Q1.

The coordinate of an object is given as a function of time by $x(t) = 7.0t - 3.0t^2$, where x is in meters and t is in seconds. At what time is the object at rest?

A) 1.2 s
B) 2.1 s
C) 0.7 s
D) 5.5 s
E) 9.7 s

Ans:

$$v = \frac{dx}{dt} = 7 - 6t = 0$$

$$\Rightarrow t = \frac{7}{6} \cong 1.2 \text{ s}$$

Q2.

The acceleration of an object, starting from rest, is shown in the **Figure 1** below. If the velocity of the object at t = 2.0 s is 5.5 m/s, find its velocity at t = 5.0 s?

A) 8.0 m/s
B) 5.7 m/s
C) 9.9 m/s
D) 3.1 m/s
E) 6.2 m/s

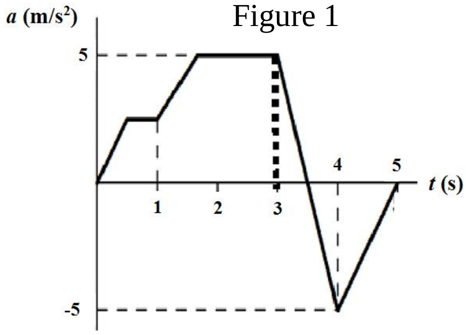


Figure 1

Ans:

$$V_{5.5} = 5.5 + 5 + \quad - \quad - 2.5$$

$$= 8 \text{ m/s}$$

Q3.

If two vectors are given by $\vec{a} = 4.0\hat{i} + 4.0\hat{j}$ and $\vec{b} = -4.0\hat{i} + 7.0\hat{j}$, find the angle between them

A) 75°
B) 57°
C) 61°
D) 47°
E) 85°

Ans:

$$\vec{a} \cdot \vec{b} = |\vec{a}||\vec{b}|\cos\theta$$

$$-16 + 28 = \sqrt{32}\sqrt{65} = \cos\theta$$

$$\Rightarrow \theta = \cos^{-1}\left(\frac{12}{\sqrt{32}\sqrt{62}}\right) \cong 75°$$

Q4.

A 1.0 kg stone is tied to a 0.50 m string and rotated at a constant speed of 4.0 m/s in a vertical circle. Find the magnitude of the tension in the string when the stone is at the bottom of the circle? [Ignore air resistance]

A) 42 N
B) 24 N
C) 64 N
D) 33 N
E) 98 N

Ans:

$$T - mg = \frac{mv^2}{r}$$

$$T = mg + \frac{mv^2}{r} = (1)(9.8) + \frac{(1)(4)^2}{0.5} = 42\ \text{N}$$

Q5.

You stand on a spring scale on the floor of an elevator. Of the following, the scale shows the highest reading when the elevator:

A) moves downward with decreasing speed.
B) remains stationary.
C) moves upward with decreasing speed.
D) moves downward with increasing speed.
E) moves upward at constant speed.

Ans:

$$N - mg = ma$$

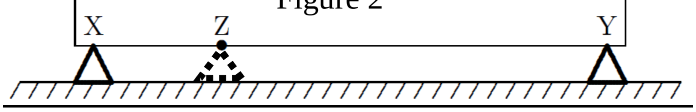
$$N = m(g + a)$$

Q6.

A uniform beam is supported by two equal 120 N forces at X and Y, as shown in **Figure 2**. The support at X is then moved to Z (half-way to the beam center). The supporting forces at Y and Z are then:

A) F_Y = 80 N, F_Z = 160 N
B) F_Y = 200 N, F_Z = 40 N
C) F_Y = 40 N, F_Z = 200 N
D) F_Y = 60 N, F_Z = 160 N
E) F_Y = 240 N, F_Z =120 N

Figure 2



Ans:

$$\sum \vec{\tau} = 0$$

$$F_z + \frac{3}{4} L - (240)\frac{L}{2} = 0$$

$$F_z = 160\ \text{N}$$

$$F_y + F_z = 240 \Rightarrow F_y = 80\ \text{N}$$

Q7.

A box is pulled up a rough, inclined plane at constant speed through application of a constant pulling force. Which one of the following statements concerning this situation is **False**? [Ignore air resistance]

A) The work done on the box by gravity is zero joules.
B) The gravitational potential energy of the box is increasing.
C) The net work done by all the forces acting on the box is zero joules.
D) The work done on the box by the normal force of the plane is zero joules.
E) The positive work is done by the pulling force on the box in moving it up the incline.

Ans:

$$W = \vec{F}_g \cdot \vec{d} \neq 0$$

Q8.

A 1.6 kg block slides down a plane at a constant speed of 2.0 m/s. The plane is inclined at 25° with the horizontal. At what rate is the frictional force doing work on the block? [Ignore air resistance]

A) –13 W
B) +13 W
C) +28 W
D) –28 W
E) +6.5 W

Ans:

$$P = \vec{f}_s \cdot \vec{v} = f_s v \cos 180 = -(1.6)(9.8)(2)\sin(25) = -13 \text{ W}$$

Q9.

A 0.75 kg mass, released from rest, is falling vertically in air. After falling through a vertical distance of 2.0 m, it is moving downward with a speed of 5.0 m/s. What is the work done by the air resistance forces (air drag force) during the vertical fall?

A) −5.3 J
B) + 5.3 J
C) −6.1 J
D) +6.1 J
E) −3.7 J

Ans:

$$W_f = \Delta E_{mech}$$

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

$$= -(0.75)(9.8)(2) + \frac{1}{2}(0.75)(25)$$

$$= -14.7 + 9.4 = -5.3 \text{ J}$$

Q10.

A 900 kg car traveling east at 15.0 m/s collides with a 750 kg car traveling north at 20.0 m/s. The cars stick together and move with a velocity $\vec{V}$. Determine the magnitude and direction of $\vec{V}$.

A) 12.2 m/s; 48.0° North of East
B) 12.2 m/s; 48.0° East of North
C) 22.2 m/s; 35.0° North of East
D) 22.2 m/s; 35.0° East of North
E) 18.2 m/s; 45.0° North of East

Ans:

$$P_{ix} = P_{fx} \Rightarrow (900)(15) = (900 + 750)v_{fx}$$

$$\Rightarrow V_{fx} = +8.18 \text{ m/s}$$

$$P_{iy} = P_{fy} \Rightarrow V_{fy} = +9.09$$

$$V = \sqrt{(8.18)^2 + (9.09)^2} = 12.2 \text{ m/s}$$

$$\theta = \tan^{-1}\left(\frac{9.09}{8.18}\right) \Rightarrow \theta = 48°$$

Q11.

A thin spherical shell has a radius of 1.90 m. An applied torque of 960 N. m gives the shell an angular acceleration of 6.20 rad/s^2 about an axis through the center of the shell. What is the mass of the shell?

A) 64.3 kg
B) 96.9 kg
C) 71.5 kg
D) 22.9 kg
E) 44.2 kg

Ans:

$$\tau = I\alpha, \qquad I_{shell} = \frac{2}{3}MR^2$$

$$\Rightarrow \frac{\tau}{\alpha} = I = \frac{960}{6.20} = \frac{2}{3}M(1.9)^2$$

$$\Rightarrow M = 64.3 \text{ kg}$$

Q12.

A uniform hoop of radius *R* and mass *M* rolls without slipping on a horizontal surface. Which form of the kinetic energy of the hoop is larger, translational or rotational?

A) Both are equal
B) Translational kinetic energy is larger
C) Rotational kinetic energy is larger
D) You need to know the speed of the hoop to tell
E) You need to know the acceleration of the hoop to tell

Ans:

$$K_{translational} = \frac{1}{2} mv^2$$

$$K_{rotational} = \frac{1}{2} I_{hoop} v^2 = \frac{1}{2} (mv^2) \frac{v^2}{r^2} = \frac{1}{2} mv^2$$

Q13.

A uniform disk rolls down an incline without slipping. What must be the incline angle if the linear acceleration of the center of mass of the disk is to have a magnitude of 0.15*g*, where *g* is the acceleration due to gravity? [Ignore air resistance]

A) 13°
B) 31°
C) 9.5°
D) 23°
E) 7.5°

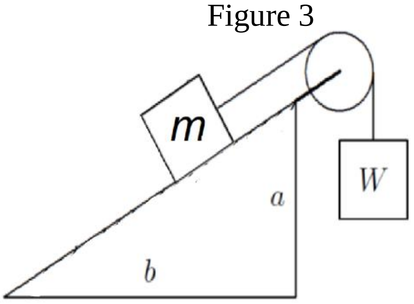
Ans:

$$-0.15\ g = a = \frac{-g\sin\theta}{1 + \frac{\left(\frac{1}{2}\cancel{MR^2}\right)}{\cancel{MR^2}}} \Rightarrow \theta = 13°$$

Q14.

The system, consisting of the two masses shown in **Figure 3,** remains at rest on a frictionless incline. The dimensions *a* = 3.0 m and *b* = 4.0 m. If *W* = 20 N, find the mass *m*.

Figure 3



A) 3.4 kg
B) 1.6 kg
C) 2.4 kg
D) 3.3 kg
E) 5.9 kg

Ans:

$$T = W = 20\ N$$

$$T - mg\sin\theta = 0$$

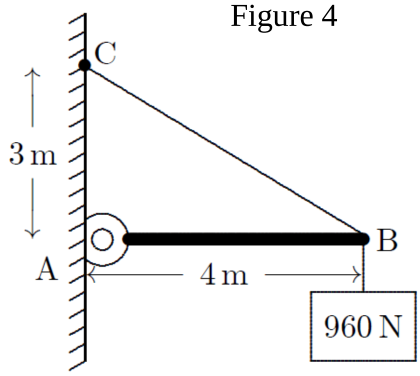
$$20 - m(9.8)\sin(36.8) = 0 \Rightarrow m = 3.40\ kg$$

Q15.

A 960 N block is suspended as shown in **Figure 4**. The beam AB is weightless and is hinged to the wall at A. Find the magnitude of the tension force of the cable BC?

A) 1595 N
B) 7211 N
C) 1200 N
D) 0
E) 1280 N

Figure 4



Ans:

$$\theta = \tan^{-1}\left(\frac{3}{4}\right) = 37^\circ$$

$$T\sin(37) = 960\ \mathrm{N}$$

$$T = \frac{960}{\sin 37} = 1595\ \mathrm{N}$$

Q16.

A cube with 2.00 cm sides is made of material with a bulk modulus of $4.70\times10^5\ N/m^2$. When it is subjected to a pressure of 2.00×10^5 Pa, the length of its any of its sides is:

A) 1.66 cm
B) 0.850 cm
C) 1.27 cm
D) 1.25 cm
E) 2.00 cm

Ans:

$$\Delta P = \beta\frac{\Delta V}{V_0} = \beta\frac{(\Delta L)^3}{L_0^3} = \beta\left(\frac{L_0^3 - L^3}{L_0^3}\right)$$

$$\frac{L_0^3 - L^3}{L_0^3} = \frac{\Delta P}{\beta} \Rightarrow L = L_0\left(1 - \frac{\Delta P}{\beta}\right)^{1/3} = 1.66\ \mathrm{cm}$$

Q17.

If Earth rotation about its axis is slowed down, at a location other than the north and south poles, which of the following statements is **TRUE**?

A) The free fall acceleration would slightly increase.
B) The free fall acceleration remains constant.
C) We would fly off Earth's surface.
D) Earth's atmosphere would float into outer space.
E) The free fall acceleration would slightly decrease.

Ans:

$$g = a_g - \omega^2 R$$

Q18.

Two point particles of 200 kg and 500 kg are separated by a distance of 0.400 m. At what distance from the 500 kg particle can a point particle of 50.0 kg mass be placed between the two particles such that the 50.0 kg particle experiences a net zero gravitational force?

A) 0.245 m
B) 0.200 m
C) 0.150 m
D) 0.100 m
E) 0.325 m

Ans:

$$\frac{Gm_{200}m_{50}}{(0.4-d)^2} = \frac{Gm_{500}m_{50}}{d^2} \Rightarrow d = 0.245\ \text{m}$$

Q19.

A satellite of Jupiter, has an orbital period of 1.77 days and an orbital radius of 4.22×10^5 km. Determine the mass of Jupiter.

A) 1.90×10^{27} kg
B) 1.15×10^{27} kg
C) 2.90×10^{27} kg
D) 2.80×10^{27} kg
E) 3.90×10^{27} kg

Ans:

$$T^2 = \frac{4\pi^2R^3}{GM_J}$$

$$\Rightarrow M_J = \frac{4\pi^2R^3}{GM_J} \Rightarrow M_J = \frac{4\pi^2R^3}{GT^2} = 1.90\times10^{27}\ \text{kg}$$

Q20.

How much work is done by the Moon's gravitational field in moving a 995 kg rock from infinity to the Moon's surface? [The Moon's radius and mass are $1.74\times10^{6}\,m$ and $7.36\times10^{22}\,kg$, respectively.]

A) 2.81×10^{9} J
B) 1.72×10^{9} J
C) 3.96×10^{9} J
D) 1.38×10^{9} J
E) 5.11×10^{9} J

Ans:

$$W = -\Delta U = -\left(-\frac{GMm}{R} - \frac{GmM}{\infty}\right)$$

$$W = \frac{GM_{moon}m}{R_m} = \frac{(6.67\times10^{-11})(7.36\times10^{22})(995)}{1.74\times10^{6}} \Rightarrow W = 2.81\times10^{9}\text{ J}$$

Q21.

A 500 kg rocket is fired from earth surface with an escape speed. Find the rocket's speed when it is at a distance of $1.50\times10^{5}\,km$ from the center of earth? [Neglect any friction and air resistance effects]

A) 2.31×10^{3} m/s
B) 2.75×10^{4} m/s
C) 3.05×10^{3} m/s
D) 1.95×10^{5} m/s
E) 4.70×10^{3} m/s

Ans:

$$\frac{1}{2}mv_i^2 - \frac{GM_Em}{R_E} = \frac{1}{2}mv_f^2 - \frac{GM_Em}{r_f}$$

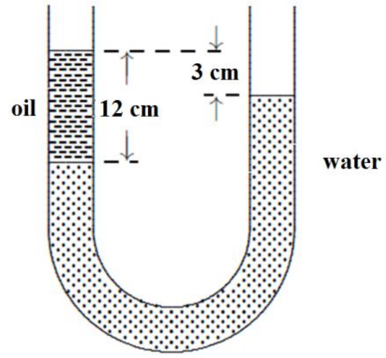
$$\Rightarrow v_f^2 = v_i^2 + 2GM_E\left(\frac{1}{r_f} - \frac{1}{R_E}\right)$$

$$\Rightarrow v_f = 2.31\times10^{3}\text{ m/s}$$

Q22.

The density of water is 1.00 g/cm^3. Determine the density of the oil filled in the left column of the U-tube shown in **Figure 5**.

Figure 5



A) 0.75 g/cm^3
B) 0.67 g/cm^3
C) 1.00 g/cm^3
D) 0.55 g/cm^3
E) 0.89 g/cm^3

Ans:

Pressure Left = Pressure Right

$$P_o + \rho_x g\,(12\text{ cm}) = P_o + \rho_W g(9\text{ cm})$$

$$\Rightarrow \rho_x = \frac{9}{12} = 0.75\text{ g/cm}^3$$

Q23.

A 13000 N vehicle is to be lifted by a 25 cm diameter hydraulic piston. What force needs to be applied to a 5.0 cm diameter piston to accomplish this?

A) 520 N
B) 260 N
C) 2600 N
D) 5200 N
E) 13000 N

Ans:

$$\text{Area of Piston} = \pi r^2 = \pi(12.5 \times 10^{-2})^2$$

$$= 4.91 \times 10^{-2}\text{m}^2$$

$$P = \frac{13000}{4.91 \times 10^{-2}} = 2.65 \times 10^5\ P_a$$

$$\Rightarrow \pi\,(2.5 \times 10^{-2})^2 = 1.96 \times 10^{-3}\text{m}^2$$

$$\Rightarrow P = (1.96 \times 10^{-3})(2.65 \times 10^5 P_a) = 520\text{ N}$$

Q24.

Salt water has larger density than fresh water. A ship can float in both fresh as well as salt waters. Compared to volume of the fresh water, the volume of water displaced in the salt water by the ship is:

A) Less
B) More
C) Same
D) Cannot be determined from the information given
E) None of the answers

Ans:

A

Q25.

A piece of aluminum with 1.0 kg mass of and density of 2700 kg/m3, suspended from a string, is completely immersed in a container filled with water. The density of water is 1000 kg/m3. Determine the tension in the string after the aluminum piece is immersed in water in the container.

A) 6.2 N
B) 5.8 N
C) 2.6 N
D) 9.1 N
E) 7.9 N

Ans:

$$T + F_b = mg$$

$$T = mg - F_b = 9.8 - \rho_w V_g$$

$$= 9.8 - (1000)\left(\frac{1}{2700}\right) g = 6.2\ \text{N}$$

Q26.

In a section of horizontal pipe with a diameter of 3.00 cm the pressure is 5.82 kPa and water is flowing with a speed of 1.50 m/s. The pipe narrows to a diameter of 2.50 cm. What is the pressure in the narrower region?

A) 4.61 kPa
B) 7.50 kPa
C) 5.82 kPa
D) 6.42 kPa
E) 4.00 kPa

Ans:

$$P_2 = P_1 + \frac{1}{2}\rho V_1^2 - \frac{1}{2}\rho \frac{A_1^2}{A_2^2} V_1^2$$

$$P_2 = 5.82 \times 10^3 + \frac{1}{2}(10^3)(1.5)^2\left(1 - \frac{(1.5)^4}{(1.25)^4}\right)$$

$$\Rightarrow P_2 = 4.61\ \text{KP}_a$$

Q27.

The position of a mass that is oscillating on a spring is given by: x = (12.3 cm) cos[(1.26 s^{-1})t]. What is the acceleration of the mass when t = 0.825 s?

A) –9.89 cm/s^2
B) 9.89 cm/s^2
C) 10.6 cm/s^2
D) –10.6 cm/s^2
E) 0 cm/s^2

Ans:

$$V = \frac{dx}{dt} = -(12.3)(1.26)\sin(1.26\ t)$$

$$a = \frac{dv}{dt} = -(15.49)(1.26)\cos(1.26)(0.825)$$

$$\Rightarrow a = -9.89\ \text{cm/s}^2$$

Q28.

A simple harmonic oscillator has amplitude of 3.50 cm and a maximum speed of 28.0 cm/s. What is its speed when its displacement is 1.75 cm?

A) 24.2 cm/s
B) 12.0 cm/s
C) 14.2 cm/s
D) 15.0 cm/s
E) 17.0 m/s

Ans:

$$x_m = 0.035\ \text{m}$$

$$\omega x_m = 28\ \text{cm/s} \Rightarrow \omega = 8\ \text{rad/s}$$

$$\Rightarrow v = \omega\sqrt{x_m^2 - x^2} = 8\sqrt{(0.035)^2 - (0.035)^2} = 0.242\ \text{m/s}$$

Q29.

A student designs a clock using a mass and a spring system. When the student tested the period of the clock, he discovered that he made error and each oscillation takes two seconds. What change can he make to fix the clock?

A) quadruple (multiply by 4) the spring constant of the spring
B) double the amplitude of the oscillations
C) double the spring constant of the spring
D) quadruple the mass
E) double the mass

Ans:

$$\omega = \sqrt{\frac{k}{m}}$$

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

$$T \rightarrow \frac{T}{2} \Rightarrow 4\left(\frac{k}{m}\right)$$

Q30.

Three physical pendulums of masses m_0, $2m_0$ and $3m_0$, have the same shape and size and are suspended at the same point. Rank the masses according to the periods of the pendulums, greatest first?

A) All tie
B) m_0, $2m_0$, $3m_0$
C) $2m_0$, m_0, $3m_0$
D) $3m_0$, $2m_0$, m_0
E) $2m_0$, $3m_0$, m_0

Ans

T is mass independent
