PHYSICS

SECTION - A

Multiple Choice Questions: This section contains 20 multiple choice questions. Each question has 4 choices (1), (2), (3) and (4), out of which **ONLY ONE** is correct.

Choose the correct answer:

1. A wire with resistance 5 ohms is redrawn to increase its length 5 times. What is the final resistance of the wire?

(1) 25 Ω (2) 16 Ω

(3) 125 Ω (4) 32 Ω

Answer (3)

Sol. $R = \rho\frac{l_0}{A_0} = 5\ \Omega$

Volume is constant so

$l_0A_0 = 5l_0A$

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

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

$= 25R$

$= 125\ \Omega$

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

(1) 8 m/s (2) 4 m/s

(3) 16 m/s (4) 32 m/s

Answer (1)

Sol. $x = 2t^2$

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

$v = 4t$

v at $t = 2$ sec = 8 m/s

3. A particle performing SHM with amplitude A starts from $x = 0$ and reaches $x = \frac{A}{2}$ in 2 s. Find time required for the particle to go from $x = \frac{A}{2}$ to $x = A$?

(1) 1.5 s (2) 4 s

(3) 6 s (4) 1 s

Answer (2)

Sol. $x = A\sin(\omega t)$

For $x = \frac{A}{2}$

$\Rightarrow \frac{A}{2} = A\sin(\omega t)$

$\omega t = \frac{\pi}{6}$

$t = \left(\frac{\pi}{6\omega}\right) = 2\text{ s} \Rightarrow \frac{\pi}{\omega} = 12\text{ s}$

When $x = A$, $= A\sin(\omega t)$

$\omega t = \frac{\pi}{2}$

$t = \left(\frac{\pi}{2\omega}\right) = \frac{1}{2}\times 12\text{ s} = 6\text{ s}$

Time taken from $\frac{A}{2}$ to $A = 6 - 2 = 4$ second.

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

(1) $\frac{1}{3}mgR_e$ (2) $\frac{1}{6}mgR_e$

(3) $\frac{1}{2}mgR_e$ (4) $\frac{1}{4}mgR_e$

Answer (2)

Sol. $U_i = -\frac{GM_em}{2R_e}$

$U_f = -\frac{GM_em}{3R_e}$

$\Delta U = U_f - U_i = \frac{GM_em}{6R_e}$

$= \frac{mgR_e}{6}$

5. A charge of 10 μC is placed at origin. Where should a charge of 40 μC be placed on x-axis such that electric field is zero at $x = 2$?

(1) $x = -2$ (2) $x = 4$

(3) $x = 6$ (4) $x = 2$

Answer (3)

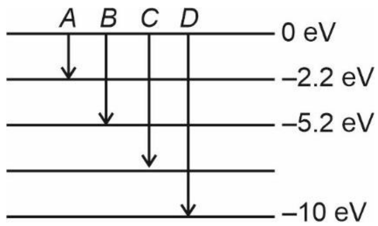
Sol. $E = 0$

$\Rightarrow \frac{1}{4\pi\varepsilon_0}\frac{10}{2^2} = \frac{1}{4\pi\varepsilon_0}\frac{40}{(x_0-2)^2}$

$\Rightarrow x_0 - 2 = 4$

$\Rightarrow x_0 = 6$

6. The diagram shown represents different transitions of electron (A, B, C, D) between the energy levels with energies mentioned along. Among the shown transitions which transition will generate photon of wavelength 124.1 nm? (hc = 1241 eV-nm)



(1) A

(2) B

(3) C

(4) D

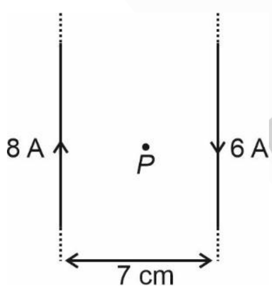
Answer (4)

Sol. So, energy of photon

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

Only D has energy to produce this wavelength.

7. Two straight infinite wires placed parallel to each other are carrying currents as shown



P is equidistant from the wires find magnetic field at point P. (Point P is in the plane of wire)

(1) 8×10^{-5} T

(2) 8×10^{-7} T

(3) 16×10^{-5} T

(4) 2×10^{-5} T

Answer 1)

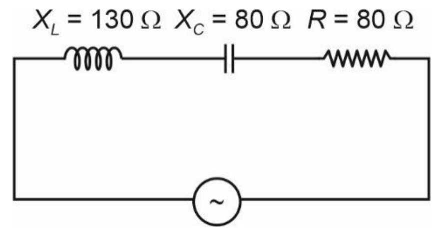
Sol. $B_{net} = \frac{\mu_0 i_1}{2\pi r_1} + \frac{\mu_0 i_2}{2\pi r_2}$

$$= 2\times10^{-7}\left[\frac{8}{\frac{3.5}{100}} + \frac{6}{\frac{3.5}{100}}\right]\text{T}$$

$$= \frac{2\times10^{-7}\times14\times100}{3.5}\text{T}$$

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

8. For an LCR series circuit $X_L = 130\ \Omega$, $X_C = 80\ \Omega$ and $R = 80\ \Omega$. The value of power factor of the circuit is equal to



(1) $\frac{\sqrt{54}}{9}$

(2) $\frac{8}{\sqrt{89}}$

(3) $\frac{8}{13}$

(4) $\frac{7}{9}$

Answer (2)

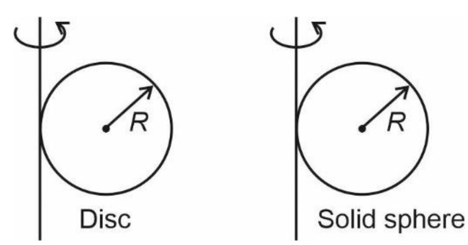
Sol. $\cos\phi = \frac{R}{Z} = \frac{R}{\sqrt{(X_L - X_C)^2 + R^2}}$

$$= \frac{80}{\sqrt{(130-80)^2 + 80^2}}$$

$$= \frac{80}{\sqrt{2500+6400}}$$

$$\cos\theta = \frac{8}{\sqrt{89}}$$

9. A disc and a solid sphere of same radius are rotated as shown in the figure. If mass of disc and solid sphere are 4 kg and 5 kg respectively then $\frac{I_{disc}}{I_{solid\ sphere}}$

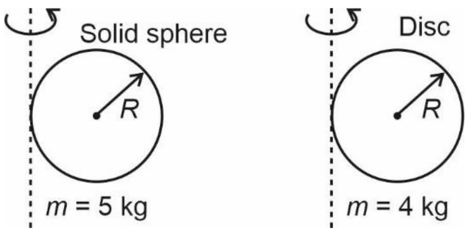


(1) $\frac{7}{5}$ (2) $\frac{25}{28}$

(3) $\frac{5}{7}$ (4) $\frac{28}{25}$

Answer (3)

Sol.



Using parallel axis theorem,

$$I_{\text{solid sphere}} = \left(\frac{2}{5}mR^2 + mR^2\right)$$

$$= \left(\frac{7}{5}mR^2\right) = 7R^2 \text{ (as } m = 5 \text{ kg)}$$

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

(as m = 4 kg)

$$\frac{I_{\text{disc}}}{I_{\text{solid sphere}}} = \frac{5R^2}{7R^2} = \frac{5}{7}$$

10. Two projectiles are thrown at 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

(1) 1 : 1

(2) 2 : 1

(3) 1 : 2

(4) 1 : 3

Answer (1)

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

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

So $R_1 = R_2$

$$\Rightarrow \frac{R_1}{R_2} = \frac{1}{1}$$

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

(1) $\frac{5}{2}R$ (2) $\frac{3}{2}R$

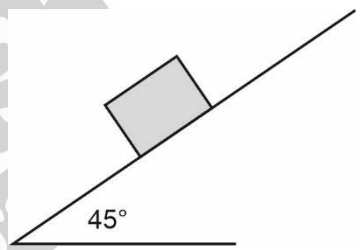
(3) $\frac{7}{2}R$ (4) $\frac{9}{2}R$

Answer (3)

Sol. For each additional vibrational mode degree of freedom is increased by 2 so new degree of freedom $f = 5 + 2 = 7$

So, $C_v = \frac{f}{2}R = \frac{7}{2}R$

12. 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?

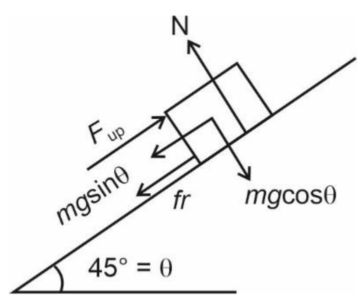


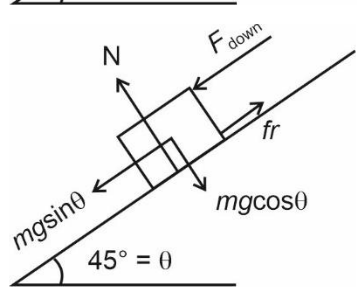
(1) 0.25 (2) 1

(3) 2 (4) 3

Answer (4)

Sol.





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

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

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

$\Rightarrow mg\sin\theta + \mu mg\cos\theta = 2\mu mg\cos\theta - 2mg\sin\theta$

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

$\mu = 3\tan\theta$

$\mu = 3$ as $\tan 45 = 1$, $\theta = 45°$

13. Correctly match the two lists

	List-I (Physical Quantity)		List-II (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.	$[ML^2T^{-2}]$

(1) P–A, Q–B, R–C, S–D

(2) P–B, Q–A, R–D, S–C

(3) P–D, Q–A, R–C, S–B

(4) P–D, Q–A, R–B, S–C

Answer (2)

Sol. $Y = \dfrac{\frac{F}{A}}{\frac{\Delta L}{L}} \Rightarrow Y = ML^{-1}T^{-2}$

$E = hf \Rightarrow h = ML^2T^{-1}$

$hf = hf_0 - \phi \Rightarrow \phi = ML^2T^{-2}$

$F = \eta A\dfrac{dv}{dx} \Rightarrow \eta = ML^{-1}T^{-1}$

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

(1) $\dfrac{1}{100}$

(2) 10

(3) $\dfrac{1}{10}$

(4) 1000

Answer (3)

Sol. $\dfrac{4}{3}\pi R^3 = 1000\dfrac{4}{3}\pi r^3$

$R = 10r$

$U_i = 4\pi R^2T$

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

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

15.

a.	Gauss law (electrostatics)	P.	$\oint\vec{B}\cdot\vec{dA} = 0$
b.	Amperes circuital law	Q.	$\oint\vec{B}\cdot\vec{dl} = \mu_0 i_{enc}$
c.	Gauss law (magnetism)	R.	$\oint\vec{E}\cdot\vec{dA} = \dfrac{q_{enc}}{\varepsilon_0}$
d.	Faraday's law	S.	$\varepsilon = \dfrac{-d\phi_B}{dt}$

(1) a-R, b-Q, c-S, d-P

(2) a-R, b-Q, c-P, d-S

(3) a-R, b-S, c-Q, d-P

(4) a-R, b-S, c-P, d-Q

Answer (2)

Sol. Gauss law for electrostatic = $\oint\vec{E}\cdot\vec{dA} = \dfrac{q_{enclosed}}{\varepsilon_0}$

Gauss law for magnetism = $\oint\vec{B}\cdot\vec{dA} = 0$

Ampere circuital law = $\oint\vec{B}\cdot\vec{dl} = \mu_0 i_{enclosed}$

Faraday's law = $\varepsilon_{induced} = \dfrac{-d\phi_B}{dt}$

16. A stationary nucleus breaks into 2 daughter nucleus having velocities in ratio 3 : 2. Find the radius of their nuclear sizes.

(1) $\left(\dfrac{2}{3}\right)^{1/2}$

(2) $\left(\dfrac{2}{3}\right)^{1/3}$

(3) $\left(\dfrac{4}{9}\right)^{1/3}$

(4) $\left(\dfrac{9}{4}\right)^{1/2}$

Answer (2)

Sol. Applying momentum conservation

$m_1 v_1 = m_2 v_2$

$\Rightarrow \dfrac{m_1}{m_2} = \left(\dfrac{v_2}{v_1}\right) = \dfrac{2}{3}$

$\Rightarrow \dfrac{A_1}{A_2} = \dfrac{2}{3}$

also, $\dfrac{R_1}{R_2} = \left(\dfrac{A_1}{A_2}\right)^{1/3}$

so, $\dfrac{R_1}{R_2} = \left(\dfrac{2}{3}\right)^{1/3}$

17. 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

(1) P(A), Q(B), R(C), S(D)

(2) P(A), Q(C), R(D), S(B)

(3) P(C), Q(A), R(B), S(D)

(4) P(B), Q(D), R(C), S(A)

Answer (3)

Sol. Adiabatic $\Rightarrow \Delta Q = 0$

Isochoric $\Rightarrow W = 0$

Isothermal $\Rightarrow \Delta U = 0$

Isobaric $\Rightarrow \Delta Q = \Delta U + W$

(Both ΔU and W are non-zero)

18.

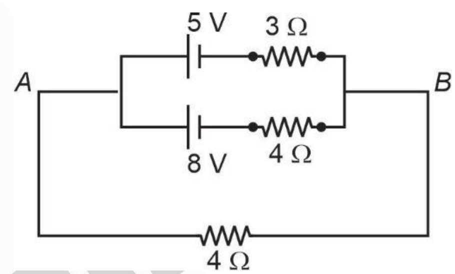
19.

20.

SECTION - B

Numerical Value Type Questions: This section contains 10 questions. In Section B, attempt any five questions out of 10. The answer to each question is a **NUMERICAL VALUE.** For each question, enter the correct numerical value (in decimal notation, truncated/rounded-off to the second decimal place; e.g. 06.25, 07.00, –00.33, –00.30, 30.27, –27.30) using the mouse and the on-screen virtual numeric keypad in the place designated to enter the answer.

21. In the circuit shown, the current (in *A*) through the 4 Ω resistor connected across *A* and *B* is $\dfrac{1}{n}$ amperes.



Find *n*

Answer (10)

Sol. $e_{\text{effective}} = \dfrac{8 \times 3 - 5 \times 4}{3+4}$ V

$= \dfrac{4}{7}$ V

$r_{\text{effective}} = \dfrac{3 \times 4}{3+4}\Omega = \dfrac{12}{7}\Omega$

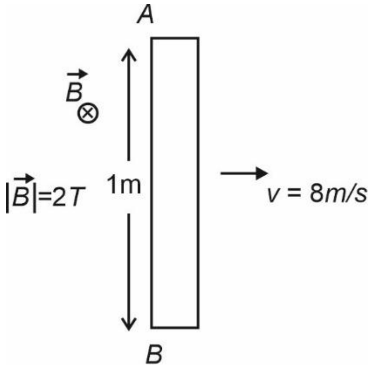
$\Rightarrow \quad i = \dfrac{\frac{4}{7}}{\frac{12}{7}+4}$ A

$= \dfrac{4}{12+28}$ A $= \dfrac{1}{10}$ A

22. 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* = 2*T* perpendicular to the plane of motion. Find the emf involved between the two ends of rod.

Answer (16.00)

Sol.

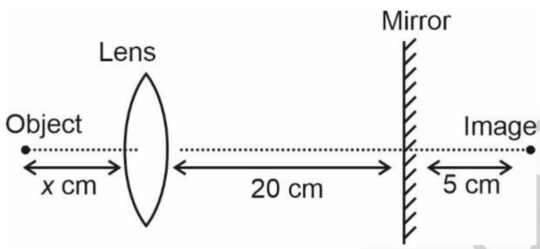


$|V_A - V_B| = Bvl$

= 2 × 8 × 1

= 16 *v*

23. In the arrangement shown:



The image shown is formed after refraction from lens and reflection from mirror. If the length of lens is 10 cm, find *x*.

Answer (30)

Sol. Writing equation for lens:

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

$$\Rightarrow x = 30 \text{ cm}$$

24. A capacitor has a capacitance of 5 μF when the medium between the plates is air. Now, a material of dielectric constant 1.5 is filled in half the separation between the plates and area same as plates. The new capacitance in μF is ________

Answer (06)

Sol. $C_0 = \dfrac{\varepsilon_0 A}{d}$ ...(i)

$$C_{new} = \frac{\dfrac{1.5\,\varepsilon_0 A}{\frac{d}{2}} \times \dfrac{\varepsilon_0 A}{\frac{d}{2}}}{\dfrac{1.5\,\varepsilon_0 A}{\frac{d}{2}} + \dfrac{\varepsilon_0 A}{\frac{d}{2}}}$$

$$= \frac{1.5 \times \dfrac{\varepsilon_0 A}{d} \times 2}{1.5 + 1}$$

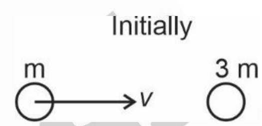
$$= \frac{6}{5}\frac{\varepsilon_0 A}{d}$$

= 6 μF

25. 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.

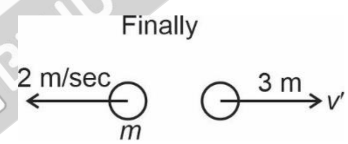
Answer (04.00)

Sol. Linear momentum is conserved.



So $mv = 3mv' - 2m$ ...(1)

Coefficient of restitution is 1 so



$$e = 1 = \frac{v' + 2}{v}$$

$v' = v - 2$ ...(2)

on solving

v = 4m/sec

26.

27.

28.

29.

30.