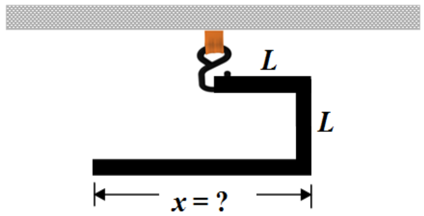
Q1.

A thin uniform metal rod is bent into three perpendicular segments, two of which have length L. What length of third segment *x* (in terms of L) should be so that the unit will hang with two segments horizontal when it is supported by a hook as shown in **Figure**

A) 3L
B) 4L
C) 5L
D) 6L
E) 7L

Figure 1



Ans:

Assume mass per unit length μ then

$$x_{com} = -L = \frac{-\mu L\left(\frac{L}{2}\right) - \mu r\left(\frac{x}{2}\right)}{\mu L + \mu L + \mu x} = -\frac{L^2 + x^2}{2(2L + x)}$$

$$x^2 - 2Lx - 3L^2 = 0$$

$$x = \frac{2L \pm 4L}{2} = 3\text{L}, -\text{L}$$

Q2.

A 30.0 kg hammer strikes, a steel nail 2.30 cm in diameter, vertically downward. During the strike, which lasted for 0.110 s, the magnitude of the change in momentum of the hammer was 900 kg.m/s. What is the average strain in the nail during the impact? (Young modulus E of steel = 20.0×10^{10} N/m^2)

A) 9.85×10^{-5}
B) 8.81×10^{-5}
C) 7.22×10^{-5}
D) 6.65×10^{-5}
E) 5.11×10^{-5}

Ans:

$$Force\ F = \frac{Change\ in\ momentum}{time} = \frac{900}{0.11} = 8182\ N$$

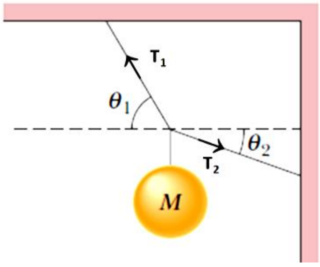
$$Avg.Strain = \frac{Stress}{E} = \frac{F/\pi r^2}{20 \times 10^{10}} = \frac{8182\ /\pi(0.0115)^2}{20 \times 10^{10}}$$

$$Avg.Strain = 9.846 \times 10^{-5}$$

Q3.

A mass M = 5.0 kg , supported by two massless strings with tensions T_1 and T_2, as shown in **Figure 2,** is hanging vertically. The system is in equilibrium. The angles of strings are $\theta_1 = 70°$ and $\theta_2 = 30°$. What are the tensions T_1 and T_2 in the strings respectively?

Figure 2



A) 66 N; 26 N
B) 63 N; 21 N
C) 67 N; 26 N
D) 68 N; 28 N
E) 70 N; 16 N

Ans:

$$\sum F_x = T_2 cos\theta_2 - T_1 cos\theta_1 = 0$$

$$T_2 = T_1 \frac{cos70}{cos30} = 0.395\, T_1$$

$$\sum F_y = T_1 sin\theta_1 - T_2 sin\theta_2 - Mg = 0$$

$$T_1 = T_2 \cdot \frac{sin\theta_2}{sin\theta_1} + \frac{Mg}{sin\theta_1} = 0.395\, T_1 \times \frac{sin30}{sin70} + \frac{5 \times 9.8}{sin70}$$

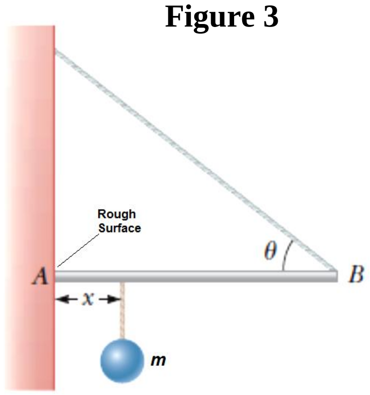
$$T_1 = 0.21\, T_1 + 52.14 \Longrightarrow T_1 = 66 \text{ N}$$

$$T_2 = 0.395 \times T_1 = 26.07 \text{ N}$$

Q4.

One end of a uniform 4.0 m long rod of 10 kg mass is supported by a cable at an angle of $\theta = 37°$ with the rod. The other end of the rod rests against the wall, where it is held by friction as shown in **Figure 3**. The coefficient of static friction between the wall and the rod is $\mu_s = 0.50$. Determine the minimum distance *x* from point *A* at which an additional mass $m = 5.0$ kg can be hung without causing the rod to slip at point *A*.

Figure 3



A) 3.2 m
B) 2.4 m
C) 2.9 m
D) 4.5 m
E) 5.9 m

Ans:

$$\sum F_x = 0 \implies n = T\cos\theta = T\cos 37 = 0.798\ \mathrm{T}$$

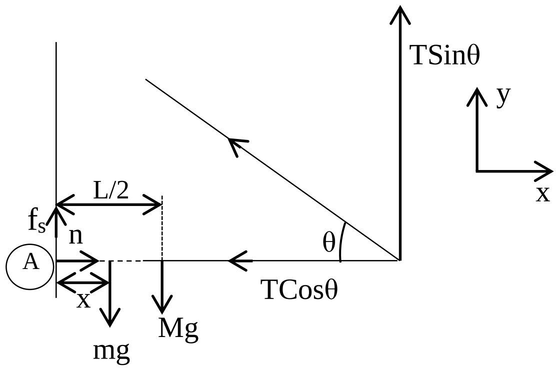
$$\sum F_y = 0 \implies f_s + T\sin\theta = (m + M)g$$

$$f_s = \mu_s n$$

$$0.5 \times 0.798\,T + T\sin 37 = (5 + 10) \times 9.8$$

$$T = 147\ \mathrm{N}$$

Taking torque about A



$$T\sin\theta L - Mg\frac{L}{2} - xmg = 0$$

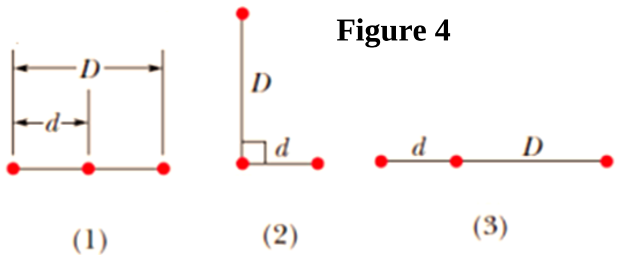
$$x = \frac{2T\sin\theta - 2Mg}{mg} = 3.22\ m$$

Q5.

The **Figure 4** shows three arrangements of three particles of equal masses. Rank the three systems according to the magnitude of the gravitational potential energy of the system, greatest first.

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

Figure 4



Ans:

$$U_1 = GM^2\left(\frac{1}{D}+\frac{1}{d}+\frac{1}{D-d}\right)$$

$$U_2 = GM^2\left(\frac{1}{D}+\frac{1}{d}+\frac{1}{\sqrt{D^2+d^2}}\right)$$

$$U_3 = GM^2\left(\frac{1}{D}+\frac{1}{d}+\frac{1}{D+d}\right)$$

Q6.

A spacecraft is in a circular orbit 5800 km above Earth's surface, is moved to a new circular orbit where its orbital speed is 10 % higher. What is the height of new circular orbit above earth surface? (Radius of earth $R_E = 6.37\times10^3$ km)

A) 3.69×10^3 km
B) 1.45×10^3 km
C) 2.77×10^3 km
D) 2.89×10^3 km
E) 4.11×10^3 km

Ans:

$$v_i^2 = \frac{GM_E}{R_i};\ v_f^2 = \frac{GM_E}{R_f}$$

$$\frac{v_f^2}{v_i^2} = \frac{R_i}{R_f} = (1.10)^2 \Rightarrow R_f = \frac{R_i}{(1.10)^2} = \frac{R_r + r_i}{(1.10)^2} = 0.826(R_E + 5800)$$

$$r_f = R_f - R_E = 3687.9\text{ km}$$

Q7.

Two identical stars are separated by a distance of 1.0×10^{10} m. Each of the star has a mass of 1.0×10^{30} kg and a radius of 1.0×10^{5} m. They are initially at rest with respect to each other. As measured from that rest frame, how fast are they moving when their separation is decreased to one-half its initial value?

A) 8.2×10^4 m/s
B) 1.4×10^4 m/s
C) 2.4×10^4 m/s
D) 5.3×10^4 m/s
E) 7.9×10^4 m/s

Ans:

$$E = K_i + U_i = K_f + U_f \Longrightarrow U_i = K_f + U_f (K_i = 0)$$

$$-\frac{GM^2}{R} = 2\left(\frac{1}{2}Mv^2\right) - \frac{GM^2}{R/2} \Longrightarrow v = \sqrt{\frac{GM}{R}}$$

$$v = \sqrt{\frac{6.67\times10^{-11}\times10^{30}}{10^{10}}} = 81.67\times10^3 \ m/s$$

Q8.

A 20 kg satellite has a circular orbit with a period of 2.5 h and a radius of 8.0×10^{6} m around a planet of unknown mass. If the magnitude of the gravitational acceleration on the surface of the planet is 5.0 m/s^2, what is the radius of the planet?

A) 7.1×10^6 m
B) 4.5×10^6 m
C) 3.3×10^6 m
D) 6.5×10^6 m
E) 8.0×10^6 m

Ans:

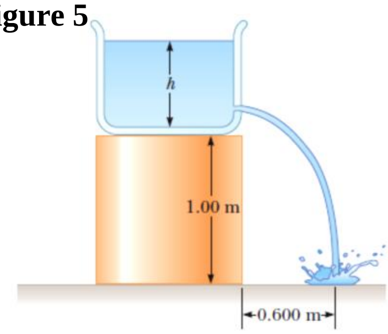
$$T^2 = \frac{4\pi^2}{GM}r^3;\ a_G = \frac{GM}{R^2} \Rightarrow T^2 = \frac{4\pi^2}{a_G R^2}\cdot r^3 \Longrightarrow R = \sqrt{\frac{4\pi^2}{a_G T^2}\times r^3}$$

$$R = \sqrt{\frac{4\pi^2\times(8\times10^6)^3}{5\times(2.5\times3600)^2}} = 7.1\times10^6 \text{ m}$$

Q9.

A jet of water is flowing out horizontally from a hole near the bottom of the tank shown in **Figure 5.** If the hole has a diameter of 3.5 mm, what is the height h of the water level in the tank?

Figure 5



A) 9.0 cm
B) 10 cm
C) 8.0 cm
D) 7.0 cm
E) 1.0 cm

Ans:

$$For\ v_0, \qquad y = x\tan\theta - \frac{gx^2}{2(v_0\cos\theta_0)^2}$$

$$y = -1; x = 0.6\ m, \theta = 0°$$

$$-1 = \frac{-9.8 \times (0.6)^2}{2v_0^2} \Rightarrow v_0^2 = 1.764\ m$$

$$Then\ \rho gh = \frac{1}{2}\rho v_0^2$$

$$h = \frac{v_0^2}{2g} = \frac{1.764}{2 \times 9.8} = 0.09\ \text{m} = 9\ cm$$

Q10.

A submarine is diving in deep ocean waters. A window in submarine has 20 cm diameter and 8.0 cm thickness. If the window can withstand a maximum force of 1.0×10^6 N, what is the maximum depth that the submarine can dive safely? The pressure inside the submarine is maintained at 1.0 atm (density of sea water = 1030 kg/m^3)

A) 3.2 km
B) 2.7 km
C) 4.1 km
D) 1.9 km
E) 4.9 km

Ans:

$$Maximum\ Pressure\ at\ Window = \frac{F}{A} = \frac{10^6}{\pi(0.1)^2} = 31.83 \times 10^6\ \text{Pa}$$

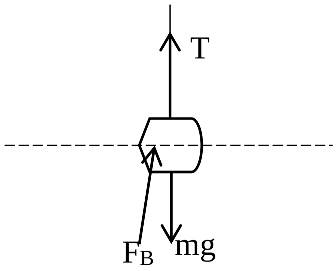
$$P_{at} + \rho gh = P_{in} + \frac{F}{A}\ (P_{at} = P_{in})$$

$$h = \frac{1}{\rho g} \times \frac{F}{A} = \frac{31.83 \times 10^6}{1030 \times 9.8} = 3153.4\ \text{m} = 3.2\ \text{km}$$

Q11.

A 5.0 kg rock whose density is 4.8×10^3 kg/m^3 is suspended in water by a string such that half of the rock's volume is inside the water. What is the tension in the string?

A) 44 N
B) 48 N
C) 51 N
D) 55 N
E) 40 N



Ans:

$$T + F_B - mg = 0 \Rightarrow T = mg - F_B$$

$$T = m_{rock} \times g - \rho_{Water} \times g \times \frac{V_{rock}}{2}$$

$$= m_{rock} \times g \left(1 - \frac{\rho_{Water}}{2 \times \rho_{rock}}\right)$$

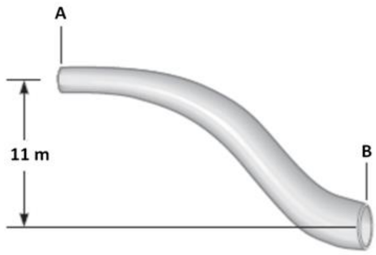
$$= 5 \times 9.8(1 - 0.104) = 43.89 \text{ N}$$

Q12.

At a point A in a pipeline the water's speed is 3.00 m/s and the gauge pressure is 5.00×10^4 Pa, as shown in **Figure 6**. Find the gauge pressure at point B, which is 11.0 m lower than the point A in the line. The pipe diameter at B is twice that at A.

A) 1.62×10^5 Pa
B) 1.75×10^5 Pa
C) 2.31×10^5 Pa
D) 1.85×10^5 Pa
E) 1.93×10^5 Pa

Figure 6



Ans:

$$P_A + \frac{1}{2}\rho v_A^2 + \rho g y_A = P_B + \frac{1}{2}\rho v_B^2 + \rho g y_B$$

$$P_2 = P_1 + \frac{1}{2}\rho(v_A^2 - v_B^2) + \rho g(y_A - y_B)$$

$$A_B v_B = A_A v_A;\ v_B = \left(\frac{A_A}{A_B}\right) v_A;\ v_B = \frac{1}{4} v_A$$

$$P_2 = P_1 + \frac{1}{2} \times 10^3 \left(3^2 - \left(\frac{3}{4}\right)^2\right) + 10^3 \times 9.8 \times 11$$

$$P_2 = 5 \times 10^4 + 4218.8 + 107800 = 162018.8 = 1.62 \times 10^5\ Pa$$

Q13.

A mass is oscillating horizontally at the end of a spring on a frictionless table with amplitude *A*. How far (in terms of *A*) is this mass from the equilibrium position of the spring when the elastic potential energy equals the kinetic energy?

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

Ans:

$$E = K + U = \frac{1}{2}kA^2 \; but \; K = U = \frac{1}{2}kx^2$$

$$\frac{1}{2}kA^2 = 2\left(\frac{1}{2}kx^2\right) = kx^2$$

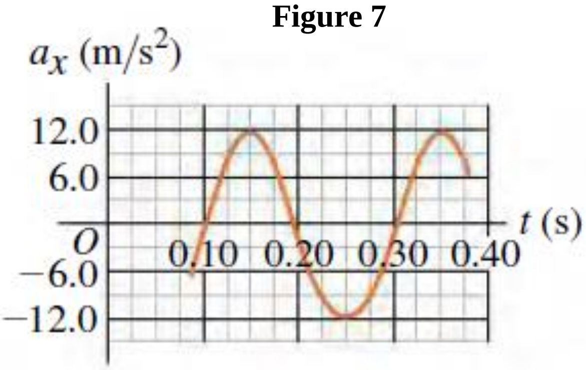
$$x = \sqrt{\frac{A^2}{2}} = \frac{A}{\sqrt{2}}$$

Q14.

A block at the end of an ideal spring of force constant of 0.1 N/cm oscillates on a frictionless, table. **Figure 7** shows the acceleration of the block as a function of time. Find the mass and the maximum displacement of the block from the equilibrium point respectively.

A) 10 g; 1.2 cm
B) 4.1 g; 1.3 cm
C) 5.5 g; 0.01 cm
D) 7.7 g; 0.30 cm
E) 8.4 g; 0.70 cm

Figure 7



Ans:

$$T = 2\pi\sqrt{\frac{m}{k}} \; ; m = \frac{kT^2}{4\pi^2}$$

$$T = 0.2\ s; \;\; k = \frac{0.1}{0.01} = 10\ N/m$$

$$m = \frac{kT^2}{4\pi^2} = \frac{10 \times (0.2)^2}{4\pi^2} = 0.010\ \text{kg}$$

$$and\ a_{max} = \omega^2 x_{max} = \left(\frac{2\pi}{0.2}\right)^2 \cdot x_{max}$$

$$x_{max} = a_{max} \times \left(\frac{0.2}{2\pi}\right)^2 = 12 \times \frac{(0.2)^2}{4\pi^2} = 0.0121\ m$$

Q15.

An object is undergoing simple harmonic motion with a period of 0.90 s and amplitude of 0.32 m. At t = 0 the object is at x = 0.32 m and is instantaneously at rest. Calculate the time it takes the object to go from x = 0.32 m to x = 0.16 m.

A) 0.15 s
B) 0.25 s
C) 0.11 s
D) 0.32 s
E) 0.46 s

Ans:

$$x = Acos(\omega t + \phi), at\ t = 0\ , x = A\ then\ \phi = \cos^{-1}(1) = 0$$

$$x = Acos\omega t$$

$$at\ t_i = 0, x = 0.32\ m\ and\ at\ t_f$$

$$x = 0.16 = 0.32\ cos(\omega t_f) \Rightarrow \omega t_f = \cos^{-1}\left(\frac{0.16}{0.32}\right) = 60° = \frac{\pi}{3}$$

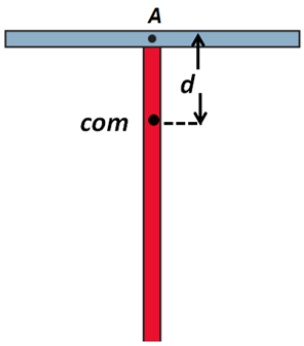
$$t_f = \frac{\pi}{3} \times \frac{1}{\omega} = \frac{\pi}{3} \times \frac{T}{2\pi} = \frac{T}{6} = \frac{0.90}{6} = 0.15\ s$$

Q16.

A physical pendulum consists of two identical and uniform meter-long sticks joined together as shown in **Figure 8**. What is the pendulum's period of oscillation about a pin inserted through point *A*, the center of the horizontal stick? The center of mass (com) of the two meter sticks is located at a distance d = 0.25 m below point A.

A) 1.83 s
B) 1.00 s
C) 1.21 s
D) 2.01 s
E) 2.91 s

Figure 8



Ans:

$$T = 2\pi\sqrt{\frac{I_{Pand}}{Mgd}}$$

$$I_{Pand} = I_{vertical} + I_{horizontal} = \frac{ML^2}{12} + \frac{ML^2}{3} = \frac{5}{12}ML^2$$

$$T = 2\pi\sqrt{\frac{\frac{5}{12}ML^2}{2M \times g \times 0.25}} = 2\pi\sqrt{\frac{\frac{5}{12} \times 1^2}{2 \times 9.8 \times 0.25}} = 1.832\ s$$

Q17.

An object position as a function of time is given by $x = 5t^4$, where x is in m and t is in s. Find the ratio of magnitude of the instantaneous velocity v of the object at t = 2 s to magnitude of the average velocity v_{avg} of the object over the interval t = 0 s to t = 2 s to

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

Ans:

$$v = \frac{dx}{dt} = 20t^3, at\ t = 2s, v = 20 \times 2^3 = 160\ m/s$$

$$v_{avg} = \frac{x(t = 2) - x(t = 0)}{2} = \frac{5 \times 2^4 - 0}{2} = 40\, m/s$$

$$\left|\frac{v}{v_{avg}}\right| = \frac{160}{40} = 4$$

Q18.

A car starts from rest at a stop sign. It accelerates at 5.0 m/s^2 for 5.0 s and then slows down at a rate of 3.0 m/s^2 till it stops at next stop sign. What is the distance between the two stop signs?

A) 167 m
B) 150 m
C) 140 m
D) 80.5 m
E) 120 m

Ans:

$$Total\ distance = x_1 + x_2$$

$$x_1 = v_1 t + \frac{1}{2}at^2 = \frac{1}{2} \times 5 \times (5)^2 = 62.5$$

$$v\ at\ end\ of\ x_1, v = a_1 t = 5 \times 5 = 25\ m/s$$

$$Then\ v_f^2 = v^2 + 2a_2 x_2 \Rightarrow x_2 = \frac{-v^2}{2a_2} = \frac{-(25)^2}{2 \times (-3)}$$

$$x_2 = 104.2\ m$$

$$Total\ distance = x_1 + x_2 = 62.5 + 104.2 = 166.67\ m$$

Q19.

Calculate $(\vec{A} \times \vec{B}) \cdot \vec{C}$ for three vectors $\vec{A}$, $\vec{B}$ and $\vec{C}$. Vector $\vec{A}$ has a magnitude of 6.00 m and angle θ_A = 20.0°. Vector $\vec{B}$ has a magnitude of 5.00 m and θ_B = 60.0°. Angles θ_A and θ_B are measured counterclockwise from the + x-axis. Vector $\vec{C}$ has a magnitude of 4.00 m and is in the +z-direction whereas vectors $\vec{A}$ and $\vec{B}$ are in the xy-plane.

A) 77.1 m
B) 79.5 m
C) 87.4 m
D) 91.2 m
E) 99.0 m

Ans:

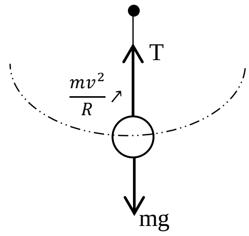
$$\vec{A} \times \vec{B} = |A||B| sin(\theta_B - \theta_A)\vec{k} = 6 \times 5 \times \sin(60 - 20) \times \vec{k} = 19.28\,\vec{k}$$

$$(\vec{A} \times \vec{B}) \cdot \vec{C} = (19.28\,\vec{k})4\vec{k} = 77.1\ m$$

Q20.

A string with negligible mass can withstand a maximum tension of 40 N without breaking. A child ties a 0.4 kg stone to one end of the string and holding the other end, rotates the stone in a vertical circle of radius 0.9 m, slowly increasing the speed until the string breaks. What is speed of the stone and its position (top of the circle or lowest point of the circle) respectively as the string breaks?

A) 9.0 m/s; lowest point of the circle
B) 6.5 m/s ; lowest point of the circle
C) 10 m/s : top of the circle
D) 12 m/s; lowest point of the circle
E) 14 m/s : top of the circle



Ans:

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

$$v = \sqrt{R\left(\frac{T}{m} - g\right)}$$

$$v = \sqrt{0.9\left(\frac{40}{0.4} - 9.8\right)} = 9.00\ m/s$$

Q21.

A ball is shot from the ground into the air. At a height of 10.0 m, its velocity is $\vec{v} = 7.70(\hat{\imath} + \hat{\jmath})$ m/s with $\hat{\imath}$ vector horizontal towards right and $\hat{\jmath}$ vector vertically upward. What is the magnitude and angle (below the horizontal) of the ball's velocity respectively just before it hits the ground? (Ignore the air resistance)

A) 17.7 m/s; 64°
B) 10.2 m/s; 54°
C) 12.5 m/s; 45°
D) 18.9 m/s; 74°
E) 19.5 m/s; 72°

Ans:

$$v_{ox} = 7.70\vec{\imath}$$

$$(v_y)^2 = (v_{oy})^2 - 9.8 \times 10.2$$

$$\Rightarrow v_{oy} = \sqrt{(v_y)^2 + 98 \times 2} = \sqrt{(7.7)^2 + 196} = 15.98$$

$$\theta_i = \tan^{-1}\left(\frac{15.98}{7.7}\right) = 64.27 = \theta_f\,, below\ horizon$$

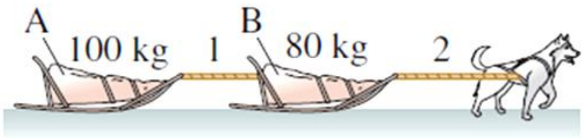
$$|v| = \sqrt{7.7^2 + 15.98^2} = 17.74\ m/s$$

Q22.

The sled dog in **Figure 9** drags sleds A and B across the frictionless snow surface. If the tension in rope 1 is 150 N, what is the tension in rope 2?

A) 270 N
B) 198 N
C) 145 N
D) 100 N
E) 277 N

Figure 9



Ans:

$$a = \frac{T_1}{m} = \frac{150}{100} = 1.5\ m/s^2$$

$$T_2 - T_1 = 80 \times a$$

$$T_2 = T_1 + 80 \times a = 150 + 80 \times 1.5 = 270\ \text{N}$$

Q23.

A spaceship lifts off vertically from surface of the Moon, where gravitational acceleration is 1.6 m/s^2. If the ship has an upward acceleration of 1.2 m/s^2 as it lifts off, what is the magnitude of the force exerted by the ship on its pilot, who weighs 735 N on Earth? Assume for direction along the spaceship motion direction.

A) 210 N
B) 165 N
C) 128 N
D) 103 N
E) 133 N

Ans:

$$F_{up} - m \times 1.6 = m \times 1.2$$

$$F_{up} = m(1.6 + 1.2) = m \times 2.8 = \frac{735}{9.8} \times 2.8 = 210\ \text{N}$$

Q24.

A car rounds a flat unbanked curve with radius R = 290 m. If the coefficient of static friction between tires and road μ_s = 0.70, what is the maximum speed v_{max} at which the driver can drive along the curve without sliding?

A) 44.6 m/s
B) 94.0 m/s
C) 83.4 m/s
D) 74.9 m/s
E) 50.2 m/s

Ans:

$$\frac{mv_{max}^2}{R} = f_s = \mu_5 mg$$

$$v_{max} = \sqrt{\mu_s Rg} = \sqrt{0.7 \times 290 \times 9.8} = 44.6 \text{ m/s}$$

Q25.

What instantaneous power is needed to push a 95.0 kg box at a constant speed of 0.650 m/s along a rough horizontal surface where coefficient of kinetic friction is 0.350?

A) 212 W
B) 190 W
C) 283 W
D) 301 W
E) 320 W

Ans:

$$P = \vec{f}_k \cdot \vec{v} = \mu_k mgv = 0.35 \times 95 \times 9.8 \times 0.65 = 211.8 \text{ W}$$

Q26.

A 5.0 g marble is fired vertically upward using a spring gun. The spring must be compressed 5.0 cm if the marble is to just reach a target 17 m above the marble's position on the compressed spring. What is the spring constant of the spring? (Ignore the air resistance and spring mass).

A) 6.7×10^2 N/m
B) 7.0×10^2 N/m
C) 5.3×10^2 N/m
D) 4.0×10^2 N/m
E) 8.0×10^2 N/m

Ans:

$$K_i + U_{gi} + U_{si} = K_f + U_{gf} + U_{sf}$$

$$U_{si} = U_{gf}\left(K_i = K_f = U_{gi} = U_{sf} = 0\right)$$

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

$$k = \frac{2mgh}{x^2} = \frac{2 \times 5 \times 9.8 \times 17 \times 10^{-3}}{(0.05)^2} = 666.4\ \text{N}/m$$

Q27.

A steel ball with mass 40 g is dropped from a height of 2.0 m onto a horizontal steel slab. The ball rebounds to a height of 1.6 m. The impulse on the ball during the impact is

A) 0.47 kg.m/s, upward
B) 0.34 kg.m/s , downward
C) 0.23 kg.m/s , upward
D) 0.50 kg.m/s, downward
E) 0.17 kg.m/s, upward

Ans:

$$For\ downward\ motion\ v_i = \sqrt{2gh_1} = \sqrt{2 \times 9.8 \times 2} = 6.26\ \text{m}/s$$

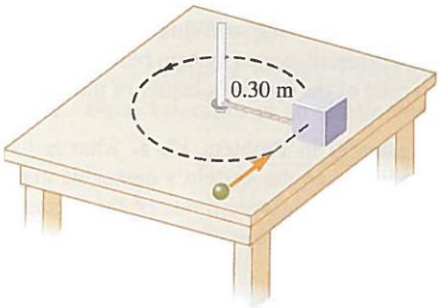
$$For\ upward\ motion\ v_f = \sqrt{2gh_2} = \sqrt{2 \times 9.8 \times 1.6} = 5.60\ \text{m}/s$$

$$\vec{J} = \Delta\vec{p} = m\left(\vec{v}_f - \vec{v}_i\right) = 0.04\left(5.6 - (-6.26)\right) = 0.474\ \text{kg.m}/s$$

Q28.

A 2.45 kg ball is shot into a 0.45 kg box that is at rest on a frictionless horizontal table. The box is attached to a 0.30 m long rope that is attached to the table on the other end, as shown in **Figure 10**. The ball initial velocity is 13.5 m/s and is perpendicular to the rope. After the collision the ball and the box stick together and move. What is the tension in the rope?

Figure 10



A) 1.26×10^3 N
B) 0.300×10^3 N
C) 0.520×10^3 N
D) 0.800×10^3 N
E) 1.10×10^3 N

Ans:

$$m_{ball} \times v_{ball} = (m_{box} \times m_{ball}) \times V_{com}$$

$$V_{com} = \frac{m_{ball} \times v_{ball}}{m_{ball} + m_{box}} = \frac{2.45 \times 13.5}{2.45 + 0.45} = 11.41 \text{ m}/s$$

$$T = \sum \frac{mV_{com}^2}{R} = \frac{(2.45 + 0.45) \times (11.41)^2}{0.3} = 1259.7 \text{ N}$$

Q29.

A disk rotates about its central axis and makes 10 revolutions as it slows down from an angular speed of 5.5 rad/s to a stop. Assuming a constant angular acceleration of the disk, calculate magnitude of the angular acceleration?

A) 0.24 rad/s^2
B) 0.10 rad/s^2
C) 0.75 rad/s^2
D) 0.93 rad/s^2
E) 1.1 rad/s^2

Ans:

$$\omega_f^2 = \omega_i^2 + 2\alpha\Delta\theta$$

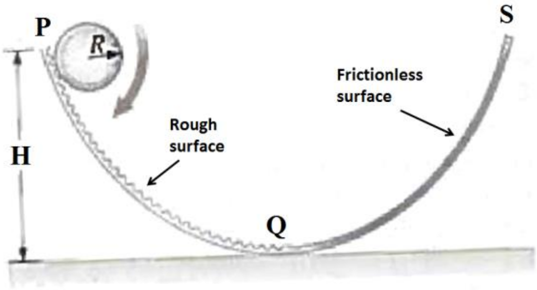
$$\alpha = \frac{\omega_f^2 - \omega_i^2}{2\Delta\theta} = \frac{-\omega_i^2}{2\Delta\theta} = \frac{-(5.5)^2}{2 \times 10 \times 2\pi}$$

$$\alpha = -0.24 \text{ rad}/s^2 \Longrightarrow |\alpha| = 0.24 \text{ rad}/s^2$$

Q30.

A uniform solid sphere of mass m and radius R, initially at rest, rolls down a parabolic path PQ from height $\boldsymbol{H}$ (assume $R << H$) as shown in **Figure 11**. Path PQ is rough and the sphere will roll down without slipping, whereas the path QS is frictionless, the sphere will slide only. Determine the vertical height above point Q reached by the sphere on the path QS.

Figure 10



A) 0.7 H
B) 0.8 H
C) 0.9 H
D) 0.5 H
E) 0.6 H

Ans:

Along PQ

$$\mathrm{mgH} = \frac{1}{2}\,\mathrm{I}\omega^2 + \frac{1}{2}\,\mathrm{mv}_{com}^2$$

$$\mathrm{I} = \frac{2}{5}mR^2;\ \omega = \frac{v_{com}}{R}$$

$$\mathrm{mgH} = \frac{1}{2}\times\frac{2}{5}mR^2\times\frac{\mathrm{v}_{com}^2}{R^2} + \frac{1}{2}m\mathrm{v}_{com}^2 = \frac{\mathrm{v}_{com}^2}{5} + \frac{\mathrm{v}_{com}^2}{2} = \frac{7}{10}\mathrm{v}_{com}^2$$

$$\mathrm{v}_{com}^2 = \frac{10\,gH}{7}$$

Along QS

$$\frac{1}{2}\,\mathrm{mv}_{com}^2 = \frac{1}{2}\,\mathrm{m}\frac{10\,gH}{7} = mgh$$

$$h = \frac{10}{14}H = 0.71\,H$$