MHT-CET PHYSICS PAPER - 2022

11TH AUGUST (SHIFT - 2)

Time : 45 Minutes **No. of Questions : 50** **Marks : 50**

1. The magnetic susceptibility of the material of a rod is 349 and permeability of vacuum μ_0 is $4\pi \times 10^{-7}$ SI units. Absolute permeability of the material of the rod in SI units is

(a) 4400×10^{-7} **(b)** 4200×10^{-7}

(c) 4800×10^{-7} **(d)** 4600×10^{-7}

2. The magnetic flux through a coil of resistance 'R' changes by an amount '$\Delta\phi$' in time 'Δt'. The total quantity of induced electric charge 'Q' is

(a) $-\frac{\Delta\phi}{\Delta t} + R$ **(b)** $\frac{\Delta\phi}{\Delta t} \times R$

(c) $\frac{\Delta\phi}{R}$ **(d)** $\frac{\Delta\phi}{\Delta t}$

3. A body weighs 500 N on the surface of the earth. At what distance below the surface of the earth it weighs 250 N ?

(Radius of earth, R = 6400 km)

(a) 6400 km **(b)** 800 km

(c) 1600 km **(d)** 3200 km

4. Three discs x, y and z having radii 2 m, 3 m and 6 m respectively are coated on outer surfaces. The wavelength corresponding to maximum intensity are 300 nm, 400 nm and 500 nm respectively. If P_x, P_y and P_z are power radiated by them respectively then

(a) P_x is maximum **(b)** P_z is maximum

(c) P_y is maximum **(d)** $P_x = P_y = P_z$

5. A stationary wave is represented by

$$y = 10 \sin\left(\frac{\pi x}{4}\right) \cos(20\pi t)$$

where x and y are in cm and t in second. The distance between two consecutive nodes is

(a) 1 cm **(b)** 8 cm

(c) 4 cm **(d)** 2 cm

6. When the rms velocity of a gas is denoted by 'v', which one of the following relations is true ?

(T = Absolute temperature of the gas.)

(a) $\frac{v^2}{T}$ = constant **(b)** v^2T = constant

(c) vT^2 = constant **(d)** $\frac{v}{T^2}$ = constant

7. A parallel plate air capacitor has a uniform electric field 'E' in the space between the plates. Area of each plate is A and the distance between the plates is 'd'. The energy stored in the capacitor is [ε_0 = permittivity of free space)

(a) $2\varepsilon_0 EAd$ **(b)** $\frac{1}{2}\varepsilon_0 E^2 Ad$

(c) $\frac{\varepsilon_0 E^2}{2Ad}$ **(d)** $\frac{E^2 Ad}{2\varepsilon_0}$

8. Two massless springs of spring constant K_1 and K_2 are connected one after the other forming a single chain, suspended vertically and certain mass is attached to the free end. If 'e_1' and 'e_2' are their respective extensions and 'f' is their stretching force, the total extension produced is

(a) $f\left(\frac{1}{K_1} + \frac{1}{K_2}\right)$ **(b)** $f\left(\frac{1}{K_1} - \frac{1}{K_2}\right)$

(c) $f(K_1 + K_2)$ **(d)** $f(K_1 - K_2)$

9. The time taken by a particle executing simple harmonic motion of period 'T', to move from the mean position to half the maximum displacement is

(a) $\frac{T}{12}$ s **(b)** $\frac{T}{2}$ s

(c) $\frac{T}{4}$ s **(d)** $\frac{T}{6}$ s

10. Using Bohr's model, the orbital period of electron in hydrogen atom in the n^{th} orbit is (ε_0 = permittivity of vacuum, h = Planck's constant, m = mass of electron, e = electronic charge)

(a) $\frac{4\varepsilon_0 nh^3}{me^2}$ **(b)** $\frac{4\varepsilon_0 n^2h^2}{me^2}$

(c) $\frac{4\varepsilon_0^2 n^3h^3}{me^4}$ **(d)** $\frac{4\varepsilon_0^2 n^2h^3}{me^3}$

11. A parallel plate capacitor is charged and then disconnected from the charging battery. If the plates are now moved further apart by pulling them by means of insulating handles, then

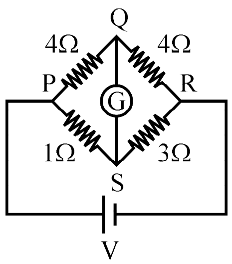
(a) the capacitance of the capacitor increases
(b) the charge on the capacitor decreases
(c) the voltage across the capacitor increases
(d) the energy stored in the capacitor decreases

12. If the kinetic energy of a free electron doubles, it's de Broglie wavelength (λ) changes by a factor

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

(c) $\sqrt{2}$ **(d)** 2

13. In the following network, the current through galvanometer will



(a) be zero
(b) flow from Q to S
(c) flow in a direction which depends on value of V
(d) flow from S to Q

14. In a medium, the phase difference between two particles separated by a distance 'x' is $\left(\frac{\pi}{5}\right)^c$. If the frequency of the oscillation of particles is 25 Hz and the velocity of propagation of the waves is 75 m/s, then the value of x is

(a) 0.4 m **(b)** 0.1 m
(c) 0.2 m **(d)** 0.3 m

15. The work done in blowing a soap bubble of radius R is 'W_1' at room temperature. Now the soap solution is heated. From the heated solution another soap bubble of radius 2R is blown and the work done is 'W_2'. Then

(a) $W_2 = W_1$ **(b)** $W_2 = 4W_1$
(c) $W_2 < 4W_1$ **(d)** $W_2 = 0$

16. A capacitor of capacitance 50μF is connected to a.c. source e = 220 sin 50t (e in volt, t in second). The value of peak current is

(a) $\frac{0.55}{\sqrt{2}}$ A **(b)** $\frac{\sqrt{2}}{0.55}$ A
(c) 0.55 A **(d)** $\sqrt{2}$ A

17. Two waves are superimposed whose ratio of intensities is 9 : 1. The ratio of maximum and minimum intensity is

(a) 9 : 1 **(b)** 4 : 1
(c) 3 : 1 **(d)** 5 : 3

18. The masses and radii of the moon and the earth are M_1, R_1 and M_2, R_2 respectively. Their centres are at a distance d apart. What should be the minimum speed with which a body of mass 'm' should be projected from a point midway between their centres, so as to escape to infinity ?

(a) $\frac{G(M_1 + M_2)}{d}$ **(b)** $2\sqrt{\frac{G(M_1 + M_2)}{d}}$

(c) $\sqrt{\frac{Gd}{M_1 + M_2}}$ **(d)** $\sqrt{\frac{M_1 + M_2}{Gd}}$

19. A monoatomic gas $\left(\gamma = \frac{5}{3}\right)$ initially at 27°C having volume 'V' is suddenly compressed to one-eighth of its original volume $\left(\frac{V}{8}\right)$. After the compression its temperature becomes

(a) 580 K **(b)** 1200 K
(c) 1160 K **(d)** 927 K

20. Two parallel conducting wires of equal length are placed distance 'd' apart, carry currents 'I_1' and 'I_2' respectively in opposite directions. The resultant magnetic field at the midpoint of the distance between both the wires is

(a) $\frac{\mu_0(I_1 - I_2)}{\pi d}$ **(b)** $\frac{\mu_0(I_1 + I_2)}{2\pi d}$

(c) $\frac{\mu_0(I_1 - I_2)}{2\pi d}$ **(d)** $\frac{\mu_0(I_1 + I_2)}{\pi d}$

21. Self inductance of a solenoid cannot be increased by

(a) decreasing its length

(b) increasing its area of cross-section

(c) increasing the current through it

(d) increasing the number of turns in it

22. For a NAND gate, the inputs and outputs are given below.

Input A	Input B	Output Y
0	1	C
0	0	D
1	0	E
1	1	F

The values taken by C, D, E, F are respectively

(a) 0, 1, 0, 0 **(b)** 1, 1, 1, 0

(c) 1, 0, 1, 1 **(d)** 0, 1, 0, 1

23. An electron and a proton having the same momenta enter perpendicularly into a magnetic field. What are their trajectories in the field ?

(a) Path of the electron is more curved than that of proton

(b) They will travel undeflected

(c) Path of the proton is more curved than that of the electron

(d) Both the electron and the proton will move along the same curved path but they will move in opposite directions

24. The resistance offered by an inductor (X_L) in an a.c. circuit is

(a) inversely proportional to inductance and frequency of the alternating current

(b) inversely proportional to frequency of alternating current and directly proportional to inductance

(c) inversely proportional to inductance and directly proportional to the frequency of alternating current

(d) directly proportional to inductance and frequency of alternating current

25. The force between the plates of a parallel plate capacitor of capacitance 'C' and distance of separation of the plates 'd' with a potential difference 'V' between the plates is

(a) $\frac{V^2 d}{C}$ **(b)** $\frac{C^2 V^2}{d^2}$

(c) $\frac{CV^2}{2d}$ **(d)** $\frac{C^2 V^2}{2d^2}$

26. Consider the following statements about stationary waves.

A. The distance between two adjacent nodes or antinodes is equal to $\frac{\lambda}{2}$ (λ = wavelength of the wave)

B. A node is always formed at the open end of the open organ pipe.

Choose the correct option from the following.

(a) Both statements A and B are wrong.

(b) Only the statement B is true.

(c) Only the statement A is true.

(d) Both statements A and B are true.

27. If the radius of the spherical gaussian surface is increased then the electric flux due to a point charge enclosed by the surface

(a) increases **(b)** remains unchanged

(c) decreases **(d)** zero

28. The wave number of the last line of the Balmer series in hydrogen spectrum will be

(Rydberg's constant = 10^7 m^{-1})

(a) 250 m^{-1} **(b)** 2.5×10^6 m^{-1}

(c) 0.25×10^9 m^{-1} **(d)** 2.5×10^5 m^{-1}

29. A bucket containing water is revolved in a vertical circle of radius r. To prevent the water from falling down, the minimum frequency of revolution required is

(g = acceleration due to gravity)

(a) $2\pi\sqrt{\frac{r}{g}}$ **(b)** $\frac{1}{2\pi}\sqrt{\frac{r}{g}}$

(c) $\frac{1}{2\pi}\sqrt{\frac{g}{r}}$ **(d)** $2\pi\sqrt{\frac{g}{r}}$

30. Two monatomic ideal gases A and B of molecular masses 'm_1' and 'm_2' respectively are enclosed in separate containers kept at the same temperature. The ratio of the speed of sound in gas A to that in gas B is given by

(a) $\sqrt{\frac{m_2}{m_1}}$ **(b)** $\frac{m_1}{m_2}$

(c) $\sqrt{\frac{m_1}{m_2}}$ **(d)** $\frac{m_2}{m_1}$

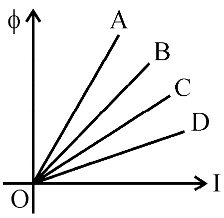
31. A particle starts oscillating simple harmonically from its mean position with time period 'T'. At time $t = \frac{T}{12}$, the ratio of the potential energy to kinetic energy of the particle is (sin 30° = cos 60° = 0.5, cos 30° = sin 60° = $\sqrt{3}/2$)

(a) 1 : 2 **(b)** 3 : 1
(c) 2 : 1 **(d)** 1 : 3

32. A hollow pipe of length 0.8 m is closed at one end. At its open end, a 0.5 m long uniform string is vibrating in its second harmonic and it resonates with the fundamental frequency of pipe. If the tension in the string is 50 N and speed of sound in air is 320 m/s, the mass of the string is

(a) 20 g **(b)** 10 g
(c) 40 g **(d)** 5 g

33. A graph of magnetic flux (ϕ) versus current (I) is drawn for four inductors A, B, C, D. Larger value of self inductance is for inductor.



(a) D **(b)** B
(c) C **(d)** A

34. A parallel beam of monochromatic light falls normally on a single narrow slit. The angular width of the central maximum in the resulting diffraction pattern

(a) decreases with increase of slitwidth
(b) may increase or decrease
(c) decreases with decrease of slitwidth
(d) increases with increase in slitwidth

35. A body moving in a circular path with a constant speed has constant

(a) momentum **(b)** velocity
(c) acceleration **(d)** kinetic energy

36. A steel coin of thickness 'd' and density 'ρ' is floating on water of surface tension 'T'. The radius of the coin (R) is [g = acceleration due to gravity]

(a) $\frac{T}{\rho g d}$ **(b)** $\frac{4T}{3\rho g d}$
(c) $\frac{3T}{4\rho g d}$ **(d)** $\frac{2T}{\rho g d}$

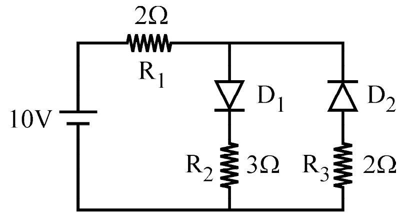
37. A door 1.2 m wide requires a force of 1 N to be applied perpendicular at the free end to open or close it. The perpendicular force required at a point 0.2 m distant from the hinges for opening or closing the door is

(a) 3.6 N **(b)** 2.4 N
(c) 1.2 N **(d)** 6.0 N

38. The thermodynamic process in which no work is done on or by the gas is

(a) isochoric process **(b)** adiabatic process
(c) isothermal process **(d)** isobaric process

39. The given circuit has two ideal diodes D_1 and D_2 connected as shown in the figure. The current flowing through the resistance R_1 will be



(a) 7 A **(b)** 3.3 A
(c) 2 A **(d)** 2.5 A

40. In a Fraunhofer diffraction at a single slit of width 'd' and incident light of wavelength 5500 Å, the first minimum is observed at an angle 30°. The first secondary maxima is observed at an angle θ, equal to

(a) $\sin^{-1}\left(\frac{1}{4}\right)$ **(b)** $\sin^{-1}\left(\frac{3}{4}\right)$
(c) $\sin^{-1}\left(\frac{\sqrt{3}}{2}\right)$ **(d)** $\sin^{-1}\left(\frac{1}{\sqrt{2}}\right)$

41. A galvanometer of resistance 200 Ω is to be converted into an ammeter. The value of shunt resistance which allows 3% of the mains current through the galvanometer is equal to (nearly)

(a) 6 Ω **(b)** 7 Ω
(c) 10 Ω **(d)** 5 Ω

42. The speed of light in two media M_1 and M_2 are 1.5×10^8 m/s and 2×10^8 m/s respectively. If the light undergoes total internal reflection, the critical angle between the two media is

(a) $\sin^{-1}\left(\frac{3}{2}\right)$ **(b)** $\sin^{-1}\left(\frac{2}{3}\right)$
(c) $\sin^{-1}\left(\frac{4}{3}\right)$ **(d)** $\sin^{-1}\left(\frac{3}{4}\right)$

43. The minimum distance between an object and its real image formed by a convex lens of focal length 'f' is

(a) 2f **(b)** 4f

(c) 1.5f **(d)** 2.5f

44. Heat given to a body, which raises its temperature by 1ºC is known as

(a) specific heat **(b)** thermal capacity

(c) water equivalent **(d)** temperature gradient

45. A shell is fired at an angle of 30º to the horizontal with velocity 196 m/s. The time of flight is

[$\sin 30^\circ = \frac{1}{2} = \cos 60^\circ$]

(a) 6.5 s **(b)** 20 s

(c) 16.5 s **(d)** 10 s

46. Three equal charges 'q_1', 'q_2' and 'q_3' are placed on the three corners of a square of side 'a'. If the force between q_1 and q_2 is 'F_{12}' and that between q_1 and q_3 is 'F_{13}', then the ratio of magnitudes $\left(\frac{F_{12}}{F_{13}}\right)$ is

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

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

47. A coil having an inductance of $\frac{1}{\pi}$ H is connected in series with a resistance of 300 Ω. If A.C. source (20 V – 200 Hz) is connected across the combination, the phase angle between voltage and current is

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

(c) $\tan^{-1}\left(\frac{5}{4}\right)$ **(d)** $\tan^{-1}\left(\frac{4}{5}\right)$

48. In a full wave rectifier circuit without filter, the output current is

(a) an eddy current

(b) a constant direct current

(c) a sinusoidal current

(d) unidirectional but not steady current

49. The excess pressure inside a soap bubble of radius 2 cm is 50 dyne/cm^2. The surface tension is

(a) 50 dyne/cm **(b)** 60 dyne/cm

(c) 75 dyne/cm **(d)** 25 dyne/cm

50. Two bodies of masses 'm' and '3m' are rotating in horizontal circles of radius 'r' and $\frac{'r'}{3}$ respectively. The tangential speed of the body of mass 'm' is n times that of the value of heavier body; while the centripetal force is same for both. The value of n is

(a) 3 **(b)** 1

(c) 9 **(d)** 6

ANSWERS

1. a	**2.** c	**3.** d	**4.** b	**5.** c
6. a	**7.** b	**8.** a	**9.** a	**10.** c
11. c	**12.** a	**13.** d	**14.** d	**15.** c
16. c	**17.** b	**18.** b	**19.** b	**20.** d
21. c	**22.** b	**23.** d	**24.** d	**25.** c
26. c	**27.** b	**28.** b	**29.** c	**30.** a
31. d	**32.** a	**33.** d	**34.** a	**35.** d
36. d	**37.** d	**38.** a	**39.** c	**40.** b
41. a	**42.** d	**43.** b	**44.** b	**45.** b
46. d	**47.** b	**48.** d	**49.** d	**50.** a

HINTS / SOLUTIONS

1. ***(a)*** The relative permeability $\mu_R = 1 + \chi$

$\therefore$ Absolute permeability $\mu = \mu_R\mu_0 = \mu_0(1 + \chi)$

$= 4\pi \times 10^{-7}[1 + 349]$

$= 350 \times 4 \times 3.142 \times 10^{-7}$

$\doteqdot 4400 \times 10^{-7}$ SI units

[Similar to Q.28, Pg. 1091 - Marvel MHT-CET - Physics]

2. ***(c)*** By Faraday's law, $e = \frac{\Delta\phi}{\Delta t}$

$\therefore\ i = \frac{e}{R} = \frac{\Delta\phi}{R\Delta t}$

$\therefore\ (i\Delta t) = \frac{\Delta\phi}{R}$ ... (1)

But $i = \frac{\Delta Q}{\Delta t}$ $\therefore\ \Delta Q = i\Delta t$

$\therefore$ From (1), $\Delta Q = \frac{\Delta\phi}{R}$

$\therefore Q = \frac{\Delta\phi}{R}$

[Similar to Q.45, Pg. 861 - Marvel MHT-CET - Physics]

3. ***(d)*** The value of g at a depth h below the surface of the earth of radius R is

$$g' = g\left[1 - \frac{d}{R}\right]$$

$$\therefore \frac{g'}{g} = 1 - \frac{d}{R} \quad \text{... (1)}$$

It is given that mg = 500 N and mg' = 250 N

$$\therefore \frac{g'}{g} = \frac{250}{500} = \frac{1}{2} \quad \text{... (2)}$$

$\therefore$ From (1) and (2), $\frac{1}{2} = 1 - \frac{d}{R}$

$$\therefore \frac{d}{R} = \frac{1}{2}$$

$$\therefore d = \frac{R}{2} = \frac{6400}{2} = 3200 \text{ km}$$

[Similar to Q.158, Pg. 155 - Marvel MHT-CET - Physics]

4. ***(b)*** According to Wien's law, $\lambda_m T$ = constant (b)

$$\therefore T = \frac{b}{\lambda_m} \quad \text{... (1)}$$

and from Stefan's law, $Q = \sigma A T^4$ ... (2)

For the disc, area $(A) = \pi r^2$

$\therefore$ From (1) and (2),

$$Q = \sigma \cdot \pi r^2 \cdot \frac{b^4}{\lambda_m^4} = \frac{Kr^2}{(\lambda m)^4}$$

where $K = \pi\sigma b^4$ is a constant

Q is the quantity of heat radiated per second or power.

Hence P_x, P_y and P_z are the powers of x, y, z.

For x we have r_1 = 2m and λ_1 = 300 nm

For y, we have r_2 = 3m and λ_2 = 400 nm

and For z, we have r_3 = 6 m and λ_3 = 500 nm

$$\therefore P_x \propto \frac{r_1^2}{\lambda_1^4} \text{ or } \frac{2^2}{(3 \times 10^{-7})^4} \text{ or } \frac{4 \times 10^{+28}}{81}$$

$$P_y \propto \frac{r_2^2}{\lambda_2^4} \text{ or } \frac{9 \times 10^{+28}}{256}$$

$$P_z \propto \frac{r_3^2}{\lambda_3^4} \text{ or } \frac{36 \times 10^{28}}{625}$$

But $\frac{4}{81} = 0.049$, $\frac{9}{250} = 0.035$ and $\frac{36}{625} = 0.0576$

$\therefore$ **P_z is maximum.**

5. ***(c)*** $y = 10 \sin\left(\frac{\pi x}{4}\right) \cos(20\pi t)$

Comparing with $y = 2A \cos\left(\frac{2\pi x}{\lambda}\right) \sin\left(\frac{2\pi t}{T}\right)$, we get

$$\frac{2\pi x}{\lambda} = \frac{\pi x}{T} \quad \therefore \frac{2}{\lambda} = \frac{1}{4}$$

$\therefore \lambda$ = 8 cm

$\therefore$ The distance between two consecutive nodes

$$= \frac{\lambda}{2} = \frac{8}{2} = 4 \text{ cm}$$

[Similar to Q.4, Pg. 607 - Marvel MHT-CET - Physics]

6. ***(a)*** The r.m.s. speed (v) of a gas is $v = \sqrt{\frac{3RT}{M}}$

i.e. $v \propto \sqrt{T}$

$\therefore v^2 \propto T \quad \therefore v^2 = KT$ or $\frac{v^2}{T}$ = constant

[Similar to Theory given on Pg. 437 - Marvel MHT-CET - Physics]

7. ***(b)*** The intensity of the electric field (E) between two plane parallel sheets of equal and opposite charges is given by $E = \frac{\sigma}{\varepsilon_0}$

$\therefore \sigma = E\varepsilon_0$ where σ = surface density of charge = $\frac{Q}{A}$

$\therefore$ Charge on either plate of the capacitor is

$Q = \sigma A = \varepsilon_0 EA$ and $C = \frac{\varepsilon_0 A}{d}$

$\therefore$ The energy stored in the capacitor is

$$U = \frac{1}{2}\frac{Q^2}{C} = \frac{(\varepsilon_0 EA)^2}{2 \cdot \frac{\varepsilon_0 A}{d}} = \frac{\varepsilon_0^2 A^2 E^2 \times d}{2\varepsilon_0 A}$$

$$\therefore \mathbf{U = \frac{1}{2}\varepsilon_0 E^2 Ad}$$

[Similar to Q.173, Pg. 722 - Marvel MHT-CET - Physics]

8. ***(a)*** For a spring F = Kx

$$\therefore x = \frac{F}{K}$$

$$\therefore x_1 = \frac{F}{K_1} \text{ and } x_2 = \frac{F}{K_2}$$

$$\text{or } e_1 = \frac{F}{K_1} \text{ and } e_2 = \frac{F}{K_2}$$

$$\therefore e_1 + e_2 = F\left(\frac{1}{K_1} + \frac{1}{K_2}\right)$$

Note : The springs are connected in series.

$\therefore$ The effective spring constant $K = \dfrac{K_1K_2}{K_1 + K_2}$

$\therefore$ Total extension

$$e = \frac{F}{K} = \frac{F(K_1 + K_2)}{K_1K_2} = \frac{F}{K_2} + \frac{F}{K_1}$$

9. *(a)* $x = A \sin \omega t = A \sin\left(\frac{2\pi t}{T}\right)$ where $x = A/2$

$$\therefore \frac{A}{2} = A \sin\left(\frac{2\pi t}{T}\right)$$

$$\therefore \frac{1}{2} = \sin\frac{\pi}{6} = \sin\left(\frac{2\pi t}{T}\right)$$

$$\therefore \frac{2\pi t}{T} = \frac{\pi}{6}$$

$$\therefore t = \frac{T}{12} s$$

[Similar to Q.34, Pg. 511 - Marvel MHT-CET - Physics]

10. *(c)* The period of an electron in the n^{th} orbit of a hydrogen atom is given by

$$T_n = \frac{2\pi r_n}{v_n}$$

and $r_n = \dfrac{\varepsilon_0 n^2 h^2}{\pi m e^2}$

and linear speed $v_n = \dfrac{e^2}{2\varepsilon_0 nh}$

$$\therefore T_n = \frac{2\pi \cdot \varepsilon_0 n^2 h^2}{\pi m e^2} \times \frac{2\varepsilon_0 nh}{e^2} = \frac{4\varepsilon_0^2 n^3 h^3}{me^4}$$

11. *(c)* For a parallel plate capacitor, $C = \dfrac{\varepsilon_0 A}{d}$

When the charging battery is disconnected and d is increased then

(a) Q remains constant

(b) $C \propto \dfrac{1}{d}$ hence if d is increased, C is decreased.

(c) $C = \dfrac{Q}{V}$ or $V = \dfrac{Q}{C}$ if C is decreased, V will increase

(d) $E = \dfrac{1}{2}\dfrac{Q^2}{C}$ if C is decreased, then E will increase

Thus (a), (b) and (d) are wrong. Only (c) is correct.

[Similar to Q.161, Pg. 721 - Marvel MHT-CET - Physics]

12. *(a)* $\lambda = \dfrac{h}{\sqrt{2mE}}$ where E is the K.E.

$$\therefore \lambda \propto \frac{1}{\sqrt{E}} \quad \therefore \frac{\lambda_2}{\lambda_1} = \sqrt{\frac{E_1}{E_2}} = \sqrt{\frac{1}{2}} = \frac{1}{\sqrt{2}}$$

$$\therefore \lambda_2 = \frac{\lambda_1}{\sqrt{2}}$$

Thus λ charges by a factor $\dfrac{1}{\sqrt{2}}$

[Similar to Q.127, Pg. 925 - Marvel MHT-CET - Physics]

13. *(d)* This is an unbalanced network.

Current through the branch PQR is $I_1 = \dfrac{V}{8}$

and current through the branch PSR = $I_2 = \dfrac{V}{4}$

$$\therefore V_P - V_Q = I_1 \times 4 = \frac{V}{8} \times 4 = \frac{V}{2}$$

and $V_P - V_S = I_2 \times 1 = \dfrac{V}{4} \times 1 = \dfrac{V}{4}$

$$\therefore (V_P - V_Q) - (V_P - V_S) = \frac{V}{2} - \frac{V}{4} = \frac{V}{4}$$

$$\therefore V_S - V_Q = \frac{V}{4}$$

$\therefore V_S > V_Q$

$\therefore$ The current will flow from **S to Q**.

[Similar to Q.78, Pg. 773 - Marvel MHT-CET - Physics]

14. *(d)* $\lambda = \dfrac{v}{n} = \dfrac{75}{25} = 3\,m$

and phase difference = $\dfrac{2\pi}{\lambda}$ (path difference)

$$\therefore \frac{\pi}{5} = \frac{2\pi}{3}x$$

$\therefore 10x = 3$

$$\therefore x = \frac{3}{10} = 0.3 \text{ m}$$

[Similar to Q.11, Pg. 1089 - Marvel MHT-CET - Physics]

15. ***[Same as MHT-CET Paper - 2021 (22nd September - Shift 1) Q. No. 31]***

[Similar to Q.117, Pg. 420 - Marvel MHT-CET - Physics]

16. *(c)* Given e = 220 sin (50t)

Comparing with $e = e_0 \sin \omega t$, we get

e_0 = 220 V, peak voltage

$C = 50\ \mu F = 50 \times 10^{-6}$ F

$$\therefore X_C = \frac{1}{\omega C} = \frac{1}{50 \times 50} \times 10^6 = 400\,\Omega$$

$\therefore I_0 = \frac{e_0}{X_C} = \frac{220}{400} = 0.55$ A

Peak current = 0.55 A

[Similar to Q.7, Pg. 1058 - Marvel MHT-CET - Physics]

17. ***(b)*** **Given :** $\frac{I_1}{I_2} = \frac{9}{1} = \frac{a_1^2}{a_2^2}$ $\therefore \frac{a_1}{a_2} = \frac{3}{1}$

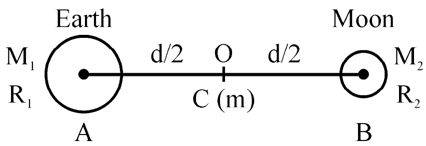
$\therefore a_1 = 3a_2$

$$\therefore \frac{I_{max}}{I_{min}} = \frac{(a_1 + a_2)^2}{(a_1 - a_2)^2} = \frac{(3a_2 + a_2)^2}{(3a_2 - a_2)^2}$$

$$= \frac{4^2}{2^2} = \frac{16}{4} = 4 : 1$$

[Similar to Q.7, Pg. 670 - Marvel MHT-CET - Physics]

18. ***(b)***



O is the midpoint of the line joining the centres of A and B. and a body (C) of mass 'm' is kept at O

The P.E. of C is

$$U = -\frac{GM_1m}{d/2} - \frac{GM_2m}{d/2} = -\frac{2Gm}{d}(M_1 + M_2)$$

Initially, C is at rest, its K.E. = 0

$\therefore$ Total energy of C = $-\frac{2Gm}{d}(M_1 + M_2)$

$\therefore$ Its binding energy = $\frac{2GM}{d}(M_1 + M_2)$ ... (1)

Let v_e be the velocity that should be given to the body to escape to infinity.

For this its K.E. = Binding energy

$$\therefore \frac{1}{2}mv_e^2 = \frac{2Gm}{d}(M_1 + M_2)$$

$$\therefore v_e^2 = \frac{4G(M_1 + M_2)}{d}$$

$$\therefore v_e = 2\sqrt{\frac{G(M_1 + M_2)}{d}}$$

19. ***(b)*** For adiabatic charge, PV^γ = constant as well as $TV^{\gamma-1}$ = constant and for a monoatomic gas $\gamma = \frac{5}{3}$

$$\therefore T_1V_1^{\gamma-1} = T_2V_2^{\gamma-1}$$

$$\therefore \frac{T_2}{T_1} = \left(\frac{V_1}{V_2}\right)^{\gamma-1} = \left(\frac{V}{V/8}\right)^{5/3-1}$$

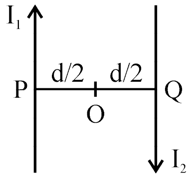
$$\therefore \frac{T_2}{T_1} = (8)^{2/3} = (2^3)^{2/3} = 4$$

$\therefore T_2 = 4T_1$ but $T_1 = 273 + 27 = 300$ K

$\therefore T_2 = 4 \times 300 = 1200$ K

[Similar to Q.26, Pg. 484 - Marvel MHT-CET - Physics]

20. ***(d)***



The magnetic field at O, due to current in P is

$$B_1 = \frac{\mu_0}{4\pi}\left(\frac{2I_1}{d/2}\right) = \frac{\mu_0}{4\pi} \times \frac{4I_1}{d} = \frac{\mu_0 I_1}{\pi d}$$

and the magnetic field at O due to current I_2 in the wire Q is

$$B_2 = \frac{\mu_0}{4\pi}\left(\frac{2I_2}{d/2}\right) = \frac{\mu_0}{4\pi} \times \frac{4I_2}{d} = \frac{\mu_0 I_2}{\pi d}$$

The currents in the wires are in opposite directions.

Hence the magnetic fields will be added.

$\therefore$ Resultant field $B = B_1 + B_2 = \frac{\mu_0}{\pi d}(I_1 + I_2)$

[Similar to Q.44, Pg. 813 - Marvel MHT-CET - Physics]

21. ***(c)*** The self inductance of a solenoid is given by

$$L = \frac{\mu_0\mu_r \cdot N^2A}{l}$$

L depends upon N, A and *l*. It does not depend upon the current flowing through it. Change in current does not affect L.

22. ***(b)*** For the NAND gate, the truth table is

Input A	**Input B**	**Output Y =** $\overline{AB}$	
0	1	1	(C)
0	0	1	(D)
1	0	1	(E)
1	1	0	(F)

Thus C = 1, D = 1, E = 1 and F = 0

For a NAND gate, there is a high output for a low input and a low output for high input.

[Similar to Theory given on Pg. 1009 - Marvel MHT-CET - Physics]

23. ***(d)*** The force produced by the magnetic field on a moving charged particle is F = qvB and this gives a C.P. force $\frac{mv^2}{r}$

$\therefore \frac{mv^2}{r} = qvB$

$\therefore r = \frac{mv}{qB} = \frac{p}{qB}$ where p = momentum

It is given that both the particles (electron and proton) have the same momenta.

Similarly they have the same charge in magnitude (e and –e) and they move in the same field (B).

$\therefore \frac{r_1}{r_2} = \frac{p_1}{q_1 B} \times \frac{q_2 B}{p_2} = 1$

$\because p_1 = p_2$ and $q_1 = q_2$

$\therefore r_1 = r_2$

$\therefore$ They will describe the same curved path.

[One will move clockwise and the other anticlockwise.]

24. ***(d)*** The resistance offered by an inductor (X_L) in an a.c. circuit is $X_L = \omega L = 2\pi f L$

$\therefore X_L \propto fL$ i.e. it is directly proportional to the inductance (L) and frequency (f).

[Similar to Theory given on Pg. 881 - Marvel MHT-CET - Physics]

25. ***(c)*** The force of attraction between the plates of a parallel plate capacitor is

$$F = \frac{\sigma^2 A}{2\varepsilon_0} = \frac{Q^2}{A^2} \times \frac{A}{2\varepsilon_0} \left(\because \sigma = \frac{Q}{A}\right)$$

$$= \frac{Q^2}{2\varepsilon_0 A} = \frac{C^2V^2}{2\varepsilon_0 A} \quad (\because Q = CV)$$

$$\therefore F = C\left[\frac{CV^2}{2\varepsilon_0 A}\right] = \frac{\varepsilon_0 A}{d} \times \frac{CV^2}{2\varepsilon_0 A}$$

$$\therefore F = \frac{1}{2}\frac{CV^2}{d}$$

[Similar to Theory given on Pg. 706 - Marvel MHT-CET - Physics]

26. ***(c)*** (A) - In a stationary wave, the distance between two adjacent nodes or antinodes = $\frac{\lambda}{2}$. This is a correct statement.

But (B) - A node is always formed at the open end of the open organ pipe.

This is a wrong statement.

$\therefore$ Only (A) is true.

27. ***(b)*** If the radius of the spherical Gaussian surface is increased, then the electric flux due to a point charge enclosed by the surface **remains constant**.

Flux depends only on the enclosed charge. It does not depend upon the size or shape of the Gaussian surface.

28. ***(b)*** Wave number = $\frac{1}{\lambda}$ = Receiprocal of wavelength

For the last line of the Balmer series, n = ∞

and the transition is from n = ∞ to n = 2

$\therefore$ Wave number $\bar{\nu} = \frac{1}{\lambda} = R\left[\frac{1}{2^2} - \frac{1}{\infty}\right] = \frac{R}{4}$

and $R = 10^7$/m

$\therefore \bar{\nu} = \frac{R}{4} = \frac{10^7}{4} = \frac{10 \times 10^6}{4} = 2.5 \times 10^6$ m/s

29. ***(c)*** At the highest point of the vertical circle, the water is not fallind down.

For this the C.F. force $\left(\frac{mv^2}{r}\right)$ = weight (mg)

$\therefore \frac{mv^2}{r} = mg \quad \therefore v^2 = rg \quad \therefore v = \sqrt{rg}$

$\therefore$ But $v = r\omega = 2\pi nr$

$\therefore 2\pi nr = \sqrt{rg}$

$\therefore n = \frac{\sqrt{rg}}{2\pi r}$

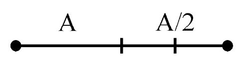
$\therefore n = \frac{1}{2\pi}\sqrt{\frac{rg}{r^2}} = \frac{1}{2\pi}\sqrt{\frac{g}{r}}$

[Similar to Q.183, Pg. 308 - Marvel MHT-CET - Physics]

30. ***(a)*** $v = \sqrt{\frac{3RT}{M}}$ or $v \propto \sqrt{\frac{1}{M}}$ at constant T

$\therefore \frac{v_1}{v_2} = \sqrt{\frac{m_2}{m_1}}$

31. ***(d)***



, t = t/2

The particle starts from the mean position.

$$x = A \sin \omega t = A \sin\left(\frac{2\pi}{T}\right) \times t$$

$$= A \sin\left(\frac{2\pi}{T} \times \frac{T}{12}\right)$$

$$= A \sin\left(\frac{\pi}{6}\right)$$

$\therefore$ $x = A \sin 30^\circ = \frac{A}{2}$ $\quad \therefore x^2 = \frac{A^2}{4}$

$\therefore$ The particle is at a distance A/2 from the mean position.

At this point its P.E. $= \frac{1}{2}Kx^2 = \frac{1}{2}m\omega^2x^2$ ... (1)

and its K.E. $= \frac{1}{2}mv^2$

$\therefore K = \frac{1}{2}m\omega^2(A^2 - x^2)$ ... (2)

$$\therefore \frac{\text{P.E.}(U)}{\text{K.E.}(K)} = \frac{x^2}{A^2 - x^2} = \frac{\frac{A^2}{4}}{A^2 - \frac{A^2}{4}} = \frac{\frac{A^2}{4}}{\frac{3A^2}{4}}$$

$$\therefore \frac{U}{K} = \frac{1}{3}$$

[Similar to Q.187, Pg. 522 - Marvel MHT-CET - Physics]

32. *(a)*

The fundamental frequency of the closed pipe (n) $= \frac{v}{4L}$

$$n = \frac{320}{4 \times 0.8} = \frac{320}{3.2} = 100\,\text{Hz}$$

For the vibrating wire, fundamental frequency (n) is

$$n' = \frac{1}{2L}\sqrt{\frac{T}{m}}$$

$\therefore$ For the second harmonic, frequency = 2n'

$$= \frac{2}{2L}\sqrt{\frac{T}{m}} = \frac{1}{L}\sqrt{\frac{T}{m}}$$

It is given that 2n' = n = 100 (Resonance)

$$\therefore 100 = \frac{1}{L}\sqrt{\frac{T}{m}} = \frac{1}{0.5}\sqrt{\frac{50}{m}}$$

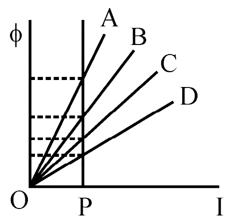
$\therefore 100 \times 0.5 = \sqrt{\frac{50}{m}}$ on squaring

$$\therefore (50)^2 = \frac{50}{m}$$

$\therefore$ 50 m = 1

$$\therefore m = \frac{1}{50}\text{ kg} = \frac{1}{50} \times 1000\text{ g} = 20\text{ gram}$$

33. *(d)*



Draw a line parallel to ϕ axis

$\because \phi = LI \quad \therefore L = \frac{\phi}{I}$ = slope of ϕ-I curve

$\therefore$ We find that the slope is maximum for A

$\therefore$ A has the maximum self inductance as OP is same for all.

34. *(a)* The angular width of the central maximum is $2\theta = \frac{2\lambda}{a}$ where a is the slit width.

$\therefore$ If a is increased, the angular width is decreased.

[Similar to Theory given on Pg. 668 - Marvel MHT-CET - Physics]

35. *(d)* A body moving in a circular path at constant speed has constant kinetic energy. The directions of momentum, velocity and acceleration change from point to points. Hence they do not remain constant. K.E. is a scalar. Others are vectors.

[Similar to Q.38, Pg. 297 - Marvel MHT-CET - Physics]

36. *(d)* Upward force (F) for the steel coin due to S.T.

$$= 2\pi r \times T \quad \left[\because T = \frac{F}{L} = \frac{F}{2\pi r}\right]$$

and it is equal to downward force due to weight = mg

= volume of coin × density × g

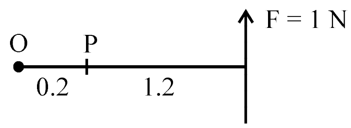
$= \pi r^2 d \times \rho \times g$ [d = thickness of the coin]

$\therefore 2\pi rT = \pi r^2 d\rho g$

$\therefore 2T = rd\rho g$

$$\therefore r = \frac{2T}{\rho dg}$$

37. *(d)*



To open or close the door, a force of 1 N is applied at a distance of 1.2m from the hinges.

Moment of the force = F × d = 1 × 1.2 = 1.2 N-m

When the force is applied at P at a distance of 0.2 m from O, then the force required to have the same moment is given by

$$1.2 = F \times 0.2 \quad \therefore F = \frac{1.2}{0.2} = 6\text{ N}$$

38. *(a)* The thermodynamic process, in which no work is done on or by the system is **isochoric process**.

In an isochoric process, V = constant $\quad \therefore dV = 0$

$\therefore$ Work done (dW) = PdV = 0

Note : dQ = 0 in adiabatic, dT = 0 in isothermal.

In isochoric, dV = 0 and in isobaric, dP = 0

[Similar to Theory given on Pg. 478 - Marvel MHT-CET - Physics]

39. ***(c)*** Diode D_1 is forward biased and diode D_2 is reverse biased. Hence no current till flow in the branch of D_2.

$\therefore$ The total effective resistance in the circuit is

$2 + 3 = 5\ \Omega$

$\therefore$ Current $I = \frac{10}{5} = 2$ A

$\therefore$ Current through $R_1 = 2$A

[Similar to Q.68, Pg. 1016 - Marvel MHT-CET - Physics]

40. ***(b)*** In Fraunhofer diffraction at a single slit of width 'd' the first minimum is observed at $\theta = 30^\circ$

$\therefore d \sin\theta = \lambda \quad \therefore d \times \sin 30^\circ = \lambda \quad \therefore \frac{d}{2} = \lambda$

The angular position of the n^{th} secondary maximum is given by $\sin\theta_n = (2n + 1)\frac{\lambda}{2d}$

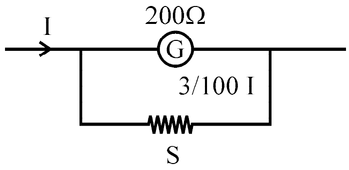
For n = 1, $\sin\theta = (2 + 1)\frac{\lambda}{2d} = \frac{3\lambda}{2d}$ but $\lambda = \frac{d}{2}$

$\therefore \sin\theta = \frac{3}{2d} \times \frac{d}{2} = \frac{3}{4}$

$\therefore \theta = \sin^{-1}\left(\frac{3}{4}\right)$

[Similar to Q.149, Pg. 680 - Marvel MHT-CET - Physics]

41. ***(a)***



The value of the required shunt (S) is calculated by using

$\frac{I_g}{I} = \frac{S}{S + G}$

$\therefore \frac{3}{100} = \frac{S}{S + 200}$

$\therefore 100\ S = 3S + 600 \quad \therefore 97\ S = 600$

$\therefore S = \frac{600}{97} \doteqdot 6\,\Omega$

[Note for S = 6, 97 S = 582 and for S = 7, 97 S = 679]

[Similar to Q.125, Pg. 777 - Marvel MHT-CET - Physics]

42. ***(d)*** $V_{M_1} = 1.5 \times 10^8$ m/s, $V_{M_2} = 2 \times 10^8$ m/s

$\because V_{M_2} > V_{M_1}$

$\therefore M_1$ is a denser medium and M_2 is a rarer medium.

$\therefore$ For critical angle, the ray must travel from M_1 to M_2

$\therefore {}_{M_1}\mu_{M_2} = \frac{V_{M_1}}{V_{M_2}} = \frac{1.5 \times 10^8}{2 \times 10^8} = \frac{3}{4}$

$\therefore {}_{M_1}\mu_{M_2} = \sin C = \frac{3}{4}$

$\therefore C = \sin^{-1}\left(\frac{3}{4}\right)$

[Similar to Q.23, Pg. 235 - Marvel MHT-CET - Physics]

43. ***(b)*** The minimum distance between an object and its real image formed by a convex lens of focal length f is **4f**.

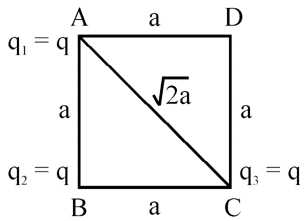
44. ***(b)*** Thermal capacity

45. ***(b)*** $\theta = 30^\circ$, v = 196 m/s

Time of flight $= \frac{2v\sin\theta}{g} = \frac{2 \times 196 \times \sin 30^\circ}{9.8}$

$= 2 \times 20 \times \frac{1}{2} = 20$ s

46. ***(d)***



Three equal charges are kept at the corners A, B, C of a square ABCD.

$\therefore$ The force between q_1 and q_2 is F_{12}

and $F_{12} = \frac{1}{4\pi\varepsilon_0}\frac{q \times q}{a^2} = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{a^2}$

and the force between q_1 and q_3 at A and C is

$F_{13} = \frac{1}{4\pi\varepsilon_0}\frac{q^2}{2a^2}$

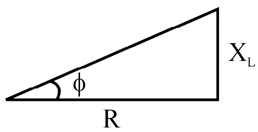
$\therefore \frac{F_{12}}{F_{13}} = \frac{q^2}{a^2} \times \frac{2a^2}{q^2} = 2$ (in magnitude)

47. ***(b)*** $L = \frac{1}{\pi}$, R = 300, f = 200 Hz

Inductive reactance $X_L = \omega L$

$= 2\pi fL = 2 \times \pi \times 200 \times \frac{1}{\pi} = 400\ \Omega$

$\therefore$ The phase angle between voltage and current in an L-R a.c. circuit



$\tan\phi = \frac{X_L}{R} = \frac{\omega L}{R} = \frac{400}{300} = \frac{4}{3}$

$\therefore \phi = \tan^{-1}\left(\frac{4}{3}\right)$

48. ***(d)*** In a full wave rectifier circuit, without filter, the output current is **unidirectional but not a steady current**.

49. ***(d)*** The excess pressure (P) in a soap bubble of radius 2 cm is 50 dyne/cm^2.

If T is the S.T., then $P = \frac{4T}{R}$

$\therefore T = \frac{PR}{4} = \frac{50 \times 2}{4}$

$\therefore T = 25$ dyne/cm

50. ***(a)*** For body A, mass = m, radius of the circle = r

For body B, mass = 3m and radius of the circle = $\frac{r}{3}$

and v and v' are the tangential speeds

For A, C.P. force = $\frac{mv^2}{r}$ ... (1)

For B, C.P. force = $\frac{3m \cdot v'^2}{r/3} = \frac{9mv'^2}{r}$ ... (2)

and it is given that v = nv'

Since the C.P. force is same for both

$\therefore \frac{mv^2}{r} = \frac{9mv'^2}{r}$

$\therefore v^2 = 9v'^2$ but v = nv'

$\therefore n^2v'^2 = 9v'^2$

$\therefore n^2 = 9 \quad \therefore n = 3$