (for the solid sphere)}$$

$$E = \frac{1}{2}Mv^2\left(1 + \frac{2}{5}\right) = \frac{7}{10}Mv^2$$

$$\frac{|\vec{L}|}{E} = \frac{\frac{2}{5}MvR}{\frac{7}{10}Mv^2} = \frac{4}{7}\left(\frac{R}{v}\right) = \frac{\pi}{22}$$

$$w = \frac{v}{R} = \frac{4}{7}\times\frac{22}{\pi} = 4$$

24. The correct answer is (3).

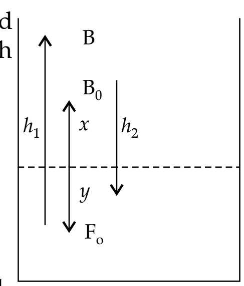
Let x = actual height of the bird

y = actual depth of the fish

h_1 = height of bird wrt fish

h_2 = depth of fish wrt bird

$h_1 = y + \mu x$



$$\frac{dh_1}{dt} = \frac{dy}{dt} + u\frac{dx}{dt}$$

$$v_{BF} = v_F + uv_B$$

$$12 = 8 + \frac{4}{3}v_B \Rightarrow v_B = 3 \text{ m s}^{-1}$$

25. The correct answer is (40).

Elastic potential energy = $\frac{1}{2} \times Y\,(\text{Strain})^2 Al$

$$\text{Strain} = \frac{\Delta l}{l} = \frac{0.02}{20} = 10^{-3}$$

$$80 = \frac{1}{2} \times 2 \times 10^{11} \times 10^{-6} \times A \times 20$$

$A = 4 \times 10^{-5}\,\text{m}^2 = 4 \times 10^{-5} \times 10^{6}\,\text{mm}^2 = 40\,\text{mm}^2$

26. The correct answer is (3).

Power gain $A_P = \beta^2 \frac{R_C}{R_B}$

β = Current gain = $\frac{I_C}{I_B} = \frac{50\text{ m}A}{500\ \mu A} = \frac{50000}{500} = 100$

$A_P = 10^4 \times \frac{1}{10} = 10^3 = 10^x$

On comparing, $x = 3$

27. The correct answer is (25).

$U = \frac{1}{2}Li^2$

$i = i_0(1 - e^{-t/\tau})$ for an R – L circuit

where, $i_0 = \frac{E}{R}$ = steady state current

$J = \frac{L}{R}$ = time constant

$\therefore \quad U = \frac{1}{2}Li_0^2(1 - e^{-t/\tau})^2$

$= U_0(1 - e^{-t/\tau})^2$

where, $U_0 = \frac{1}{2}Li_0^2$ = steady state energy

Rate, $\quad r = \frac{dU}{dt} = \frac{2U_0}{\tau}(1 - e^{-t/\tau})$

$$r = \frac{2U_0}{\tau}(e^{-t/\tau} - e^{-2t/\tau}) \qquad \text{...(i)}$$

For maximum rate (r_{max}),

$\frac{dr}{dt} = 0$

$\frac{dr}{dt} = \frac{2U_0}{\tau}\left[-\frac{1}{\tau}e^{-t/\tau} + \frac{2}{\tau}e^{-2t/\tau} = 0\right]$

$\frac{e^{-t/\tau}}{\tau}[-1 + 2e^{-t/\tau}] = 0$

$\rightarrow e^{-t/\tau}$ which is possible only at $t \rightarrow \infty$

Hence $-1 + 2e^{-t/\tau} = 0$

$\rightarrow \quad e^{-t/\tau} = \frac{1}{2}$ from (i), $r_{max} = \frac{2U_0}{\tau}\left(\frac{1}{2} - \frac{1}{4}\right) = \frac{U_0}{2\tau}$

$$r_{max} = \frac{\frac{1}{2}Li_0^2}{2\tau} = \frac{1}{4}Ri_0^2 = \frac{1}{4} \times 25 \times \left(\frac{E}{25}\right)^2$$

$$= \frac{E^2}{100} = \frac{E^a}{2b}$$

Comparing we get

$a = 2 \Rightarrow b = 50$

$\frac{b}{a} = \frac{50}{2} = 25$

28. The correct answer is (16).

$P_1 = \frac{V_0^2}{R}$

When the wire is cut into two equal halves, each has a resistance = $\frac{R}{2} \Rightarrow P_2 = \frac{V_0^2}{\frac{R}{2}} + \frac{V_0^2}{\frac{R}{2}} = \frac{4V_0^2}{R} = 4P_1$

$$\frac{P_2}{P_1} = \frac{4}{1} = \frac{\sqrt{x}}{1}$$

On comparing, $x = 16$

29. The correct answer is (4).

$y = A\cos 30°$ at any instant

Given $A = 40$ cm = 0.4 m

KE = $200 = \frac{1}{2}m\left[\omega\sqrt{A^2 - y^2}\right]^2 = \frac{1}{2}K(A^2 - y^2)$

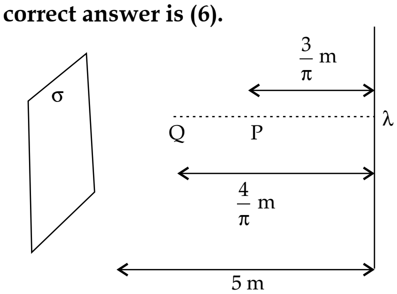
$y = 0.4 \times \frac{\sqrt{3}}{2} = 0.2\sqrt{3}$ where, $k = m\omega^2$

$k = \frac{400}{A^2 - y^2} = \frac{400}{0.16 - 0.12} = \frac{400}{0.04}$

$= 10^4$ N m $= 1 \times 10^x$

On comparing, $x = 4$

30. The correct answer is (6).



$E_P = \frac{\sigma}{2\varepsilon_0} - \frac{\lambda}{2\pi\varepsilon_0\left(\frac{3}{\pi}\right)} = \frac{\sigma}{2\varepsilon_0} - \frac{\lambda}{6\varepsilon_0}$

Given $|\lambda| = 2\,|\sigma|$

$E_P = \frac{\sigma}{2\varepsilon_0} - \frac{2\sigma}{6\varepsilon_0} = \frac{\sigma}{6\varepsilon_0}$

$E_Q = \frac{\sigma}{2\varepsilon_0} - \frac{\lambda}{2\pi\varepsilon_0\left(\frac{4}{\pi}\right)} = \frac{\sigma}{2\varepsilon_0} - \frac{\lambda}{8\varepsilon_0}$

Putting $|\lambda| = 2\,|\sigma|$

$E_Q = \frac{\sigma}{2\varepsilon_0} - \frac{2\sigma}{8\varepsilon_0} = \frac{\sigma}{4\varepsilon_0}$

$\frac{E_P}{E_Q} = \frac{\sigma}{6\varepsilon_0} \times \frac{4\varepsilon_0}{\sigma} = \frac{2}{3} = \frac{4}{a}$

On comparing, $a = 6$