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JEE (MAIN) 2024

MEMORY BASED QUESTIONS & SOLUTIONS

SHIFT-2

DATE & DAY: 31st January 2024 & Wednesday

PAPER-1

Duration: 3 Hrs.
Time: 03:00 PM - 06:00 PM

SUBJECT: PHYSICS

REGISTERED & CORPORATE OFFICE (CIN: U80302RJ2007PLC024029):
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PART : PHYSICS

1. By what percent will the illumination (Power) of lamp decreases if the current drops by 20%. if resistance of the lamp is assumed to be constant

(1) 12% (2) 24% (3) 36% (4) 48%

Ans. **(3)**

Sol. $P_1 = I^2R$

$P_2 = (0.8I)^2R = 0.64I^2R$

$P_2 = 0.64\ P_1$

% drop of Power $= \frac{P_2 - P_1}{P_1} \times 100 = \frac{(0.64-1)P_1}{P_1} \times 100$

$= -0.36 \times 100$

$= 36\%$ drop

2. Mass of the moon is (1/144) times mass of a planet. Its diameter is 1/16 times diameter of the planet. If the escape velocity from the surface of planet is V, then the escape velocity from surface of moon will be-

(1) $\frac{V}{3}$ (2) $\frac{V}{2}$ (3) $\frac{V}{6}$ (4) $\frac{V}{8}$

Ans. **(1)**

Sol. $V_e\sqrt{\frac{2GM}{R}}$, $\frac{V_{moon}}{V_{planet}} = \frac{\sqrt{\frac{2GM_m}{R_m}}}{\sqrt{\frac{2GM_p}{R_p}}} = \sqrt{\frac{M_m}{M_p}}\sqrt{\frac{R_p}{R_m}}$

$\Rightarrow \frac{V_{moon}}{V} = \sqrt{\frac{1}{144}}\sqrt{\frac{16}{1}} \Rightarrow V_{moon} = \frac{4}{12}V = \frac{V}{3}$

3. The speed of sound in oxygen at STP will be approximately? (Given R = 8.3 J/mol K and $\gamma = 1.4$)

(1) 320 (2) 315 (3) 330 (4) 325

Ans. **(2)**

Sol. At STP T = 273 K

$V = \sqrt{\frac{\gamma RT}{M}}$ (Speed of sound)

$V = \sqrt{\frac{1.4 \times 8.3 \times 273}{32 \times 10^{-3}}} = 314.5$ m/s

4. Force on a 2 kg particle varies with time as $\vec{F} = 6t\hat{i} - 6t^2\hat{j}$. Particle start from rest. Find power delivered by the force as a function of time.

(1) $9t^3 + 4t^5$ (2) $9t^3 + 6t^5$ (3) $6t^2 + 3t^4$ (4) $4t^2 + 6t^3$

Ans. **(2)**

Sol. $\vec{F} = 6t\hat{i} - 6t^2\hat{j}$

$\Rightarrow \vec{a} = \frac{\vec{F}}{m} = 3t\hat{i} - 3t^2\hat{j}$ (m = 2kg)

$\Rightarrow \frac{d\vec{v}}{dt} = 3t\hat{i} - 3t^2\hat{j}$

$\Rightarrow \int_0^{\vec{v}} d\vec{v} = \frac{3t^2}{2}\hat{i} - t^3\hat{j}\Big|_0^t$

$\Rightarrow \vec{v} = \frac{3t^2}{2}\hat{i} - t^3\hat{j}$

$P = \vec{F} \cdot \vec{v}$

$\Rightarrow P = ((6t\hat{i} - 6t^2\hat{j}) \cdot \left(\frac{3t^2}{2}\hat{i} - t^3\hat{j}\right)$

$P = 9t^3 + 6t^5$

5. If in the given expression, $E = \frac{b - x^2}{at}$, where E represents energy, x represents length and t represents

time Then, find dimension of $\frac{a}{b}$.

(1) $M^{-1}L^{-2}T$ (2) $M^{-1}L^{-2}T^{-1}$ (3) $M^{-1}L^{-2}T^{-2}$ (4) $M^{-1}L^{2}T$

Ans. **(1)**

Sol. $E=\frac{b}{at}-\frac{x^2}{at} \Rightarrow [E]=\left[\frac{b}{at}\right]=\left[\frac{x^2}{at}\right]$

$[E]=\left[\frac{x^2}{at}\right] \Rightarrow \left[ML^2T^{-2}\right] = \frac{\left[L^2\right]}{[a][T]}$

$\Rightarrow [a]=\frac{\left[ML^2T^{-2}\right][T]}{\left[L^2\right]}=\left[MT^{-1}\right]$

$\Rightarrow [E] = \frac{[b]}{\left[MT^{-1}\right][T]} \Rightarrow [b]=\left[ML^2T^{-2}\right]\left[MT^{-1}\right][T]$

$[b]=\left[M^2L^2T^{-2}\right]$

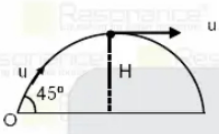
$\left[\frac{a}{b}\right]=\frac{\left[MT^{-1}\right]}{\left[M^2L^2T^{-2}\right]}=M^{-1}L^{-2}T$

6. A particle is projected at an angle 45° with horizontal with speed u. Find the angular momentum of particle about the point of projection at the time when it reaches maximum height.

(1) $\frac{mu^3}{4g}$ (2) $\frac{mu^3}{4\sqrt{2}g}$ (3) $\frac{mu^3}{2\sqrt{2}g}$ (4) $\frac{\sqrt{2}mu^3}{4g}$

Ans. **(2)**

Sol.



$u\cos 45° = \frac{u}{\sqrt{2}}$

$H=\frac{u^2\sin^2\theta}{2g}=\frac{u^2}{4g}$

Angular momentum = mvH $\Rightarrow m\frac{u}{\sqrt{2}}.\frac{u^2}{4g}=\frac{mu^3}{4\sqrt{2}g}$

7. 3 moles of oxygen gas and 2 moles of argon gas are mixed together. If the total internal energy of mixture is xRT. Find the value of x.

(1) $\frac{19}{2}$ (2) 10 (3) 11 (4) $\frac{21}{2}$

Ans. **(4)**

Sol. For oxygen n = 3 mol

f_1 = 5 (D.O.F)

U_1 (internal energy) = $\frac{f_1}{2}nRT=\frac{5}{2}\times nRT=\frac{15}{2}RT$

for argon

n = 2 moles

f_2 = 3 (D.O.F)

$U_2=\frac{f_2}{2}nRT=\frac{3}{2}\times 2RT=\frac{6}{2}RT$

Total internal energy of mixture = $U_1 + U_2$

$=\frac{15}{2}RT+\frac{6}{2}RT=\frac{21}{2}RT$

$x=\frac{21}{2}$

8. Magnetic flux passing through a loop of resistance 8Ω is given by $\phi = 5t^2 - 3t + 5$. Find current in the loop at t = 2second.

(1) 1.125 A (2) 2.25 A (3) 4.25 A (4) 2.125 A

Ans. **(4)**

Sol. $\varepsilon = -\frac{d\phi}{dt}$

$= -\frac{d}{dt}(5t^2 - 3t + 5)$

$\varepsilon = -(10t - 3)$

at t = 2sec.

$\varepsilon = -(10 \times 2 - 3) = -17$

$i = \frac{\varepsilon}{R} = \frac{17}{8}$ Ampere

i = 2.125 Ampere

9. A nucleus x has mass number 192 and there is a second nucleus y having radius half of radius of x. Find mass number of y nucleus.

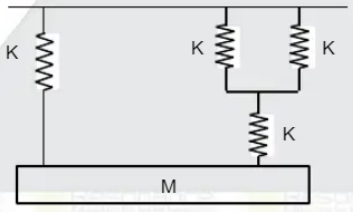
(1)18 (2) 24 (3) 12 (4) 14

Ans. **(2)**

Sol. $\frac{R_x}{R_y} = \frac{R_0(192)^{\frac{1}{3}}}{R_0(A)^{\frac{1}{3}}}$

on solving A = 24

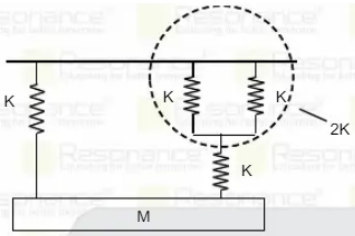
10. The period of oscillation of system shown below is $\pi\sqrt{\frac{am}{5k}}$ then a is ___



(1) 4 (2) 12 (3) 16 (4) 8

Ans. **(2)**

Sol.

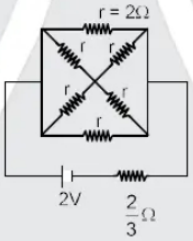


$K_{eq} = \frac{2k}{3} + k = \frac{5k}{3}$

$T(\text{Time period}) = 2\pi\sqrt{\frac{M}{k_{eq}}} = \pi\sqrt{\frac{12M}{5k}}$

$a = 12$

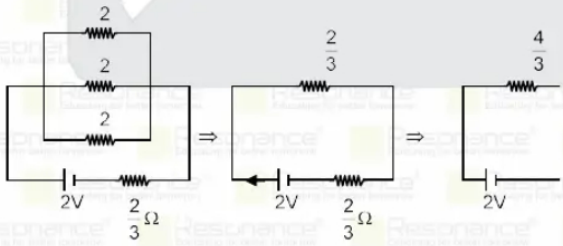
11. In the given figure, find the power delivered by the battery



(1) 1 W (2) 2 W (3) 5 W (4) 3 W

Ans. **(4)**

Sol.



$P = \frac{V^2}{R} = \frac{(2)^2}{(4/3)} = \frac{4}{4} \times 3$

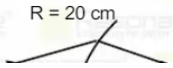
$P = 3$ watt

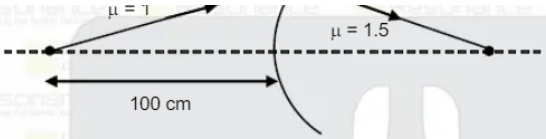
12. A point object is placed in air at 100 cm from a convex spherical refractive surface having radius of curvature 20 cm and refractive index on other side is $\mu = 1.5$. Find image distance

(1) 75 cm (2) 100 cm (3) 200 cm (4) 50 cm

Ans. **(2)**

Sol.





$$\frac{\mu_2}{V}-\frac{\mu_1}{u}=\frac{\mu_2-\mu_1}{R}$$

$$\Rightarrow \frac{1.5}{V}-\frac{1}{(-100)}=\frac{1.5-1}{20}$$

$$\Rightarrow \frac{1.5}{V}+\frac{1}{100}=\frac{1}{40} \Rightarrow \frac{1.5}{V}=\frac{1}{40}-\frac{1}{100}$$

$$\Rightarrow \frac{1.5}{V}=\frac{5-2}{200} \Rightarrow \frac{1.5}{V}=\frac{3}{200}$$

$$\Rightarrow V=\frac{200\times 1.5}{3}$$

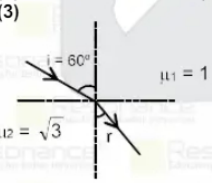
$$\Rightarrow V = 100 \text{ cm}$$

13. Unpolarised light from air is incident on transparent glass at incident angle 60º. If reflected ray is completely polarized, then angle of refraction is -

(1) 15° (2) 60° (3) 30° (4) 45°

Ans. **(3)**

Sol.



$\mu = \tan i$ (Brewster's law)

$\mu_2 = \tan 60^\circ = \sqrt{3}$

$\mu_1 \sin i = \mu_2 \sin r$ – (Snell's law)

$1 \times \sin 60^\circ = \sqrt{3} \sin r$

$$\frac{\sqrt{3}}{2}=\sqrt{3}\sin r \Rightarrow \sin r=\frac{1}{2}$$

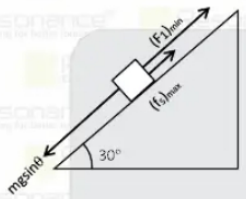
$r = 30^\circ$

14. Find the difference between minimum force required to prevent the block from sliding down and minimum force required to just push it up the plane. The inclined plane is at 30° from horizontal and mass of the block is 5 Kg (use μ= 0.1, g=10m/s^2)

(1) $5\sqrt{3}$ N (2) $2\sqrt{3}$ N (3) 5 N (4) 8 N

Ans. **(1)**

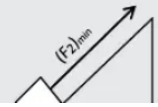
Sol.

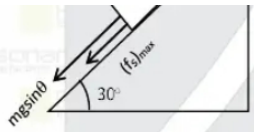


$(F_1)_{min} + (f_s)_{max} = mg\sin\theta$

$(F_1)_{min} + \mu mg\cos\theta = mg\sin\theta$

$(F_1)_{min} = mg\sin\theta - \mu mg\cos\theta$





$(F_2)_{min} = (f_s)_{max} + mg\sin\theta$

$(F_2)_{min} = \mu mg\cos\theta + mg\sin\theta$

$\because (F_2)_{min} - (F_1)_{max} = 2\mu mg\cos\theta$

$= 2 \times 0.1 \times 5 \times 10 \times \cos 30°$

$= 5\sqrt{3}$ Newton

15. **Statement-1 :** E.M. waves posses energy.

Statement-2 : When E.M. Waves strike a surface they apply pressure on it.

(1) Both statements are true

(2) Both statements are false

(3) Statement-1 is true and statement-2 is false

(4) Statement-1 is false and statement-2 is true

Ans. **(1)**

Sol. Theory Based

16. Two vector of equal magnitude A are inclined at an angle θ with each other. Find the magnitude of resultant vector

(1) $2A\cos\left(\frac{\theta}{2}\right)$ (2) $2A\sin\left(\frac{\theta}{2}\right)$ (3) $2A\cos\theta$ (4) $2A\sin\theta$

Ans. **(1)**

Sol.

$|\text{Resultant}| = \sqrt{A^2 + A^2 + 2A^2\cos\theta}$

$= \sqrt{2A^2 + 2A^2\cos\theta}$

$= \sqrt{2}A\sqrt{1+\cos\theta}$

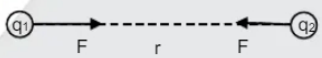
$= 2A\cos\left(\frac{\theta}{2}\right)$

17. The force between two charged particle separated by a distance 'r' when placed in air is F. If these charges are immersed in a medium of dielectric constant K = 5. Then find the separation between them to keep the force same.

(1) $\frac{r}{\sqrt{3}}$ (2) $\sqrt{5}r$ (3) $\sqrt{3}r$ (4) $\frac{r}{\sqrt{5}}$

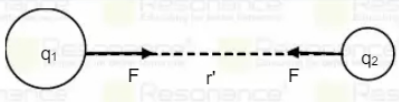
Ans. **(4)**

Sol. Case – I : In air



$F = \frac{q_1 q_2}{4\pi\varepsilon_0 r^2}$ (Electrostatic force)

Case -2 : In medium (K = 5)



$q_1 q_2$ $q_1 q_2$

$$F = \frac{[illegible]}{4\pi\varepsilon_0 K \times r'^2} = \frac{[illegible]}{4\pi\varepsilon_0 \times 5r'^2}$$

$$5r'^2 = r^2$$

$$r' = \frac{r}{\sqrt{5}}$$

18. Length of a pendulum is 20 cm and error in its measurement is 2mm. If it completes 50 oscillations in 40 sec. and time was measured by a watch of resolution 1 sec. Find % error in calculation of acceleration due to gravity

(1) 8 % (2) 4 % (3) 2 % (4) 6 %

Ans. **(4)**

Sol. $T = 2\pi\sqrt{\frac{\ell}{g}} \quad \left[T = \frac{40}{50} = \frac{4}{5}s\right]$

$$g = \frac{4\pi^2\ell}{T^2}$$

$$\frac{\Delta g}{g} \times 100\% = \frac{\Delta \ell}{\ell} \times 100\% + 2\frac{\Delta T}{T} \times 100\%$$

$$\frac{\Delta g}{g} \times 100\% = \left(\frac{0.2}{20}\right) \times 100 + 2 \times \frac{1}{40} \times 100$$

$$\frac{\Delta g}{g} \times 100\% = 6\%$$

19. A nucleus has mass number A_1 and volume V_1. Another nucleus has mass number A_2 and volume V_2 If relation between mass number is $A_2 = 4A_1$ then find V_2

(1) 2 V_1 (2) 8 V_1 (3) 4V_1 (4) V_1

Ans. **(3)**

Sol. $r = r_0(A)^{\frac{1}{3}}$

$$V_1 = \frac{4}{3}\pi r^3 = \frac{4}{3}\pi\left(r_0(A_1)^{\frac{1}{3}}\right)^3 = \frac{4}{3}\pi(r_0)^3 A_1$$

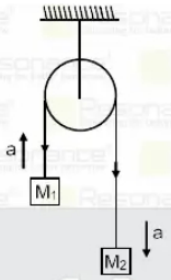
$$V_2 = \frac{4}{3}\pi\left(r_0(A_2)^{\frac{1}{3}}\right)^3 = \frac{4}{3}\pi r_0^3 A_2$$

$A_2 = 4A_1$ (given)

$$V_2 = \frac{4}{3}\pi r_0^3(4A_1) = 4V_1$$

$V_2 = 4V_1$

20. In the given pulley block system



given a = g/8

find the ratio of $\frac{M_1}{M_2} = ?$

(1) $\frac{7}{8}$ (2) $\frac{5}{7}$ (3) $\frac{9}{7}$ (4) $\frac{7}{9}$

Ans. **(4)**

Sol. $a = \frac{(M_2 - M_1)}{M_1 + M_2} g$

$\frac{g}{8} = \frac{(M_2 - M_1)}{M_1 + M_2} \times g$

$M_1 + M_2 = 8M_2 - 8M_1$

$\frac{M_1}{M_2} = \frac{7}{9}$

21. The frequency of incident light is equal to threshold frequency for the metal surface υ_{th}. When frequency is halved and intensity is doubled then the number of photo electrons will be

(1) Doubled

(2) halved

(3) Will remain same

(4) Photo electrons will not be emitted

Ans. **(4)**

Sol. electrons will not release below the reshold frequency $\upsilon < \upsilon_{th}$

Here, $\upsilon = \frac{\upsilon_{th}}{2}$

22. Find average power in electric circuit if source voltage V=20 sin (100 t) & current in the circuit is i = 2 sin(100t+π/3)

(1) 5 W (2) 10 W (3) $5\sqrt{3}$ W (4) $10\sqrt{3}$ W

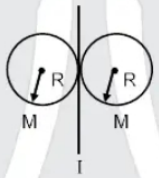
Ans. **(2)**

Sol. $P_{avg} = \frac{i_m V_m}{2} \cos\phi = \frac{20 \times 2}{2} \times \cos \pi/3$

$= 20 \times \frac{1}{2} = 10$ W

$= 20 \times \frac{1}{2} = 10$ W

23. Two solid spheres each of mass 2 kg and radius 75 cm are arranged as shown. Find moment of inertia of the system about the gives axis shown.



(1) $\frac{63}{20}$ kg.m^2 (2) $\frac{126}{30}$ kg.m^2 (3) $\frac{7}{5}$ kg.m^2 (4) $\frac{9}{7}$ kg.m^2

Ans. **(1)**

Sol. $I = 2(MR^2) + 2\left(\frac{2}{5}MR^2\right)$

$I = \frac{14MR^2}{5}$

$I = \frac{14}{5} \times 2 \times \left(\frac{3}{4}\right)^2$

$I = \frac{28}{5} \times \frac{9}{16}$

$I = \frac{63}{20}$ kg.m^2

24. A resistor of 25Ω is in left side with resistor x on the right side. Resistance per unit length is r and now the resistance per unit length is changed by 2r. Find the change in balance position, If the earlier balanced position was 40 cm from the left side.

(1) Does not shift

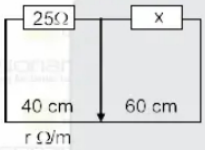
(2) Shift by 10 cm right

(3) Shift by 20 cm right

(4) Shift by 10 cm left

Ans. **(1)**

Sol.



Given bridge balanced.

when r is change by 2r balance condition does not change became resistance ratio for balanced bridge will match.