Q1.

A ball moves up a slope. At the end of three seconds, its velocity is 20 cm/s; at the end of eight seconds, its velocity is zero. What is the magnitude of its average acceleration from the third to the eighth second?

A) 4.0 cm/s^2
B) 2.5 cm/s^2
C) 5.0 cm/s^2
D) 6.0 cm/s^2
E) 1.5 cm/s^2

Ans:

$$a = \frac{\Delta v}{\Delta t} = \frac{20}{8-3} = \frac{20}{5} = 4 \text{ cm/s}^2$$

Q2.

A student drives from his university to his home. He first drives 50.0 km due east, then 50.0 km 30.0° south of east, then 50.0 km 60.0° south of east and reaches to his home. How much does he need to drive if he goes straight from his university to home? (Assume a straight road is available.)

A) 137 km
B) 150 km
C) 121 km
D) 100 km
E) 210 km

Ans:

X = East, Y = North

$$X = 50 + 50\cos 30^0 + 50\cos 60^0$$

$$Y = 50 sin 30^0 + 50\sin 60^0$$

$$R = \sqrt{X^2 + Y^2} = 137 \text{ km}$$

Q3.

An object is fired vertically upward from the flat surface of a truck moving at a constant speed of 40 km/h on a straight horizontal road. The object falls: (ignore air resistance)

A) on the truck surface
B) in front of the truck
C) behind the truck
D) either behind or in front of the truck, depending on the initial vertical speed of the object
E) to the side of the truck

Ans:

A

Q4.

A man of mass 71.4 kg is in an elevator that is accelerating upward at 4.00 m/s^2. The force exerted on him by the elevator floor is:

A) 985 N
B) 270 N
C) 416 N
D) 700 N
E) 127 N

Ans:

$$W - mg = +ma \Rightarrow W = mg + ma$$

$$W = 700 + \frac{700}{9.8} \times 4 = 985 \text{ N}$$

Q5.

The speed of a 4.0-N block, sliding across a horizontal ice surface, decreases at the rate of 0.61 m/s^2. The coefficient of kinetic friction between the block and ice is:

A) 0.062
B) 0.025
C) 0.041
D) 0.082
E) 0.012

Ans:

$$f = ma$$

$$\mu \cancel{m} g = \frac{\cancel{m}}{9.8} \times 0.61$$

$$\mu = \frac{0.61}{9.8} = 0.062$$

Q6.

Camping equipment weighing 6.0×10^3 N is pulled by campers across a frozen lake using a horizontal rope. The coefficient of kinetic friction is 0.050. The work done by the campers in pulling the equipment 1.0×10^3 m at constant velocity is:

A) 3.0×10^5 J
B) 1.0×10^5 J
C) 2.0×10^5 J
D) 4.0×10^5 J
E) 5.0×10^5 J

Ans:

$$\Delta K + \Delta U_g = W_a + \left(W_f\right)$$

$$W_a = \Delta K + W_f = \frac{1}{2}mv^2 + \mu mg\Delta X$$

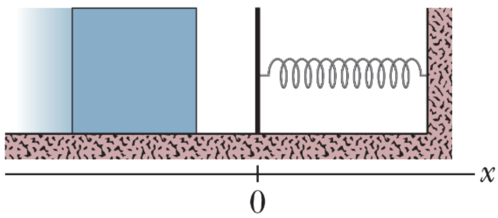
$$= 0.05\times6000\times1000 = 3.0\times10^5\,J$$

Q7.

A block of mass m = 2.5 kg slides on a horizontal rough surface head on into a spring of spring constant k = 320 N/m, as shown in **Figure 1**. When the block stops, it has compressed the spring by 7.5 cm. The coefficient of kinetic friction between block and floor is 0.25. What is the block's speed just as it reaches the spring?

A) 1.0 m/s
B) 2.0 m/s
C) 3.0 m/s
D) 4.0 m/s
E) 5.0 m/s

Figure 1



Ans:

$$\Delta U_s + \Delta K = W_f$$

$$\frac{1}{2}kx^2 + \frac{1}{2}mv_0^2 = -\mu mgX$$

$$v_0 = \sqrt{2\mu gX + \frac{K}{m}X^2} = \sqrt{2\times0.25\times9.8\times0.075 + \frac{320}{2.5}\times0.075^2} = 1.0\ \mathrm{m/s}$$

Q8.

A projectile of mass 0.500 kg is fired with an initial speed of 10.0 m/s at an angle of 60.0° above the horizontal. The potential energy of the projectile-Earth system when the projectile is at its highest point (relative to the potential energy when the projectile is at ground level) is:

A) 18.8 J
B) 27.7 J
C) 32.5 J
D) 46.2 J
E) 55.3 J

Ans:

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

$$K - K_0 + U - U_0 = 0$$

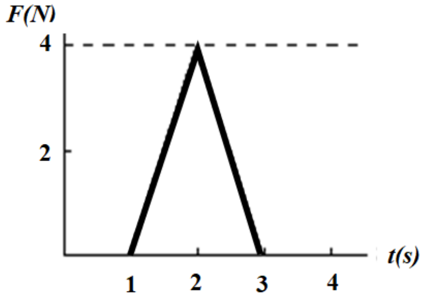
$$U = \frac{1}{2}mv_0^2 - \frac{1}{2}m(v_0 cos60°)^2$$

$$U = \frac{1}{2} \times 0.5 \times 10^2 - \frac{1}{2} \times 0.5 \left(10 \times \frac{1}{2}\right)^2 = 18.8 \ \ J$$

Q9.

A 5-kg object moves along the x-axis and it is subjected to a force $\vec{F}$ in the positive x direction. A graph of F as a function of time t is shown in **Figure 2**. Find the change in velocity of the object from the time t = 1 s to t = 3 s.

Figure 2



A) 0.8 m/s
B) 0.3 m/s
C) 0.6 m/s
D) 0.1 m/s
E) 0.5 m/s

Ans:

$$F = \frac{\Delta P}{\Delta t}$$

$$\Delta P = F\Delta t$$

$m\Delta v =$ Area under the curve

$$5\Delta v = \frac{1}{2}(3-1)\times(4-0) \Rightarrow \Delta v = \frac{4}{5} = 0.8 \text{ m/s}$$

Q10.

A child is riding on a large merry-go-round at the distance of 2.00 m from its center. The marry-go-round moves with constant angular speed and the child travels a distance of 300 m in 60.0 s. Find the radial acceleration of the child.

A) 12.5 m/s^2
B) zero
C) 36.0 m/s^2
D) 54.1 m/s^2
E) 24.5 m/s^2

Ans:

$$a = \frac{v^2}{r} = \frac{\left(\frac{300}{60}\right)^2}{20} = \frac{25}{2} = 12.5 \text{ m/s}^2$$

Q11.

A flywheel has a rotational inertia of 0.140 kg.m^2 about its central axis. If its angular momentum decreases from 3.00 kg m^2/s to 0.800 kg m^2/s in 1.50 s, what is the magnitude of the average torque acting on the flywheel about its central axis during this period?

A) 1.47 N.m
B) 2.51 N.m
C) 3.27 N.m
D) 6.70 N.m
E) 5.45 N.m

Ans:

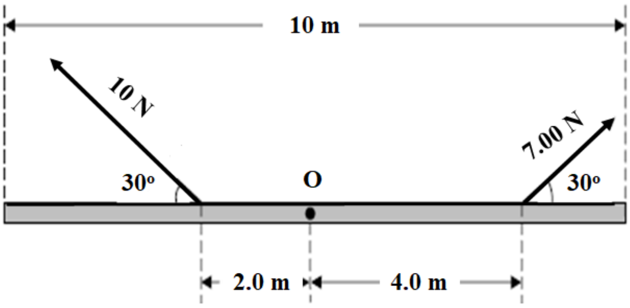
$$\tau = \left|\frac{\Delta L}{\Delta t}\right| = \left|\frac{L - L_0}{1.5}\right| = \left|\frac{0.8-3}{1.5}\right| = 1.47\, N.m$$

Q12.

A uniform rod of length 10 m and mass 2.0 kg is pivoted about its center of mass O. Two forces of 10 N and 7.0 N are applied to the rod, as shown in **Figure 3**. What is the magnitude of the angular acceleration of the rod about O?

A) 0.24 rad/s^2
B) 0.15 rad/s^2
C) 0.37 rad/s^2
D) 0.41 rad/s^2
E) 0.67 rad/s^2

Figure 3



Ans:

$-2\times 10\sin 30° + 7\sin 30°\times 4 = I\alpha$

$$4 = \frac{1}{12} mL^2\alpha$$

$$\alpha = \frac{4\times 12}{2\times 100} = 0.24 rad/s^2$$

Q13.

A small disc, initially at rest, rolls (without slipping) down an incline plane of angle 30° and reaches to the bottom of the incline with its center of mass velocity of 2.0 m/s. What would be its speed at the bottom of the same incline if the disc slides from rest (without rolling) from the same initial point? (Assume size of the disc is negligible as compared to the length of the incline)

A) 2.4 m/s
B) 3.7 m/s
C) 4.6 m/s
D) 6.2 m/s
E) 1.1 m/s

Ans:

For rolling

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

$$\frac{1}{2}I\omega^2 + \frac{1}{2}mv_0^2 - mgh = 0$$

$$\frac{1}{2}\times\frac{1}{2}mR^2\frac{v_0^2}{R^2} + \frac{1}{2}mv^2 = mgh \Rightarrow \frac{3}{4}v_0^2 = gh$$

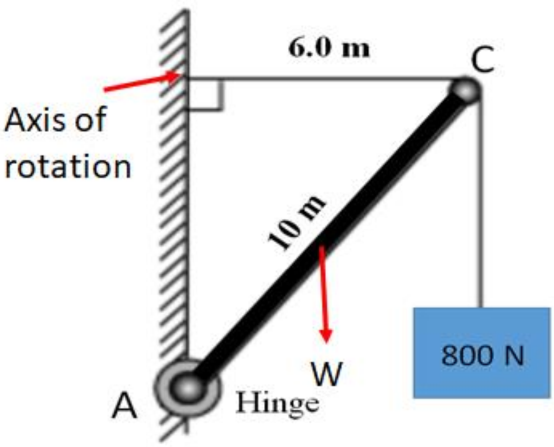
For sliding

$$\frac{1}{2}mv^2 = mgh \Rightarrow v = \sqrt{2gh} = \sqrt{\frac{3}{2}}v_0 = 2.4 \text{ m/s}$$

Q14.

A 10-m long uniform rod (AC) of weight 400 N is hinged to a wall at A. It is supporting an 800-N block as shown in **Figure 4**. Find the magnitude of the hinge force.

Figure 4



A) 1.42×10^3 N
B) 3.50×10^2 N
C) 4.50×10^2 N
D) 5.06×10^3 N
E) 2.31×10^3 N

Ans:

$W + 800 = F_v$

$F_v = 1200\ N$

$-400 \times 3 - 800 \times 6 + F_h 8 = 0$

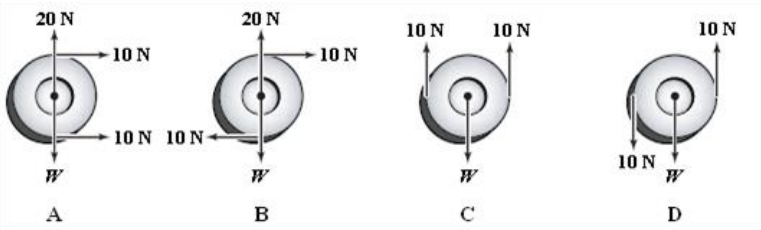
$F_h = \frac{6000}{8} = 750\ N$

$F = \sqrt{F_a^2 + F_h^2} = \sqrt{1200^2 + 750^2} = 1.42 \times 10^3$N

Q15.

Figure 5 show forces applied to a wheel that weighs 20 N. The symbol *W* stands for the weight. In which diagram(s) is(are) the wheel in static equilibrium?

Figure 5



A) C
B) A
C) B
D) C and A
E) D

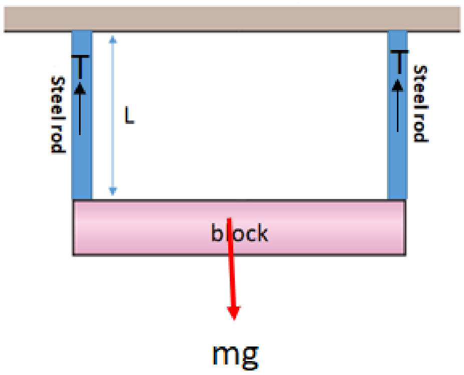
Ans:

A

Q16.

Figure 6 shows a uniform block which is held in a horizontal position by two vertical steel rods at its ends. Each of the rods has length, L = 1.0 m, cross sectional area of 1.0×10^{-3} m^2 and young's modulus of 2.0×10^{11} N/m^2. If the increase in the length of any one of the rods is 2.5×10^{-6} m, find the mass of the block.

Figure 6



A) 100 kg
B) 150 kg
C) 200 kg
D) 250 kg
E) 300 kg

Ans:

$$mg = 2T$$

$$T = \frac{mg}{2}$$

$$Y = \frac{\frac{T}{A}}{\frac{\Delta L}{L}} = \frac{mgL}{2A\Delta L}$$

$$m = \frac{2YA\Delta L}{gL} = 100 \text{ kg}$$

Q17.

Mars has a mass of about 0.108 times the mass of Earth and a diameter of about 0.533 times the diameter of Earth. If your mass is 50.0 kg what will be your weight on the surface of the Mars?

A) 186 N
B) 140 N
C) 207 N
D) 325 N
E) 451 N

Ans:

$$W_m = mg_m = \frac{GmM_m}{R_m^2} = \frac{0.108GmM_E}{0.533^2R_E^2} = \frac{0.108\times 50}{0.533^2}9.8 = 186\ N$$

Q18.

A 1.0-kg projectile has an escape velocity of 7.0 km/s at the surface of a planet. The corresponding escape velocity for a 2.0 kg projectile is: (Ignore air resistance)

A) 7.0 km/s
B) 14 km/s
C) 3.5 km/s
D) 2.4 km/s
E) 21 km/s

Ans:

A

Q19.

An object is released from rest when it is at a height *h* above the surface of a planet of mass *M* and radius *R*. What is the speed of the object just before striking the surface of the planet? Neglect any air resistance. Let $h = 4.0\times10^{6}$ m, $R = 5.0\times10^{6}$ m, and $M = 4.0\times10^{24}$ kg.

A) 6.9 km/s
B) 1.3 km/s
C) 2.5 km/s
D) 4.6 km/s
E) 5.2 km/s

Ans:

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

$$U_g - U_{og} + K - K_0 = 0$$

$$\frac{1}{2}mv^2 = +GMm\left(\frac{1}{R} - \frac{1}{R+h}\right)$$

$$v = \sqrt{2GM\left(\frac{1}{R} - \frac{1}{R+h}\right)} \cong 6.9 \text{ km/s}$$

Q20.

A satellite of mass 125 kg is in a circular orbit around a certain planet. If the period of revolution of the satellite is 8.05×10^{3} s, and its mechanical energy is -1.87×10^{9} J, what is its radius?

A) 7.01×10^{6} m
B) 8.00×10^{6} m
C) 9.25×10^{6} m
D) 5.10×10^{6} m
E) 6.00×10^{6} m

Ans:

$$T^2 = \frac{4\pi^2}{Gm} r^3 \Longrightarrow E = -\frac{GMm}{2r} \Rightarrow GM = -\frac{2Er}{m}$$

$$T^2 = \frac{4\pi^2 m}{-2Er} r^3 \Longrightarrow r = \sqrt{\frac{-2E}{4\pi^2 m}}\, T = 7.01 \times 10^6$$

Q21.

Three identical particles each having mass of 2.00 kg are placed at the corners of an equilateral triangle of sides 0.500 m. Find the amount of energy required to take one of the masses to infinity. Assume the gravitational potential energy is zero at infinity.

A) 1.07×10^{-9} J
B) 2.35×10^{-9} J
C) 3.01×10^{-9} J
D) 4.98×10^{-9} J
E) 7.53×10^{-9} J

Ans:

$$U_0 = \frac{-3\, Gm^2}{r^2};\ \ U = -\frac{Gm^2}{r}$$

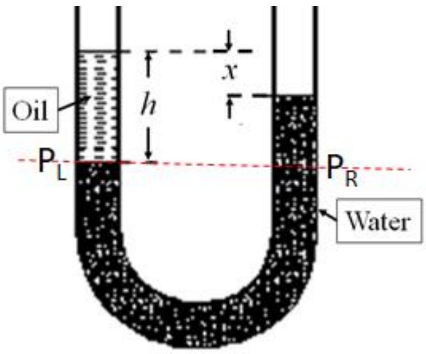
$$W_a = \Delta U = U - U_0$$

$$W_a = \frac{2Gm^2}{r} = 1.07 \times 10^{-9}\text{J}$$

Q22.

A U-shaped tube is filled with water and oil as shown in **Figure 7**. If h = 20 cm and x = 2.0 cm, find the density of the oil.

Figure 7



A) 0.90 g/cm^3
B) 0.70 g/cm^3
C) 1.0 g/cm^3
D) 1.3 g/cm^3
E) 0.50 g/cm^3

Ans:

$$P_L = P_R$$

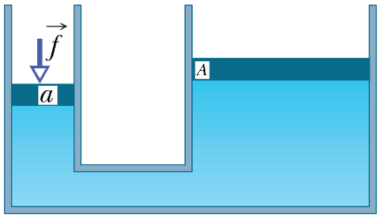
$$\rho_{oil} g h = \rho_w g (h - x)$$

$$\rho_{oil} = \rho_w \frac{(h-x)}{h} = 0.90\ g/cm^3$$

Q23.

Figure 8 shows a schematic of hydraulic lift. Right piston in a hydraulic lift has an area that is three times the area of the left piston. When the pressure at the smaller piston is increased by Δp the pressure at the larger piston:

Figure 8



A) increases by Δp
B) increases by $\Delta p/3$
C) increases by $3\Delta p$
D) increases by $6\Delta p$
E) does not change

Ans:

A

Q24.

Water flows through a cylindrical pipe of varying cross-section. The velocity is 3.0 m/s at a point where the pipe diameter is 1.0 cm. At a point where the pipe diameter is 3.0 cm, the velocity is:

A) 0.33 m/s
B) 0.25 m/s
C) 0.71 m/s
D) 0.90 m/s
E) 0.11 m/s

Ans:

$$A_1 v_1 = A_2 v_2$$

$$v_2 = \frac{\pi(d_1/2)^2}{\pi(d_2/2)^2} \cdot v_1 = \frac{1}{9} \times 3 = 0.33\, m/s$$

Q25.

A closed empty bottle has a mass of 112 g. If fully submerged in water it displaces 1.63×10^{-4} m^3 of water. What volume of mercury ($\rho_{Hg} = 13.6\times10^3$ kg/m^3) must be added to the empty bottle so that it will just submerge?

A) 3.75 cm^3
B) 2.15 cm^3
C) 1.00 cm^3
D) 4.50 cm^3
E) 5.25 cm^3

Ans:

b = bottle, m = mercury, w = water

$$F_b = m_w g = \rho_w V_w g = (m_b + m_m) g$$

$$\Rightarrow \rho_w V_w = m_b + \rho_m V_m$$

$$\Rightarrow V_m = \frac{\rho_w}{\rho_m} V_w - \frac{m_b}{\rho_m} = 3.75\, cm^3$$

Q26.

A water main-line enters a house 2.0 m below ground. A smaller diameter pipe carries water to a tap 5.0 m above ground, on the second floor. Water flows at 2.0 m/s in the main line and at 7.0 m/s on the second floor. The pressure in the main line is 2.0×10^5 Pa; then the difference in pressure between the main line and the second floor is:

A) 9.1×10^4 Pa with the main line at the higher pressure
B) 2.3×10^4 Pa with the main line at the higher pressure
C) 6.9×10^4 Pa with the main line at the lower pressure
D) 2.3×10^4 Pa with the main line at the lower pressure
E) 6.9×10^4 Pa with the main line at the higher pressure

Ans:

1 = mainline, 2 = second floor

$$P_1 + \rho_1 g h_1 + \frac{1}{2}\rho v_1^2 = P_2 + \rho_2 g h_2 + \frac{1}{2}\rho v_2^2$$

$$\Delta P = \rho g(h_2 - h_1) + \frac{1}{2}\rho(v_2^2 - v_1^2)$$

$$\Delta P = 10^3 \times 9.8(7-0) + \frac{1}{2}10^3(7^2 - 2^2)$$

$$= 9.1 \times 10^4 P_a \text{ with the main line at the higher pressure}$$

Q27.

A block attached to a spring undergoes simple harmonic motion on a horizontal frictionless surface. The total energy of block-spring system is 50.0 J. When the displacement is half the amplitude, the kinetic energy is:

A) 37.5 J
B) 12.0 J
C) 25.1 J
D) 18.5 J
E) 50.7 J

Ans:

$$E = \frac{1}{2}kx_m^2 = 50 \text{ J}$$

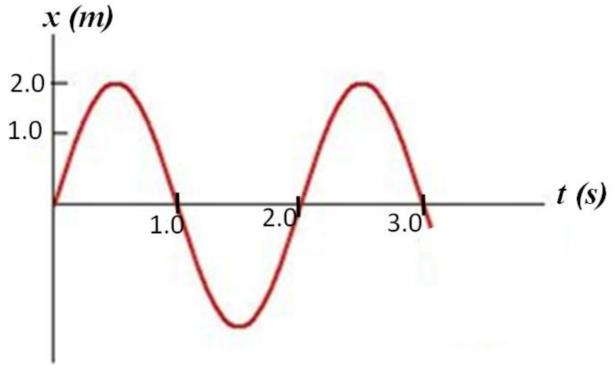
$$U_{\frac{1}{2}} = \frac{1}{2}k\frac{x_m^2}{4} = \frac{50}{4} = 12.5\, J$$

$$K_{\frac{1}{2}} = 50 - 12.5 = 37.5 \text{ J}$$

Q28.

Figure 9 shows a mass oscillating as $x = x_m \cos(\omega t + \varphi)$. Find the values of maximum speed and the phase constant φ, respectively.

Figure 9



A) 6.3 m/s and 90°
B) 6.3 m/s and zero
C) 3.1 m/s and zero
D) 3.1 m/s and 90°
E) 2.6 m/s and zero

Ans:

$$V = \omega y_m = \frac{2\pi}{T} y_m = \frac{2\pi}{2} 2$$

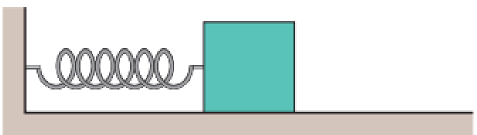
$$\Rightarrow V = 6.3\ m/s$$

$$Sine\ Curve, So\ \Phi = 90°$$

Q29.

A 3.00 kg block, attached to a horizontal spring of spring constant 7500 N/m, executes simple harmonic motion of amplitude 2.00 cm on a frictionless surface as shown in **Figure 10**. Find the total distance travelled by the block in 5.03 seconds.

Figure 10



A) 320 cm
B) 110 cm
C) 210 cm
D) 180 cm
E) 560 cm

Ans:

$$T = 2\pi\sqrt{\frac{m}{k}} = 0.1257\ s$$

$$d = \frac{t}{T} \times 4 \times y_m = 320\ cm$$

Q30.

Three hoops, each is pivoted at a point on the rim, and is allowed to swing as a physical pendulum. The masses and radii of the hoops are,
hoop 1: M = 150g and R = 50 cm
hoop 2: M = 200g and R = 40 cm
hoop 3: M = 250g and R = 30 cm

Rank the hoops according to the periods of their motions, **smallest to largest**.

A) 3, 2, 1
B) 1, 2, 3
C) 3, 1, 2
D) 2, 3, 1
E) 1, 3, 2

Ans:

$$T = 2\pi\sqrt{\frac{I}{mgh}} = \sqrt{\frac{mR^2}{mgR}} = \sqrt{\frac{R}{g}}$$

$$T \propto \sqrt{R}$$