



**PAPER-1(B.E./B. TECH.)**

# **JEE (Main) 2021**

**Questions & Solutions**

(Reproduced from memory retention)

Date : 24 February, 2021 (SHIFT-1) Time ; (9.00 am to 12.00 pm)

Duration : 3 Hours | Max. Marks : 300

**SUBJECT : PHYSICS**

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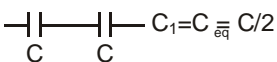
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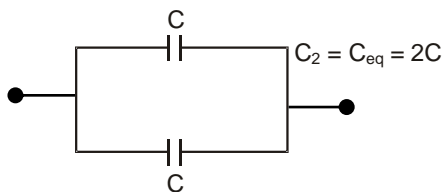
**PHYSICS**

1. If two identical capacitor once connected in series ( $C_{eq} = C_1$ ) and once connected in parallel ( $C_{eq} = C_2$ ) then find ratio  $\frac{C_1}{C_2}$ .

- (1)  $\frac{3}{4}$                       (2)  $\frac{5}{6}$                       (3)  $\frac{4}{3}$                       (4)  $\frac{1}{4}$

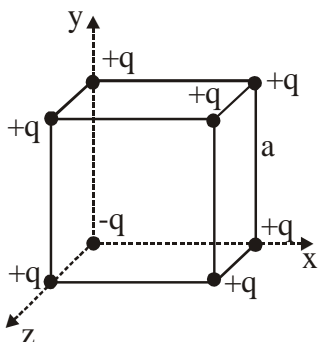
Ans. (4)

Sol.   $C_1 = C_{eq} = C/2$



$$\frac{C_1}{C_2} = \frac{1}{4}$$

2.



Find electric field at centre of cube ?

- (1)  $\frac{-2q}{\pi 3\sqrt{3}\epsilon_0 a^2} [\hat{i} + \hat{j} + \hat{k}]$                       (2)  $\frac{q}{\pi 3\sqrt{3}\epsilon_0 a^2} [\hat{i} + \hat{j} + \hat{k}]$   
 (3)  $\frac{-q}{\pi 3\sqrt{3}\epsilon_0 a^2} [\hat{i} + \hat{j} + \hat{k}]$                       (4)  $\frac{2q}{\pi 3\sqrt{3}\epsilon_0 a^2} [\hat{i} + \hat{j} + \hat{k}]$

Ans. (1)

Sol. If we consider two point charges +q and -q at position of -q charge, then after interchanging -q charge with +q charge, net electric field at centre of cube is zero due to symmetry. Now remaining charges are -2q so net electric field at centre is  $\left(\frac{-8kq}{3a^2}\right)$ .

3. In a transistor if increase in emitter current is 4 mA and corresponding increase in collector current is 3.5 mA. Find  $\beta$ .

- (1) .875                      (2) .5                      (3) 7                      (4) 1

Ans. (3)

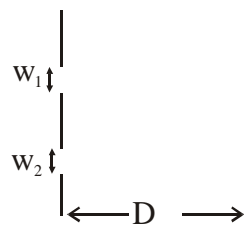
Sol.  $\Delta I_E = 4$

$\Delta I_C = 3.5$

$$\alpha = \frac{\Delta I_C}{\Delta I_E} = \left(\frac{3.5}{4}\right) = \left(\frac{7}{8}\right)$$

$$\beta = \frac{\alpha}{1 - \alpha} = \frac{\frac{7}{8}}{1 - \frac{7}{8}} = 7$$

4. If  $\frac{w_1}{w_2} = \frac{1}{3}$  (w is width) and its given that amplitude is proportional to w. Find  $\frac{I_{\max}}{I_{\min}}$ .



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

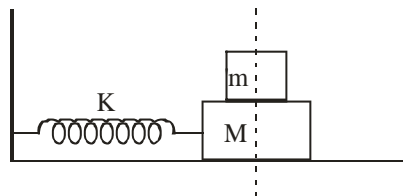
Ans. (3)

Sol.  $\frac{A_1}{A_2} = \frac{1}{3}$                        $A_1 = x, A_2 = 3x$

$$\frac{I_{\max}}{I_{\min}} = \left(\frac{(A_1 + A_2)^2}{(A_1 - A_2)^2}\right) = \frac{(4x)^2}{(2x)^2} = \frac{16}{4} = 4 : 1$$

5. If a small block of mass  $m$  is placed gently on  $M$  when it is passing through its mean position.

Find it's new amplitude of SHM, if initial amplitude is  $A$ .



- (1)  $\sqrt{\frac{M}{M+m}}$  (A)                      (2)  $\sqrt{\frac{M+m}{M}}$  (A)                      (3)  $\sqrt{\frac{M+m}{2M}}$  (A)                      (4)  $\sqrt{\frac{M}{M-m}}$  (A)

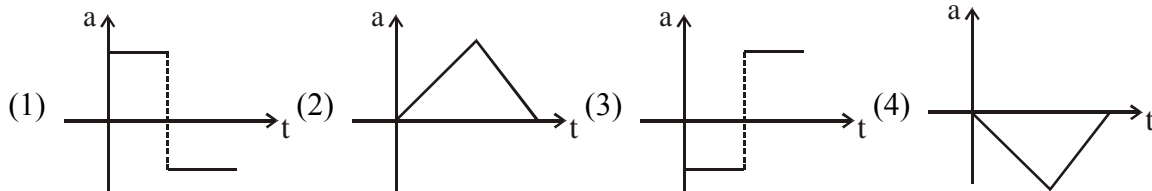
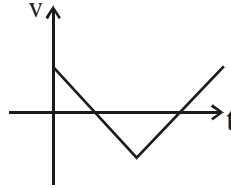
Ans. (1)

**Sol.** Velocity at mean position is =  $A\omega$   
Conserving momentum  $MA\omega_0 = (M + m)V'$

$$V' = \frac{MA\omega_0}{M+m} = (A')\sqrt{\frac{K}{M+m}}$$

$$A' = \frac{MA\sqrt{\frac{K}{M}}}{M+m} \times \sqrt{\frac{M+m}{K}} = \sqrt{\frac{M}{M+m}}A$$

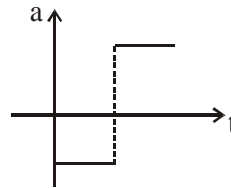
6. From given velocity time graph which of the following is acceleration time graph.



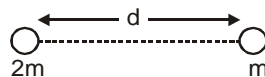
**Ans.** (3)

**Sol.**

$$\left. \begin{aligned} v &= -mt + C \\ \frac{dv}{dt} &= -m \end{aligned} \right| \left. \begin{aligned} v &= mt - C \\ \frac{dv}{dt} &= m \end{aligned} \right|$$



7. Two stars are rotating about their common center of mass. Find the period of revolution of mass  $m$  about center of mass.



- (1)  $2\pi\sqrt{\frac{d^3}{3Gm}}$       (2)  $2\pi\sqrt{\frac{3Gm}{d^3}}$       (3)  $\frac{1}{2\pi}\sqrt{\frac{d^3}{3Gm}}$       (4)  $\frac{1}{2\pi}\sqrt{\frac{3Gm}{d^3}}$

**Ans.** (1)

**Sol.**

$$\frac{G(m)(2m)}{d^2} = m\omega^2 \times \frac{2d}{3}$$

$$\frac{2Gm}{d^2} = \omega^2 \times \frac{2d}{3}$$

$$\omega^2 = \frac{3Gm}{d^3}$$

$$\omega = \sqrt{\frac{3Gm}{d^3}} ; \quad T = 2\pi\sqrt{\frac{d^3}{3Gm}}$$

8. Find relation between modulus

If

$Y \rightarrow$  young's modulus

$K \rightarrow$  Bulk modulus

$\eta \rightarrow$  modulus of rigidity

(1)  $K = \frac{\eta Y}{9\eta - 3Y}$

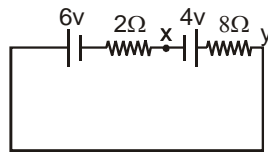
(2)  $Y = \frac{\eta K}{9\eta - 3K}$

(3)  $K = \frac{\eta Y}{9\eta + 3Y}$

(4)  $Y = \frac{\eta K}{9\eta + 3K}$

Ans. (1)

9. Circuit is given find  $|V_x - V_y|$



(1) 5.6 volt

(2) 3.6 volt

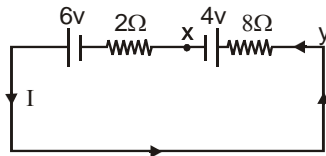
(3) 10 v

(4) 240 volt

Ans. (1)

Sol. Current  $I = \frac{6-4}{10} = \frac{1}{5}$  A

$v_x + 4 + 8 \times \frac{1}{5} = v_y$



$v_x - v_y = -5.6v$

10. If work =  $\alpha \cdot \beta^2 \cdot e^{-\frac{x^2}{\alpha \cdot K T}}$ ,

where,  $K =$  Boltzmann constant,  $T =$  temp, then find dimension of  $\beta$

(1)  $M^1 L^1 T^{-2}$

(2)  $M^{-1} L^{-1} T^2$

(3)  $M^1 L^2 T^{-2}$

(4)  $M^2 L^1 T^2$

Ans. (1)

Sol.  $\frac{x^2}{\alpha K T} =$  dimensionless

$\frac{L^2}{K T} \Rightarrow \alpha$

$\alpha \Rightarrow \frac{L^2}{v^2 M} = L^2 M^{-1} L^{-2} T^2 = M^{-1} T^2$

work =  $\alpha \cdot \beta^2 \cdot$  (dimensionless)

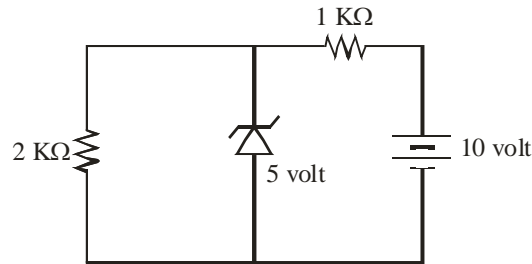
$$M^1 L^1 T^{-2} \cdot L^1 = M^{-1} T^2 \beta^2$$

$$v = \sqrt{\frac{3KT}{M}}$$

$$\frac{v^2 \cdot M}{3} = KT$$

$$\beta = M^1 L^1 T^{-2}$$

11. Zener diode is connected in circuit as shown. Find current in 2kΩ resistance.



- (1) 2.5mA                      (2) 30mA                      (3) 10mA                      (4) 20mA

Ans. (1)

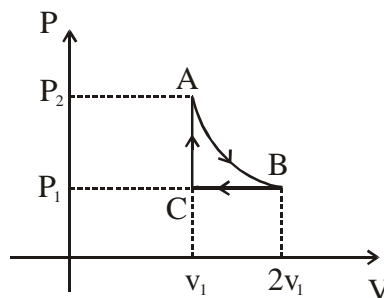
Sol. Zener diode breakdown

$$\Rightarrow i = \frac{5}{2 \times 10^{-3}} = 2.5 \times 10^{-3}$$

$$x \times 10^{-4} = 2.5 \times 10^{-3}$$

$$x = 2.5 \text{mA}$$

12. Given AB is Isothermal and BC is Isobaric and CA is isochoric process. Find total work done in cyclic process. (Given  $p_1 v_1 = nRT$ ).



- (1)  $nRT [\ln 2 - 2]$                       (2)  $2nRT [\ln 2 - 1/2]$                       (3)  $nRT [\ln 2 - 1/2]$                       (4)  $nRT [\ln 2 + 2]$

Ans. (2)

**Sol.**  $W_{AB} = 2 P_1 V_1 \ln 2$   
 $W_{BC} = -P_1 V_1$   
 $W_{CA} = 0$   
 $W_{ABCA} = (2 P_1 V_1 \ln 2 - P_1 V_1)$   
 $= nRT (2 \ln 2 - 1)$

**13.** A side of cube a is made from 6 identical sheet. If coefficient of linear expansion is  $\alpha$  and temperature is now made  $T + \Delta T$  from temperature  $T$  then find change in volume

(1)  $\Delta V = 3a^3 \alpha \Delta T$     (2)  $\Delta V = \frac{4}{3} \pi a^3 \alpha \Delta T$     (3)  $\Delta V = 4a^3 \alpha \Delta T$     (4)  $\Delta V = 6a^3 \alpha \Delta T$

**Ans. (1)**

**Sol.**  $\frac{\Delta V}{V} = \gamma \Delta T$   
 $= 3\alpha \Delta T$   
 $\Delta V = 3a^3 \alpha \Delta T$

**14.** If intensity after passing through a polaroid is 100 Lumen. Now this same polaroid is rotated by  $30^\circ$  about it's axis then find new intensity after passing through it.

(1) 50 Lumen    (2) 100 Lumen    (3) 25 Lumen    (4) 65 Lumen

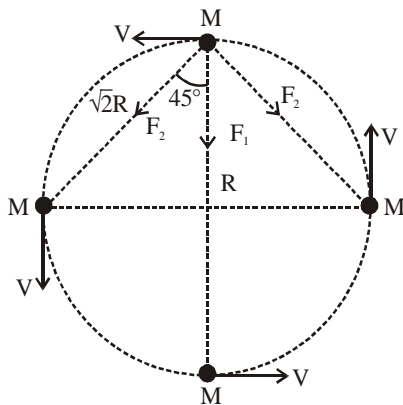
**Ans. (2)**

**Sol.**  $I_{P_1} = I_{P_2} = 100$  Lumen

**15.** Four particles, each of mass 1 kg and equidistant from each other, move along a circle of radius 1 m under the action of their mutual gravitational attraction. The speed of each particle is :

(1)  $\sqrt{G(1+2\sqrt{2})}$     (2)  $\frac{1}{2} \sqrt{G(1+2\sqrt{2})}$     (3)  $\sqrt{G}$     (4)  $\sqrt{2\sqrt{2}G}$

**Ans. (2)**



**Sol.**

Net force on one particle  
 $F_{net} = F_1 + 2F_2 \cos 45^\circ = \text{Centripetal force}$

$$\Rightarrow \frac{GM^2}{(2R)^2} + \left[ \frac{2GM^2}{(\sqrt{2}R)^2} \cos 45^\circ \right] = \frac{MV^2}{R}$$

$$V = \frac{1}{2} \sqrt{\frac{GM}{R}} (1 + 2\sqrt{2})$$

$$v = \frac{1}{2} \sqrt{G(1 + 2\sqrt{2})}$$

16. Choose the correct options.

**Column-I**

(P) Adiabatic

(Q) Isothermal

(R) Isochoric

(S) Isobaric

**Column-II**

(i) Pressure constant

(ii) Volume constant

(iii) Temperature constant

(iv) Heat content constant

from above match the column find out correct options.

(1) P-iv ; Q-iii ; R-ii ; S-i

(2) P-iv ; Q-iii ; R-i ; S-ii

(3) P-iii ; Q-ii ; R-iv ; S-i

(4) P-iv ; Q-ii ; R-iii ; S-i

**Ans. (1)**

**Sol.** P-iv ; Q-iii ; R-ii ; S-i

17. Relation between radius of curvature & focal length of a convex mirror is.

(1)  $f = \frac{R}{2}$

(2)  $R = \frac{f}{2}$

(3)  $2f = 3R$

(4) none

**Ans. (1)**

**Sol.**  $\frac{R}{2} = f$



18.  $I_1$  = Moment of Inertia of ring of mass  $M$  and radius  $R$  about its diameter.

$I_2$  = Moment of Inertia of Disc of mass  $M$  and radius  $R$  through central axis perpendicular to plane of ring.

$I_3$  = Moment of Inertia of solid cylinder mass  $M$  and radius  $R$  about its axis.

$I_4$  = Moment of Inertia of solid sphere through its diameter.

$$(1) I_1 + I_2 = I_3 + \frac{5}{4}I_4$$

$$(2) I_1 = I_2 = I_3 < I_4$$

$$(3) I_1 > I_2 = I_3 = I_4$$

$$(4) I_1 + I_2 = I_3 + \frac{2}{5}I_4$$

Ans. (1)

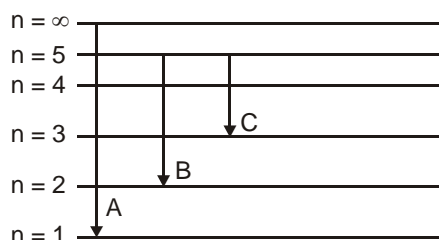
Sol.  $I_1 = \frac{MR^2}{2}$

$$I_2 = \frac{MR^2}{2}$$

$$I_3 = \frac{MR^2}{2}$$

$$I_4 = \frac{2}{5}MR^2$$

19. Spectral lines of hydrogen atoms are given is below



Which of the following is correct for spectral lines A, B & C

- (1) Series limit of lyman, 3<sup>rd</sup> line of Balmer, 2<sup>nd</sup> line of paschan
- (2) Series limit of lyman, 2<sup>nd</sup> line of Balmer, 2<sup>nd</sup> line of paschan
- (3) 2<sup>nd</sup> line of lyman, 3<sup>rd</sup> line of Balmer, 2<sup>nd</sup> line of paschan
- (4) Series limit of lyman, 3<sup>rd</sup> line of Balmer, 3<sup>rd</sup> line of paschan

Ans. (1)

**Sol.** A → Series limit of laymen

B → 3<sup>rd</sup> line of Balmer

C → 2<sup>nd</sup> line of paschan

**20. Statement-1:** de-Broglie wavelength of proton varies inversely with linear momentum.

**Statement-2:** As  $\lambda$  increases, energy and momentum increases.

(1) Statement-1 is true and Statement-2 is false.

(2) Statement-1 is false and Statement-2 is true.

(3) Statement-1 is false and Statement-2 is false.

(4) Statement-1 is true and Statement-2 is true.

**Ans. (1)**

**Sol.**  $\lambda = \frac{h}{p}$

**21.** A 220 volts AC supply is given to the primary circuit of transformer and as output of 12 volts DC is taken out using rectifier. If secondary number of turns was 24, then find the no. of turns in primary coil.

**Ans. 440**

**Sol.**  $\frac{N_p}{N_s} = \frac{V_p}{V_s}$

$$\frac{N_p}{24} = \frac{220}{12} ; \quad N_p = 440$$

**22.** A vertical cross-section of plane is  $y = \frac{x^2}{4}$ , coefficient of friction is 0.5. Find maximum height at which particle can stay (in cm).

**Ans. 25 cm**

**Sol.**  $\mu \geq \tan \theta = \frac{dy}{dx} = \frac{dx}{4} = \frac{x}{2}$

$$0.5 \geq \frac{x}{2}$$

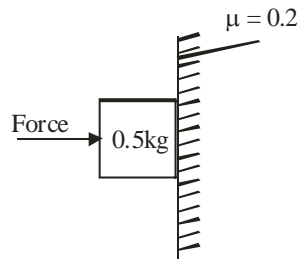
$$x \leq 1$$

$$\sqrt{4y} \leq 1$$

$$2\sqrt{y} \leq 1$$

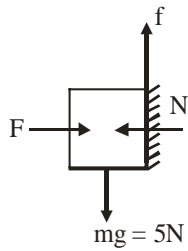
$$y \leq \frac{1}{4}$$

23. Find out minimum force required to stop block from falling (given  $g = 10 \text{ m/s}^2$ )



Ans. 25

Sol.  $F = N$ ,  $f = 0.2 \times N$

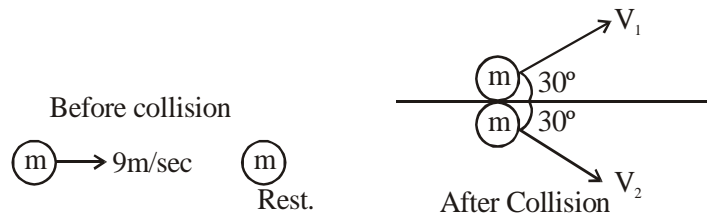


$$0.2 N \leq 5$$

$$N \leq 25$$

24. Two identical particles of same mass are shown just before collision and just after collision than

$\frac{v_1}{v_2}$  is



Ans. 1

Sol. Using linear momentum conservation in y-direction

$$P_i = 0$$

$$P_f = m \times \frac{1}{2} v_1 - m \times \frac{1}{2} v_2$$

$$v_1 = v_2$$

25.  $i = 20t + 8t^2$

Find charge flown during  $0 \leq t \leq 15$

Ans. 11250

**Sol.**  $\frac{dq}{dt} = (20t + 8t^2)$

$$\int dq = \int_0^{15} (20t + 8t^2) dt$$

$$\Delta q = \left[ 20 \frac{t^2}{2} + \frac{8t^3}{3} \right]_0^{15}$$

$$= \frac{20 \times (15)^2}{2} + \frac{8 \times (15)^3}{3}$$

$$\Delta q = 11250 \text{ C}$$

- 26.** A 100 kg block can be lift by placing a mass m on a piston (hydraulic lift). If diameter of piston placed at one end is increased by 4 times and that of second piston is decreased by 4 times. Now same mass m is placed at piston then how many kg weight can be lift up for the new set up?

**Ans.** 25600

**Sol.** Initially  $\frac{100g}{A_1} = \frac{mg}{A_2}$  .....(i)

Initially  $\frac{Mg}{16A_1} = \frac{mg}{\left(\frac{A_2}{16}\right)}$  .....(ii)

$$\frac{100 \times 16}{M} = \frac{1}{16} = M = 25600 \text{ kg}$$

- 27.** Two planet are revolving about planet with  $\frac{T_1}{T_2} = \frac{1}{8}$ . Find the ratio of the angular speed  $\frac{\omega_1}{\omega_2}$

**Ans.** 8

**Sol.** Ratio of time period

$$\frac{T_1}{T_2} = \frac{1}{8}$$

$$\frac{2\pi}{\omega_1} = \frac{1}{8}$$

$$\frac{\omega_1}{2\pi} = \frac{1}{8}$$

$$\omega_2$$

$$\frac{\omega_1}{\omega_2} = 8$$

$$\omega_2$$

- 28.** An electromagnetic wave is propagating in medium, where  $\mu_r = \epsilon_r = 2$ . If speed of light in medium is  $x \times 10^7$  m/s. Find out x.

**Ans.** 15

**Sol.**  $n = \sqrt{\mu_r \epsilon_r} = 2$

$$v = \frac{c}{n} = \frac{3 \times 10^8}{2} = 15 \times 10^7 \text{ m/s}$$

$$x = 15$$

29.  $V_m = 20 \sin [100 \pi t + \frac{\pi}{4}]$

$$V_c = 80 \sin [10^4 \pi t + \frac{\pi}{6}]$$

For amplitude modulation wave findout percentage modulation index.

Ans. 25

Sol.  $m\% = \frac{A_m}{A_c} \times 100 = \frac{20}{80} \times 100 = 25\%$

30. In AC series R-L-C resonance circuit Resistance  $R = 6.28$  ohm, frequency 10 MHz and self inductance  $L = 2 \times 10^{-4}$  Henry is given. Find Quality factor of circuit.

Ans. 2000

Sol.  $Q = \frac{X_L}{R} = \frac{\omega L}{R} = \frac{2\pi f L}{R}$

$$Q = \frac{2\pi \times 10^6 \times 10 \times 2 \times 10^{-4}}{6.28} = 2000$$

$$Q = 2000$$