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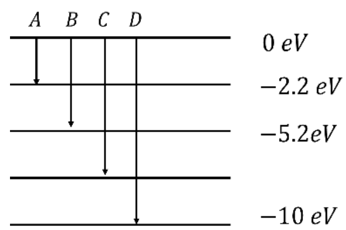
JEE Main 2023 (Memory based)

25 January 2023 - Shift 2

Answer & Solutions

PHYSICS

1. The diagram shown represents different transitions of electron (A, B, C, D) between the energy level with energies mentioned. Among the shown transitions which transition will generate photon of wavelength $124.1\ nm.(hc = 1241\ eVnm)$.



A. A
B. B
C. C
D. D

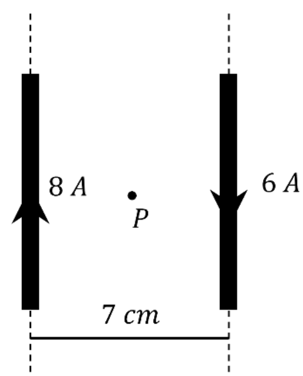
Answer (D)

Solution:

$$\Delta \mathrm{E} = \frac{\mathrm{hc}}{\lambda} = \frac{1241}{124.1} = 10eV$$

Only option D has energy to produce this wavelength.

2. Two straight wires placed parallel to each other are carrying currents as shown. P is equidistant from the wires. Find the magnetic field at point P.



A. $8 \times 10^{-5}\ T$
B. $8 \times 10^{-7}\ T$
C. $16 \times 10^{-5}\ T$
D. $2 \times 10^{-5}\ T$

Answer (A)

Solution:

$$B_{net} = \frac{\mu_0 i_1}{2\pi r_1} + \frac{\mu_0 i_2}{2\pi r_2}$$

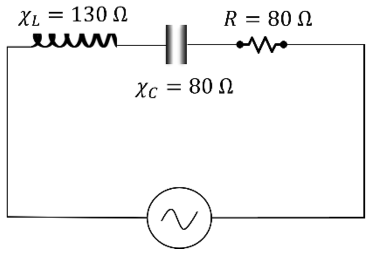
$$= \frac{2 \times 10^{-7}}{3.5 \times 10^{-2}}[8 + 6]\ T$$

$$= \frac{2 \times 10^{-7} \times 14}{3.5 \times 10^{-2}}\ T$$

$$= 8 \times 10^{-5}\ T$$

3. For a LCR series circuit $\chi_L = 130\ \Omega$, $\chi_C = 80\ \Omega$ and $R = 80\ \Omega$. The value of power factor of the circuit is equal to:

A. $\sqrt{54}/9$
B. $8/\sqrt{89}$
C. $8/13$
D. $7/9$

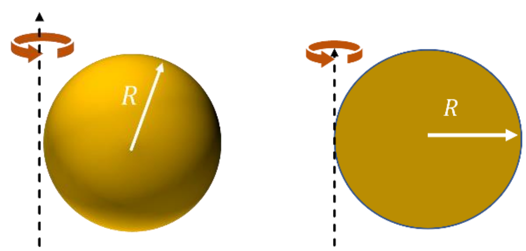


Answer (B)

Solution:

$$\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{(\chi_L - \chi_C)^2 + R^2}}$$
$$\cos\phi = \frac{80}{\sqrt{(130-80)^2 + 80^2}}$$
$$\cos\phi = \frac{80}{\sqrt{2500 + 6400}} = \frac{8}{\sqrt{89}}$$

4. A disk & a solid sphere of same radius are rotated as show in the figure. If masses of disk & solid sphere are $4\ kg$ & $5kg$ respectively then $\frac{I_{disc}}{I_{solid\ sphere}} =$



A. $7/5$
B. $25/28$
C. $5/7$
D. $28/25$

Answer (C)

Solution:

Using parallel axis theorem,

$$I_{Solid\ sphere} = \left(\frac{2}{5}mR^2 + mR^2\right)$$
$$(m = 5\ Kg)$$
$$= \left(\frac{7}{5}mR^2\right) = 7R^2$$

$$I_{disc} = \left(\frac{1}{4}mR^2 + mR^2\right)$$
$$(m = 4\ Kg)$$
$$= \left(\frac{5}{4}mR^2\right) = 5R^2$$

5. Two projectiles are thrown at an angle of projection α and β with the horizontal. If $\alpha + \beta = 90°$ then ratio of range of two projectiles on horizontal plane is equal to

A. $1:1$
B. $2:1$
C. $1:2$
D. $1:3$

Answer (A)

Solution:

Range of the first projectile

$$R_1 = \frac{u^2 \sin 2\alpha}{g}$$

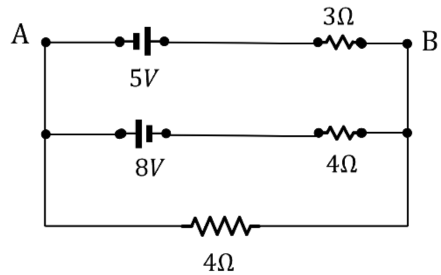
Range of the Second projectile

$$R_2 = \frac{u^2 \sin 2\beta}{g} = \frac{u^2 \sin 2(90-\alpha)}{g} = \frac{u^2\, sin\, 2\alpha}{g}$$

So, $R_1 = R_2$

$R_1 : R_2 = 1:1$

6. In the circuit shown , the current $(in\ A)$ through the 4Ω resistor connected across A & B is $\frac{1}{n}$ Amperes. Find n



Answer (10)

Solution:

For the equivalent cell of the combination

$$r_{eq} = \frac{3\times 4}{3+4} = \frac{12}{7}\ \Omega$$

$$E_{eq} = \left(\frac{8}{4} - \frac{5}{3}\right) \times \frac{12}{7}\ V = \frac{4}{7}\ V$$

Current in the external $4\ \Omega$ resistor

$$I = \frac{E_{eq}}{r_{eq}+4} = \frac{4}{7\left(\frac{12}{7}+4\right)} = \frac{1}{10}\ A$$

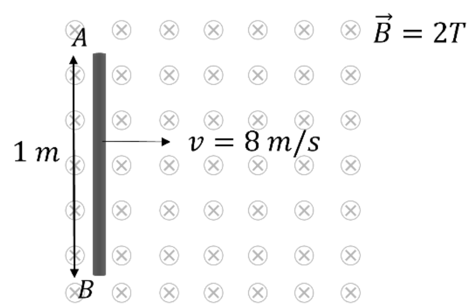
$n = 10$

7. A metal rod of length $1\ m$ is moving perpendicular to its length with $8\ m/s$ velocity along positive x –axis. If a magnetic field $B = 2T$ exist perpendicular to the plane of motion. Find the emf induced between the 2 end of rod.

Answer (16)

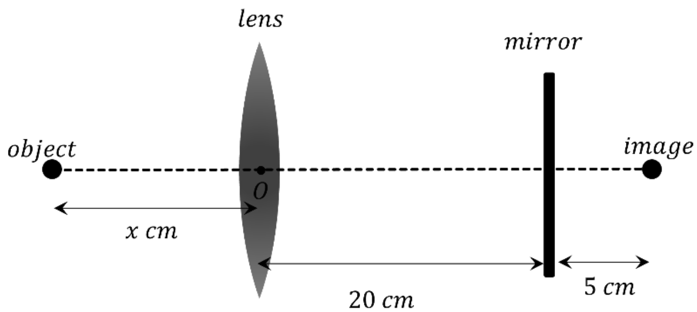
Solution:

$$|V_A - V_B| = Bvl$$
$$= 2 \times 8 \times 1$$
$$= 16\ V$$



8. In the arrangement shown. The image shown is formed after refraction from lens and reflection from mirror. If the

focal length of lens is $10\ cm$, find x.



Answer (30)

Solution:

Image formed by mirror I is $5\ cm$ behind the mirror

$$r_{eq} = \frac{3 \times 4}{3+4} = \frac{12}{7}\ \Omega$$

Image formed by lens I_{lens} must be $5\ cm$ in front of the mirror

For the lens,

$u = -x\ cm\ v = 15\ cm\ f = 10\ cm$

$$\frac{1}{v} - \frac{1}{u} = \frac{1}{f}$$

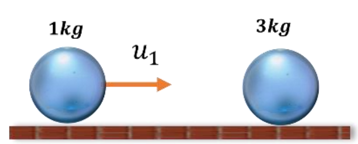
$$\Rightarrow \frac{1}{15} - \frac{1}{-x} = \frac{1}{10}$$

$\Rightarrow x = 30$

9. A particle of mass $1\ kg$ is moving with a velocity towards a stationary particle of mass $3\ kg$. After collision, the lighter particle returns along same path with speed $2\ m/s$. If the collision was elastic, then speed of $1\ kg$ particle before collision is ______________ m/s.

Answer (4)

Solution:



Before collision

$m_1 = 1\ kg$ and $m_2 = 3kg$

Conserving linear momentum

$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$

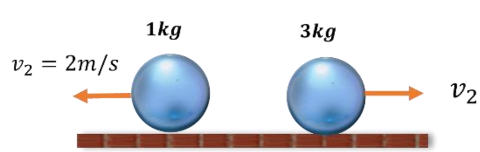
$u_1 + 0 = 2 + 3v_2$ -------------(1)

For elastic collision

$$e = \frac{velocity\ of\ separation}{velocity\ of\ approach} = 1$$

$$\Rightarrow \frac{v_1 + v_2}{u_1} = 1$$

$\Rightarrow 2 + v_2 = u_1$ ------------(2)



After collision

From (1) and (2)

$u_1 = 4\ m/s$

10. A wire with resistance $5\ \Omega$ is redrawn to increase its length 5 times. What is the final resistance of the wire?

A. $25\ \Omega$
B. $16\ \Omega$
C. $125\ \Omega$
D. $32\ \Omega$

Answer (C)

Solution:

Resistance of wire can be given as:

$R = \frac{\rho l}{A} = 5\ \Omega$

Volume is constant So,

$l_0 A_0 = 5 l_0 A$

$A = \frac{A_0}{5}$

$R' = \rho \frac{5 l_0}{A_0/5} = \frac{25 \rho l_0}{A_0} = 25\ R = 125\ \Omega$

11. Find the velocity of the particle if the position of the particle is given by $x = 2t^2$ at $t = 2\ sec$.

A. $8\ m/s$
B. $4\ m/s$
C. $16\ m/s$
D. $32\ m/s$

Answer (A)

Solution:

Given: $x = 2t^2$

$\frac{dx}{dt} = 4t$

$v = 4t$

v (at $t = 2\ s$) $= 8\ m/s$

12. A particle performing SHM with amplitude A starts from $x = 0$ and reaches $x = A/2$ in $2\ s$. Find the time required for the particle to go from $x = A/2$ to $x = A$.

A. $1.5\ s$
B. $4\ s$
C. $6\ s$
D. $1\ s$

Answer (B)

Solution:

Let equation of SHM be: $x = A \sin\left(\frac{2\pi}{T} t\right)$

Time to go from $x = 0\ to\ \ x = A/2$

$t_1 = \frac{T}{12}$

Time to go from $x = A/2\ to\ \ x = A$

$t_2 = \frac{T}{4} - \frac{T}{12} = \frac{T}{6}$

$\frac{t_2}{t_1} = 2 \Rightarrow t_2 = 2 \times 2\ s = 4\ s$

13. An object of mass m is placed at a height R_e from the surface of the earth. Find the increase in potential energy of the object if the height of the object is increased to $2R_e$ from the surface. (R_e: $Radius\ of\ the\ earth$)

A. $\frac{1}{3}mgR_e$

B. $\frac{1}{6}mgR_e$

C. $\frac{1}{2}mgR_e$

D. $\frac{1}{4}mgR_e$

Answer (B)

Solution:

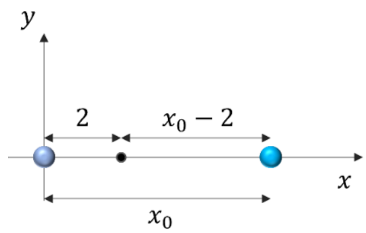
$$U_i = -\frac{GM_e m}{R_e + R_e}$$
$$U_f = -\frac{GM_e m}{R_e + 2R_e}$$
$$\Delta U = U_f - U_i = \frac{GM_e m}{6R_e} = \frac{mgR_e}{6}$$

14. A charge of $10\ \mu C$ is placed at origin. Where should a charge of $40\ \mu C$ be placed on $x -$ axis such that electric field is zero at $x = 2$.

A. $x = -2$
B. $x = 4$
C. $x = 6$
D. $x = 2$

Answer (C)

Solution:



For electric field to be zero:

$$\frac{1}{4\pi\epsilon_0} \times \frac{10}{2^2} = \frac{1}{4\pi\epsilon_0} \times \frac{40}{(x_0 - 2)^2}$$
$$x_0 - 2 = 4$$
$$x_0 = 6$$

15. What will be the molar specific heat capacity of an isochoric process of a diatomic gas if it has additional vibrational mode?

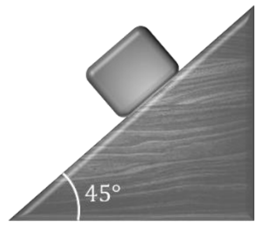
A. $\frac{5}{2}R$
B. $\frac{3}{2}R$
C. $\frac{7}{2}R$
D. $\frac{9}{2}R$

Answer (C)

Solution:

For each additional vibrational mode degree of freedom is increased by 2 so new degree of freedom
$f = 3 + 2 + 2 = 7$
$C_V = \frac{f}{2} \times R = \frac{7}{2} R$
Volume is constant in isochoric process.

16. A block is placed on a rough inclined plane with $45°$ inclination. If minimum force required to push the block up the incline is equal to 2 times the minimum force required to slide the block down the inclined plane, then find the value of coefficient of friction between block and incline.



A. 0.25
B. 1
C. 2
D. 3

Answer (B)

Solution:

$F_{up} = mg \sin\theta + \mu mg \cos\theta$

$F_{down} = \mu mg \cos\theta - mg \sin\theta$

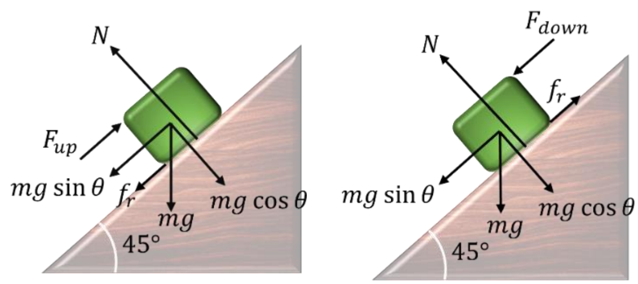
$F_{up} = 2F_{down}$

$mg \sin\theta + \mu mg \cos\theta = 2(\mu mg \cos\theta - mg \sin\theta)$

$3 \sin\theta = \mu \cos\theta$

$\mu = 3 \tan\theta$

$\mu = 3 \tan 45° = 1$



17. Correctly match the two lists:

List I	List II
Physical Quantity	**Dimensions**
P. Young's Modulus	A. $[ML^2T^{-1}]$
Q. Planck's Constant	B. $[ML^{-1}T^{-2}]$
R. Work function	C. $[ML^{-1}T^{-1}]$
S. Co-efficient of viscosity	D. $[ML^2T^{-2}]$

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

Answer (B)

Solution:

$$[Young's\ Modulus] = \frac{\left[\frac{F}{A}\right]}{\left[\frac{\Delta L}{L}\right]} = [ML^{-1}T^{-2}]$$

$$[Planck's\ Constant] = \frac{[E]}{[f]} = [ML^2T^{-1}]$$

$$[Work\ function] = [ML^2T^{-2}]$$

$$[Co-efficient\ of\ Viscosity] = [ML^{-1}T^{-1}]$$

18. A big drop is divided into 1000 identical droplets. If the big drop had surface energy U_i and all small droplets together had a surface energy U_f, then $\frac{U_i}{U_f}$ is equal to

A. $1/100$
B. 10
C. $1/10$
D. 1000

Answer (C)

Solution:

Volume will remain constant in the process.

$$\frac{4}{3}\pi R^3 = 1000 \times \frac{4}{3}\pi r^3 \Rightarrow R = 10r$$

Surface energy of big drop,

$$U_i = 4\pi R^2 T$$

Surface energy of all the small drops,

$$U_f = 1000 \times 4\pi r^2 T = 40\pi R^2 T$$

Taking the ratio, we get,

$$\frac{U_i}{U_f} = \frac{4\pi R^2 T}{40\pi R^2 T} = \frac{1}{10}$$

19. Correctly match the two lists

List I	List II
a. Gauss law (electrostatics)	$P. \oint \vec{B}.d\vec{A} = 0$
b. Amperes circuital law	$Q. \oint \vec{B}.d\vec{l} = \mu_o i_{inclosed}$
c. Gauss law (Magnetism)	$R. \oint \vec{E}.d\vec{A} = \frac{q_{in}}{\epsilon_o}$
d. Faraday's law	$S. \epsilon = -\frac{d\phi_B}{dt}$

A. $a \to R,\ b \to Q,\ c \to S, d \to P$
B. $a \to R,\ b \to Q,\ c \to P, d \to S$
C. $a \to R,\ b \to S,\ c \to Q, d \to P$
D. $a \to R,\ b \to S,\ c \to P, d \to Q$

Answer (B)

Solution:

Gauss law (electrostatics)= $\oint \vec{E}.d\vec{A} = \frac{q_{in}}{\epsilon_o}$

Amperes circuital law= $\oint \vec{B}.d\vec{l} = \mu_o i_{inclosed}$

Gauss law (Magnetism)= $\oint \vec{B}.d\vec{A} = 0$

Faraday's law, $\epsilon = -\frac{d\phi_B}{dt}$

20. A stationary nucleus breaks into two daughter nuclei having velocities in the ration $3:2$. find the radius of their nuclear sizes.

A. $\left(\frac{2}{3}\right)^{1/2}$

B. $\left(\frac{2}{3}\right)^{1/3}$

C. $\left(\frac{4}{9}\right)^{1/3}$

D. $\left(\frac{9}{4}\right)^{1/2}$

Answer (B)

Solution:

Applying momentum conservation:

$m_1 v_1 = m_2 v_2$

$\frac{m_1}{m_2} = \frac{v_2}{v_1} = \frac{2}{3} \dots\dots\dots (1)$

As nuclear density is constant:

$$\frac{m_1}{m_2} = \frac{V_1}{V_2} = \frac{\frac{4}{3}\pi r_1^3}{\frac{4}{3}\pi r_2^3} = \left(\frac{r_1}{r_2}\right)^3 \dots\dots (2)$$

From (1) and (2):

$$\frac{r_1}{r_2} = \left(\frac{2}{3}\right)^{1/3}$$

21. Match the two lists:

List I	List II
P. Adiabatic process	A. No work done by or on gas.
Q. Isochoric process	B. Some amount of heat given is converted into internal energy.
R. Isobaric process	C. No heat exchange.
S. Isothermal process	D. No change in internal energy.

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

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

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

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

Answer (C)

Solution:

Adiabatic ⇒ $\Delta Q = 0$

Isochoric⇒ $W = 0$

Isothermal⇒ $\Delta U = 0$

Isobaric⇒ $\Delta Q = \Delta U + W$ (Both ΔU and W are non-zero