Q1.

A truck driver passes a car that is initially at rest while travelling at a constant speed of 37 m/s. At that instant, the car starts to follow the truck with a constant acceleration of 4.0 m/s^2. How fast is the car travelling when it reaches the truck?

A) 74 m/s
B) 43 m/s
C) 92 m/s
D) 65 m/s
E) 51 m/s

Ans:

$$\left.\begin{array}{l}\text{Truck: } d_T = v_T.t \\ \text{Car: } \quad d_c = \frac{1}{2}a.t^2\end{array}\right\} \begin{array}{l} d_T = d_c \\ v_T.t = \frac{1}{2}at^2 \Rightarrow t = \frac{2v_T}{a} = 18.5\ \text{s}\end{array}$$

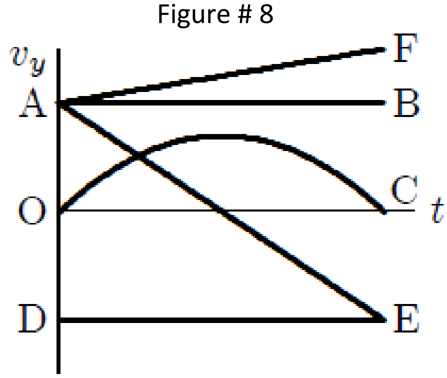
$$v_c = a.t = 4.0 \times 18.5 = 74\ \text{m/s}$$

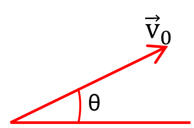
Q2.

A projectile is fired from ground level at an angle of 45° above the horizontal. Which of curves in **Figure 8** represents the vertical component of the velocity as a function of time?

Figure # 8

A) AE
B) OC
C) DE
D) AB
E) AF





Ans:

$$v_y = v_{0y} - \frac{1}{2}gt^2$$

$$\left.\begin{array}{l}\therefore v_y > 0 \longrightarrow \textit{going up} \\ v_y = 0 \longrightarrow \text{top} \\ v_y < 0 \longrightarrow \textit{going down}\end{array}\right\} \text{curve AE}$$

Also, v_y is linear vs time

Q3.

Wind blows with a speed of 60.0 km/h from the north towards south. A plane flies at 45.0° north of east at a speed of 200 km/h relative to the wind. The resultant speed of the plane relative to the ground is

A) 163 km/h
B) 176 km/h
C) 100 km/h
D) 143 km/h
E) 120 km/h

Ans:

$w \longrightarrow$ wind; $p \longrightarrow$ plane ; $g \longrightarrow$ ground

$$\vec{v}_{wg} = -6.00\,\hat{j}\ (k/h)$$

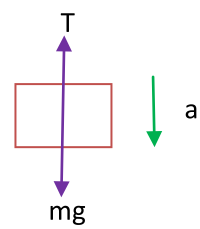
$$\vec{v}_{pw} = (200 \times \cos 45)\hat{i} + (200 \times \sin 45)\hat{j} = 141\,\hat{i} + 141\hat{j}\ (km/h)$$

$$\vec{v}_{pg} = \vec{v}_{pw} + \vec{v}_{wg} = 141\,\hat{i} + 81\,\hat{j}\ (km/h)$$

$$\therefore v_{pg} = [(141)^2 + (81)^2]^{\frac{1}{2}} = 163\ km/h$$

Q4.

A body hangs from a spring balance attached to the ceiling of an elevator which has a downward acceleration of 2.45 m/s^2. If the balance reads 50.0 N, what is the magnitude of the true weight of the body?



A) 66.7 N
B) 37.7 N
C) 74.2 N
D) 50.0 N
E) 40.0 N

Ans:

$$ma = mg - T$$

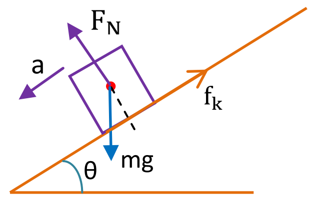
$$mg = ma + T$$

$$mg = \left(1 - \frac{a}{g}\right) = T \Rightarrow mg = \frac{T}{1 - a/g} = \frac{50.0}{1 - \left(\frac{2.45}{9.8}\right)} = 66.7\ N$$

Q5.

A block of weight 100 N is released from the top of a rough plane inclined at an angle of 42.0°. The coefficient of kinetic friction between the block and the incline is 0.500. As the block slides down the incline, what is the magnitude of the net force on the block?

A) 29.8 N
B) 87.2 N
C) 66.8 N
D) 50.2 N
E) 36.6 N



Ans:

$$F_{net} = ma = mg\sin\theta - f_k$$

$$\therefore F_{net} = mg\sin\theta - \mu_k . f_N$$

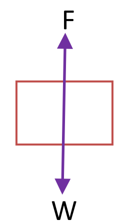
$$= mg\sin\theta - \mu_k . mg\sin\theta$$

$$= mg(\sin\theta - \mu_k . \cos\theta) = 29.8 \text{ N}$$

Q6.

A machine raises a 400 kg mass vertically upward at a constant speed of 0.200 m/s. What is the power output of the machine?

A) 784 W
B) 432 W
C) 802 W
D) 256 W
E) 311 W



Ans:

Constant speed: $a = 0$

$$\Rightarrow F = W = mg$$

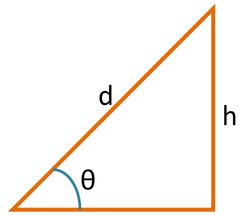
$$P_F = \vec{F}.\vec{v} = F.v = mgv$$

$$= 400 \times 9.8 \times 0.2 = 784 \text{ W}$$

Q7.

A 5.00 kg block is given an initial velocity of 5.00 m/s up a smooth 20.0° incline. How far along the incline has the block moved when its velocity is 1.50 m/s?

A) 3.39 m
B) 1.45 m
C) 33.3 m
D) 15.1 m
E) 5.68 m



$\sin\theta = \frac{h}{d}$

Ans:

$$\Delta K + \Delta U_g = 0$$

$$\Delta U_g = -\Delta K$$

$$mgh = -\frac{1}{2}m(v_f^2 - v_i^2)$$

$$h = \frac{1}{2g}(v_i^2 - v_f^2) = \frac{1}{19.6} \times (25 - 2.25) = 1.16 \text{ m}$$

$$d = \frac{h}{\sin\theta} = \frac{1.16}{\sin 20°} = 3.39 \text{ m}$$

Q8.

A block of mass 1.00 kg is forced against a horizontal spring, compressing it by 0.200 m. When released, the block moves on a horizontal table with a coefficient of kinetic friction of 0.200. The spring constant is 100 N/m. What distance will the block move before coming to rest?

A) 1.02 m
B) 1.51 m
C) 0.72 m
D) 1.87 m
E) 5.33 m

Ans:

$$\Delta K + \cancelto{0}{\Delta U_s} = W_f$$

$$\cancel{-}\frac{1}{2}kx^2 = \cancel{-}f_k.d$$

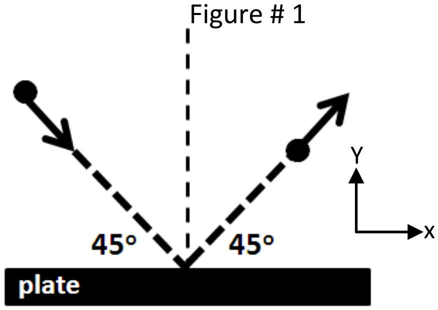
$$\frac{1}{2}kx^2 = \mu_k.mgd$$

$$\therefore d = \frac{k.x^2}{2\mu_k.mg} = \frac{100 \times 0.04}{2 \times 0.2 \times 1 \times 9.8} = 1.02 \text{ m}$$

Q9.

A 2.00 kg ball with a speed of 50.0 m/s strikes a plate at an angle of 45.0° and rebounds at the same speed and angle, as shown in **Figure 1**. Find the change in the linear momentum of the ball.

A) 141 kg·m/s perpendicular to the plate
B) 100 kg·m/s perpendicular to the plate
C) 141 kg·m/s at 45.0° to the plate
D) 100 kg·m/s at 45.0° to the plate
E) 200 kg·m/s at 45.0° to the plate



Ans:

$$\vec{p}_i = mv\cos\theta\ \hat{\imath} - mv\sin\theta\ \hat{\jmath}$$

$$\vec{p}_f = mv\cos\theta\ \hat{\imath} + mv\sin\theta\ \hat{\jmath}$$

$$\Delta\vec{p} = \vec{p}_f - \vec{p}_i = 2mv\sin\theta\,\hat{\jmath}$$

$$= \cancel{2} \times 2 \times 50 \times \frac{\sqrt{2}}{\cancel{2}}\ \hat{\jmath} = 141\ (\mathrm{kg.m/s})\hat{\jmath}$$

Q10.

A body **A** of mass M_1, travelling with speed V makes an elastic collision with another body **B** of mass M_2 at rest. After the collision, body **A** continues to move in the original direction with speed $V/2$. What is M_2 in terms of M_1?

A) $M_2 = M_1/3$
B) $M_2 = M_1/2$
C) $M_2 = 3M_1/2$
D) $M_2 = M_1/4$
E) $M_2 = 2M_1$

Ans:

$$v_{1f} = \frac{M_1 - M_2}{M_1 + M_2} v_{1i}$$

$$\frac{\cancel{V}}{2} = \frac{M_1 - M_2}{M_1 + M_2}\cancel{V}$$

$$2M_1 - 2M_2 = M_1 + M_2$$

$$M_1 = 3M_2 \Rightarrow M_2 = M_1/3$$

Q11.

A wheel, with a radius of 37 cm, is initially travelling with a constant speed of 80 km/h. The brakes are applied and, without sliding, the wheel is brought to rest in 3.0 s with uniform deceleration. What is the magnitude of the angular acceleration of the wheel about the axle?

A) 20 rad/s^2
B) 7.4 rad/s^2
C) 3.1 rad/s^2
D) 13 rad/s^2
E) 11 rad/s^2

Ans:

$$v_i = 80\,\frac{km}{h}\cdot\frac{1h}{3600s}\cdot\frac{1000\,m}{km} = 22.2\ m/s$$

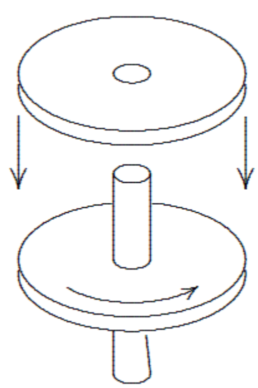
$$\omega_i = \frac{v_i}{R} = \frac{22.2}{0.37} = 60\ rad/s$$

$$\overset{0}{\cancel{\omega_f}} = \omega_i - \alpha t \Rightarrow \alpha = \frac{\omega_i}{t} = \frac{60}{3} = 20\ rad/s^2$$

Q12.

A disk of rotational inertial I_1 is initially rotating freely with angular speed ω. Then, a second stationary disk, with rotational inertia $I_2 = I_1/2$, is dropped on the first disk, as shown in **Figure 2**. Finally, the two disks rotate as a unit. What is the final angular speed?

Figure # 2



A) 2ω/3
B) ω/2
C) 2ω
D) 3ω/4
E) ω/3

Ans:

$$L_i = I_i.\omega_i = I_1.\omega$$

$$I_f = I_1 + I_2 = I_1 + \frac{I_1}{2} = \frac{3I_1}{2}$$

$$L_f = I_f.\omega_f = \frac{3I_1}{2}\,\omega_f$$

conservation of angular momentum:

$L_i = L_f$:

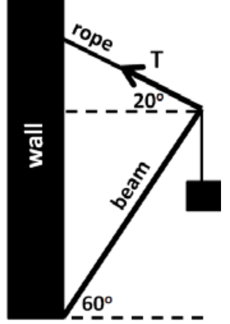
$$\cancel{I_1}\omega = \frac{3\cancel{I_1}}{2}\,\omega_f \Rightarrow \omega_f = \frac{2\omega}{3}$$

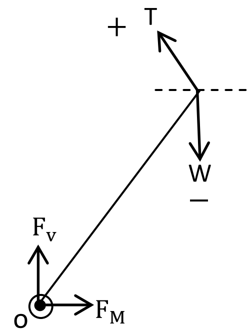
Q13.

A block with a weight of 10.0 kN is supported by a massless rope attached to a 4.00 m massless beam that can pivot at the base, as shown in **Figure 3**. Find the magnitude of the tension (***T***) in the rope.

A) 5.08 kN
B) 6.14 kN
C) 8.26 kN
D) 4.77 kN
E) 3.07 kN

Figure # 3





Ans:

Consider the Free-Body Diagram of the beam:

Calculate the torque about the pivot o:

$\Sigma\tau_0 = 0$:

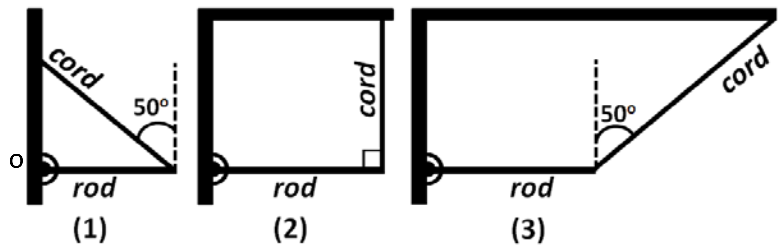
$$-W.\cancel{L}.\sin 30^{\circ} + T.\cancel{L}.\sin 80^{\circ} = 0$$

$$\therefore T = \frac{\sin 30°}{\sin 80°} \times (10.0) = 5.08 \text{ kN}$$

Q14.

Figure 11 shows three situations in which a horizontal rod is supported by a hinge on a wall at one end and a cord at the other end. Rank the situations according to the magnitude of the force on the rod from the cord, greatest first.

Figure 11



A) (1 and 3 tie) then 2
B) 2 then (1 and 3 tie)
C) All tie
D) 1, 2, 3
E) 3, 2, 1

Ans:

Calculate the torque about the pivot (o)

$\Sigma\tau_0 = 0$:

$$(1): -W.\frac{\cancel{L}}{2} + T.\cancel{L}.\sin40^{\circ} = 0$$

$$T = \frac{W}{25\sin40^{\circ}} = 0.78\text{ W}$$

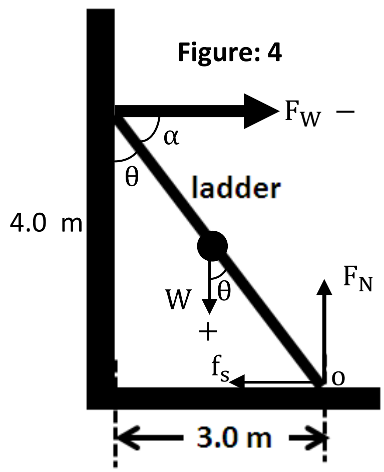
$$(2): T = \frac{W}{2\sin90^{\circ}} = 0.50\text{ W}$$

$$(3): T = \frac{W}{2\sin40^{\circ}} = 0.78\text{ W}$$

Q15.

A 5.0 m long, 10 kg ladder is leaning against a frictionless vertical wall, while the bottom of the ladder rests 3.0 m away from the wall on a horizontal rough floor, as shown in **Figure 4**. What is the magnitude of the force of static friction between the floor and the ladder?

A) 37 N
B) 59 N
C) 98 N
D) 49 N
E) 29 N



Ans:

$\Sigma F_x = 0:\ f_s = F_w \quad (1)$

$\Sigma F_y = 0:\ f_N = W \quad (2)$

$\Sigma \tau_0 = 0:\ W.\frac{\cancel{L}}{2}.\sin\theta - F_W.\cancel{L}.\sin\alpha = 0$

$\frac{W}{2}\sin\theta = F_w.\cos\theta$

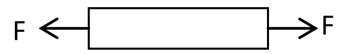
$F_w = \frac{W}{2}.\tan\theta = \frac{W}{2} \times \frac{3}{4} = \frac{3W}{8}$

$= \frac{3}{8} \times 10 \times 9.8 = 36.75\ \text{N} \ \rightarrow 37\ \text{N}$

Q16.

A certain wire stretches 0.90 cm when an outward force with magnitude *F* is applied perpendicular to the cross section of each end. The same forces are applied to a wire of the same material but with three times the diameter and three times the length. The second wire stretches:

A) 0.30 cm
B) 0.10 cm
C) 0.90 cm
D) 2.7 cm
E) 8.1 cm



Ans:

$$\frac{F}{A} = E.\frac{\Delta L}{L}$$

$$\Rightarrow \Delta L = \frac{F.L}{E.A} = \frac{F.L}{\frac{\pi}{4}E.D^2}$$

$$\Delta L_1 = \frac{4F}{\pi E}.\frac{L}{D^2}$$

$$\Delta L_2 = \frac{4F}{\pi E}.\frac{3L}{9D^2}$$

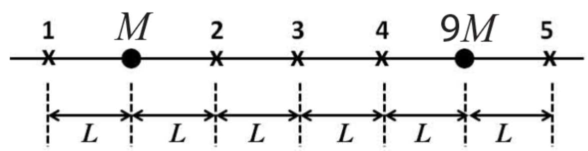
$$\frac{\Delta L_2}{\Delta L_1} = \frac{3\cancel{L}}{9\cancel{D}^2}.\frac{\cancel{D}^2}{\cancel{L}} = \frac{1}{3}$$

$$\Rightarrow \Delta L_2 = \frac{\Delta L_1}{3} = \frac{0.9}{3} = 0.30 \text{ cm}$$

Q17.

Two fixed particles of masses M and $9M$ are arranged as shown in **Figure 5**. At which of the indicated points can a third particle of mass m be placed so that the net gravitational force on it due to the two particles be zero?

Figure 5



A) 2
B) 1
C) 3
D) 4
E) 5

Ans:

* The third particle should be between M and 9 M.

* It should be closer to the weaker mass.

∴ The only possibility is 2

Q18.

A planet has mass M and radius R. The gravitational potential energy of an object on the surface of this planet is –12 J. How much work needs to be done by an external agent to move this object at constant speed to an altitude of 2R above the surface of the planet?

A) 8.0 J
B) 12 J
C) 10 J
D) 6.0 J
E) 4.0 J

Ans:

$$U_i = -\frac{G_m M}{R} = -12\text{ J} \Rightarrow \frac{G_m M}{R} = 12$$

$$U_f = -\frac{G_m M}{3R} = -\frac{1}{3} \times 12 = -4.0\text{ J}$$

$$\Delta U = U_f - U_i = -4.0 + 12 = +8.0\text{ J} = W_{app}$$

Q19.

A satellite of mass 150 kg is in a circular orbit of radius 7.0×10^6 m around a planet. If the period of revolution is 8100 s, what is the mechanical energy of the satellite in orbit?

A) -2.2×10^9 J
B) -1.1×10^9 J
C) $+2.2 \times 10^9$ J
D) $+1.1 \times 10^9$ J
E) $+1.7 \times 10^9$ J

Ans:

$$E = -\frac{GmM}{2R}$$

$$T = \frac{2\pi R}{v} \Rightarrow v = \frac{2\pi R}{T}$$

$$K = \frac{1}{2}mv^2 = \frac{m}{2}.\frac{4\pi^2R^2}{T^2} = \frac{2\pi^2mR^2}{T^2} = +2.2 \times 10^4 \text{ J}$$

$$\text{In orbit: } E = -K = -2.2 \times 10^9 \text{ J}$$

Q20.

Assume that Earth is a uniform solid sphere. What is the magnitude of the gravitational acceleration (a_g) at a distance of $R_E/2$ from the center of Earth, where R_E is the radius of Earth?

A) 4.9 m/s^2
B) 9.8 m/s^2
C) 19.6 m/s^2
D) 2.5 m/s^2
E) zero

Ans:

$$ma_g = F_g : \cancel{m}a_g = \frac{G\cancel{m}M}{r^2} \Rightarrow a_g = \frac{GM}{r^2}$$

$$\text{What is M?} \quad M = \frac{\frac{4\pi}{3}r^3}{\frac{4\pi}{3}{R_E}^3}.M_E = \left(\frac{r}{R_E}\right)^3.M_E = \frac{M_E}{8}$$

$$\Rightarrow a_g = G.\frac{M_E}{8}.\frac{4}{{R_E}^2} = \frac{1}{2}\frac{GM_E}{{R_E}^2} = \frac{1}{2} \times 9.8 = 4.9 \text{ m/s}^2$$

Q21.

The average distance of Mars from the Sun is 1.52 times that of Earth from the Sun. Calculate the number of (Earth) years required for Mars to make one revolution around the Sun.

A) 1.87
B) 3.12
C) 0.615
D) 11.9
E) 0.241

Ans:

β = constant, E = Earth, M = Mars, R = distance from Sun, T = period

$$T^2 = \beta . R^3$$

$$T_M{}^2 = \beta . R_M{}^3$$

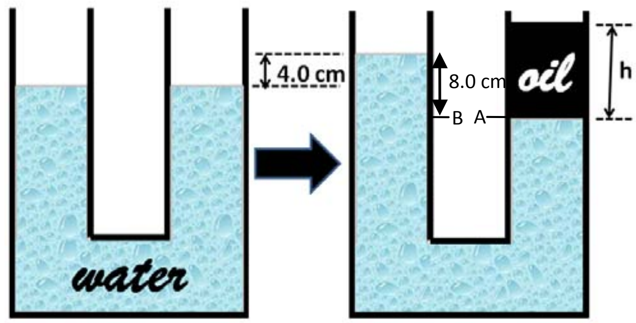
$$T_E{}^2 = \beta . R_E{}^2$$

$$\left(\frac{T_M}{T_E}\right)^2 = \left(\frac{R_M}{R_E}\right)^3 \Rightarrow T_M = \left(\frac{R_M}{R_E}\right)^{1.5} . T_E = \left(\frac{1.52}{1}\right)^{1.5} \times 1.0 = 1.87$$

Q22.

A uniform U-tube is partially filled with water. Then, oil of density 0.80 g/cm^3 is poured into the right arm until the water level in the left arm rises 4.0 cm above the initial water level (see **Figure 10**). The length of the oil column (h) is then:

Figure 10



A) 10 cm
B) 8.0 cm
C) 6.0 cm
D) 12 cm
E) 9.0 cm

Ans:

$$p_A = p_{atm} + \rho_o . gh$$

$$p_B = p_{atm} + \rho_w . g. (8)$$

Equate: $p_A = p_B$

$$\cancel{p_{atm}} + \rho_o . \cancel{g}. h = \cancel{p_{atm}} + \rho_w . \cancel{g}. (8)$$

$$\Rightarrow h = \left(\frac{\rho_w}{\rho_o}\right)(8) = \left(\frac{1.0}{0.8}\right)(8) = 10 \text{ cm}$$

Q23.

A container, having a total volume of 1000 cm^3 and a mass of 120 g, floats on water. What mass of sand can it carry without sinking in water?

A) 880 g
B) 640 g
C) 120 g
D) 930 g
E) 760 g

Ans:

Floating: weight (W) = Buoyant force (F_B)

Total weight : $W = W_x + (0.12\times9.8) = W_x + 1.176$

Buoyant force: $F_B = \rho_w . V . g = 10^3 \times 10^{-3} \times 9.8 = 9.8$ N

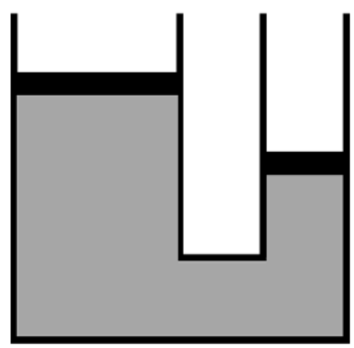
$\Rightarrow W_x + 1.176 = 9.8 \Rightarrow W_x = 8.624$ N

$$\Rightarrow m = \frac{8.624}{9.8} = 0.88 \text{ kg} = 880 \text{ g}$$

Q24.

A U-tube has dissimilar arms, one having twice the diameter of the other, as shown in **Figure 9**. It contains an incompressible fluid, and is fitted with a sliding piston in each arm, with each piston in contact with the fluid. When the piston in the narrow arm is pushed down a distance *d*, the piston in the wide arm rises a distance:

Figure 9



A) *d*/4
B) *d*
C) 2*d*
D) *d*/2
E) 4*d*

Ans:

The volume is the same:

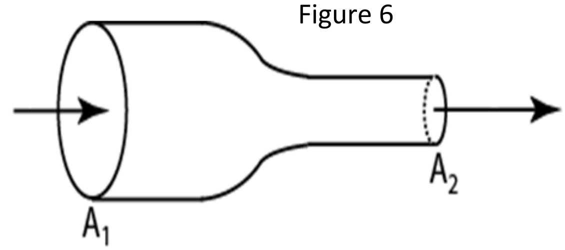
$V_{right} = V_{left}$

$$\cancel{\pi} \times \frac{\cancel{D^2}}{4} \times d = \cancel{\pi} \times \frac{\cancel{4}\cancel{D^2}}{\cancel{4}} \times l \Rightarrow l = \frac{d}{4}$$

Q25.

Water flows through a horizontal pipe of varying cross section, as shown in **Figure 6**, with A_1 = 10.0 cm^2 and A_2 = 5.00 cm^2. The pressure difference between the two sections is 300 Pa. What is the water speed at the left section of the pipe?

Figure 6



A) 0.447 m/s
B) 0.201 m/s
C) 0.894 m/s
D) 0.803 m/s
E) 0.148 m/s

Ans:

Continuity Equation: $A_1 v_1 = A_2 v_2 \;\Rightarrow 10\, v_1 = 5\, v_2 \;\Rightarrow\; v_2 = 2v_1$

Bernoulli Equation: $p_1 + \frac{1}{2}\rho {v_1}^2 = p_2 + \frac{1}{2}\rho {v_2}^2$

$$p_1 - p_2 = \frac{1}{2}\rho\left({v_2}^2 - {v_1}^2\right)$$

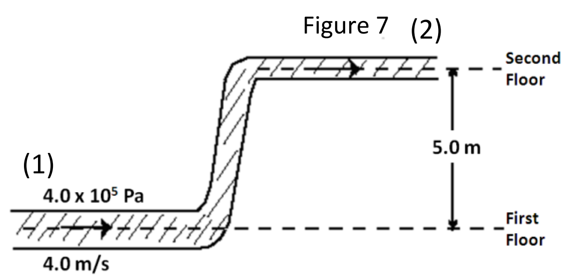
$$300 = 500\left(4{v_1}^2 - {v_1}^2\right) \Rightarrow v_1 = 0.447 \text{ m/s}$$

Q26.

As shown in **Figure 7**, water enters the first floor of a house through a pipe with a cross sectional area of 3.0 cm^2, and at an absolute pressure of 4.0×10^5 Pa. The pipe leads to the second floor, 5.0 m above the first floor, where the cross sectional area decreases to 0.80 cm^2. The flow velocity in the first floor is 4.0 m/s. What is the pressure at the higher level?

A) 2.5×10^5 Pa
B) 2.0×10^5 Pa
C) 4.0×10^5 Pa
D) 3.5×10^5 Pa
E) 3.0×10^5 Pa

Figure 7



Ans:

Continuity: $A_1 v_1 = A_2 v_2$

$3 \times 4 = 0.8\, v_2 \Rightarrow v_2 = 15 \text{ m/s}$

Bernoulli:

$$p_1 + \frac{1}{2}\rho {v_1}^2 + \cancelto{0}{\rho g y_1} = p_2 + \frac{1}{2}\rho {v_2}^2 + \rho g y_2$$

$$p_2 = p_1 + \frac{\rho}{2}\left({v_1}^2 - {v_2}^2\right) - \rho g h$$

$$= 4.0 \times 10^5 + 500(16 - 225) - (10^3 \times 9.8 \times 5)$$

$$= 4.0 \times 10^5 - 1.045 \times 10^5 - 0.49 \times 10^5$$

$$= 2.465 \times 10^5 \text{Pa} \Rightarrow 2.5 \times 10^5 \text{Pa}$$

Q27.

A particle executes simple harmonic motion on a horizontal frictionless surface, with the equilibrium position at $x = 0$. At $t = 0$, it is released from rest at a displacement $x = 0.5$ m. If the frequency of oscillation is 5 Hz, find the displacement x at $t = 0.02$ s.

A) 0.4 m
B) 0.5 m
C) 0.3 m
D) 0.2 m
E) 0.1 m

Ans:

$$x(t) = x_m . \cos(\omega t + \phi)$$

$$v(t) = -\omega x_m . \sin(\omega t + \phi)$$

$$0 = -\omega x_m . \sin\phi \Rightarrow \phi = 0$$

$$x(t) = x_m . \cos \omega t$$

$$0.5 = x_m . \cos 0 \Rightarrow x_m = 0.5$$

$$\Rightarrow x(t) = 0.5 . \cos \omega t = 0.5 \times \cos(2\pi \times 5 \times 0.02) = 0.4 \text{ m}$$

Q28.

A 0.25 kg block oscillates on the end of a spring with a spring constant of 100 N/m. If the system has a maximum kinetic energy of 5.0 J, what is the amplitude of oscillation?

A) 0.32 m
B) 0.17 m
C) 0.24 m
D) 0.68 m
E) 0.96 m

Ans:

$$K_{max} = E = \frac{1}{2} k {x_m}^2$$

$$x_m = \sqrt{\frac{2. K_{max}}{k}} = \sqrt{\frac{2 \times 5.0}{100}} = 0.32 \text{ m}$$

Q29.

The rotational inertia of a uniform rod, of mass M and length L, about its end is $ML^2/3$. Such a rod is pivoted vertically from one end and set into oscillation as a physical pendulum. If $L = 0.80$ m, what is the period of oscillation?

A) 1.5 s
B) 0.35 s
C) 0.23 s
D) 4.3 s
E) 0.88 s

Ans:

$$I_p = \frac{ML^2}{3}, \qquad h = \frac{L}{2} \quad \Rightarrow \frac{I_p}{Mgh} = \frac{1}{Mg} \cdot \frac{ML^2}{3} \cdot \frac{2}{L} = \frac{2L}{3g}$$

$$T = 2\pi \cdot \sqrt{\frac{2L}{3g}} = 2\pi \times \sqrt{\frac{2 \times 0.8}{3 \times 9.8}} = 1.5 \text{ s}$$

Q30.

A mass-spring system executing simple harmonic motion has amplitude x_m. When the kinetic energy of the object equals twice the potential energy stored in the spring, what is the displacement (x) of the object from the equilibrium position?

A) $x_m/\sqrt{3}$
B) $\sqrt{3}\,x_m$
C) x_m
D) $x_m/2$
E) $x_m/3$

Ans:

$$K = 2U$$

$$E = K + U = 2U + U = 3U$$

$$\cancel{\frac{1}{2}}\,\cancel{k}.x_m{}^2 = 3 \times \cancel{\frac{1}{2}} \times \cancel{k}x^2$$

$$x^2 = \frac{x_m{}^2}{3} \Rightarrow x = \frac{x_m}{\sqrt{3}}$$
