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. If the height of the tower used for L.O.S is increased by 21% then percentage change in range is

(1) 10% (2) 21%

(3) 19% (4) 42%

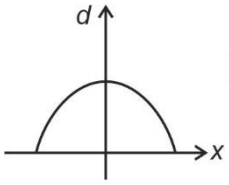
Answer (1)

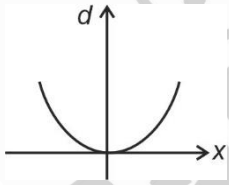
Sol. $l = \sqrt{2Rh}$

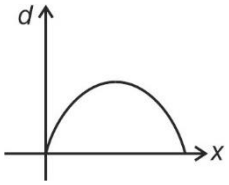
$l' = \sqrt{2R(1.21h)} = 1.1\sqrt{2Rh}$

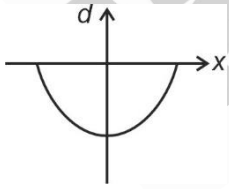
$\frac{l'-l}{l} = (0.1) = 10\%$

2. Select the correct graph showing the difference (d) between total energy and potential energy of a particle in linear SHM with position x of the particle ($x = 0$ is the mean position)

(1) 

(2) 

(3) 

(4) 

Answer (1)

Sol. $d = T.E - P.E$

$= K.E$ ($\because$ Total energy is conserved)

$= \frac{1}{2}m\omega^2(A^2 - x^2)$

3. A dipole of charge 0.01 C and separation 0.4 mm, is placed in an electric field of strength 10 dyne/C. Find the maximum torque exerted on the dipole in the field.

(1) 4×10^{-9} Nm (2) 2×10^{-10} Nm

(3) 4×10^{-10} Nm (4) 2×10^{-9} Nm

Answer (3)

Sol. $P = 0.01 \times 0.4 \times 10^{-3} = 4 \times 10^{-6}$ cm

$E = 10 \times 10^{-5}$ N

$|\tau| = |\vec{P} \times \vec{E}| = 4 \times 10^{-6} \times 10 \times 10^{-5} = 4 \times 10^{-10}$ Nm

4. Two bodies having same linear momentum have ratio of kinetic energy as 16 : 9. Find the ratio of masses of these bodies.

(1) $\frac{9}{16}$ (2) $\frac{4}{3}$

(3) $\frac{3}{4}$ (4) $\frac{16}{9}$

Answer (1)

Sol. $\frac{P^2}{2m} = K$

$\Rightarrow \frac{K_1}{K_2} = \left(\frac{m_2}{m_1}\right) = \frac{16}{9} = \left(\frac{m_2}{m_1}\right)$

$\left(\frac{m_1}{m_2}\right) = \frac{9}{16}$

5. What is the centre of gravity of semi-circular disc of radius (R)?

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

(3) $\frac{R}{2}$ (4) $\frac{3R}{8}$

Answer (2)

Sol. $y_{cm} = \int_0^R \frac{dmy}{M} = \int_0^R \frac{\frac{M(\pi r dr)\cdot 2r}{\pi}}{\frac{(\pi R^2)}{2}} = \frac{4}{\pi R^2}\int_0^R r^2 dr = \frac{4R}{3\pi}$

6. The work function for two metals are 9 eV and 4.5 eV. Find the approx. difference between their threshold wavelengths. (Use hC = 1240 eV–nm)

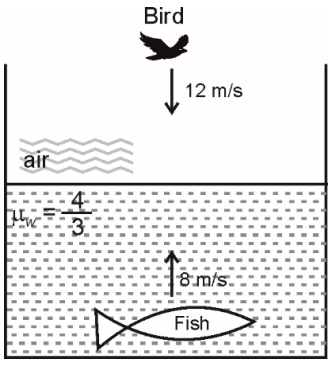
(1) 138 nm (2) 130 nm

(3) 112 nm (4) 145 nm

Answer (1)

Sol. $\Delta\lambda = \left[\frac{1240}{4.5} - \frac{1240}{9}\right]$ nm

7. In the given figure, find the speed of bird as seen by fish.



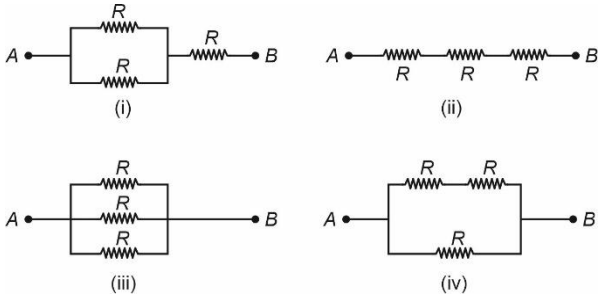
(1) 24 m/s (2) 16 m/s

(3) 20 m/s (4) 12 m/s

Answer (1)

Sol. $\frac{v_{b/f}}{\frac{4}{3}} = \frac{-8}{\frac{4}{3}} + \frac{(-12)}{1}$

8. Select increasing order of power consumption.



(1) $P_1 < P_2 < P_4 < P_3$

(2) $P_3 < P_4 < P_1 < P_2$

(3) $P_4 < P_3 < P_1 < P_2$

(4) $P_2 < P_1 < P_4 < P_3$

Answer (4)

Sol. Suppose battery of emf ε is applied across each circuit.

$$\therefore \quad P_1 = \frac{\varepsilon^2}{R_{eq}} = \frac{\varepsilon^2}{\left(\frac{3R}{2}\right)} = 0.67\frac{\varepsilon^2}{R}$$

$$P_2 = \frac{\varepsilon^2}{R_{eq}} = \frac{\varepsilon^2}{3R} = 0.33\frac{\varepsilon^2}{R}$$

$$P_3 = \frac{\varepsilon^2}{R_{eq}} = \frac{\varepsilon^2}{\left(\frac{R}{3}\right)} = 3\frac{\varepsilon^2}{R}$$

$$P_4 = \frac{\varepsilon^2}{R_{eq}} = \frac{\varepsilon^2}{\left(\frac{2R}{3}\right)} = 1.5\frac{\varepsilon^2}{R}$$

Increasing order is $\rightarrow P_2 < P_1 < P_4 < P_3$

9. Pressure for polytropic process P varies with volume V as $P = aV^{-3}$, find out the bulk modulus.

(1) $3V$ (2) $3P$

(3) P (4) V

Answer (2)

Sol. $P = aV^{-3}$

$$\frac{dP}{dV} = -3aV^{-4}$$

$$\Rightarrow -V\frac{dP}{dV} = \left(3aV^{-3}\right) = (3P)$$

10. For the given radioactive decay

$${}^{298}_{94}X \longrightarrow {}^{294}_{92}Y + {}^{4}_{2}\alpha + Q\text{-value},$$

binding energy per nucleon of X, Y and α are a, b and c. The Q-value is equal to

(1) $(294b + 4c - 298a)$ (2) $(92b + 2c - 94a)$

(3) $(294b + 4c + 298a)$ (4) $(92b + 2c + 94a)$

Answer (1)

Sol. Q-value = $(\text{B.E.})_{\text{product}} - (\text{B.E.})_{\text{reaction}}$

11. Energy of He^+ in 2nd orbit is –13.6 eV then energy of Be^{+++} in $n = 4$.

(1) – 3.4 eV (2) – 27.2 eV

(3) – 13.6 eV (4) – 54.4 eV

Answer (3)

Sol. $E = -13.6\frac{Z^2}{n^2}$ eV

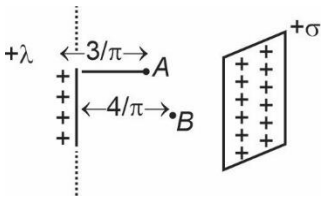
For He^+ (Z = 2, n = 2), $E = -13.6\left(\frac{2^2}{2^2}\right)$ eV

$= -13.6$ eV

For Be^{+++} (Z = 4, n = 4), $E = -13.6\left(\frac{4^2}{4^2}\right)$ eV

$= -13.6$ eV

12. A line charge of linear charge density λ and a large non-conducting sheet of charge density σ are placed parallel to each other as shown. Find ratio of electric field at A to that at B.



(1) $\frac{3}{4}\left(\frac{\lambda - 3\sigma}{\lambda + 4\sigma}\right)$ (2) $\frac{4}{3}\left(\frac{\lambda - 3\sigma}{\lambda - 4\sigma}\right)$

(3) $\frac{2}{3}\left(\frac{\lambda - 4\sigma}{\lambda - 3\sigma}\right)$ (4) $\frac{3}{2}\left(\frac{\lambda - 4\sigma}{\lambda - 3\sigma}\right)$

Answer (2)

Sol. $\frac{E_A}{E_B} = \frac{\frac{\lambda}{2\pi\varepsilon_0\left(\frac{3}{\pi}\right)} - \frac{\sigma}{2\varepsilon_0}}{\frac{\lambda}{2\pi\varepsilon_0\left(\frac{4}{\pi}\right)} - \frac{\sigma}{2\varepsilon_0}}$

13. Which of the following show time varying magnetic field?

(1) Linearly varying

(2) Permanent magnet

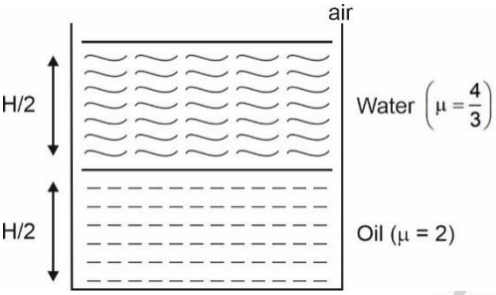
(3) Antenna signal

(4) Constant electric field

Answer (3)

Sol. Antenna signal carries sinusoidal EM wave where $\vec{E}$ and $\vec{B}$ both varying with time.

14. Find the apparent depth of bottom of beaker shown in figure, filled with water and oil.



(1) $\frac{5H}{8}$ (2) $\frac{4H}{5}$

(3) $\frac{3H}{4}$ (4) $\frac{7H}{8}$

Answer (1)

Sol. $d_{app} = \frac{H/2}{4/3} + \frac{H/2}{2} = \frac{5H}{8}$

15. If a particle is moving in a uniform circular motion of radius 1 m, is having velocity $3\hat{j}$ m/s at point *B*. What are the velocity ($\vec{v}$) and acceleration ($\vec{a}$) at diametrically opposite point *A*.

(1) $\vec{v}_A = 3\hat{j}$ m/s

$\vec{a}_A = -9\hat{i}$ m/s^2

(2) $\vec{v}_A = -3\hat{j}$ m/s

$\vec{a}_A = 9\hat{i}$ m/s^2

(3) $\vec{v}_A = -3\hat{i}$ m/s

$\vec{a}_A = +9\hat{j}$ m/s^2

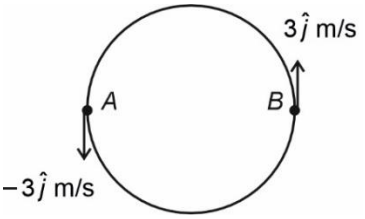
(4) $\vec{v}_A = +3\hat{i}$ m/s

$\vec{a}_A = +9\hat{j}$ m/s^2

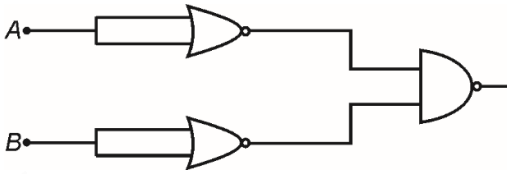
Answer (2)

Sol. $\vec{v}_A = -3\hat{j}$ m/s

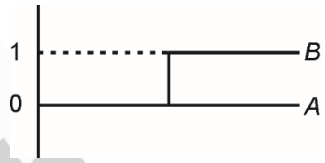
$\vec{a}_A = 9\hat{i}$ m/s^2



16. The input signal is given below for the circuit

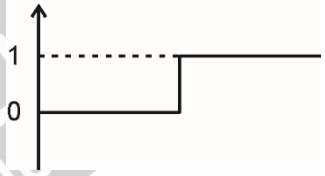


Input graph of A and B is

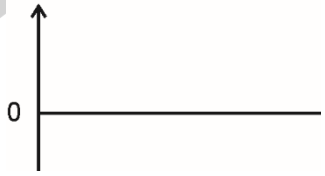


Pick the correct output graph for the circuit.

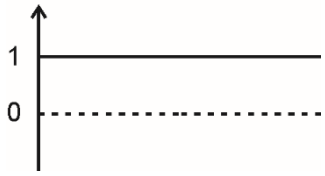
(1) Output



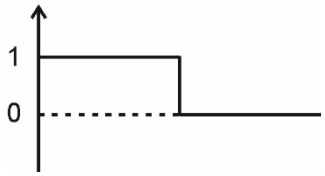
(2) Output



(3) Output



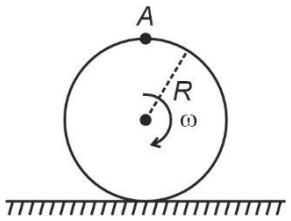
(4) Output



Answer (1)

Sol. $\overline{(\overline{A} \cdot \overline{B})} = \overline{\overline{A+B}} = (A+B) =$ OR gate

17. Find the displacement of point *A* on the top of the disc rolling without slipping on horizontal surface with angular speed ω, in half rotation.

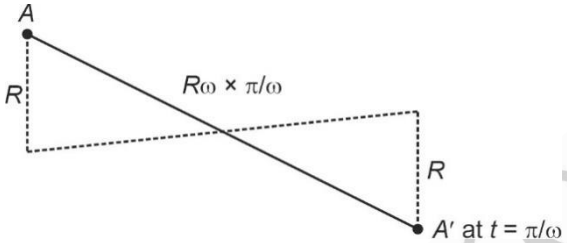


(1) $R\sqrt{\pi^2+2}$ (2) $R\sqrt{\pi^2+\frac{1}{4}}$

(3) $R\sqrt{\pi^2+4}$ (4) $R\sqrt{\frac{\pi^2}{2}+1}$

Answer (3)

Sol.



$AA' = \sqrt{(2R)^2+(\pi R)^2}$

$= R\sqrt{\pi^2+4}$

18. A point *R* is at $\left(\frac{5}{8},\frac{3}{8},\frac{1}{8}\right)$ and a plane mirror is placed on *xy* plane such that normal to the plane mirror from *R* intersect at point *P* on mirror. Find distance of image formed by the mirror and object.

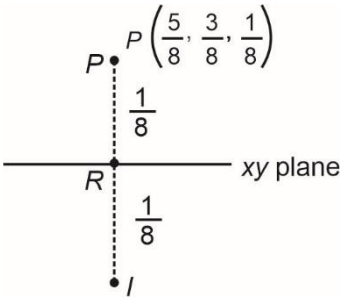
(1) $\frac{1}{2}$ m (2) $\frac{1}{4}$ m

(3) $\frac{1}{8}$ m (4) 1 m

Answer (2)

Sol. Distance between object and image is

$= PR + RI = 2\left(\frac{1}{8}\right) = \frac{1}{4}$ m



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. If a wire of resistance R is connected across V_0, then power is P_0. The wire is cut into two equal parts and connected with V_0 individually, then sum of power dissipated is P_1 then $\frac{P_0}{P_1}$ is $\frac{1}{x}$ find the value of *x*.

Answer (4)

Sol. $P_0 = \left(\frac{V_0^2}{R}\right)$

$P_1 = \frac{V_0^2}{\frac{R}{2}} + \frac{V_0^2}{\frac{R}{2}} = \frac{4V_0^2}{R}$

$\frac{P_0}{P_1} = \frac{1}{4}$

22. A particle is performing SHM having position $x = A\cos(30°)$, and $A = 40$ cm. If its kinetic energy at this position is 200 J. The value of force constant in $\left(\frac{kN}{m}\right)$ is

Answer (10)

Sol. $x = 40\times\frac{\sqrt{3}}{2} = 20\sqrt{3}$ cm as $\omega = \sqrt{\frac{K}{m}}$

$\frac{1}{2}mv^2 = \frac{1}{2}m\omega^2\left(A^2-x^2\right) = 200$

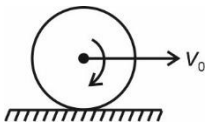
$\Rightarrow \frac{1}{2}\times m\times\frac{K}{m}(0.16-0.12) = 200$

$K = \frac{400}{0.04} = 10000$ N/m

23. Solid sphere rolls on horizontal plane. Ratio of angular momentum about COM to total energy is $\frac{\pi}{22}$. Find ω = ?

Answer (4)

Sol.



$L = I_{COM}\,\omega$ and $K = \frac{1}{2}I_{COM}\omega^2 + \frac{1}{2}Mv_0^2$

$L = \frac{2}{5}MR^2\frac{v_0}{R}$ $\quad K = \frac{1}{2}\left(\frac{2}{5}MR^2\right)\frac{v_0^2}{R^2} + \frac{1}{2}Mv_0^2$

$L = \frac{2MRv_0}{5}$ $\quad K = \frac{7}{10}Mv_0^2$

Ratio $\frac{L}{K} = \frac{4}{7}\frac{R}{v_0} = \frac{\pi}{22} \Rightarrow \omega = \frac{4}{7}\times\frac{22}{22}\times 7 = 4$

24. If $m = 5 \pm 0.2$ and $v = 20 \pm 0.4$, calculate error in measurement of K.E.

Answer (8)

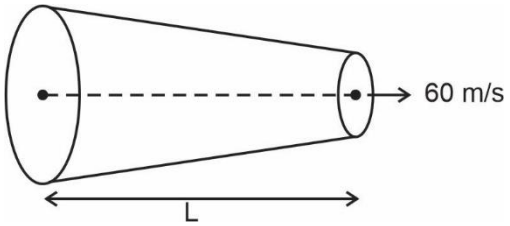
Sol. % error in $m = \frac{0.2}{5}\times 100 = 4\%$

% error in $v = \frac{0.4}{20}\times 100 = 2\%$

% error in $\frac{1}{2}mv^2$ = (% error in m) + 2 (% error in v)

= 4 + 2 (2) = 8%

25. Water is flowing inside the conical type tube having ratio of area of cross-section 6 : 1. If the speed of water outlet through smaller area is 60 m/s, then the pressure difference across these two cross-section is $x \times 10^4$ Pa, find the value of x. (Assume incompressible fluid, density of water = 1000 kg/m^3)



Answer (175)

Sol. $A_1v_1 = A_2v_2$

$\Rightarrow$ $6v_1 = 60$

$v_1 = 10$ m/s

$\Delta P = \frac{1}{2}\rho\left(60^2 - 10^2\right)$

$= \frac{1}{2}\times 1000\left(3600 - 100\right)$

$= \frac{3500}{2}\times 1000$

$= 175 \times 10^4$

26. Train A of length l is moving with speed 108 km/hr. Another train B of length $4l$ is moving parallel to train A with speed 72 km/hr. They both move through a tunnel of length $60l$ and train B takes 35 s more time than train A to pass through the tunnel, if they enter the tunnel simultaneously. Find the length (in m) of tunnel.

Answer (1575)

Sol. $t_A = \frac{2l + 60l}{30}$, $t_B = \frac{8l + 60l}{20}$

Also, $t_B - t_A = 35$

$\frac{68l}{20} - \frac{62l}{30} = 35$

$l = \frac{105}{4}$ m

$\therefore$ Length of tunnel = $60\left(\frac{105}{4}\right) = 1575$ m

27.

28.

29.

30.