VIDYAPEETH ACADEMY
SINCE 2013
IIT JEE | NEET | FOUNDATION

Head Office: 2nd Floor, Grand Plaza, Fraser Road, Dak Bunglow, Patna - 01

JEE Main 2023 (Memory based)

31 January 2023 - Shift 2

Answer & Solutions

PHYSICS

1. Match the radiation listed in column-I with their uses listed in column-II correctly.

Column-I	Column-II
A) UV rays	P) Physiotherapy
B) Infra Red rays	Q) Treatment of cancer
C) X-Rays	R) Lasik eye surgery
D) Microwave rays	S) Aircraft navigation

A. $A-S,\ B-P, C-R, D-Q$
B. $A-R,\ B-P, C-Q, D-S$
C. $A-Q,\ B-P, C-S, D-R$
D. $A-R,\ B-P, C-S, D-Q$

Answer (B)

Solution:

UV rays are used for Lasik eye surgery.
IR is used for physiotherapy.
X-Rays are used for cancer treatment.
And Microwaves are used for aircraft navigation.

2. During an adiabatic process performed on a diatomic gas $725\,J$ of work is done on the gas. The change in internal energy of the gas is equal to

A. $495\,J$
B. $725\,J$
C. $225\,J$
D. $Zero$

Answer (B)

Solution:

For adiabatic process, $Q = 0$
So,
$\Delta U + W = 0$
Work done on gas will be negative
$\Delta U - 725 = 0 \Rightarrow \Delta U = 725\,J$

3. Two balls are projected with equal speed $(40\ m/s)$, one at an angle of $30°$ and other at $60°$ with horizontal. Find the ratio of maximum heights of both the balls.

A. $1/4$
B. $3/1$
C. $1/3$
D. $4/1$

Answer (C)

Solution:

Maximum height of projectile can be given as:

$$H_{max} = \frac{u^2 \sin^2 \theta}{2g}$$

Ratio of Maximum heights for same velocity:

$$Ratio = \frac{\sin^2 30°}{\sin^2 60°} = \frac{1}{3}$$

4. Find ionization energy of 2^{nd} excited state of Li^{2+}. It is given that ionization energy of ground state of hydrogen atom is $13.6\ eV$.

A. $20.4\ eV$
B. $27.2\ eV$
C. $6.8\ eV$
D. $13.6\ eV$

Answer (D)

Solution:

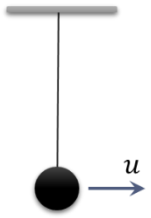
For Li^{+2} ion in 2^{nd} excited state, $Z = 3\ and\ n = 3$.

Ionisation energy can be calculated as:

$$E = 13.6(3)^2\left[\frac{1}{3^2} - 0\right] = 13.6\ eV$$

5. A ball of mass $1\ kg$ is hanging from $1\ m$ long inextensible string which can withstand maximum tension of $400\ N$. Find the maximum speed u that should be given to the ball.

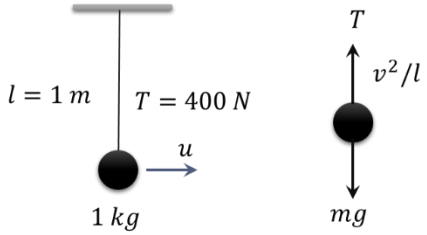
A. $\sqrt{390}\ m/s$
B. $\sqrt{410}\ m/s$
C. $20\ m/s$
D. $22\ m/s$



Answer (A)

Solution:

$$T = mg + m\left(\frac{v^2}{l}\right)$$
$$400 = 10 + v^2/1$$
$$v = \sqrt{390}\ m/s$$



6. Match the physical quantities given in Column−I with the physical dimensions in column-II

Column-I	Column-II
(A) Torque	$(P)\ ML^{-1}T^{-2}$
(B) Stress	$(Q)\ ML^{2}T^{-2}$
(C) Pressure Gradient	$(R)\ ML^{-2}T^{-2}$
(D) Angular momentum	$(S)\ ML^{2}T^{-1}$

A. $A-S,\ B-P, C-R, D-Q$
B. $A-Q,\ B-P, C-R, D-S$
C. $A-P,\ B-S, C-R, D-Q$
D. $A-Q,\ B-P, C-S, D-R$

Answer (B)

Solution:

$$[\tau] = [r][F] = [L][MLT^{-2}] = [ML^2T^{-2}]$$
$$[Stress] = \frac{[F]}{[A]} = \frac{[MLT^{-2}]}{[L^2]} = [ML^{-1}T^{-2}]$$
$$[Pressure\ Gradient] = [P]/[Z] = \frac{[ML^{-1}T^{-2}]}{[L]} = [ML^{-2}T^{-2}]$$
$$[Angular\ Momentum] = [\tau][t] = [ML^2T^{-2}][T] = [ML^2T^{-1}]$$

7. A lens of refractive index 1.5 and focal length $15\ cm$ in air is submerged in water. Change in focal length of lens is $(\mu = 4/3)$

A. $45\ cm$
B. $60\ cm$
C. $30\ cm$
D. $10\ cm$

Answer (A)

Solution:

When lens is placed in air,

$$\frac{1}{f} = \left(\frac{\mu_2}{\mu_1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right)$$
$$\frac{1}{15} = \left(\frac{1.5}{1} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \ldots\ldots (1)$$

When submerged in water $(\mu = 4/3)$

$$\frac{1}{f'} = \left(\frac{1.5}{4/3} - 1\right)\left(\frac{1}{R_1} - \frac{1}{R_2}\right) \ldots\ldots (2)$$

Diving equation (1) and (2)

$$\frac{f'}{15} = \left(\frac{0.5 \times 4}{0.5}\right) \Rightarrow f' = 60\ cm$$

$$\Delta f = f' - f = 60 - 15 = 45\ cm$$

8. In a moving coil galvanometer, number of turns in the coil are increased to increase the current sensitivity by 50%. Find percentage change in voltage sensitivity.

A. $-50\ \%$
B. $50\ \%$
C. No change
D. 25%

Answer (C)

Solution:

Current sensitivity:
$\frac{\theta}{I} = \frac{nAB}{K}$

Voltage sensitivity $= \frac{naB}{KR}$

As current sensitivity increases by 50% so, number of turns increases by $50\ \%$

Resistance increases by $50\ \%$

Therefore, voltage sensitivity remains constant.

9. The equation of two simple harmonic motions are given by $y_1 = 10\sin\left(\omega t + \frac{\pi}{3}\right)$ and $y_2 = 5\left[\sin(\omega t) + \sqrt{3}\cos(\omega t)\right]$. The amplitude of resultant $\mathrm{S.H.M.}$ is

A. $10\ m$
B. $20\ m$
C. $5\ m$
D. $15\ m$

Answer (B)

Solution:

$y_1 = 10\sin\left(\omega t + \frac{\pi}{3}\right)$
$y_2 = 5\left[\sin(\omega t) + \sqrt{3}\cos(\omega t)\right] = 10\,sin\left(\omega t + \frac{\pi}{3}\right)$
Resultant of the SHM
$y_{resultant} = y_1 + y_2$
$= 10\sin\left(\omega t + \frac{\pi}{3}\right) + 10\sin\left(\omega t + \frac{\pi}{3}\right)$
$= 20\sin\left(\omega t + \frac{\pi}{3}\right)$
Amplitude $= 20\ m$

10. A body has weight W on the surface of earth. Find the weight at a height $9\ times$ the radius of earth.

A. $W/100$
B. $W/81$
C. $W/64$
D. $W/121$

Answer (A)

Solution:

$W = \frac{GM_e m}{R_e^2}$ ……(1)

$W' = \frac{GM_e m}{(R_e + 9R_e)^2}$ ……(2)

From (1) and (2),

$W' = \frac{W}{100}$

11. A wire is first coiled in n circular turns and current I is run through it. Now the same wire is coiled in N circular turns and same current I is run through it. If B_1 and B_2 are the magnetic field at centre of two coil respectively then $\frac{B_1}{B_2}$ is equal to

A. $\sqrt{\frac{n}{N}}$
B. $\left(\frac{n}{N}\right)^2$
C. $\frac{n}{N}$
D. $\frac{n^3}{N^3}$

Answer (B)

Solution:

Let the length of wire is l,

Radius of the first coil $R_1 = \frac{l}{2\pi n}$

Radius of the second coil $R_2 = \frac{l}{2\pi N}$

$B_1 = \frac{\mu_0 nI}{2R_1} = \frac{\mu_0 nI}{\frac{2l}{2\pi n}} = \frac{\mu_0 \pi n^2 I}{l}$

$B_2 = \frac{\mu_0 NI}{2R_2} = \frac{\mu_0 NI}{\frac{2l}{2\pi N}} = \frac{\mu_0 \pi N^2 I}{l}$

$\frac{B_1}{B_2} = \left(\frac{n}{N}\right)^2$

12. For a medium, it is given that: Young's modulus $= 3.2 \times 10^{10}\ N/m^2$, Density $= 8000\ kg/m^3$. Find the speed of sound in this medium.

A. $1000\ m/s$
B. $2000\ m/s$
C. $500\ m/s$
D. $4000\ m/s$

Answer (B)

Solution:

$v_s = \sqrt{\frac{Y}{\rho}}$

$= \sqrt{\frac{3.2 \times 10^{10}}{8000}}$

$= 2000\ m/s$

13. When current of $4\ Amperes$ is made to run through a resistance of $R\ ohms$ for $10\ seconds$, it produces heat energy of $H\ units$. Now if $16\ Amperes$ of current is made to flow through same resistance for $10\ seconds$ then heat energy produced will be:

A. $16\ H$
B. $4\ H$
C. $8\ H$
D. $2\ H$

Answer (A)

Solution:

$H = i^2Rt = 4^2 \times R \times 10 = 160R$
$H' = I^2Rt = 16^2 \times R \times 10 = 2560R = 16H$

14. Across an inductor of $5mH$, an AC source with potential given as $268\sin(200\pi t)$ volts is used. The value of inductive reactance provided by inductor is equal to

A. $2\pi\ \Omega$
B. $\pi/2\ \Omega$
C. $20\pi\ \Omega$
D. $\pi\ \Omega$

Answer (D)

Solution:

$\chi_L = \omega L = 200\pi \times 5 \times 10^{-3} = \pi\ \Omega$

15. In a series RLC circuit, $R = 80\ \Omega$, $\mathrm{X_L} = 100\ \Omega$, $\mathrm{X_C} = 40\ \Omega$. If the source voltage is $2500\cos(628t)\ Volts$, Find peak current $(in\ Amperes)$

Answer (25)

Solution:

$Z = \sqrt{R^2 + (X_L - X_c)^2}$
$= \sqrt{80^2 + (100 - 40)^2}$
$= 100\ \Omega$

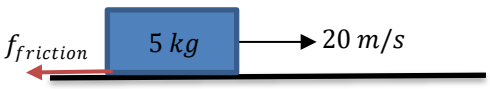
$\Rightarrow I_0 = \frac{V_0}{Z} = \frac{2500}{100}\ A\ = 25\ A$

16. A body moving horizontally has an initial speed of $20\ m/s$. Due to friction, body stops after $5\ sec$. If mass of body is $5\ kg$, coefficient of friction is $x/5$. Find x. (Take $g = 10\ m/s^2$)

Answer (0.4)

Solution:

$u = 20m/s$
$t = 5\ s$
$f_{friction} = \mu mg$
$a = \frac{f_{friction}}{m} = -\mu g$
$v = u + at = 20 + (-\mu g)(5)$
$0 = 20 - 50\mu$
$\mu = 0.4$

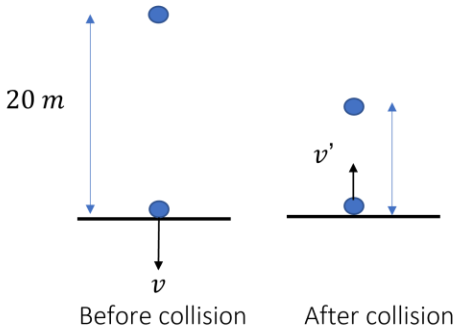


17. A ball was dropped from $20\ m$ height from ground. Find the height $(in\ m)$ up to which it rises after the collision. (Use $e = \frac{1}{2},\ g = 10\ m/s^2$)

Answer (5)

Solution:

$$h = \frac{v^2}{2g}$$
$$v' = ev$$
$$h' = \frac{(v')^2}{2g} = \frac{e^2v^2}{2g} = e^2h = 0.5^2 \times 20 = \frac{20}{4} = 5\ m$$
$$h' = 5\ m$$



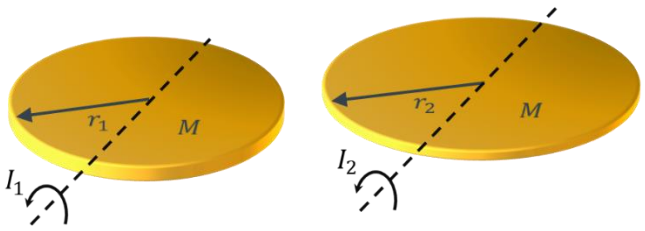
18. Two discs of same mass, radii $r_1,\ r_2$, thickness $1\ mm$ and $0.5\ mm$, have densities in the ratio $3:1$. the ratio of their moment of inertia about diameter is $1:x$. Find x.

Answer (6)

Solution:

Mass of both disc is equal:

So, $M_1 = M_2$
$$\pi r_1^2 h_1 \rho_1 = \pi r_2^2 h_2 \rho_2$$
$$r_1^2 \times \frac{h_1}{h_2} \times \frac{\rho_1}{\rho_2} = r_2^2$$
$$\Rightarrow r_1^2 \times 2 \times \frac{\rho_1}{\rho_2} = r_2^2$$
$$\Rightarrow \frac{r_1^2}{r_2^2} = \frac{\rho_2}{2\rho_1} = \frac{1}{6} \qquad \left(\therefore \frac{\rho_2}{\rho_1} = \frac{1}{3}\right)$$



Ratio of MOI:

$$\frac{\frac{1}{4}Mr_1^2}{\frac{1}{4}Mr_2^2} = \frac{r_1^2}{r_2^2} = \frac{1}{6}$$

19. Two wavelengths $\lambda_1 = 600\ nm$ and $\lambda_2 = 800\ nm$ are used in a $YDSE$ experiment. Their maxima coincide at certain locations on the screen. Find the minimum separation $(in\ mm)$ between such a location and central maxima. It is given that $d = 0.35\ mm$ and $D = 7\ m$.

Answer (48)

Solution:

$$n_1 \times \frac{\lambda_1 D}{d} = n_2 \times \frac{\lambda_2 D}{d}$$
$$\Rightarrow 6n_1 = 8n_2$$
$$\Rightarrow Maximum, n_1 = 4 \ \ and\ n_2 = 3$$

So, first coincidence is the 4^{th} maxima of $\lambda = 600\ nm$ with third maxima of wavelength $800\ nm$

$$Min.separation = 4 \times \frac{600\ nm \times 7\ m}{0.35\ mm} = 48 \times 10^{-3}\ m \Rightarrow Min.separation = 48\ mm$$

20. A particle is in uniform circular motion with time period $4\ s$ and radius $\sqrt{2}\ m$. Find the magnitude of displacement $(in\ m)$ is $3\ s$.

Answer (2)

Solution:

$$\theta = \frac{3}{4} \times 2\pi = \frac{3\pi}{2}$$
$$\Rightarrow |Displacement| = \sqrt{2}\, R = 2\, m$$