JEE Main 2019 April Physics Paper with Solutions

1. A capacitor of capacitance C = 15 pF is charged with voltage V = 500 V. The electric field inside the capacitor with dielectric is 10^6 V/m and the area of the plate is 10^{-4} m^2, then the dielectric constant of the medium is: ($\epsilon_o = 8.85 \times 10^{-12}$ in SI units)

a.12.47

b. 8.47

c. 10.85

d. 14.85

Solution: (b)

C = 15PF

V = 500V

E = 10^6 V/m

A = 10^{-4} m^2

C = $k\epsilon_oA/d$

Or, E = V/d

E = $500C/[k\epsilon_oA]$

$$K = \frac{Vc}{A\varepsilon_0 E} = \frac{500 \times 15 \times 10^{-12}}{10^{-4} \times 10^6 \times 8.85 \times 10^{-12}}$$

= 8.47

2. The electric field of EM wave is 6 volt/m. The magnetic field associated with the wave if the wave is propagating in the +x direction and electric field along y-axis is:

a. $10^{-8}T\hat{K}$

b. $2\times\ 10^{-8}T\hat{K}$

c. $3\times\ 10^{-8}T\hat{K}$

d. $4\times\ 10^{-8}T\hat{K}$

Solution: (b)

E = BC

$$B=\frac{E}{C}=\frac{6}{3\times 10^{8}}=2\times 10^{-8}T(along\, z-axis)$$

3. An electron of H-atom de-exits from energy level m_1 = 2 to h_2 = 1 and the emitted photon is incident on He^+ion in ground state and first excited states which of following transition is possible.

a. n_1 to h_4

b. n_2 to h_4

c. n_2 to h_3

d. n_1 to n_4

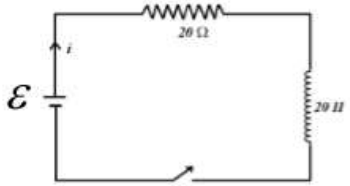
Solution: (b)

$E_H = 13.6(1/1^2 – 1/2^2) = 10.2$ ev

$E_H = 13.6(2)^2(1/2^2 – 1/h^2) = 10.2$ ev

On substituting options n = 4

4. The switch is closed at t = 0. The time after which the rate of dissipation of energy in the resistor is equal to rate at which energy is being stored in the inductor is:



a. ln 2

b. (1/2)ln 2

c. (1/4)ln 2

d. 2 ln 2

Solution (a)

$$i = \frac{E}{R}(1 - e^{-\frac{Rt}{L}})$$
$$\frac{di}{dt} = \frac{E}{L}e^{-\frac{t}{\tau}}, where\ \tau = \frac{L}{R}$$
$$i^2R = (L\frac{di}{dt})$$
$$\frac{E}{R}R(1 - e^{-\frac{t}{\tau}}) = L\frac{E}{L}e^{-}\frac{t}{\tau}$$

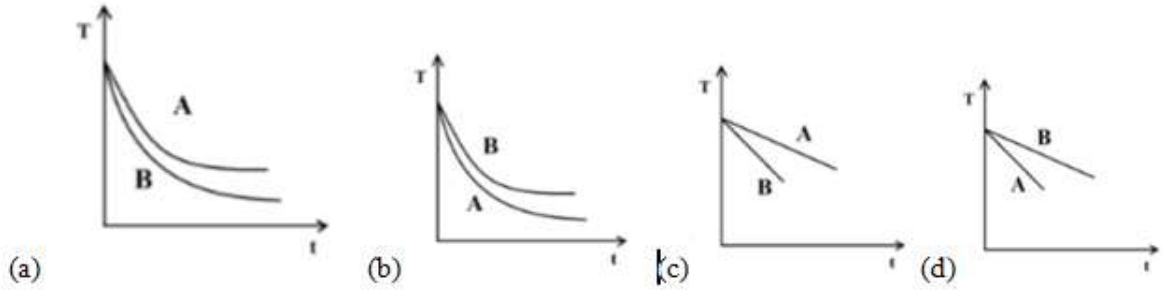
$1 = 2e^{-e/\tau}$

$\ln 2 = t/\tau$

$t = \tau \ln 2$

5. Two identical containers of same emissivity containing liquids A & B at same temperature of 60°c initially and densities P_A and P_B respectively. Where, $P_A < P_B$. Which plot best represents the temperature variation of both with time? Given

$$\begin{pmatrix} S_A = 100\frac{J}{kg-k^1} \\ S_B = 2000\frac{J}{kg-k} \end{pmatrix}$$

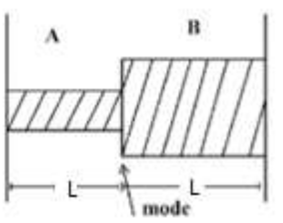


Solution: (b)

$$\frac{d\theta}{dt} = \frac{\theta e A\left(T_0^m - T_0^A\right)}{ms}$$

$$\frac{d\theta}{dt}\alpha\frac{1}{ms}$$

6. The system of 2 rods shown in fig is vibrating at the same frequency and forming a standing wave. The ratio of the number of antinodes in the two rods if radius of rod B is twice the radius of A is:



a. 1

b. 2

c. 3

d. 4

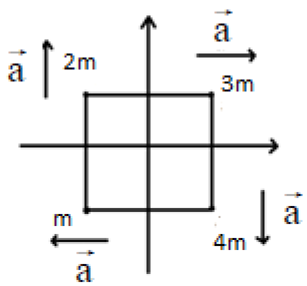
Solution: (b)

$$f = \frac{P}{2\alpha}\sqrt{\frac{T}{\pi r^2 \ell P}}$$

$$P\alpha\frac{1}{r}\frac{P_1}{P_2} = \frac{r_1}{r_2} = \frac{2r}{r}$$

$$\frac{P_1}{P_2} = 2$$

7. At the given instant the four particles having masses and acceleration as shown in the fig lie at vertices of a square. Acceleration of the mass of the system is:



a. $\frac{1}{5}\left(\hat{i} + \hat{j}\right)$

b. $\frac{1}{5}\left(\hat{j} - \hat{i}\right)$

c. $\frac{1}{5}\left(\hat{i} - \hat{j}\right)$

d. $\frac{1}{5}\left(\hat{i} + \hat{j}\right)$

Solution: c

$$a_{am} = \frac{m_1a_1+m_2a_2+m_3a_3+m_4a_4}{m_1+m_2+m_3+m_4} = \frac{m\left(-a\hat{i}\right)+2m\left(a\hat{j}\right)+3m\left(a\hat{i}\right)+4m\left(-a\hat{j}\right)}{m+2m+3m+4m}$$

$$= \frac{2i-2\hat{j}}{10} = \left(\frac{\hat{i}}{5} - \frac{\hat{j}}{5}\right)$$

8. In YDSE ratio of Amplitude of wave is 1: 3. The ratio of I max: I min is:

a. 1: 4

b. 4: 1

c. 1: 1

d. 1: 9

Solution: (b)

$$\frac{I_{max}}{I_{min}} = \left(\frac{A_1 + 3A_1}{A_1 - 3A_1}\right)^2 = \frac{4}{1}$$

9. Two particles are moving perpendicular to each other with de-Broglie wave length λ_1 and λ_2 if they collide and stick then the de-Broglie wave length of system after collision is:

a. $\lambda = \frac{\lambda_1 \lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}}$

b. $\lambda = \frac{\lambda_1}{\sqrt{\lambda_1^2 + \lambda_2^2}}$

c. $\lambda = \frac{\sqrt{\lambda_1^2 + \lambda_2^2}}{\lambda_2}$

d. $\lambda = \frac{\lambda_1 \lambda_2}{\sqrt{\lambda_1 + \lambda_2}}$

Solution: (a)

Pi + Pj = P

$$\frac{h}{\lambda_1}\hat{\imath} + \frac{h}{\lambda_2}\hat{\jmath} = \frac{h}{\lambda}$$

$$\frac{1}{\lambda} = \sqrt{\frac{1}{\lambda_1} + \frac{1}{\lambda_2}}$$

$$\lambda = \frac{\lambda_1 \lambda_2}{\sqrt{\lambda_1^2 + \lambda_2^2}}$$

10. Ship moving with velocity $\vec{V}_1 = 30\hat{i} + 50\hat{j}$ from position (0, 0) and ship B moving with velocity $\vec{V_2} = -10\hat{i}$ from position (80, 150). The time for minimum separation is

a. 6

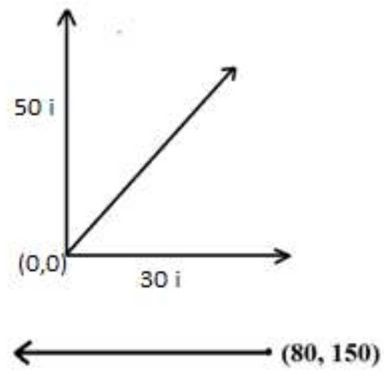
b. 2.2

c. 2.4

d. None

Solution: (c) approx

$$V_1 = 30\hat{i} + 50\hat{j}$$
$$r = -80\hat{i} - 150\hat{j}$$
$$V_2 = -10\hat{i}$$



Component of V_1 along r is

$V.r/V^2 = 2.6$

11. A carbon resistance with colour bard is 200 Ω. If red bard is replaced by green bard then the new resistance is

a. 500 Ω

b. 300 Ω

c. 400 Ω

d. 100 Ω

Solution: (a)

Red → 2

Green → 5

New resistance → 500 Ω

12. Dimension of $\sqrt{(\epsilon_o/\mu_o)}$ are

a. $[ML^2T^{-3}A^{-2}]$

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

c. $[M^2L^2T^{-3}A^{-2}]$

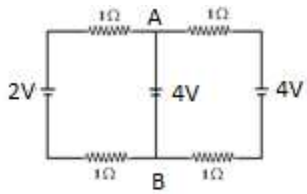
d. $[M^{-1}L^2T^3A^2]$

Solution: (b)

$$\sqrt{\frac{\varepsilon_0}{\mu_0}} = \sqrt{\frac{\varepsilon_0\varepsilon_0}{\mu_0\varepsilon_0}} \Rightarrow \varepsilon_0.C$$

$$\frac{Col^2}{Nm^2}(m/s) = \frac{I^2T^2 \not{L} T^{-1}}{M\not{L}T^{-2}L^2} = [M^{-1}L^{-2}T^3A^2]$$

13. A electric circuit is shown in figure. The potential different between the points A & B is:



a. 10/3

b. 20/3

c. 5/3

d. 7/3

Solution: (a)

Using nodal method

$$\frac{V_A{}^{-2}}{2\Omega}+\frac{V_A-4}{2}+\frac{V_A-4}{2}=0$$

$V_A/2$ -1 + $V_A/2$ – 2 + $V_A/2$ – 2 = 0

V_A = 10/3

14. 10 particles each of mass 10^{-26} kg are striking perpendicularly on a wall of area 1 m^2 with speed 10^4 m/s in 1 sec. The pressure on the wall if collision is perfectly elastic is:

a. 2 N/m^2

b. 4 N/m^2

c. 6 N/m^2

d. 8 N/m^2

Solution: (a)

Collision Frequency = 10^{22}

ΔP per particle = mV_2

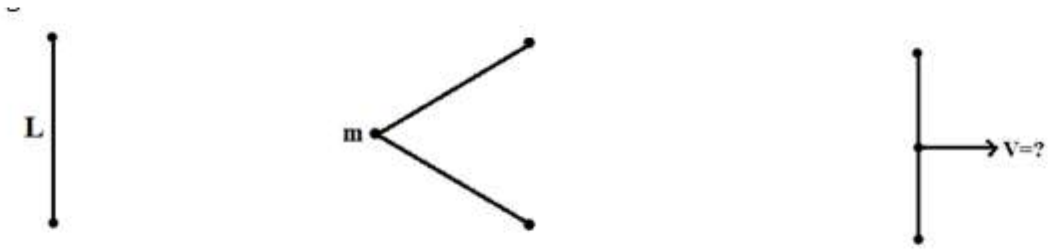
F = ΔP/1 sec = 10^{22} x mv

= 10^{22} x 10^{-26} x 2 x 10^4 = 2

P = F/A = 2/1 = 2 N/m^2

15. An elastic string of Length 42 cm and cross section area 10^{-4} m^2 is attached between two pegs at distance 6mm as shown in the figure. A particle of mass m is kept at midpoint of

string stretched as shown in figure by 20 cm and released. As the string attains natural Length, the particle attains a speed of 20 m/s. Then young modulus Y of string is of order.**



a. 10^8

b. 10^{12}

c. 10^6

d. 10^4

Solution: (c)

Elastic stream energy × volume = kinetic energy

Vol x (1/2)stress x strain = (1/2) mv^2

Vol(1/2) (stress/strain) $strain^2$= (1/2) mv^2

= (1/2) y $strain^2$vol = (1/2) mv^2

$$Y = \frac{m \times v^2}{AL\left(\frac{\Delta \ell}{\ell}\right)^2}$$

Y = [(0.05 x400 x0.42)/$(0.2)^2$ x 10^{-4}]

Y = 2.1 x 10^6 N/m^2

16. The density of a circular disc is given as σ = p_o X where 'X' is the distance from the centre. Its moment of inertia about an axis perpendicular to inertia about an axis perpendicular to its plane and passing through its edge is:

a. $(15/16)P_o\pi R^5$

b. $(16/15)P_o\pi R^5$

c. $(6/5)P_o\pi R^5$

d. $(5/6)P_o\pi R^5$

Solution: (b)

Using parallel axis

$dI = dmx^2 + d\,MR^2$

$$dI = \int P_0 2\pi x^2 dx . x^2 + \int P_0 2\pi x^2 dx R^2$$
$$= \frac{P_0 2\pi R^2}{5} + \frac{P_0 2\pi R^5}{3} = \frac{16 P_0 \pi R^5}{15}$$

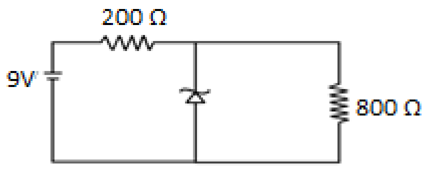
17. The circuit shown in the figure. Determine the current through Zener diode. (Given: Zener diode break down. Voltage V_2 = 5.6 V)

a. 7 mA

b. 17 mA

c. 10 mA

d. 15 mA



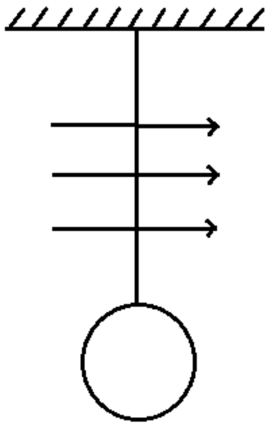
Solution: (c)

$I_1 = I_2 + I_2$

$3.4/200=I_2+5.6/800$

$I_2 = 10$ mA.

18. A small sphere of mass m = 2gm having charge Q = 5 mc is suspended using an insulated string as shown in figure. The angle Ө made by the sphere with the vertical if it is placed in an electric field of magnitude 2000 y/m towards right is



a. $\tan^{-1}(5)$

b. $\tan^{-1}(0.5)$

c. $\tan^{-1}(2)$

d. $\tan^{-1}(0.2)$

Solution: (b)

F = mg tan Ө

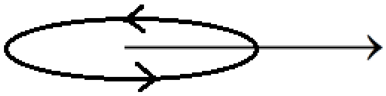
$$\tan\theta = \frac{F}{mg}$$

$$\theta = \tan^{-1}\left(\frac{QE}{mg}\right)$$

$$= \tan^{-1}\left(\frac{5\times10^{-6}\times2000}{7\times10^{-3}\times10}\right)$$

$$= \tan^{-1}\left(\frac{1}{2}\right) = \tan^{-1}(0.5)$$

19. A circular loop of radius r having N number of turns carries current I is placed in a uniform magnetic field $\vec{B}$ parallel to the plane of the loop. The torque on the loop is



a. $Nl\pi r^2B$

b. $N^2l\pi r^2B$

c. $Nl^2\pi r^2B$

d. $Nl\pi r^2B^2$

Solution: (a)

$\tau = M \times B$

$= MB \sin \Theta$

$= NI \pi r^2 \times B(1)$

$= NI \pi r^2B$

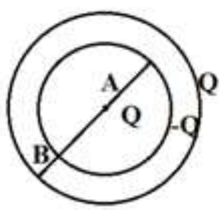
20. A conducting sphere is enclosed by a hollow conducting shell. Initially the inner sphere has a charge Q. While the outer one is un charged. The potential difference between the two spherical surface is found to be V. Later on the outer shell is given a charge – 4Q.The new potential difference between the two surfaces.

a.1V

b. – IV

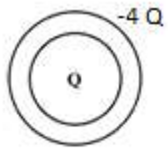
c. – 2V

d. 2V



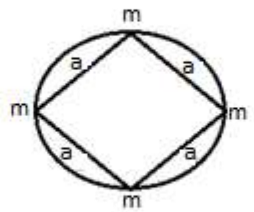
Solution: (a)

$$V_A = \frac{KQ}{a} + \frac{K(-Q+Q)}{b}$$
$$\Delta V = KQ\left({}^1/_a - {}^1/_b\right)$$
$$V_A = \frac{KQ}{a} - \frac{K4Q}{b}$$
$$V_B = \frac{KQ}{b} - \frac{K4Q}{b}$$



$\Delta V = V$

21. Four particle each of mass m are undergoing circular motion under the influence of action of their mutual gravitational interaction while being at the vertices of a square of side a. Their speeds are



a. √(2GM/a)

b. 1.16 √(GM/a)

c. 1.5 √(2M/a)

d. √(GM/a)

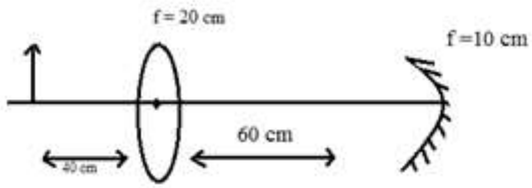
Solution: (b)

Gravitation Force = mv^2/r

$$r = \sqrt{a^2 - (\frac{a}{\sqrt{2}})^2} = \frac{a}{\sqrt{2}}$$
$$\frac{Gm^2}{a^2}cos45^0 + \frac{Gm^2}{(\sqrt{2}a)^2} + \frac{Gm^2}{a^2}cos45^0 = mv^2/(a/\sqrt{2})$$
$$\frac{Gm^2}{a^2}[\frac{1}{\sqrt{2}} + \frac{1}{2} + \frac{1}{\sqrt{2}}] = (mv^2\sqrt{2})/a$$

1.16 √(GM/a) is the answer.

22. A converging lens of focal length 20 cm is placed between an object & a concave mirror of focal length 10 cm as shown in figure. The final image is



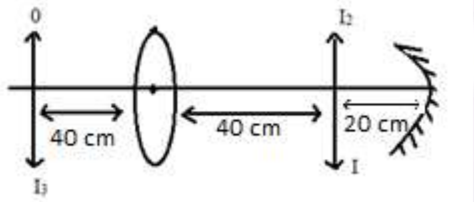
a. Coinciding with object, enlarged, Inverted real

b. Coinciding with object, same size, erect, real

c. Coinciding with object, same size, Inverted, Vertical

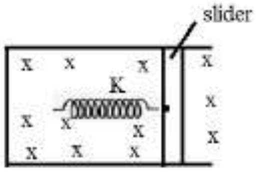
d. Coinciding with object, same size, Inverted, real

Solution: (d)



Coinciding with object, same size, Inverted, real

23. A conducting slider of resistance R (10 Ω) mass 50g & length 10 cm is kept on a U – shaped frame as shown in figure. There is a uniform magnetic field (B = 0.1T) perpendicular to plane of frame. These slider is attached to a spring (K = 0.5 N/m). It is displaced by A_Θ & released time is which amplitude become A /e is



a. 9000 s

b. 10000 s

c. 12000 s

d. 15000 s

Solution: b

$$-Kx - i\ell B = m\frac{d^2x}{d\ell^2}$$

$$-Kx\frac{B^2\ell^2}{R}\frac{dx}{d\ell} - m\frac{d^2x}{d\ell^2} = 0$$

Comparing with

$$-Kx - b\frac{dx}{dt} - m\frac{d^2x}{d\ell^2} = 0 \ \&$$

$$A = A_0e^{(-b/2m)t}$$

$$\frac{B^2\ell^2}{R.2m}t = 1$$

$$t = \frac{2mR}{B^2\ell^2} = 10,000s$$

24. An A.C source of voltage V = 220 sin (100 πt) volts is connected with R = 50 Ω. The time interval in which the current goes from its peak value to half of the peak value is

a. 1/400 sec

b. 1/50 sec

c. 1/300 sec

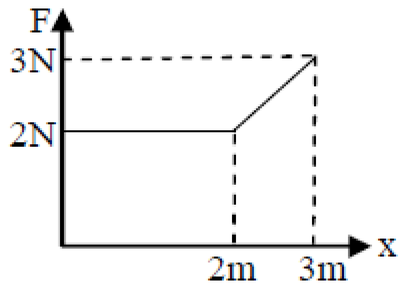
d. 1/200

Solution: (c)

For oscillation to go from max to half is T / 6

1/[50x6] = (1/300) sec

25. Force displacement graph of a particle starting from rest is given in the figure shown. The kinetic energy of particle at x = 3m is



a. 6.5 J

b. 7.5 J

c. 6 J

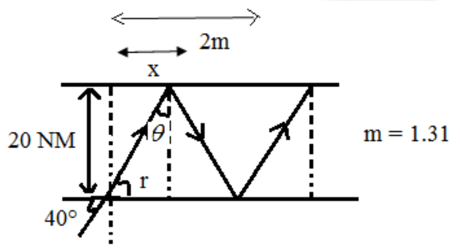
d. 5 J

Solution: (a)

Area under graph is work done which kg =- kj w = k_6

W = 3 x 2 + (1/2)(1)(1) = 6.5 J

26. Find out the no of reflection after which light ray will exit from (Given sin 40° = 0.64)



a. 130000

b. 57803

c. 140000

d. 150000

Solution: (b)

x = (20 mm)/tan r = 20√3 m

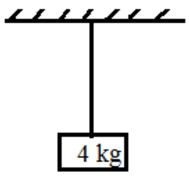
For one reflection

Nx = 20√3 m = 2m

Therefore, $n = 2/[20\sqrt{3} \times 10^{-6}\ m]$

= 57803

27. A block of mass 4 kg is suspended from the ceiling with the help of a steel wire off radius 2 mm and negligible mass. Find the stress in the wire ($g = \pi^2$)



a. 4×10^6

b. 3×10^5

c. 3.14×10^6

d. 2×10^6

Solution: (c)

Stress = $F/A = mg/\pi r^2$

$= 3.14 \times 10^6\ N/m^2$

28. A liquid of coefficient of viscosity η = 1 poise is flowing in a pipe of radius 3 cm on such that the rate of volume flow is 1000 / min. determine the Reynolds numbers.

a. 3536

b. 3500

c. 3400

d. 3600

Solution: (a)

$\eta = 1$ poise

r = 3 cm

dv/dt = 1000 l/min

$N_0 = Pv\ D/h = 1000/0.1 \times (1/60\pi r^2) \times 2r$

= 3536.