Q1.

A race car makes 10 rounds with an average speed of 200.0 km/h. If the first nine rounds were done at an average speed of 196.0 km/hr, then find the average speed that must be maintained for the last round.

A) 245.0 km/h
B) 200.0 km/h
C) 196.0 km/h
D) 396.0 km/h
E) 296.0 km/h

Ans:

$$200 = \frac{10\text{ L}}{\frac{9\text{L}}{196} + \frac{\text{L}}{\text{v}_{10}}} \Rightarrow \text{v}_{10} = 245\text{ km/h}$$

Q2.

You throw a stone off a bridge downward with initial speed *v*. When the stone has fallen 4.0 m, you drop a second stone. As the two stones continue to fall, which one of the following statements is correct. [Ignore air resistance]

A) The velocities of both stones increase at the same rate.
B) The velocity of the first stone increases faster than the velocity of the second.
C) The velocity of the second stone increases faster than the velocity of the first.
D) The velocities of both stones remain constant.
E) The velocities of both stones will decrease in magnitude.

Ans:

A

Q3.

Two vectors are given by $\vec{A} = 3.00\hat{i} + A_y\hat{j}$ and $\vec{B} = -2.00\hat{i} + 4.00\hat{j}$, if the angle between $\vec{A}$ and $\vec{B}$ is 90.0°, then find A_y

A) 1.5
B) 3.00
C) 1.00
D) −3.00
E) −1.00

Ans:

$$\vec{\text{A}} \cdot \vec{\text{B}} = 0$$

$$(3)(-2) + (A_y)(4) = 0$$

$$\Rightarrow A_y = 1.5$$

Q4.

A particle leaves the origin with an initial velocity $\vec{v} = 4.0\hat{i}$ m/s. It experiences a constant acceleration $\vec{a} = (-1.0\hat{i} - 0.50\hat{j})$ m/s^2. What is the velocity of the particle when it reaches its maximum x coordinate?

A) $-2.0\hat{j}$ m/s
B) $-3.0\hat{j}$ m/s
C) $-1.5\hat{i}$ m/s
D) $-3.0\hat{i}$ m/s
E) 0

Ans:

$V_{fx} = 0$

$4\hat{\imath} - (1)t\,\hat{\imath} = 0 \;\Rightarrow t = 4s$

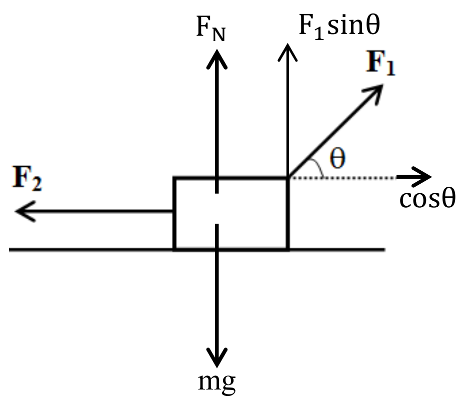
$V_{fy} = (-0.5)(4) = -2\ m/s$

$V_f = -2\,\hat{\jmath}\ m/s$

Q5.

Figure 1 shows two constant forces F_1= 60 N and F_2= 30 N applied to a box of mass 10 kg and it slides with a constant velocity on a horizontal frictionless surface. Find the magnitude of the normal force.

Figure 1



A) 46 N
B) 98 N
C) 49 N
D) 9.8 N
E) 53 N

Ans:

$F_1\cos\theta = F_2$

$\cos\theta = \frac{F_2}{F_1} = \frac{1}{2}$

$\Rightarrow \theta = 60°$

$F_N = mg - F_1\sin\theta = 46\ N$

Q6.

A car passes over the top of a circular vertical hill of 20 m radius. If the magnitude of the normal force on the car and its speed at the top of the hill is 9.8 kN and 10 m/s, respectively, then find the mass of the car. [Ignore air resistance]

A) 2.0×10^3 kg
B) 1.5×10^3 kg
C) 2.5×10^3 kg
D) 1.0×10^3 kg
E) 1.3×10^3 kg

Ans:

$$mg - F_N = \frac{mv^2}{R}$$

$$m = \frac{F_N}{g - \frac{v^2}{R}} = 2 \times 10^3 \text{ kg}$$

Q7.

A light-weight object and a heavy-weight object are sliding with equal speeds along a horizontal frictionless surface and then they both slide up the same frictionless hill. Which one of the following statements is correct. [Ignore air resistance]

A) Both objects will slide up to the same height.
B) The heavyweight object will reach higher height because it has greater kinetic energy.
C) The lightweight object will reach higher height because it has smaller kinetic energy.
D) The lightweight object will reach higher height because it weighs less.
E) The heavyweight object will reach higher height because it has greater momentum.

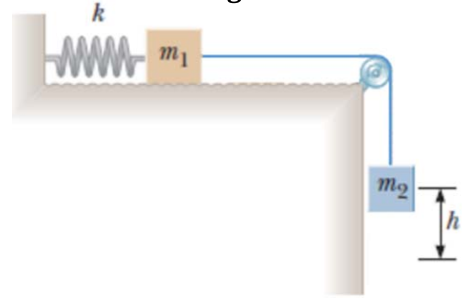
Ans:

$$\frac{1}{2}mv^2 = mgh$$

Q8.

Figure 2 shows two blocks connected by a massless string that passes over a frictionless pulley. The block of mass $m_1 = 5.00$ kg is connected to a spring of force constant 400 N/m. Initially, the system is released from rest when the spring is unstretched. If the hanging block of mass $m_2 = 3.00$ kg falls a distance $h = 0.100$ m before coming to rest, calculate the coefficient of kinetic friction between the block of mass m_1 and the surface.

Figure 2



A) 0.192
B) 0.235
C) 0.154
D) 0.289
E) 0.350

Ans:

$$\cancelto{0}{\Delta K} + \Delta U + \Delta U_s = W_{nc}$$

$$0 - m_2 g h + \frac{1}{2} k x^2 = -\mu_k m_1 g (0.1)$$

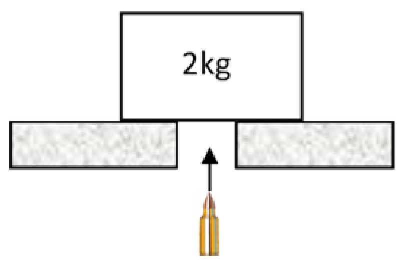
$$-2.94 + 2 = -4.9 \mu_k$$

$$\mu_k \cong 0.192$$

Q9.

In **Figure 3,** a 100 g bullet moving directly upward at 200 m/s strikes and stay inside a 2.0 kg block initially at rest. To what maximum height does the block-bullet system rise above the initial position?

Figure 3



Bullet: 100 g; 200 m/s

A) 4.6 m
B) 9.2 m
C) 7.6 m
D) 5.1 m
E) 2.3 m

Ans:

$$\vec{P}_i = \vec{P}_f$$

$$(0.1)(200) = (0.1 + 2) v_{bB}$$

$$\Rightarrow v_{bB} = 9.52 \text{ m/s}$$

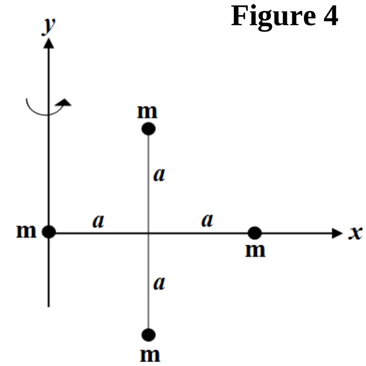
$$\Delta K = -\Delta U$$

$$\frac{1}{2}(2.1)(9.52)^2 = (2.1)(9.8) h \Rightarrow h = 4.6 \text{ m}$$

Q10.

In **Figure 4,** four identical particles, each with mass *m*, are arranged in the *xy*-plane. They are connected by light sticks of negligible mass to form a rigid body. Find the ratio of the rotational inertia of this system about the *y*-axis to the rotational inertia about the *x*-axis.

Figure 4



A) 3
B) 1
C) 2
D) 6
E) 1/2

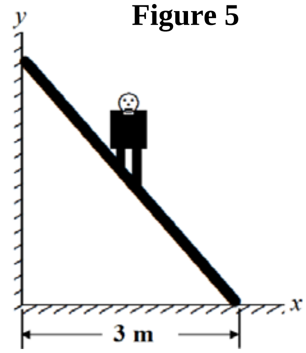
Ans:

$$\frac{I_y}{I_x} = \frac{6ma^2}{2ma^2} = 3$$

Q11.

An 800 N man stands halfway up a 5.0 m long ladder of negligible weight. The base of the ladder is 3.0 m from the wall as shown in **Figure 5**. Assuming that the wall-ladder contact is frictionless, then find the magnitude of force that the wall pushes against the ladder.

Figure 5



A) 300 N
B) 400 N
C) 100 N
D) 500 N
E) 200 N

Ans:

$$\sum \tau_0 = 0$$

$$(F)(4) = (800)(1.5)$$

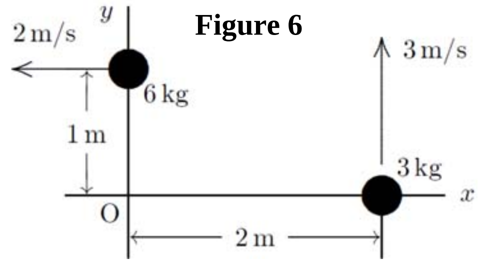
$$\Rightarrow F = 300\ N$$

Q12.

Two objects are moving in the *xy* plane as shown in **Figure 6**. The magnitude of their total angular momentum (about the origin O) is:

A) 30 $kg.m^2/s$
B) 6 $kg.m^2/s$
C) 12 $kg.m^2/s$
D) 78 $kg.m^2/s$
E) 0

Figure 6



Ans:

$$\vec{L}_1 = 2\hat{\imath} \times 3\,(3\hat{\jmath}) = 18\,\hat{k}$$

$$\vec{L}_2 = (\hat{\jmath}) \times 6\,(-2\hat{\imath}) = 12\,\hat{k}$$

$$|\vec{L}_{tot}| = |\vec{L}_1 + \vec{L}_2| = |30\,\hat{k}\,| = 30\text{ kg}\,\frac{m^2}{s}$$

Q13.

Two Satellites A and B are orbiting the earth; Satellite A is 4 times as far from the earth's center as Satellite B. Find the ratio of the period of satellite A to the period of satellite B.

A) 8
B) 1/8
C) 64
D) 1/64
E) 16

Ans:

$$\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{r_A}{r_B}\right)^3 = 4^3$$

$$\frac{T_A}{T_B} = 4^{3/2} = 8$$

Q14.

A uniform solid sphere has a mass of 1.5×10^{4} kg and a radius of 1.0 m. A particle of mass m = 1.0 kg is inserted and placed at a distance of 0.85 m from the center of the sphere. Find the magnitude of the gravitational force due to the sphere on the particle.

A) 8.5×10^{-7} N
B) 1.9×10^{-7} N
C) 3.6×10^{-7} N
D) 9.9×10^{-7} N
E) 0

Ans:

$$F = \frac{GmM}{r^2} = \frac{GmMr}{R^3} = 8.5 \times 10^{-7}\mathrm{N}$$

Q15.

Determine the speed of the Hubble Space Telescope orbiting at a height of 598 km above the earth's surface.

A) 7.57×10^{3} m/s
B) 7.91×10^{3} m/s
C) 25.8×10^{3} m/s
D) 2.58×10^{3} m/s
E) 2.56×10^{3} m/s

Ans:

$$\frac{GmM}{r^2} = \frac{mv^2}{r}$$

$$\Rightarrow v = 7.57 \times 10^{3}\ \mathrm{m/s}$$

Q16.

A 10.0 kg rock headed directly towards Earth, has a speed of 10.0 km/s relative to Earth when it is located 4 Earth radii from Earth's surface. Neglecting the effects of the Earth's atmosphere on the rock, find the rock's mechanical Energy just before it reaches Earth's surface.

A) 3.75×10^{8} J
B) 4.45×10^{3} J
C) 1.25×10^{8} J
D) 2.38×10^{3} J
E) 5.11×10^{9} J

Ans:

$$E_i = \frac{1}{2}mv^2 - \frac{GmM_E}{5R_E} = E_f$$

$$= 3.75 \times 10^{8}\ J$$

Q17.

If an object is fired from a planet surface with a speed equal to the escape speed. Which one of the following statements is correct. [Neglect any friction effects]

A) The Mechanical energy of the object at the planet's surface must be zero.
B) The Mechanical energy of the object at the planet's surface must be greater than zero.
C) The Mechanical energy of the object at the planet's surface must be less than zero.
D) The escape speed from the planet's surface depends on the object's mass.
E) The escape speed from the planet's surface depends on the object's radius.

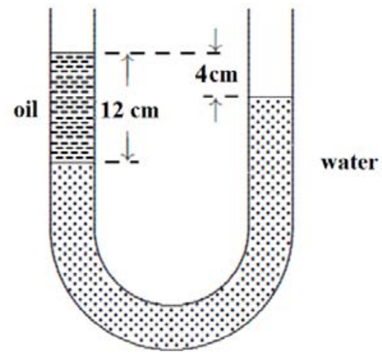
Ans:

$$E_{surface} = E_{\infty} = 0$$

Q18.

Figure 7 shows a U-shaped tube open to the air at both ends. If density of water is 1.00 g/cm^3, then determine the density of the oil filled in the left column of the U-tube.

Figure 7



A) 0.67 g/cm^3
B) 0.75 g/cm^3
C) 1.50 g/cm^3
D) 0.33 g/cm^3
E) 0.89 g/cm^3

Ans:

$$\rho_{oil} = \frac{\rho_w h_w}{h_{oil}} = \frac{(1)(8)}{12} = 0.67\ g/cm^3$$

Q19.

Imagine holding two identical bricks A and B completely under water. Brick A is just below the surface of the water, while brick B is at a greater depth. Which one of the following statements is correct.

A) The force needed to hold brick B in place equals the force needed to hold brick A in place.
B) The force needed to hold brick B in place is larger than the force needed to hold brick A in place.
C) The force needed to hold brick B in place is less than the force needed to hold brick A in place.
D) The buoyant force on A is larger than the buoyant force on B
E) The buoyant force on B is larger than the buoyant force on A

Ans:

$$F_{needed} = mg - F_B$$

Q20.

A piece of aluminum of 27.00 kg mass and density 2700 kg/m^3, suspended from a string, is completely immersed in a container filled with water. The density of water is 1000 kg/m^3. Determine the tension in the string after the aluminum piece is immersed in water.

A) 166.6 N
B) 176.7 N
C) 132.2 N
D) 187.6 N
E) 153.2 N

Ans:

$$F_B = \rho_W \frac{m}{\rho} g = 98\ \text{N}$$

$$T = mg - F_B$$

$$= (27)(9.8) - 98 = 166.6\ \text{N}$$

Q21.

A water line enters a house 2.0 m below ground. A smaller diameter pipe carries water to house roof located at height 5.0 m above the ground. If water flows at 2.0 m/s in the entrance line and at 7.0 m/s on the roof. Find the difference in pressure between the main line entrance and the roof.

A) 9.11×10^4 Pa
B) 9.44×10^4 Pa
C) 6.49×10^4 Pa
D) 2.65×10^4 Pa
E) 4.32×10^4 Pa

Ans:

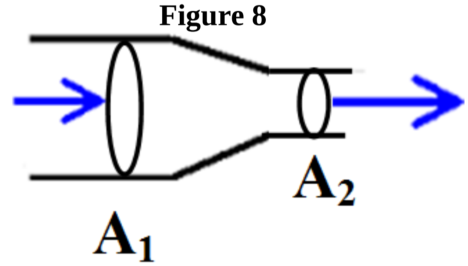
$$P_1 - P_2 = \frac{1}{2}\rho V_2^2 - \frac{1}{2}\rho V_1^2 + \rho g(7)$$

$$= 9.11 \times 10^4 \text{Pa}$$

Q22.

Figure 8 shows water flowing through a horizontal tube of variable cross section, with A_1 = 30.0 cm^2 and A_2 = 20.0 cm^2. The pressure difference between the two sections is 150 Pa. Find the water speed at the wider section of the tube.

Figure 8



A) 0.490 m/s
B) 0.119 m/s
C) 0.284 m/s
D) 0.994 m/s
E) 0.774 m/s

Ans:

$$P_1 - P_2 = \frac{1}{2}\rho\left(\frac{3}{2}V_1\right)^2 - \frac{1}{2}\rho V_1^2$$

$$150 = 1125V_1^2 - 500V_1^2$$

$$\Rightarrow V_1 = 0.49\ \text{m/s}$$

Q23.

The displacement of an object oscillating on a spring is given by $x(t) = x_m\cos(\omega t + \phi)$. If at $t = 0$, the displacement is zero and the velocity is in the negative x direction, then the phase constant ϕ (in rad) is:

A) π/2
B) π
C) 3π/2
D) 2π
E) 0

Ans:

$$x(+) = x_m\cos(\omega t + \Phi)$$

$$0 = x_m\cos(\Phi) \Rightarrow \Phi = \frac{\pi}{2}, \frac{3\pi}{2}$$

$$v(+1) = -x\omega\sin\Phi$$

$$\Rightarrow \sin\Phi = +ve \Rightarrow \Phi = \frac{\pi}{2}\ \text{rad}$$

Q24.

A 0.25 kg mass oscillates on the end of a spring with a spring constant of 200 N/m. If the system has an energy of 6.0 J, then find the maximum speed of the block.

A) 6.9 m/s
B) 3.4 m/s
C) 4.9 m/s
D) 0.17 m/s
E) 0.24 m/s

Ans:

$$E = \frac{1}{2} kX_m^2$$

$$V_{max} = x_m^{\omega}$$

$$x_m = \sqrt{\frac{2E}{k}} = 0.245 \text{ m} \implies v = x_m\omega = 6.9 \text{ m/s}$$

Q25.

A physical pendulum consists of a uniform meter stick that is pivoted at the 40.0 cm mark of the meter. The center of mass of the meter stick is located at 50.0 cm mark. Find the period of oscillation of the pendulum.

A) 1.94 s
B) 2.01 s
C) 1.41 s
D) 2.89 s
E) 1.02 s

Ans:

$$T = 2\pi\sqrt{\frac{I}{mgh}}$$

$$I = \frac{1}{12} mL^2 + m(0.1)^2 = 0.0933$$

$$\implies T = \sqrt{\frac{0.0933}{(m)(9.8)(0.4)}} = 1.94 \text{ s}$$
