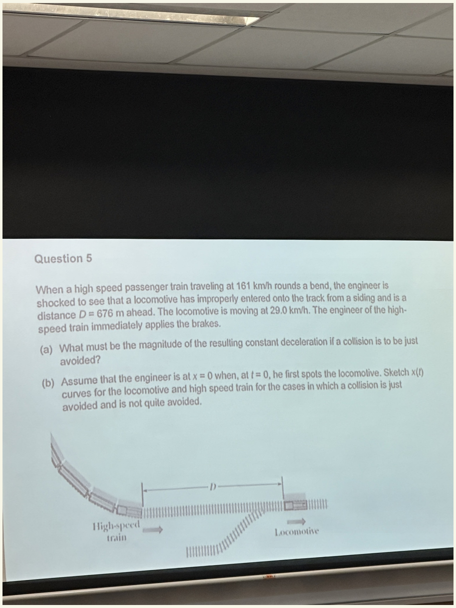


a) V_L

$\parallel$

$V_{Tf} = V_{Ti} + a_T t$

$t = \dfrac{V_{Tf} - V_{Ti}}{a_T}$

$V_{Tf}^2 = V_{Ti}^2 + 2a_T(D + d)$

$d = V_L\left(\dfrac{V_L - V_{Ti}}{a_T}\right)$

$V_{Tf}^2 = V_{Ti}^2 + 2a_T\left(D + V_L \cdot \dfrac{(V_{Tf} - V_{Ti})}{a_T}\right)$

$8.1^2 = 44.7^2 + 2a_T\left(676 + 8.1 \cdot \dfrac{(8.1 - 44.7)}{a_T}\right)$

$a_T = -5.1\,m/s^2$

$V_L = 29\,km/h$

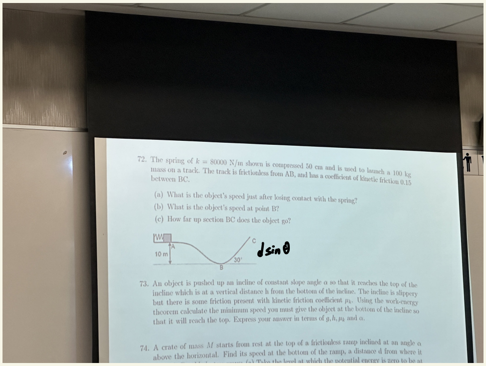
$= 29 \times \dfrac{1000}{3600}$

$= 8.1\,m/s$

$V_T = 161\,km/s$

$= 161 \times \dfrac{1000}{3600}$

$= 44.7\,m/s$



a) $\cancel{\frac{1}{2}}mv^2 = \cancel{\frac{1}{2}}kx^2$

$$v = \sqrt{\frac{kx^2}{m}}$$

$$= \sqrt{\frac{80000(0.5)^2}{100}}$$

$$= 14.14 \, m/s$$

b) $mgh + \frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2$

$$v_f = \sqrt{\frac{2mgh + mv_i^2}{m}}$$

$$= 19.9 \, m/s^2$$

c) $W_{fr} + TE_B = TE_C$

$$(-F_{fr}d) + \frac{1}{2}mv_f^2 = mg(d\sin\theta)$$

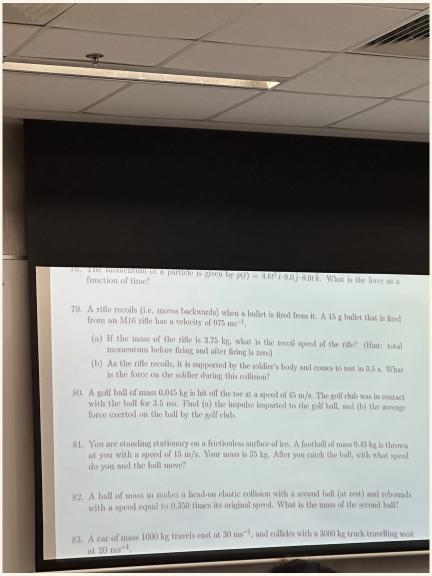
$$\frac{1}{2}mv_f^2 = mg(d\sin\theta) + F_{fr}d$$

$$F_N = mg\cos\theta$$

$$F_{fr} = \mu_k mg\cos\theta$$

$$d = \frac{\frac{1}{2}mv_f^2}{mg\sin\theta + \mu_k mg\cos\theta}$$

$$\approx 32.1 \, m$$



$m_B = 0.015\,kg$ $\quad$ $m_R = 3.75\,kg$

$V_B = 975\,m/s$ $\quad$ $V_R = ?$

a)

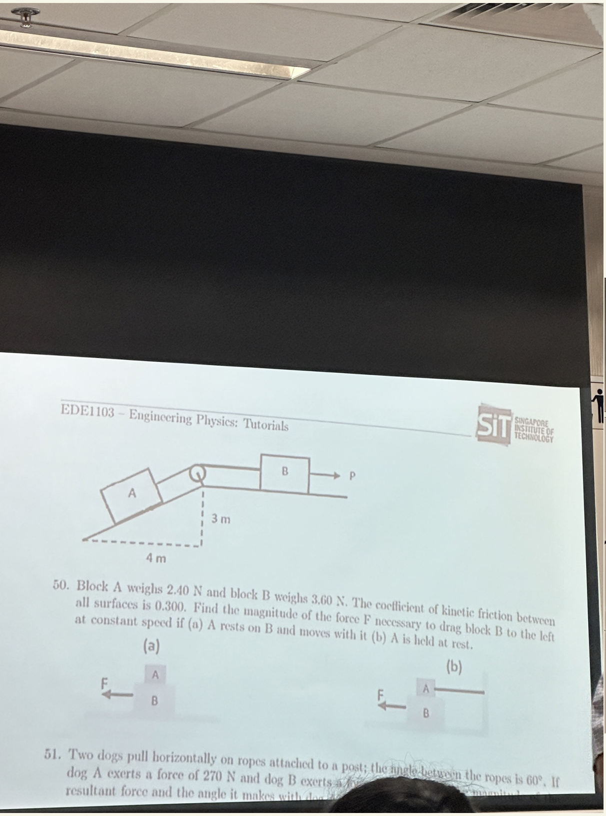
$$P_0 = P_1$$

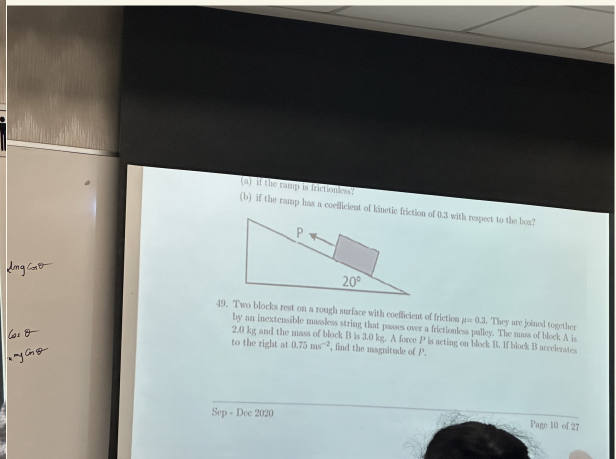
$$0 = m_R V_R + m_B V_B$$

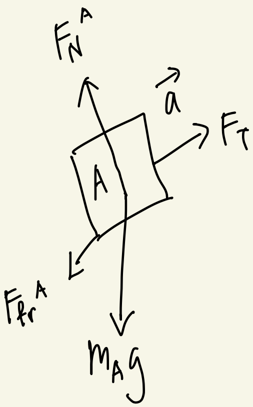
$$V_R = -\frac{m_B V_B}{m_R}$$

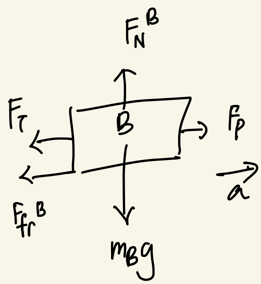
$$= -3.9\,m/s$$

3.9 m/s in the left direction









For B : $F_p - F_T - F_{fr}^B = m_B a$

$F_p - F_T - \mu m_B g = m_B a$

For A : $F_T - m_A g \sin\theta - \mu m_A g \cos\theta = m_A a$

$F_p = 29.03 N$

Question 1

A car's velocity as a function of time is given by $v_x = \alpha + \beta t^2$, where α = 3.00 m/s and β = 0.100 m/s^3.

(a) Calculate the average acceleration for the time interval t = 0 to t = 5.00 s.

(b) Calculate the instantaneous acceleration for t = 0 and t = 5.00 s.

(c) Draw the $v_x - t$ and the $a_x - t$ graphs for the car's motion between t = 0 and t = 5.00 s.

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answers

(a) a_{xavg} = 0.5 m/s^2; (b) a_x (t = 0 s) = 0 m/s^2; a_x (t = 5 s) = 1 m/s^2

a)

$$V_x = \alpha + \beta t^2$$
$$= 3 + 0.1t^2$$

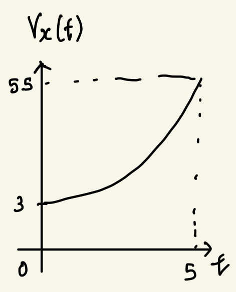
$$A_{avg} = \frac{\Delta V_x}{\Delta t}$$
$$= \frac{V_x(5) - V_x(0)}{5 - 0}$$
$$= \frac{5.5 - 3}{5}$$
$$= 0.5 m/s^2$$

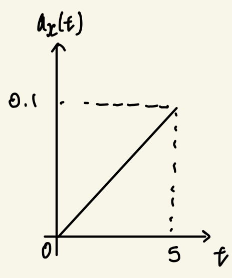
b)

$$a_x(t) = \frac{dV_x}{dt} = 2\beta t$$
$$= 0.2t$$

$$a_x(0) = 0 m/s^2$$
$$a_x(5) = 0.1 m/s^2$$

c)





Question 2

A toy rocket is rising at a constant speed of 20 m/s. When it is 24 m above the ground, a bolt comes loose.

(a) How long does the bolt take to land?
(b) What is its maximum height?
(c) At what speed does it hit the ground?

Adapted from Benson, "University Physics", Revised Edition, John Wiley & Sons, inc., 1996.

Answer

(a) 5.1 s; (b) 44 m; (c) -30 m/s

a)

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$-24 = 0 + 20t + \frac{1}{2}(-9.8)t^2$$

$$4.9t^2 - 20t - 24 = 0$$

$t = 5.05$ or $t = -0.97$ (reject)

$\approx 5.1s$

$$v = v_0 + at$$

$$x = x_0 + v_0 t + \frac{1}{2}at^2$$

$$x - x_0 = \frac{1}{2}(v_0 + v)t$$

$$v^2 = v_0^2 + 2a(x - x_0)$$

b)

$$0 = 20^2 + 2(-9.8)(x-24)$$

$x \approx 44m$

c)

$$0 - 24 = \frac{1}{2}(20 + v)(5.1)$$

$v = -29.4m \approx -30m/s$

Question 3

A stone is thrown vertically upward. On its way up it passes point A with speed *v*, and point B, 3.00 m higher than A, with speed ½*v*. Calculate (a) the speed *v* and (b) the maximum height reached by the stone above point B.

Answer

(a) 8.85 m/s; (b) 1.00 m

a) Initial V_0 unknown $a = -9.8 m/s^2$ $V_B = \frac{1}{2} V_a$

$$V_a^2 = V_0^2 + 2a(X_a)$$

$$V_0^2 = 2a(X_a) - V_a^2 \quad - ①$$

$$V_B^2 = V_0^2 + 2a(X_a + 3)$$

$$V_0^2 = 2a(X_a+3) - \left(\frac{1}{2}V_a\right)^2 \quad - ②$$

$$2a(X_a) - V_a^2 = 2a(X_a+3) - \frac{1}{4}V_a^2$$

$$-\frac{3}{4}V_a^2 = 2a(3)$$

$$V_a = \sqrt{-4(2a)}$$

$$= \sqrt{-4(2 \times -9.8)}$$

$$= 8.85 m/s$$

b) set final velocity to 0

$$0 = V_a^2 + 2a(X - X_a)$$

$$(X - X_a) = \frac{-V_a^2}{2a}$$

$$= \frac{-(8.85)^2}{2(-9.8)}$$

$$\approx 4.00 m$$

$4 - 3 = 1.00m$ above pt B

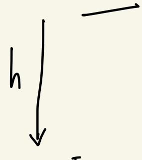
Question 4

A flower pot falls off a balcony. It takes 0.10 s to pass a window of height 1.25 m. From what height above the bottom of the window did it fall?

Answer

Height above window: 8.6 m

$a = 9.8\,m/s^2$



$h' = 1.25$ window

$t_1 = 0.1s$

$v = v_0 + at$

$v_1 = at$

$x = x_0 + v_0 t + \frac{1}{2}at^2$

$h' = 0 + v_1 t_1 + \frac{1}{2}a(t_1)^2$

$1.25 = (9.8)(t)(0.1) + \frac{1}{2}(9.8)(0.1)^2$

$t = 1.22$

$h = 0 + 0 + \frac{1}{2}(9.8)(1.22)^2$

$= 7.29$

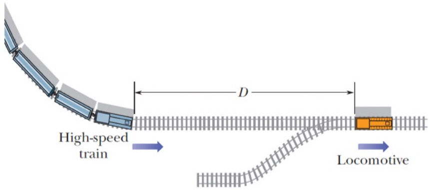
$7.29 + 1.25 \approx 8.6m$

Question 5

When a high speed passenger train traveling at 161 km/h rounds a bend, the engineer is shocked to see that a locomotive has improperly entered onto the track from a siding and is a distance D = 676 m ahead. The locomotive is moving at 29.0 km/h. The engineer of the high-speed train immediately applies the brakes.

(a) What must be the magnitude of the resulting constant deceleration if a collision is to be just avoided?

(b) Assume that the engineer is at x = 0 when, at t = 0, he first spots the locomotive. Sketch $x(t)$ curves for the locomotive and high speed train for the cases in which a collision is just avoided and is not quite avoided.



Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answer

(a) $a_x = 0.994 \text{ m/s}^2$

a) $V_T = 161 \text{ km/h}$ $\quad\quad V_L = 29.0 \text{ km/h}$

$= 44.7 \text{ m/s}$ $\quad\quad = 8.05 \text{ m/s}$

$D = 676 \text{ m}$

$\Delta x_L = V_L t \quad\quad \Delta x_T = D + \Delta x_L$

$V = V_0 + at$

$t = \dfrac{V - V_0}{a}$

$= \dfrac{V_L - V_T}{a}$

$$\frac{\Delta x_T}{t} = \frac{\frac{1}{2}(V_T + V_L)\cancel{t}}{\cancel{t}}$$

$$\frac{D + V_L t}{t} = \frac{1}{2}(V_T + V_L)$$

$$\frac{D}{t} + \frac{V_L \cancel{t}}{\cancel{t}} = \frac{1}{2}(V_T + V_L)$$

$$\frac{D}{t} = \frac{1}{2}(V_T + V_L) - V_L$$

$$= \frac{V_T - V_L}{2}$$

$$\frac{D}{\frac{V_L - V_T}{a}} = \frac{V_T - V_L}{2}$$

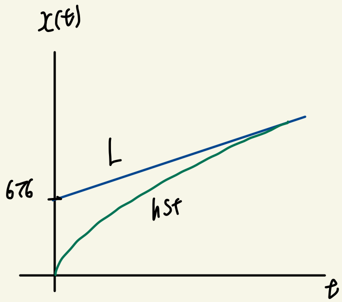
$$D\left(\frac{a}{V_L - V_T}\right) \div D = \frac{V_T - V_L}{2} \div D$$

$$\frac{a}{V_L - V_T} = \frac{V_T - V_L}{2D}$$

$$a = \frac{V_T - V_L}{2D}\left(V_L - V_T\right)$$

$$= -0.994 m/s^2$$

Constant deceleration at $0.994 m/s^2$



Question 6

Crickets Chirpy and Milada jump from the top of a vertical cliff. Chirpy drops downward and reaches the ground in 2.70 s, while Milada jumps horizontally with an initial speed of 95.0 cm/s. How tall is the cliff and how far from the base of the cliff will Milada hit the ground? Ignore air resistance.

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answers

Height of cliff: 35.7 m. Horizontal distance: 2.57 m

a)

$\downarrow a = 9.8 m/s^2$

b)

$V_m = 95 cm/s$

$= 0.95 m/s$

$0.95 \times 2.7 = 2.57 m$

$$h = 0 + 0 + \frac{1}{2}at^2$$

$$= \frac{1}{2}(9.8)(2.7)^2$$

$$\approx 35.7 m$$

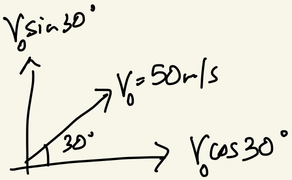
A medieval catapult could project a 75.0 kg stone at 50 m/s at 30.0º above the horizontal. Suppose the target is a fortress wall of height 12.0 m at a horizontal distance of 200. m.

(a) Would the stone hit the wall?
(b) If so, at what height?
(c) And at what angle?

Adapted from Benson, "University Physics", Revised Edition, John Wiley & Sons, inc., 1996.

Answers

(a) Yes; (b) h = 10.9 m; (c) 335º



a) horizontal range $= V_0 \cos 30° \times t$

$$0 = 0 + V_0 \sin 30° t + \frac{1}{2}(-9.8)(t^2)$$

$$-4.9t^2 + 25t = 0$$

$$t = 0 \quad \text{or} \quad t = 5.1$$

horizontal range $= V_0 \cos 30° \times 5.1$

$$= 220$$

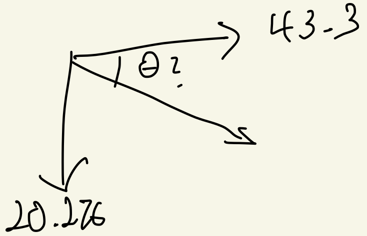
Yes

b) time take to hit at 200 m : $\frac{200}{50\cos 30^\circ} = 4.62s$

$$x = 0 + 50\sin 30^\circ (4.62) + \frac{1}{2}(-9.8)(4.62)^2$$

$$\approx 10.9 m$$

c)



$$V = 50\sin 30^\circ + (-9.8)(4.62)$$

$$= -20.276$$

$$\theta = \tan^{-1}\left(\frac{20.276}{43.3}\right) = 25^\circ$$

$$360^\circ - 25^\circ = 335^\circ$$

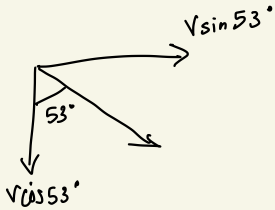
Question 9

A plane, diving with constant speed at an angle of 53.0° with the vertical, releases a projectile at an altitude of 730 m. The projectile hits the ground 5.00 s after release. (a) What is the speed of the plane? (b) How far does the projectile travel horizontally during its flight? What are the (c) horizontal and (d) vertical components of its velocity just before striking the ground?

Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answer

(a) 202 m/s; (b) 806 m; (c) 161 m/s; (d) - 171 m/s



a)

$$730 = 0 + 5V\cos 53° + \frac{1}{2}(9.8)(5)^2$$

$$V = 201.8$$

$$\approx 202 \, m/s$$

b) $V\sin 53° \times 5 = 806$

c) $V_x = 202\sin 53°$

$= 161 \, m/s$

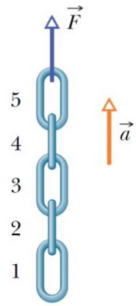
d) $V_y = V\cos 53° + (9.8)(5)$

$= 170.5$

$\approx 171 \, m/s$

Question 1

A chain consisting of five links, each of mass 0.100 kg, is lifted vertically with constant acceleration of magnitude $a = 2.50\ m/s^2$. Find the magnitudes of (a) the force on link 1 from link 2, (b) the force on link 2 from link 3, (c) the force on link 3 from link 4, and (d) the force on link 4 from link 5. Then find the magnitudes of (e) the force on the top link from the person lifting the chain and (f) the net force accelerating each link.

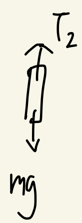


Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answers

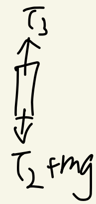
(a) 1.23 N; (b) 2.46 N; (c) 3.69 N; (d) 4.92 N; (e) 6.15 N; (f) 0.250 N

a) $F = ma$



$$T_2 - mg = ma$$
$$T_2 = ma + mg$$
$$= 0.1(2.5 + 9.8)$$
$$= 1.23\,N$$

b)



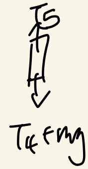
$$T_3 - (T_2 + mg) = ma$$
$$T_3 = ma + T_2 + mg$$
$$= 1.23 + 1.23$$
$$= 2.46\,N$$

c)

$$T_4 - (T_3 + mg) = ma$$

$$T_4 = ma + T_3 + mg$$
$$= 2.46 + 1.23$$
$$= 3.69N$$

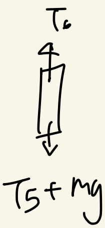
d)



$$T_5 - (T_4 + mg) = ma$$

$$T_5 = ma + T_4 + mg$$
$$= 3.69 + 1.23$$
$$= 4.92N$$

e)



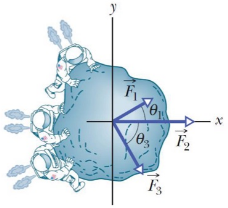
$$T_6 - (T_5 + mg) = ma$$

$$T_6 = ma + T_5 + mg$$
$$= 4.92 + 1.23$$
$$= 6.15N$$

f) $F_{net} = ma$
$$= 0.1 \times 2.5$$
$$= 0.25N$$

Question 2

Three astronauts, propelled by jet backpacks, push and guide a 120 kg asteroid toward a processing dock, exerting the forces shown in the figure, with F_1 = 32 N, F_2 = 55 N, F_3 = 41 N, θ_1 = 30°, and θ_3 = 60°. What is the asteroid's acceleration (a) in unit-vector notation and as (b) a magnitude and (c) a direction relative to the positive direction of the x axis?

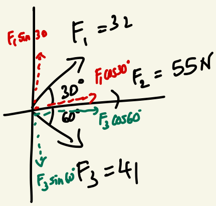


Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answers

(a) (0.86 m/s²)**i** - (0.16 m/s²)**j** ; (b) 0.88 m/s²; (c) -11º

a)



$F_{1x} = 32 \cos 30° = 27.7$

$F_{1y} = 32 \sin 30° = 16$

$F_{3x} = 41 \cos 60° = 20.5$

$F_{3y} = 41 \sin 60° = 35.5°$

$F_{2x} = 55N$

$F_{2y} = 0$

$\Sigma F_{net} = \Sigma F_x + \Sigma F_y$

$= (27.7 + 20.5 + 55)i + (16 - 35.5 + 0)j$

$= 103.21i - 19.5j$

$a = \frac{F}{m}$

$= (0.86)i - (0.16)j$

b) $\sqrt{(0.86)^2 + (0.16)^2}$

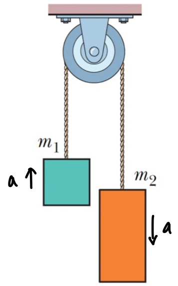
$= 0.88 \, m/s^2$

c) $\theta = \tan^{-1}\left(\frac{-0.16}{0.86}\right)$

$= -11°$

Question 4

Two blocks connected by a cord (of negligible mass) that passes over a frictionless pulley (also of negligible mass). The arrangement is known as Atwood's machine. One block has mass m_1 = 1.30 kg; the other has mass m_2 = 2.80 kg. What are (a) the magnitude of the blocks' acceleration and (b) the tension in the cord?

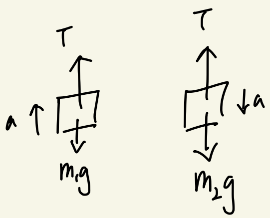


Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answer

(a) 3.6 m/s^2; (b) 17 N

a)



$$F_{1net} = m_1 a \qquad F_{2net} = m_2 a$$

$$T - m_1 g = m_1 a \quad -① \qquad m_2 g - T = m_2 a \quad -②$$

Add ① and ② : $T - m_1 g + m_2 g - T = m_1 a + m_2 a$

$$a = \frac{m_2 g - m_1 g}{m_1 + m_2}$$

$$\approx 3.6 \, m/s^2$$

b)

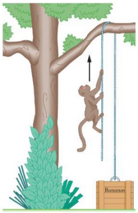
$$T = m_1 a + m_1 g$$

$$= (1.3)(3.6) + (1.3)(9.8)$$

$$= 17N$$

Question 5

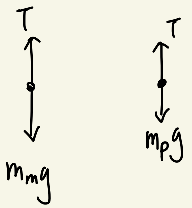
A 10 kg monkey climbs up a massless rope that runs over a frictionless tree limb and back down to a 15 kg package on the ground. (a) What is the magnitude of the least acceleration the monkey must have if it is to lift the package off the ground? If, after the package has been lifted, the monkey stops its climb and holds onto the rope, what are the (b) magnitude and (c) direction of the monkey's acceleration and (d) the tension in the rope?



Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answer

(a) 4.9 m/s^2; (b) 2.0 m/s^2; (c) Upwards; (d) 120 N



a) Package side $a\uparrow$

$T = 15 \times 9.8$

$= 147$

monkey side $a\downarrow$

$T = m_m g + ma$

$147 = 10 \times 9.8 + (10)a$

$a = 4.9 m/s^2$

b) monkey stop $a\uparrow$

$a = \frac{F_{net}}{\text{total mass}}$

$= \frac{15 \times 9.8 - 10 \times 9.8}{15 + 10}$

$= 1.96$

$\approx 2 m/s^2$

$a\uparrow$ upwards

d) $ma = T - m_m g$

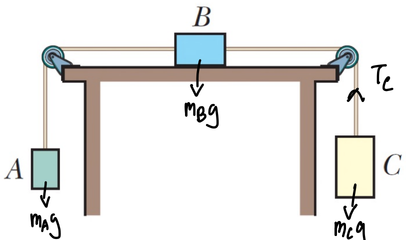
$T = ma + m_m g$

$= 118$

$\approx 120N$

Question 6

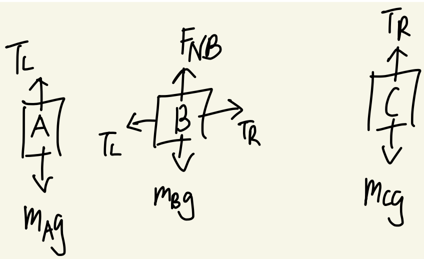
Three blocks are connected by cords that loop over frictionless pulleys. Block B lies on a frictionless table; the masses are m_A = 6.00 kg, m_B = 8.00 kg, and m_C = 10.0 kg. When the blocks are released, what is the tension in the cord at the right connecting B and C?



Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answer

82 N



$$m_A a = T_L - m_A g \quad -①$$

$$m_B a = T_R - T_L \quad -②$$

$$m_C a = m_C g - T_R \quad -③$$

sum of ① ② & ③ :

$$m_C g - m_A g = m_A a + m_B a + m_C a$$

$$a = \frac{m_C g - m_A g}{m_A + m_B + m_C}$$

$$= \frac{9.8(10-6)}{6+8+10}$$

$$= 1.63 m/s^2$$

$$=$$

$$T_R = m_C g - m_C a$$

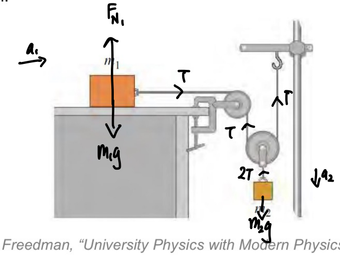
$$= 10(9.8) - 10(1.63)$$

$$= 81.7N$$

$$\approx 82N$$

Question 7 *

In terms of m_1, m_2, and g, find the acceleration of each block in the figure. There is no friction anywhere in the system.



Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answer

$$a_1 = \frac{2m_2 g}{4m_1 + m_2};\ a_2 = \frac{m_2 g}{4m_1 + m_2}$$

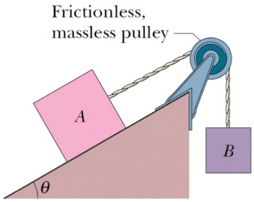
$$T = m_1 a_1$$

$$m_2 g - 2T = m_2 a_2$$

$$m_2 g - 2(m_1 a_1) = m_2 a_2$$

Question 8

Body A weighs 102 N, and body B weighs 32 N. The coefficients of friction between A and the incline are $\mu_s = 0.56$ and $\mu_k = 0.25$. The angle θ is 40°. Let the positive direction of an x axis be up the incline. In unit-vector notation, what is the acceleration of A if A is initially (a) at rest, (b) moving up the incline, and (c) moving down the incline?



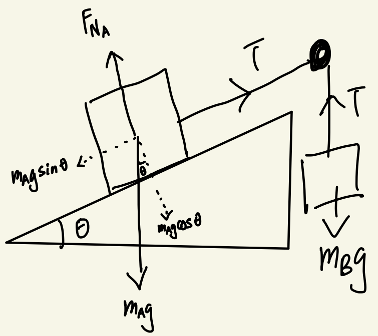
Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answers

(a) 0 m/s; (b) (-3.9 m/s²) **i**; (c) (-1.0 m/s²) **i**;

a) at rest, no F_{net} ∴ $a = 0\ m/s^2$

b)



$m_A g = 102N$ $\mu_k = 0.25$

$m_B g = 32N$ $\mu_s = 0.56$

$\theta = 40°$

$$T - m_A g \sin\theta - \mu_k \cdot m_A g \cos\theta = m_A a \quad -①$$

$$m_B a = m_B g - T \quad -②$$

From ①: $T = m_A a + m_A g \sin\theta + \mu_k \cdot m_A g \cos\theta$

sub into ②: $m_B a = m_B g - m_A a - m_A g \sin\theta - \mu_k \cdot m_A g \cos\theta$

$$m_B a + m_A a = m_B g - m_A g \sin\theta - \mu_k \cdot m_A g \cos\theta$$

$$a = \frac{m_B g - m_A g \sin\theta - \mu_k \cdot m_A g \cos\theta}{m_B + m_A}$$

$$= \frac{32 - 102\sin 40° - 0.25 \cdot 102\cos 40°}{\frac{102+32}{9.8}}$$

$$= -3.88$$

$$\approx (-3.9)i \ m/s^2$$

c)

$$T + \mu_K \cdot m_A g\cos\theta - m_A g\sin\theta = m_A a \quad - (3)$$

$$m_B a = m_B g - T \quad - (2)$$

from (2) : $T = m_B g - m_B a$

sub into (1) :

$$m_B g - m_B a + \mu_K \cdot m_A g\cos\theta - m_A g\sin\theta = m_A a$$

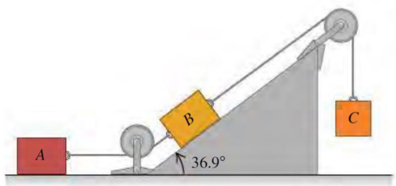
$$a(m_A + m_B) = m_B g + \mu_K \cdot m_A g\cos\theta - m_A g\sin\theta$$

$$a = \frac{32 + 0.25 \times 102\cos 40 - 102\sin 40°}{\frac{102+32}{9.8}}$$

$$\approx -1.0 \ m/s^2$$

Question 9

Blocks A, B, and C are connected by ropes of negligible mass. Both A and B weigh 25.0 N each, and the coefficient of kinetic friction between each block and the surface is 0.35. Block C descends with constant velocity. (a) Draw separate free-body diagrams showing the forces acting on A and on B. (b) Find the tension in the rope connecting blocks A and B. (c) What is the weight of block C? (d) If the rope connecting A and B were cut, what would be the acceleration of C?



Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

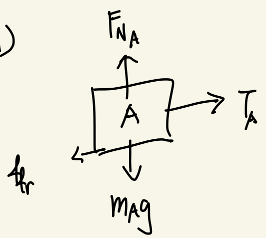
Answer

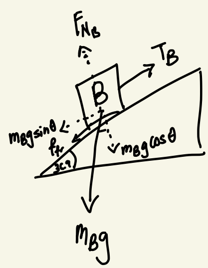
(b) 8.8 N; (c) 31.0N; (d) 1.54 m/s^2

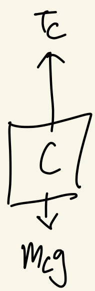
$m_A g = 25\text{ N}$ $\mu_k = 0.35$

$m_B g = 25\text{N}$

a)







b)

$$T_A = 25 \times 0.35$$
$$= 8.75$$
$$\approx 8.8\text{N}$$

c) $T_C = T_A + T_B$

$$T_B = m_B g \sin\theta + f_{fr}$$
$$= 25 \sin 36.9° + 0.35 \times 25 \cos 36.9°$$
$$= 22\text{ N}$$

$$T_C = 8.8 + 22$$
$$\approx 31\text{N}$$

d)

$$T_C - mg\sin\theta - f_{fr} = (m_B + m_C)a$$

$$a = \frac{8.8}{\frac{31+25}{9.8}}$$

$$= 1.54 m/s^2$$

Question 1

A 200 g ball thrown vertically up with an initial speed of 20 m/s reaches a maximum height of 18 m. Find: (a) the change in its kinetic energy; (b) the work done by gravity. (c) Explain why the quantities are not equal.

Adapted from Benson, "University Physics", Revised Edition, John Wiley & Sons, inc., 1996.

Answer

(a) -40 J; (b) -35 J;

a) $\Delta KE = KE_f - KE_i$

$$= 0 - \frac{1}{2}(0.2)(20)^2$$

$$= -40$$

b) wd by gravity $= 0.2 \times -9.8 \times 18$

$$\approx -35 J$$

Question 2

A baseball is thrown from the roof of a 22.0 m tall building with an initial velocity of magnitude 12.0 m/s and directed at an angle of 53.1° above the horizontal. (a) What is the speed of the ball just before it strikes the ground? Use energy methods and ignore air resistance. (b) What is the answer for part (a) if the initial velocity is at an angle of 53.1° below the horizontal? (c) If the effects of air resistance are included, will part (a) or (b) give the higher speed?

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answer

(a) 24.0 m/s; (b) 24.0 m/s; (c) part (b)

a)

$$mgh + \frac{1}{2}mv_i^2 = \frac{1}{2}mv_f^2$$

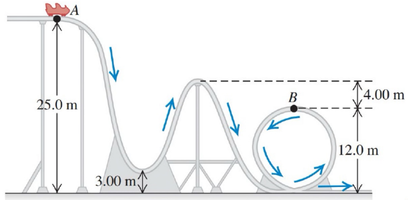
$$2\cancel{m}gh + \cancel{m}v_i^2 = \cancel{m}v_f^2$$

$$v_f = \sqrt{2(9.8)(22) + (12)^2}$$

$$\approx 24 \, m/s^2$$

Question 3

A 350 kg roller coaster starts from rest at point A and slides down the frictionless loop-the-loop shown in the figure. (a) How fast is this roller coaster moving at point B? (b) How hard does it press against the track at point B?



Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answer

(a) 16.0 m/s; (b) 1.15×10^4 N.

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

$$350(9.8)(25) = 350(9.8)(12) + \frac{1}{2}(350)v^2$$

$$v = 15.9 \approx 16.0 \, m/s^2$$

Question 4

You are testing a new amusement park roller coaster with an empty car of mass 120 kg. One part of the track is a vertical loop with radius 12.0 m. At the bottom of the loop (point A) the car has speed 25.0 m/s, and at the top of the loop (point B) it has speed 8.0 m/s. As the car rolls from point A to point B, how much work is done by friction?

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answer

-5500 J

$$KE_A + PE_A + W_{fr} = KE_B + PE_B$$

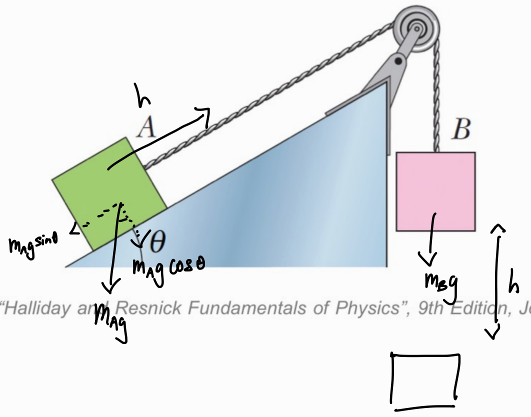
$$\frac{1}{2}(120)(25)^2 + 0 + W_{fr} = \frac{1}{2}(120)(8)^2 + (120)(9.8)(24)$$

$$W_{fr} = -5436$$

$$\approx -5500\,J$$

Question 5

In the figure, the pulley has negligible mass, and both it and the inclined plane are frictionless. Block A has a mass of 1.0 kg, block B has a mass of 2.0 kg, and angle θ is 30°. If the blocks are released from rest with the connecting cord taut, what is their total kinetic energy when block B has fallen 25 cm?



Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answers

3.7 J

$V_i = 0 m/s$

$V_f = 0 m/s$

Work energy principal

$W_{net} = \Delta KE$

$= KE_f - \cancel{KE_i}^{0}$

$= \frac{1}{2} m v_f^2$

$W^B_{gravity} = f . d$

$= m_B g h \approx 2.0 \times (9.8) \times (0.25) \approx 4.9 J$

$W^A_{gravity} = m_A g \sin\theta . h . \cos 180°$

$= 1 \times 9.8 \sin 30 \times 0.25 . \cos 180°$

$= -1.225 J$

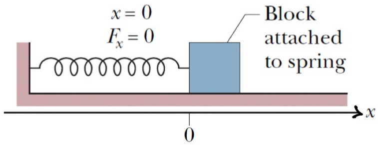
$W_{net} = 4.9 - 1.225 \approx 3.7 J$

Question 6

A spring and block are in the arrangement shown below. When the block is pulled out to $x = 4.0$ cm, we must apply a force of magnitude 360 N to hold it there. We pull the block to $x = 11$ cm and then release it. How much work does the spring do on the block as the block moves from $x_i = 5.0$ cm to (a) $x = 3.0$ cm, (b) $x = -3.0$ cm, (c) $x = -5.0$ cm, and (d) $x = -9.0$ cm?

Spring Constant, $k = \frac{F}{x}$

$= 9kN/m$



Adapted from Walker, “Halliday and Resnick Fundamentals of Physics”, 9th Edition, John Wiley & Sons, Inc., 2011.

Answers

(a) 7.2 J; (b) 7.2 J; (c) 0; (d) - 25 J

a) $k = \frac{360}{0.04} = 9kN/m$

$TE = \underset{\text{elastic}}{PE} = \frac{1}{2}kx^2$ (11cm)

$TE \rightarrow KE + PE$

$TE = KE + PE \Rightarrow KE_i = TE - PE_i$ (" f, " f)

$$W_{sp} = \Delta KE = KE_f - KE_i$$

$$= TE - PE_f - (TE - PE_i)$$

$$= PE_i - PE_f = -\Delta PE$$

$$= \frac{1}{2}k(0.05)^2 - \frac{1}{2}k(0.03)^2$$

$$= 7.2J$$

b)

$W_{sp} = 7.2J$ since $(-0.03)^2 = (0.03)^2$

c) 0

d)

$$W_{sp} = \frac{1}{2}k(0.05)^2 - \frac{1}{2}k(-0.09)^2$$

$$= -25J$$

Question 7

A spring of negligible mass has force constant k = 1600 N/m. (a) How far must the spring be compressed for 3.20 J of potential energy to be stored in it? (b) You place the spring vertically with one end on the floor. You then drop a 1.20 kg book onto it from a height of 0.800 m above the top of the spring. Find the maximum distance the spring will be compressed.

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answer

(a) 6.32 cm; (b) 12 cm

a)

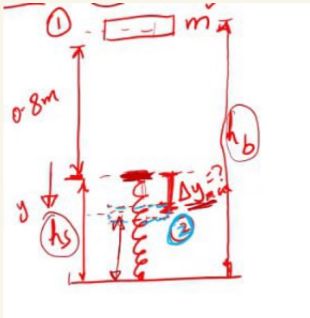
$$3.2 = \frac{1}{2}kx^2$$

$$x = \sqrt{4\times10^{-3}}$$

$$= 0.0632\,m$$

$$\approx 6.32\,cm$$

b)



$$TE_1 = GPE = mgh_b$$

$$TE_2 = mg(h_s - \Delta y_{max}) + \frac{1}{2}k\Delta y_{max}^2$$

$$TE_1 = TE_2$$

$$mg\,h_s - mg\Delta y_{max} + \frac{1}{2}k\Delta y_{max}^2 = mgh_b$$

$$\frac{1}{2}k\Delta y_{max}^2 - mg\Delta y_{max} = mg(\overbrace{h_b - h_s}^{0.8\,m})$$

$$\frac{1}{2}(1600)\Delta y_{max}^2 - 1.2(9.8)\Delta y_{max} = (1.2)(9.8)(0.8)$$

$$\Delta y_{max} = 0.116\,m \quad or \quad \Delta y_{max} = -0.101\,m$$

$$\approx 12\,cm$$

Question 8

You are an industrial engineer with a shipping company. As part of the package-handling system, a small box with mass 1.60 kg is placed against a light spring that is compressed 0.280 m. The spring has force constant k = 45.0 N/m. The spring and box are released from rest, and the box travels along a horizontal surface for which the coefficient of kinetic friction with the box is μ_k = 0.300. When the box has travelled 0.280 m and the spring has reached its equilibrium length, the box loses contact with the spring. (a) What is the speed of the box at the instant when it leaves the spring?

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answers

(a) 0.747 m/s;

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

$$= 1.764$$

$$TE_{①} = PE = 1.764 J$$

$$TE_{②} = \frac{1}{2}mv^2$$

$$F_{fr} = \mu_k F_N = \mu_k mg$$

negative

$$TE_{②} = TE_{①} + W_{fr}$$

-0.28

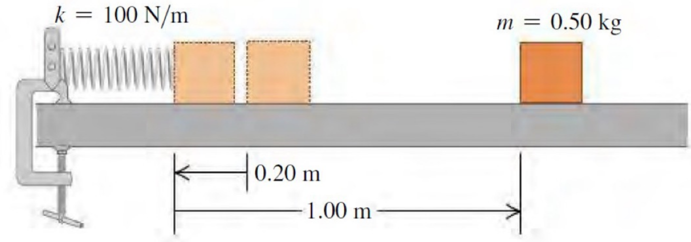
$$\frac{1}{2}mv^2 = \frac{1}{2}kx^2 + \mu_k mg \cdot x$$

$$v = \sqrt{\frac{\frac{1}{2}kx^2 + \mu_k mg \cdot x}{\frac{1}{2}m}}$$

$$= 0.747 m/s$$

Question 9

A block with mass 0.50 kg is forced against a horizontal spring of negligible mass, compressing the spring a distance of 0.20 m. When released, the block moves on a horizontal tabletop for 1.00 m before coming to rest. The force constant k is 100 N/m. What is the coefficient of kinetic friction μ_k between the block and the tabletop?



Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answer

0.41

$m_B = 0.5kg \qquad k = 100\ N/m$

$$TE_{1} = PE = \frac{1}{2}kx^2$$

$$= \frac{1}{2}(100)(0.2)^2$$

$$= 2$$

$$TE_{2} = PE - W_{fr} = 0$$

$$PE = W_{fr}$$

$$2 = \mu_k (0.5 \times 9.8 \times 1)$$

$$\mu_k \approx 0.41$$

Question 1

A 0.0450 kg golf ball initially at rest is given a speed of 25.0 m/s when a club strikes it. If the club and ball are in contact for 2.00 ms, what average force acts on the ball? Is the effect of the ball's weight during the time of contact significant? Why or why not?

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answer

562 N

$$J = mv$$
$$= 0.045 \times 25$$
$$= 1.125 N$$
$$F_{avg} = \frac{1.125}{2 \times 10^{-3}}$$
$$\approx 562 N$$

Question 2

A 10.0 g marble slides to the left at a speed of 0.400 m/s on the frictionless, horizontal surface of an icy New York sidewalk and has a head-on, elastic collision with a larger 30.0 g marble sliding to the right at a speed of 0.200 m/s. Find the velocity of each marble (magnitude and direction) after the collision. (Since the collision is head-on, all motion is along a line.).

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answers

30.0 g marble moves left at 0.100 m/s. 10.0 g marble moves right at 0.500 m/s;

$m_1 = 0.01\,kg \qquad m_2 = 0.03\,kg$

T_0 : $\quad v_{2_0} = 0.2\,m/s \qquad v_{1_0} = 0.4\,m/s$

$m_2 \longrightarrow \qquad\qquad \longleftarrow m_1$

T_1 : $\quad \overset{v_{21}}{\bullet\!\!\longrightarrow} \quad \overset{v_{11}}{\bullet\!\!\longrightarrow}$

By CM $\quad P_0 = P_1$

$$0.01 \times \underbrace{(-0.4)}_{-v_{1_0}} + 0.03 \times 0.2 = m_1 v_{11} + m_2 v_{21}$$

$$v_{21} = 0.667 - 0.333\,v_{11}$$

By Ck for elastic collision,

$$\frac{1}{2} \times 0.01 \times 0.4^2 + \frac{1}{2} \times 0.03 \times 0.2^2 = \frac{1}{2} \times 0.01 \times v_{11}^2 + \frac{1}{2} \times 0.03 \times v_{21}^2$$

$$1.4 \times 10^{-3} = 5 \times 10^{-3} \times v_{11}^2 + 15 \times 10^{-3} \times (0.667 - 0.333 v_{11})^2$$

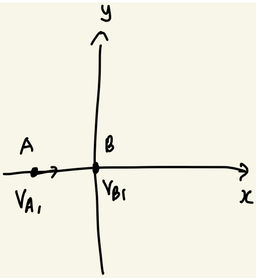
Question 3

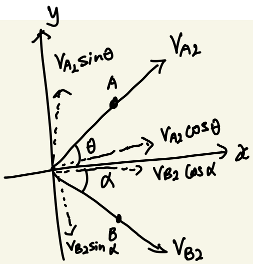
Jack (mass 55.0 kg) is sliding due east with speed 8.00 m/s on the surface of a frozen pond. He collides with Jill (mass 48.0 kg), who is initially at rest. After the collision, Jack is traveling at 5.00 m/s in a direction 34.0º north of east. What is Jill's velocity (magnitude and direction) after the collision? Ignore friction.

Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answers

Magnitude: 5.46 m/s; Direction: 36.0º south of east





$m_A = 55\,kg$ $\quad$ $m_B = 48\,kg$

$V_{A1} = 8\,m/s$ $\quad$ $V_{B1} = 0$

$V_{A2} = 5\,m/s$ $\quad$ $V_{B2} = ?$

$\theta = 34°$ $\quad$ $\alpha = ?$

For x,

$$m_A V_{A1} + m_B V_{B1} = m_A V_{A2}\cos\theta + m_B V_{B2}\cos\alpha$$

$$V_{B2}\cos\alpha = \frac{55\times 8 + 0 - 55\times 5\cos 34°}{48}$$

$$= 4.417$$

For y,

$$0 = m_A V_{A2}\sin\theta + (-m_B V_{B2}\sin\alpha)$$

$$V_{B2}\sin\alpha = \frac{55\times 5\sin 34°}{48}$$

$$= 3.204$$

$$\frac{\cancel{V_{B2}}\sin\alpha}{\cancel{V_{B2}}\cos\alpha} = \tan\alpha = \frac{3.204}{4.417}$$

$$\alpha = \tan^{-1}\left(\frac{3.204}{4.417}\right)$$

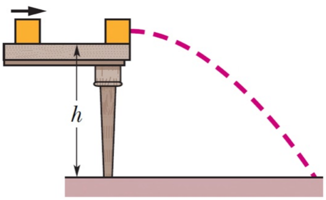
$\approx 36°$

magnitude of v = $\sin 36° = \frac{3.204}{v}$

$v = 5.45$ m/s

Question 4

A 3.2 kg box of running shoes slides on a horizontal frictionless table and collides with a 2.0 kg box of ballet slippers initially at rest on the edge of the table, at height *h* = 0.40 m. The speed of the 3.2 kg box is 3.0 m/s just before the collision. If the two boxes stick together because of packing tape on their sides, (a) what is their kinetic energy just before they strike the floor? (b) How far will it travel?



Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answers

(a) 29 J; (b) 0.528 m

a)

$3.2 \times 3 + 2 \times 0 = 5.2 \times V$

$V = 1.84 \text{ m/s}^2$

$KE = \frac{1}{2}(2+3.2)(1.84)^2 + (2+3.2)(9.8)(0.4)$

≈ 29 J

Question 5

A cart with mass 340 g moving on a frictionless linear air track at an initial speed of 1.2 m/s undergoes an elastic collision with an initially stationary cart of unknown mass. After the collision, the first cart continues in its original direction at 0.66 m/s. (a) What is the mass of the second cart? (b)What is its speed after impact?

Adapted from Walker, "Halliday and Resnick Fundamentals of Physics", 9th Edition, John Wiley & Sons, Inc., 2011.

Answers

(a) 99 g; (b) 1.9 m/s;

a) $340g = 0.34kg$

By CM,

$$0.34 \times 1.2 + \cancel{m_2 v_0}^{0} = 0.34 \times 0.66 + m_2 v_1$$

$$m_2 v_1 = 0.1836$$

$$m_2 = \frac{0.1836}{v_1} \quad -①$$

By CK

$$\frac{1}{2}(0.34)(1.2)^2 + 0 = \frac{1}{2}(0.34)(0.66)^2 + \frac{1}{2} m_2 v_1^2$$

$$m_2 v_1^2 = 0.341496 \quad -②$$

Sub ① into ②:

$$\left(\frac{0.1836}{\cancel{v_1}}\right) v_1^{\cancel{2}} = 0.341496$$

$$v_1 \approx 1.9 \, m/s$$

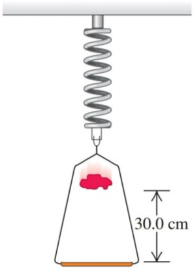
$$m_2 = \frac{0.1836}{1.86}$$

$$\approx 0.099 kg$$

$$\approx 99g$$

Question 6 *

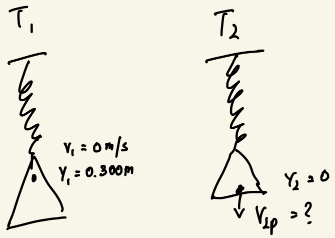
A 0.150 kg frame, when suspended from a coil spring, stretches the spring 0.070 m. A 0.200 kg lump of putty is dropped from rest onto the frame from a height of 30.0 cm. Find the absolute value of the maximum distance the frame moves downward from its initial position.



Adapted from Young and Freedman, "University Physics with Modern Physics", 14th Edition, Pearson, 2015.

Answer

0.295 m

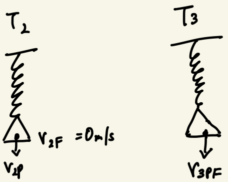


$U_{G_1} + \cancel{KE_1} = \cancel{U_{G_2}} + KE_2$; $\cancel{m_p} g y_1 = \frac{1}{2} \cancel{m_p} v_{2p}^2$

$v_{2p} = \sqrt{2 g y_1}$

$= \sqrt{2 \times 9.8 \times 0.3}$

$= 2.425$

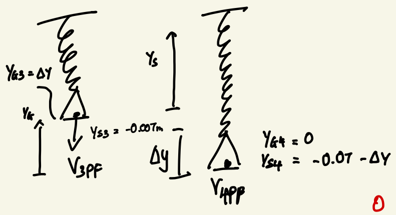


$P_2 = P_3$

$0.2 \times 2.425 = (0.200 + 0.15) v_{3PF}$

$v_{3PF} = 1.386$ m/s

T_3



$$U_{G3} + U_{S3} + KE_3 = \overset{0}{\cancel{U_{G4}}} + U_{S4} + \overset{0}{\cancel{KE_4}}$$

$$ky = mg \; ; \; k = \frac{m_F g}{y}$$

$$= 21 N/m$$

$$m_{FP} g Y_{G3} + \frac{1}{2} k Y_{S3}^2 + \frac{1}{2} m_{FP} V_{SPF}^2 = \frac{1}{2} k Y_{S4}^2$$

$$0.350 \times 9.8 \Delta Y + \frac{1}{2} 21 (-0.070)^2 + \frac{1}{2} (0.35)(1.386)^2 = \frac{1}{2} k (-0.070 - \Delta y)^2$$

$$3.43 \Delta Y + 0.05145 + 0.3362 = 10.5 (4.9 \times 10^{-3} + \Delta y^2 + 0.14 \Delta y)$$

$$3.43 \Delta Y + 0.3877 = 0.05145 + 1.47 \Delta Y + 10.5 \Delta Y^2$$

$$-10.5 \Delta Y^2 + 1.96 \Delta Y + 0.33625 = 0$$

$$\Delta Y = +\underline{0.295 m} \text{ or } \Delta Y = -0.108$$