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JEE (Main)

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

2021

COMPUTER BASED TEST (CBT) Memory Based Questions & Solutions

Date: 27 July, 2021 (SHIFT-2) | TIME : (3.00 p.m. to 6.00 p.m)

SUBJECT: PHYSICS

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PART : PHYSICS

1. Two masses each of mass 1 kg are separated by a distance $2R$, rotating under their mutual gravitation force. Find their angular velocity :

(1) $\frac{1}{2} \sqrt{\frac{G}{R^3}}$

(2) $\sqrt{\frac{G}{R^3}}$

(3) $\sqrt{\frac{2G}{R^3}}$

(4) $\sqrt{\frac{G}{2R^3}}$

Ans. (1)

Sol. $\frac{Gm^2}{4R^2} = m\omega^2 R$

$\sqrt{\frac{Gm}{R}}$

$$\omega = \sqrt{\frac{4\pi^2}{T^2}}$$

$$\omega = \frac{1}{2} \sqrt{\frac{G}{R^3}}$$

2. A conducting wire has resistance 16Ω at 15°C and 20Ω at 100°C . Find temperature coefficient of resistance

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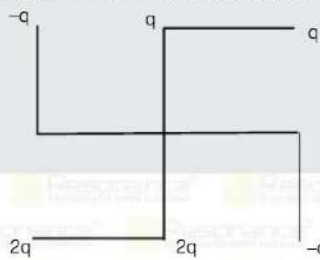
Ans. (1)

Sol. $R' = R(1 + \alpha\Delta t)$

$$20 = 16(1 + \alpha \cdot 85)$$

$$\alpha = \frac{\frac{20}{16} - 1}{85} = \frac{1}{4 \times 85} = \frac{1}{340} ^\circ\text{C}^{-1}$$

3. In the figure each side has length ℓ . Find electric field at centre :



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Ans. (3)

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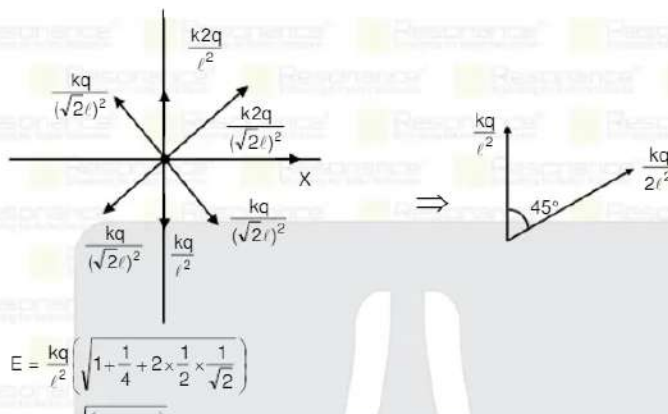
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Sol.



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4. A force $F = F_0 \left[1 - \left(\frac{T-t}{T} \right)^2 \right]$ start to act on a ball of mass m at $t = 0$. Initially ball was at rest. Find velocity of the ball at $t = 2T$:

(1) $\frac{F_0}{m} \left[\frac{4T}{3} \right]$

(2) $\frac{F_0}{m} \left[\frac{3T}{2} \right]$

(3) $\frac{F_0}{m} \left[\frac{T}{3} \right]$

(4) $\frac{F_0}{m} \left[\frac{T}{2} \right]$

Ans. (1)

Sol. acceleration of ball

$$a = \frac{F}{m}$$

$$a = \frac{F_0}{m} \left[1 - \left(\frac{T-t}{T} \right)^2 \right]$$

$$\frac{dv}{dt} = \frac{F_0}{m} \left[1 - \left(\frac{T-t}{T} \right)^2 \right]$$

$$v = \frac{F_0}{m} \left[2T + \frac{1}{3T^2} (T-t)^3 \right]_0^{2T}$$

$$v = \frac{F_0}{m} \left[2T + \frac{1}{3T^2} (T-2T)^3 \right] - \left[0 + \frac{T^3}{3T^2} \right]$$

$$v = \frac{F_0}{m} \left[\frac{4T}{3} \right]$$

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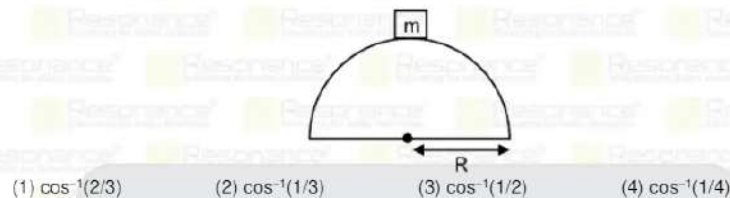
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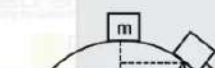
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5. A block of mass m as shown in figure is released from rest from the top of a fixed smooth hemisphere. Find the angle made by this particle with vertical at the instant when it loses contact with the hemisphere:



Ans. (1)

Sol.



From work energy theorem $W = \Delta K$

$$Mg(R - R \cos \theta) = \frac{1}{2} mv^2$$

$$v = \sqrt{2gR(1 - \cos \theta)}$$

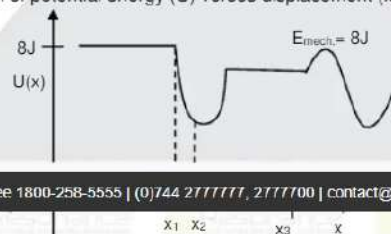
$$\text{To loose contact } \frac{mv^2}{R} = mg \cos \theta$$

$$M2g(1 - \cos \theta) = mg \cos \theta$$

$$2 - 2 \cos \theta = \cos \theta$$

$$\cos \theta = 2/3 ; \theta = \cos^{-1}(2/3)$$

6. Figure shows variation of potential energy (U) verses displacement (x) graph :



Find the correct statement :

(1) $x < x_1$, KE is least and body has constant speed.

(2) $x = x_2$, K.E is minimum

(3) $x < x_1$, K.E is maximum and velocity is maximum

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(4) $x > x_2$ K.E. is minimum so velocity is minimum
Ans. (1)
Sol. $K + U = E$ mechanical energy = constant

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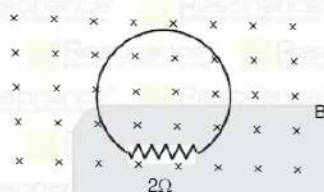
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7. Magnetic flux in a circular loop having resistance of 2Ω is varying with time as $\phi = 10t^2 + 20t$. What will be the current in circuit at $t = 5$ sec. (in Ampere)

- (1) 20 (2) 40 (3) 60 (4) 80

Ans. (3)

Sol.



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at $t = 5$ sec, $\varepsilon = 120$ V

$$\text{thus, } i = \frac{\varepsilon}{R} = \frac{120}{2} = 60 \text{ Amp.}$$

8. Match list-I with list-II and select the correct option from below the list

List-I

1. Electric field intensity (E)
2. Magnetic permeability (μ_0)
3. Electrical permittivity (ϵ_0)
4. Capacitance (C)

- (1) 1 → (ii), 2 → (iii), 3 → (iv), 4 → (i)
 (3) 1 → (iii), 2 → (iv), 3 → (ii), 4 → (i)

List-II (Dimension)

- (i) $M^{-1}L^{-2}T^{-4}$
 - (ii) $M^{-1}L^{-3}T^{-4}$
 - (iii) $ML^{-1}T^{-3}$
 - (iv) $ML^2T^{-4}I^{-2}$
- (2) 1 → (iii), 2 → (i), 3 → (iii), 4 → (ii)
 (4) 1 → (ii), 2 → (iv), 3 → (i), 4 → (iii)

Ans. (3)

9. A block of mass 1kg connected to a massless spring fixed from one end executing SHM. Initially at mean position. Its amplitude is 5 cm and time period is 0.2 sec. Find potential energy after 0.05 sec.

- (1) 1 J (2) 3 J (3) 5 J (4) 5 J

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Ans. (4)

Sol. At $t = \frac{T}{4}$ particle is at extreme. $U = K.E_{\max} = \frac{1}{2} m\omega^2 A^2$, $T = 2\pi\sqrt{\frac{m}{K}}$

$$= \frac{1}{2} m \left(\frac{2\pi}{0.2} \right)^2 A^2$$

$$= \frac{1}{2} \times 100 \pi^2 \times \frac{25}{10000} = \frac{5}{4} \text{ J}$$

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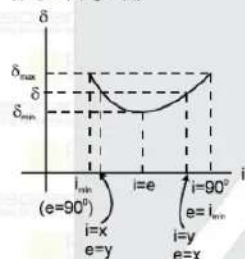
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10. Which of the following is correct graph between deviation (δ) and angle of incident 'i', if a ray of light passes through a prism :

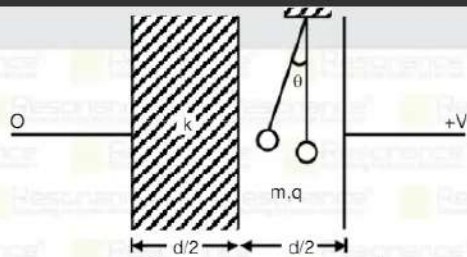


Ans. (2)

Sol. $\therefore \delta = i + e - A$.



11. Pendulum bob of mass m and charge q is hinge between the plates of a parallel plate capacitor. The first half of space between the plates is filled with dielectric of dielectric constant K and another half is vacuum,



- (1) $\tan^{-1} \frac{qvk}{(k+1)mgd}$ (2) $\tan^{-1} \frac{2qvk}{(k+1)mgd}$ (3) $\tan^{-1} \frac{3qvk}{(k+1)mgd}$ (4) $\tan^{-1} \frac{4qv(k+1)}{(k)mgd}$

Ans. (2)

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Sol. (C_{eq}) Equivalent capacitance = $\frac{c_0 A}{\frac{d}{2k} + \frac{d}{2}} = \frac{2c_0 Ak}{d(k+1)}$

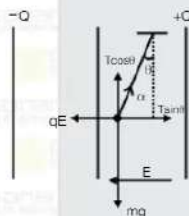
potential difference = V

charge on capacitor = $v \times C_{eq} = \frac{2c_0 AVk}{d(k+1)}$



$$\Rightarrow \text{Electric field in vacuum} = \frac{Q}{A\epsilon_0} \Rightarrow \frac{2Vk\epsilon_0 A}{d(k+1)A\epsilon_0}$$

$$E = \frac{2Vk}{d(k+1)}$$



As bob is in equilibrium

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

$$\tan\theta = \frac{q2Vk}{mgd(k+1)}$$

$$\theta = \tan^{-1}\left(\frac{2qVk}{mgd(k+1)}\right)$$

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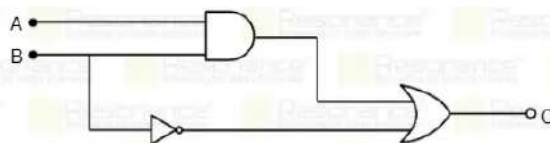
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12. For the given gate circuit, choose the correct truth table ?



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(1)	0	1	0
	1	0	1
	1	1	1
	A	B	C
	0	0	1
(3)	0	1	1
	1	0	1
	1	1	1

Ans. (3)

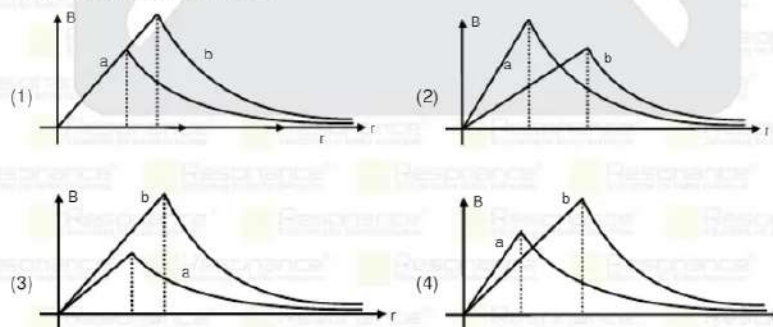
(2)	0	1	0
	1	0	1
	1	1	1
	A	B	C
	0	0	1
(4)	0	1	0
	1	0	0
	1	1	0

13. Write the approx. Value of plank's constant & permittivity constant :

- (1) 6.6×10^{-34} J-s, 8.85×10^{-12} F/m
 (2) 6.6×10^{-19} J-s, 8.85×10^{-12} F/m
 (3) 6.6×10^{-34} J-s, 9×10^9 m/F
 (4) None

Ans. (1)

of magnetic field intensity v/s r :



Ans. (2)

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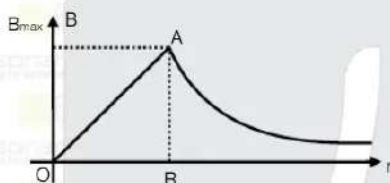
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Sol. B due to wire :

$$r < R \quad B = \frac{\mu_0 J r}{2}$$

$$\text{where } J = \frac{i}{\pi R^2}$$

$$\text{for wire of radius } b \quad J_2 = \frac{i}{\pi b^2}$$



slope of OA = J

$$B_{\max} = \frac{\mu_0 J R}{2} = \frac{\mu_0 i R}{2\pi R^2} = \frac{\mu_0 i}{2\pi R}$$

we can see slope of wire of radius a (J_1) > slope of wire of radius b (J_2)

as $b > a$ then $B_{\max}$ for $a > B_{\max}$ for b .

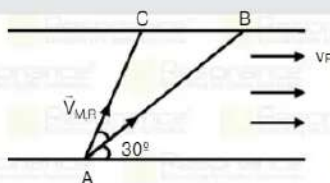
So Ans (B)

15. If Thomson model is considered and α rays are bombard on this model then, α rays will :

Ans. (3)

Sol. Theory based

16. A man crosses a river flowing with speed same as speed of man with respect to river. If man cross the river along path AB making an angle of 30° with the direction of river flow. Man starts swimming along line AC, making an angle θ with path AB. then value of θ was ?



(1) 60°

(2) 30°

(3) 45°

(4) 75°

Ans. (2)

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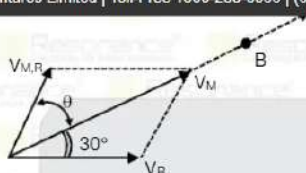


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Sol. $\vec{V}_M = \vec{V}_{MR} + \vec{V}_R$

V_M should be along line AB

$$\Rightarrow |\vec{V}_{MR}| = |\vec{V}_R|$$



$\therefore V_M$ should be along angle bisector of angle between $\vec{V}_{MR}$ and $\vec{V}_R$

$$\therefore \theta = 30^\circ$$

17. Two Carnot engines A and B are operated in series. The first one, A receives heat at T_1 ($=600$ K) and rejects to a reservoir at temperature T_2 . The second engine B receives heat rejected by the first engine and, in turn, rejects to a heat reservoir at T_3 ($=400$ K). Calculate the temperature T_2 if the work outputs of the two engines are equal :

- (1) 500 K (2) 300 K (3) 600 K (4) 400 K

Ans. (1)

Sol.



$$W = Q_1 - Q_2$$

$$W = Q_2 - Q_3$$

$$Q_1 - Q_2 = Q_2 - Q_3$$

$$Q_1 + Q_3 = 2Q_2$$

$$\frac{Q_1}{Q_2} + \frac{Q_3}{Q_2} = 2$$

$$\frac{T_1}{T_2} + \frac{T_3}{T_2} = 2 \Rightarrow T_2 = \frac{T_1 + T_3}{2} = 500 \text{ K.}$$

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18. An electron and a proton combined to form a H-atom in which electron is in 2nd excited state. From this

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- (1) 9.0 eV (2) 3.1 eV (3) 7.1 eV (4) 13.6 eV

Ans. (1)

Sol. $E = 13.6 \left[\frac{1}{n_1^2} - \frac{1}{n_2^2} \right] \text{ eV}$

$$E = 13.6 \left[\frac{1}{1} - \frac{1}{(3)^2} \right]$$

$$E = 13.6 \left[\frac{8}{9} \right] = 12.1 \text{ eV}$$

$$KE_{\max} = E - \frac{hc}{\lambda_0} = 12.1 - \frac{12400}{4000} \text{ eV}$$

$$= 12.1 - 3.1 \text{ eV} = 9.0 \text{ eV}$$

19. Rain drops are falling vertically on earth with speed of 20m/s. Now wind start blowing horizontally with speed of 5m/s and a cyclist is moving with speed of 35 m/s opposite to the wind. Then find the velocity of rain with which rain hitting the cyclist.

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Ans. (3)

Sol. $V_{RQ} = V_{RW} + V_{WQ}$

$$= -20\hat{j} + 5\hat{i}$$

$$V_{\text{rain, cy}} = V_{\text{rain}} - V_{\text{cy}}$$

$$= -20\hat{j} + 5\hat{i} - 35(-\hat{i}) = -20\hat{j} + 40(\hat{i})$$

$$V_{\text{rain, cy}} = \sqrt{20^2 + 40^2} = 20\sqrt{5} \text{ m/s}$$

20. A beaker filled to the height of 12 cm was given, find the location where a hole should be made for max range.



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Ans. 6

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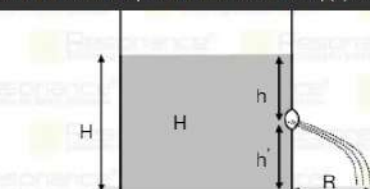
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R is maximum when $h' = h$

$$\therefore h' = h = H/2$$

$$= 12/2 = 6$$

21. A particle performing SHM is given by $x = A \sin(\omega t + \phi)$. At $t = 0$, particle is at $x = 2$ and its velocity is 2ω then find amplitude :

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

Ans. (1)

Sol. $2 = A \sin(0 + \phi)$

$$\Rightarrow \sin \phi = \frac{2}{A}$$

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$$\Rightarrow \cos \phi = \sqrt{1 - \frac{4}{A^2}} = \sqrt{\frac{A^2 - 4}{A^2}}$$

$$V = \frac{dx}{dt}$$

$$V = A\omega \cos(\omega t + \phi)$$

$$\Rightarrow 2\omega = A\omega \cos(0 + \phi)$$

$$\Rightarrow 2 = A \cos \phi$$

$$\Rightarrow A = \frac{2}{\cos \phi} \dots \dots \dots (i)$$

$$\Rightarrow A = \frac{2}{\sqrt{\frac{A^2 - 4}{A^2}}}$$

$$\Rightarrow A = \frac{2A}{\sqrt{A^2 - 4}}$$

$$\Rightarrow \sqrt{A^2 - 4} = 2$$

$$\Rightarrow A = \pm \sqrt{8}$$

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22. A body of mass m at rest starts moving along straight line by a machine delivering a constant power.

Distance travelled by body in time t is :

- (1) $\frac{4\sqrt{2p}}{3} \times t^{3/2}$ (2) $\frac{2\sqrt{2p}}{3} \times t^{3/2}$ (3) $\frac{\sqrt{2p}}{3} \times t^{3/2}$ (4) $2\sqrt{3\frac{2p}{m}} \times t^{3/2}$

Ans. (2)

Sol. Energy supply = Pt

in t sec

$$Pt = \frac{1}{2}mv^2$$

$$v = \sqrt{\frac{2pt}{m}}$$

$$\frac{dS}{dt} = \sqrt{\frac{2p}{m}} \sqrt{t}$$

$$S = \frac{2\sqrt{2p}}{3} t^{3/2}$$

$$t^{3/2} = \frac{3S}{2\sqrt{2p}}$$

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$$S = \frac{2\sqrt{2p}}{3} \times t^{3/2}$$

23. In a communication, a message signal of amplitude 4 V is modulated with carrier signal of amplitude 12V, then find modulation index.

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

Ans. (2)

$$\therefore m = \frac{A_{\max} - A_{\min}}{A_{\max} + A_{\min}} = \frac{16 - 8}{16 + 8} = \frac{8}{24} = \frac{1}{3}$$

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24. 1 moles of an ideal gas undergoes adiabatic process, which increases the temperature from 27°C to 37°C. Gas is polyatomic has 4 vibrational modes of freedom. Find net work :

- (1) Work done by the gas 528 J (2) Work done on the gas 582 J
(3) Work done on the gas 382 J (4) Work done by the gas 382 J

Ans. (2)

Sol. $f = 3 + 3 + (4 \times 2)$

$$f = 14$$

$$W = \frac{P_1 V_1 - P_2 V_2}{\gamma - 1} = \frac{nR(T_1 - T_2)}{\gamma - 1}$$

$$= \frac{1 \times 8.314 \times (-10)}{\left(\frac{8}{7} - 1\right)} \left(\because \gamma = 1 + \frac{2}{f} = \frac{8}{7}\right)$$

$$= -582 \text{ J}$$

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