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

JEE (Main) 2020

COMPUTER BASED TEST (CBT)

Memory Based Questions & Solutions

Date: 07 January, 2020 (SHIFT-1) | TIME : (9.30 a.m. to 12.30 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT : PHYSICS

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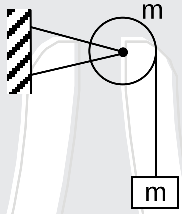
PART : PHYSICS

Straight Objective Type (सीधे वस्तुनिष्ठ प्रकार)

This section contains **20 Single choice questions.** Each question has 4 choices (1), (2), (3) and (4) for its answer, out of which **Only One** is correct.

इस खण्ड में **20 एकल विकल्पी प्रश्न** हैं। प्रत्येक प्रश्न के 4 विकल्प (1), (2), (3) तथा (4) हैं, जिनमें से **सिर्फ एक सही** है।

1. A block of mass m is suspended from a pulley in form of a circular disc of mass m & radius R. The system is released from rest, find the angular velocity of disc when block has dropped by height h. (there is no slipping between string & pulley)



(1) $\frac{1}{R}\sqrt{\frac{4gh}{3}}$ (2) $\frac{1}{R}\sqrt{\frac{2gh}{3}}$ (3) $R\sqrt{\frac{2gh}{3}}$ (4) $R\sqrt{\frac{4gh}{3}}$

Ans. **(1)**

Sol. $mgh = \frac{1}{2}mv^2 + \frac{1}{2}I\omega^2$

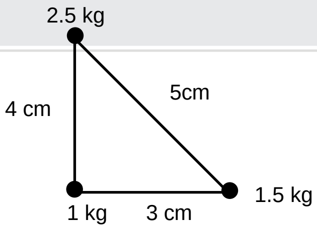
$v = \omega R$ (no slipping)

$mgh = \frac{1}{2}m\omega^2R^2 + \frac{1}{2}\frac{mR^2}{2}\omega^2$

$mgh = \frac{3}{4}m\omega^2R^2$

$\omega = \sqrt{\frac{4gh}{3R^2}} = \frac{1}{R}\sqrt{\frac{4gh}{3}}$

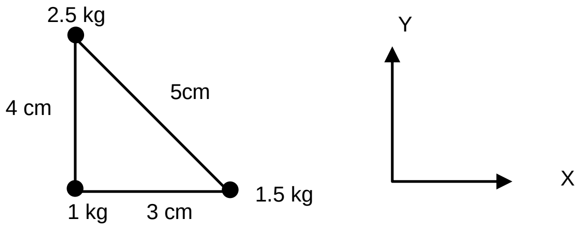
2. Three point masses 1kg, 1.5 kg, 2.5 kg are placed at the vertices of a triangle with sides 3cm,4cm and 5cm as shown in the figure. The location of centre of mass with respect to 1kg mass is :



(1) 0.6 cm to the right of 1 kg and 2 cm above 1 kg mass
(2) 0.9 cm to the right of 1kg and 2 cm above 1 kg mass
(3) 0.9 cm to the left of 1kg and 2 cm above 1kg mass
(4) 0.9 cm to the right of 1 kg and 1.5 cm above 1kg mass

Ans. **(2)**

Sol. Take 1kg mass at origin



$$X_{cm} = \frac{1\times0+1.5\times3+2.5\times0}{5} = 0.9\text{cm}$$

$$Y_{cm} = \frac{1\times0+1.5\times0+2.5\times4}{5} = 2\text{cm}$$

3. In a single slit diffraction set up, second minima is observed at an angle of 60°. The expected position of first minima is

(1) 25° (2) 20° (3) 30° (4) 45°

Ans. **(1)**

Sol. For 2nd minima

d sinθ = 2λ

$\sin\theta = \frac{\sqrt{3}}{2}$ (given)

$\Rightarrow \quad \frac{\lambda}{d} = \frac{\sqrt{3}}{4}$ … (i)

So for 1st minima is

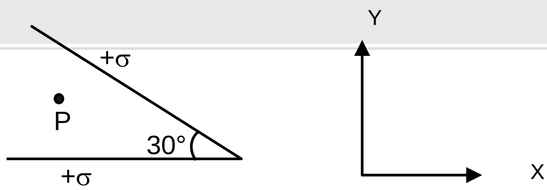
d sinθ = λ

$\sin\theta = \frac{\lambda}{d} = \frac{\sqrt{3}}{4}$ (from equation (i))

θ = 25.65° (from sin table)

$\theta \approx 25°$

4. There are two infinite plane sheets each having uniform surface charge density +σ C/m². They are inclined to each other at an angle 30° as shown in the figure. Electric field at any arbitrary point P is:

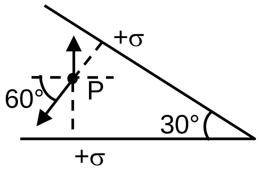


(1) $\frac{\sigma}{2\varepsilon_0}\left[\left(1-\frac{\sqrt{3}}{2}\right)\hat{y}-\frac{1}{2}\hat{x}\right]$ (2) $\frac{\sigma}{2\varepsilon_0}\left[\left(1+\frac{\sqrt{3}}{2}\right)\hat{y}-\frac{1}{2}\hat{x}\right]$

(3) $\frac{\sigma}{2\varepsilon_0}\left[\left(1-\frac{\sqrt{3}}{2}\right)\hat{y}+\frac{1}{2}\hat{x}\right]$ (4) $\frac{\sigma}{2\varepsilon_0}\left[\left(1+\frac{\sqrt{3}}{2}\right)\hat{y}+\frac{1}{2}\hat{x}\right]$

Ans. **(1)**

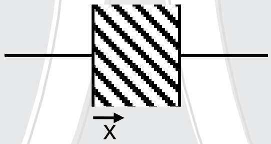
Sol.



$$\vec{E} = \frac{\sigma}{2\varepsilon_0}\cos 60°(-\hat{x}) + \left[\frac{\sigma}{2\varepsilon_0} - \frac{\sigma}{2\varepsilon_0}\sin 60°\right](\hat{y})$$

$$\vec{E} = \frac{\sigma}{2\varepsilon_0}\left[\left(1 - \frac{\sqrt{3}}{2}\right)\hat{y} - \frac{1}{2}\hat{x}\right]$$

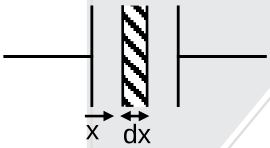
5. A parallel plate capacitor with plate area A & plate separation d is filled with a dielectric material of dielectric constant given by $k = k_0(1 + \alpha x)$. Calculate capacitance of system: (given $\alpha d << 1$).



(1) $\frac{k_0\varepsilon_0 A}{d}(1+\alpha^2 d^2)$ (2) $\frac{k_0\varepsilon_0 A}{d}\left(1+\frac{\alpha d}{2}\right)$ (3) $\frac{k_0\varepsilon_0 A}{2d}(1+\alpha d)$ (4) $\frac{k_0\varepsilon_0 A}{2d}\left(1+\frac{\alpha d}{2}\right)$

Ans. **(2)**

Sol. Capacitance of element = $\frac{k\varepsilon_0 A}{dx}$



Capacitance of element, C' = $\frac{k_0(1+\alpha x)\varepsilon_0 A}{dx}$

$$\sum \frac{1}{C'} = \int_0^d \frac{dx}{k_0\varepsilon_0 A(1+\alpha x)}$$

$$\frac{1}{C} = \frac{1}{k_0\varepsilon_0 A\alpha}\ell n(1+\alpha d)$$

Given $\alpha d << 1$

$$\frac{1}{C} = \frac{1}{k_0\varepsilon_0 A\alpha}\left(\alpha d - \frac{\alpha^2 d^2}{2}\right)$$

$$\frac{1}{C} = \frac{d}{k_0\varepsilon_0 A}\left(1 - \frac{\alpha d}{2}\right)$$

$$C = \frac{k_0\varepsilon_0 A}{d}\left(1 + \frac{\alpha d}{2}\right)$$

6. A long solenoid of radius R carries a time dependent current $I = I_0 t(1 - t)$. A ring of radius 2R is placed coaxially near its centre. During the time interval $0 \le t \le 1$, the induced current I_R and the induced emf V_R in the ring vary as:

(1) current will change its direction and its emf will be zero at t = 0.25sec.
(2) current will not change its direction & emf will be maximum at t = 0.5sec
(3) current will not change direction and emf will be zero at 0.25sec.
(4) current will change its direction and its emf will be zero at t = 0.5sec.

Ans. **(4)**

Sol. $I = I_0 t - I_0 t^2$

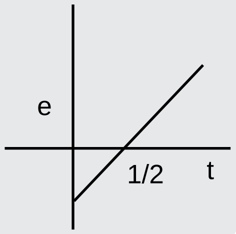
$\phi = BA$

$\phi = \mu_0 n I A$

$V_R = -\dfrac{d\phi}{dt} = -\mu_0 n A I_0 (1 - 2t)$

$V_R = 0$ at $t = \dfrac{1}{2}$

and $I_R = \dfrac{V_R}{\text{Resistance of loop}}$



7. If 10% of intensity is passed from analyser, then, the angle by which analyser should be rotated such that transmitted intensity becomes zero. (Assume no absorption by analyser and polarizer).

(1) 60° (2) 18.4° (3) 45° (4) 71.6°

Ans. (B)

Sol. $I = I_0 \cos^2\theta$

$\dfrac{I_0}{10} = I_0 \cos^2\theta$

$\cos\theta = \dfrac{1}{\sqrt{10}} = 0.31$

$\theta = 71.6°$

angle rotated should be = 90° – 71.6° = 18.4°

8. Three moles of ideal gas A with $\dfrac{C_P}{C_V} = \dfrac{4}{3}$ is mixed with two moles of another ideal gas B with $\dfrac{C_P}{C_V} = \dfrac{5}{3}$.

The $\dfrac{C_P}{C_V}$ of mixture is (Assuming temperature is constant)

(1) 1.5 (2) 1.42 (3) 1.7 (4) 1.3

Ans. **(2)**

Sol. $\gamma_{\text{mixture}} = \dfrac{n_1C_{P_1} + n_2C_{P_2}}{n_1C_{V_1} + n_2C_{V_2}} = \dfrac{n_1\dfrac{\gamma_1 R}{\gamma_1 - 1} + n_2\dfrac{\gamma_2 R}{\gamma_2 - 1}}{\dfrac{n_1R}{\gamma_1 - 1} + \dfrac{n_2R}{\gamma_2 - 1}}$

on rearranging we get,

$\dfrac{n_1 + n_2}{\gamma_{mix} - 1} = \dfrac{n_1}{\gamma_1 - 1} + \dfrac{n_2}{\gamma_2 - 1}$

$\dfrac{5}{\gamma_{mix} - 1} = \dfrac{3}{1/3} + \dfrac{2}{2/3}$

$\dfrac{5}{\gamma_{mix} - 1} = 9 + 3 = 12$

$\Rightarrow \gamma_{mixure} = \dfrac{17}{12} = 1 + \dfrac{5}{12}$

$\gamma_{mix} = 1.42$

9. Given magnetic field equation is $B = 3 \times 10^{-8} \sin(\omega t + kx + \phi)\ \hat{j}$

then appropriate equation for electric field (E) will be :

(1) $20 \times 10^{-9} \sin(\omega t + kx + \phi)\ \hat{k}$

(2) $9 \sin(\omega t + kx + \phi)\ \hat{k}$

(3) $16 \times 10^{-9} \sin(\omega t + kx + \phi)\ \hat{k}$

(4) $3 \times 10^{-9} \sin(\omega t + kx + \phi)\ \hat{k}$

Ans. **(2)**

Sol. $\dfrac{E_0}{B_0}$ = C (speed of light in vacuum)

$E_0 = B_0C = 3 \times 10^{-8} \times 3 \times 10^{8}$

$= 9$ N/C

So $E = 9 \sin(\omega t + kx + \phi)$

10. There is a LCR circuit , If it is compared with a damped oscillation of mass m oscillating with force constant k and damping coefficient 'b'. Compare the terms of damped oscillation with the devices in LCR circuit.

(1) $L \to m$, $C \to \dfrac{1}{k}$, $R \to b$

(2) $L \to m$, $C \to k$, $R \to b$

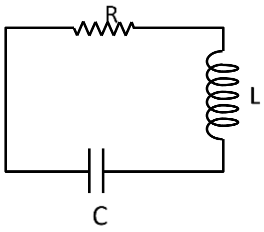
(3) $L \to k$, $C \to b$, $R \to m$

(4) $L \to \dfrac{1}{m}$, $C \to \dfrac{1}{k}$, $R \to \dfrac{1}{b}$

Ans. **(1)**

Sol. In damped oscillation

$ma + bv + kx = 0$



$m\dfrac{d^2x}{dt^2} + b\dfrac{dx}{dt} + kx = 0$ ...(i)

In the circuit

$$-iR - L\frac{di}{dt} - \frac{q}{c} = 0$$

$$L\frac{d^2q}{dt^2} + R\frac{dq}{dt} + \frac{1}{c}.q = 0 \quad ...(ii)$$

Comparing equation (i) and (ii)

$$m = L,\ b = R,\ k = \frac{1}{c}$$

11. A lift can hold 2000kg, friction is 4000N and power provided is 60HP. (1 HP = 746W) Find the maximum speed with which lift can move up.

(1) 1.9 m/s (2) 1.7 m/s (3) 2 m/s (4) 1.5 m/s

Ans. **(1)**

Sol. $4000 \times V + mg \times V = P$

$$\frac{60 \times 746}{4000 + 20000} = V$$

$V = 1.86$ m/s. ≈ 1.9 m/s.

12. A H–atom in ground state has time period $T = 1.6 \times 10^{-16}$ sec. find the frequency of electron in first excited state

(1) 7.8×10^{14} (2) 7.8×10^{16} (3) 3.7×10^{14} (4) 3.7×10^{16}

Ans. **(1)**

Sol. $T \propto \frac{r}{v} \propto \frac{n^2}{z} \times \frac{n}{z} \propto \frac{n^3}{z^2}$

$$\frac{T_1}{T_2} = \frac{n_1^3}{n_2^3} = \frac{1}{8}$$

$T_2 = 8T_1$

$= 8 \times 1.6 \times 10^{-16} = 12.8 \times 10^{-16}$

$$f_2 = \frac{1}{12.8 \times 10^{-16}} \approx 7.8 \times 10^{14}$$

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