

RECOMMENDED PROBLEMS

CHAPTER 9



@GENERALPHYSICSA

Physics A – Serway

إعداد

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معيدي قسم الفيزياء في الجامعة الإسلامية

5. A baseball approaches home plate at a speed of 45.0 m/s , moving horizontally just before being hit by a bat. The batter hits a pop-up such that after hitting the bat, the baseball is moving at 55.0 m/s straight up. The ball has a mass of 145 g and is in contact with the bat for 2.00 ms . What is the average vector force the ball exerts on the bat during their interaction?

30. As shown in Figure P9.30, a bullet of mass m and speed v passes completely through a pendulum bob of mass M . The bullet emerges with a speed of $v/2$. The pendulum bob is suspended by a stiff rod (not a string) of length ℓ and negligible mass. What is the minimum value of v such that the pendulum bob will barely swing through a complete vertical circle?

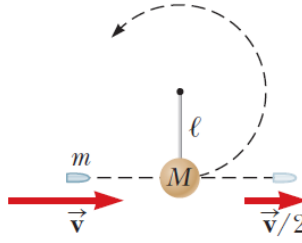


Figure P9.30

- 31.** A 12.0-g wad of sticky clay is hurled horizontally at a 100-g wooden block initially at rest on a horizontal surface. The clay sticks to the block. After impact, the block slides 7.50 m before coming to rest. If the coefficient of friction between the block and the surface is 0.650, what was the speed of the clay immediately before impact?

- 33.** Two blocks are free to slide along the frictionless, **AMT** wooden track shown in Figure P9.33. The block of **W** mass $m_1 = 5.00$ kg is released from the position shown, at height $h = 5.00$ m above the flat part of the track. Protruding from its front end is the north pole of a strong magnet, which repels the north pole of an identical magnet embedded in the back end of the block of mass $m_2 = 10.0$ kg, initially at rest. The two blocks never touch. Calculate the maximum height to which m_1 rises after the elastic collision.

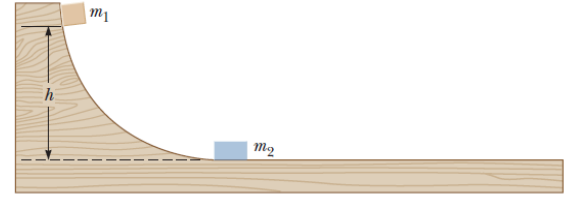


Figure P9.33

37. An object of mass 3.00 kg, moving with an initial velocity of $5.00\hat{i}$ m/s, collides with and sticks to an object of mass 2.00 kg with an initial velocity of $-3.00\hat{j}$ m/s. Find the final velocity of the composite object.

- 41.** A billiard ball moving at 5.00 m/s strikes a stationary ball of the same mass. After the collision, the first ball moves at 4.33 m/s at an angle of 30.0° with respect to the original line of motion. Assuming an elastic collision (and ignoring friction and rotational motion), find the struck ball's velocity after the collision.

45. Four objects are situated along the y axis as follows: a **W** 2.00-kg object is at +3.00 m, a 3.00-kg object is at +2.50 m, a 2.50-kg object is at the origin, and a 4.00-kg object is at -0.500 m. Where is the center of mass of these objects?

49. A rod of length 30.0 cm has linear density (mass per length) given by $\lambda = 50.0 + 20.0x$ where x is the distance from one end, measured in meters, and λ is in grams/meter. (a) What is the mass of the rod? (b) How far from the $x = 0$ end is its center of mass?

55. A ball of mass 0.200 kg with a velocity of $1.50\hat{\mathbf{i}}\text{ m/s}$ meets a ball of mass 0.300 kg with a velocity of $-0.400\hat{\mathbf{i}}\text{ m/s}$ in a head-on, elastic collision. (a) Find their velocities after the collision. (b) Find the velocity of their center of mass before and after the collision.

- 67.** A 3.00-kg steel ball strikes a wall with a speed of 10.0 m/s at an angle of $\theta = 60.0^\circ$ with the surface. It bounces off with the same speed and angle (Fig. P9.67). If the ball is in contact with the wall for 0.200 s, what is the average force exerted by the wall on the ball?

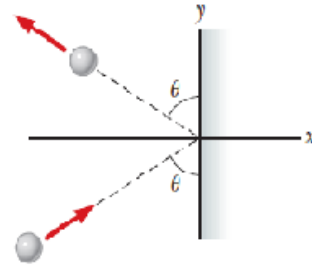


Figure P9.67

68. (a) Figure P9.68 shows three points in the operation of the ballistic pendulum discussed in Example 9.6 (and shown in Fig. 9.9b). The projectile approaches the pendulum in Figure P9.68a. Figure P9.68b shows the situation just after the projectile is captured in the pendulum. In Figure P9.68c, the pendulum arm has swung upward and come to rest at a height h above its initial position. Prove that the ratio of the kinetic energy of the projectile–pendulum system immediately after the collision to the kinetic energy immediately before is $m_1/(m_1 + m_2)$. (b) What is the ratio of the momentum of the system immediately after the collision to the momentum immediately before? (c) A student believes that such a large decrease in mechanical energy must be accompanied by at least a small decrease in momentum. How would you convince this student of the truth?

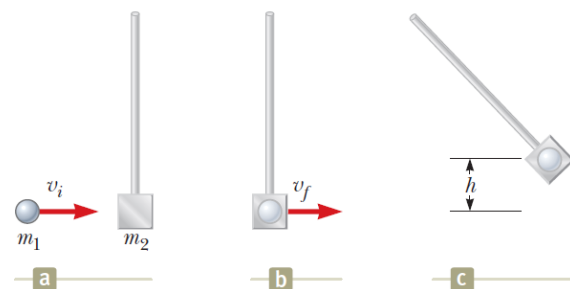


Figure P9.68 Problems 68 and 86. (a) A metal ball moves toward the pendulum. (b) The ball is captured by the pendulum. (c) The ball–pendulum combination swings up through a height h before coming to rest.

- 69. Review.** A 60.0-kg person running at an initial speed of 4.00 m/s jumps onto a 120-kg cart initially at rest (Fig. P9.69). The person slides on the cart's top surface and finally comes to rest relative to the cart. The coefficient of kinetic friction between the person and the cart is 0.400. Friction between the cart and ground can be ignored. (a) Find the final velocity of the person and cart relative to the ground. (b) Find the friction force acting on the person while he is sliding across the top surface of the cart. (c) How long does the friction force act on the person? (d) Find the change in momentum of the person and the change in momentum of the cart. (e) Determine the displacement of the person relative to the ground while he is sliding on the cart. (f) Determine the displacement of the cart relative to the ground while the person is sliding. (g) Find the change in kinetic energy of the person. (h) Find the change in kinetic energy of the cart. (i) Explain why the answers to (g) and (h) differ. (What kind of collision is this one, and what accounts for the loss of mechanical energy?)

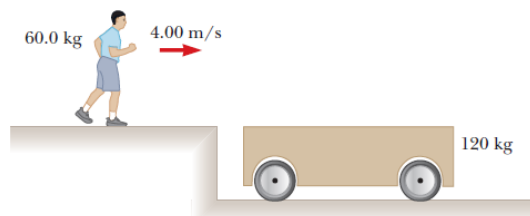


Figure P9.69

70. A cannon is rigidly attached to a carriage, which can move along horizontal rails but is connected to a post by a large spring, initially unstretched and with force constant $k = 2.00 \times 10^4 \text{ N/m}$, as shown in Figure

P9.70. The cannon fires a 200-kg projectile at a velocity of 125 m/s directed 45.0° above the horizontal. (a) Assuming that the mass of the cannon and its carriage is 5 000 kg, find the recoil speed of the cannon. (b) Determine the maximum extension of the spring. (c) Find the maximum force the spring exerts on the carriage. (d) Consider the system consisting of the cannon, carriage, and projectile. Is the momentum of this system conserved during the firing? Why or why not?

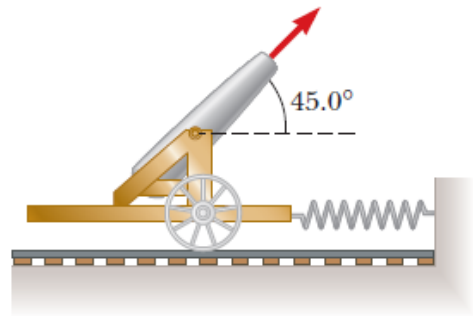


Figure P9.70

- 71.** A 1.25-kg wooden block rests on a table over a large hole as in Figure P9.71. A 5.00-g bullet with an initial velocity v_i is fired upward into the bottom of the block and remains in the block after the collision. The block and bullet rise to a maximum height of 22.0 cm. (a) Describe how you would find the initial velocity of the bullet using ideas you have learned in this chapter. (b) Calculate the initial velocity of the bullet from the information provided.

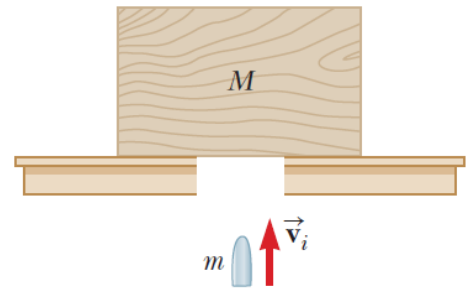


Figure P9.71
Problems 71 and 72.

73. Two particles with masses m and $3m$ are moving toward each other along the x axis with the same initial speeds v_i . The particle with mass m is traveling to the left, and particle with mass $3m$ is traveling to the right. They undergo a head-on elastic collision, and each rebounds along the same line as it approached. Find the final speeds of the particles.

- 75.** Two gliders are set in motion on a horizontal air track. A spring of force constant k is attached to the back end of the second glider. As shown in Figure P9.75, the first glider, of mass m_1 , moves to the right with speed v_1 , and the second glider, of mass m_2 , moves more slowly to the right with speed v_2 . When m_1 collides with the spring attached to m_2 , the spring compresses by a distance $x_{\max}$, and the gliders then move apart again. In terms of v_1 , v_2 , m_1 , m_2 , and k , find (a) the speed v at maximum compression, (b) the maximum compression $x_{\max}$, and (c) the velocity of each glider after m_1 has lost contact with the spring.

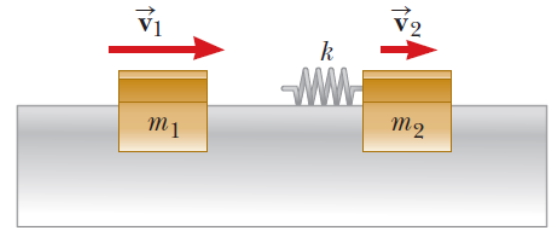


Figure P9.75

77. Two blocks of masses $m_1 = 2.00 \text{ kg}$ and $m_2 = 4.00 \text{ kg}$ are released from rest at a height of $h = 5.00 \text{ m}$ on a frictionless track as shown in Figure P9.77. When they meet on the level portion of the track, they undergo a head-on, elastic collision. Determine the maximum heights to which m_1 and m_2 rise on the curved portion of the track after the collision.



Figure P9.77

80. A small block of mass $m_1 = 0.500$ kg is released from rest at the top of a frictionless, curve-shaped wedge of mass $m_2 = 3.00$ kg, which sits on a frictionless, horizontal surface as shown in Figure P9.80a. When the block leaves the wedge, its velocity is measured to be 4.00 m/s to the right as shown in Figure P9.80b. (a) What is the velocity of the wedge after the block reaches the horizontal surface? (b) What is the height h of the wedge?

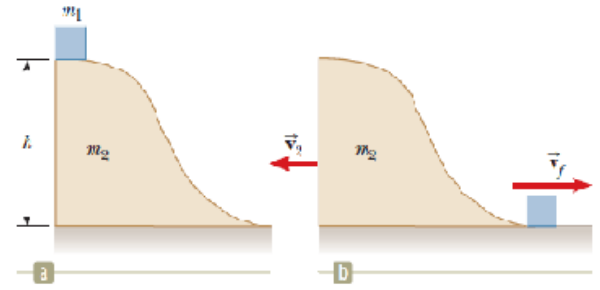


Figure P9.80

- 81. Review.** A bullet of mass $m = 8.00$ g is fired into a block of mass $M = 250$ g that is initially at rest at the edge of a table of height $h = 1.00$ m (Fig. P9.81). The bullet remains in the block, and after the impact the block lands $d = 2.00$ m from the bottom of the table. Determine the initial speed of the bullet.

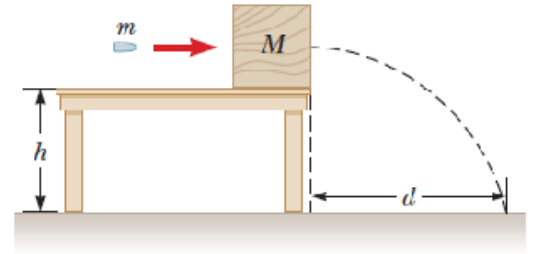


Figure P9.81 Problems 81 and 82.

- 89.** A 5.00-g bullet moving with an initial speed of $v_i = 400$ m/s is fired into and passes through a 1.00-kg block as shown in Figure P9.89. The block, initially at rest on a frictionless, horizontal surface, is connected to a spring with force constant 900 N/m. The block moves $d = 5.00$ cm to the right after impact before being brought to rest by the spring. Find (a) the speed at which the bullet emerges from the block and (b) the amount of initial kinetic energy of the bullet that is converted into internal energy in the bullet-block system during the collision.

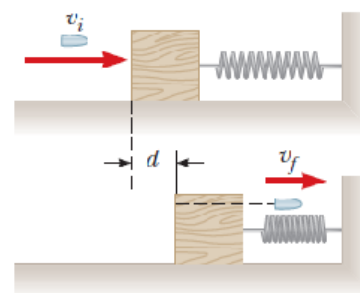


Figure P9.89

ch 9:

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9.5) $V_i = 45 \text{ m/s} \hat{i}$ find F

$V_f = 55 \text{ m/s} \hat{j}$

$m = 145 \text{ g}$

$\Delta t = 2 \text{ ms}$

$$F = \frac{\Delta p}{\Delta t}, \quad \frac{\Delta p}{\Delta t} = \frac{m(V_f - V_i)}{\Delta t}$$

$$= \frac{145 \times 10^{-3} (55 \hat{j} - 45 \hat{i})}{2 \times 10^{-3}}$$

$$\vec{F}_{\text{on ball}} = (-3.26 \hat{i} + 3.99 \hat{j}) \times 10^3 \text{ N}$$

$$F_{\text{on bat}} = -F_{\text{on ball}} = (3.26 \hat{i} - 3.99 \hat{j}) \text{ kN}$$



9.7)

V_{gp}

a) what is the velocity V_{pi}

$$V_{gp} = V_{gi} + V_{pi}$$



$$P_{gi} + P_{pi} = P_{gf} + P_{pf}$$

$$0 = m_g V_{gi} + m_p V_{pi}$$

$$= m_g (V_{gp} + V_{pi}) + m_p V_{pi}$$

$$\left(V_{pi} = - \frac{m_g V_{gp}}{m_g + m_p} \right)$$

b) V_{gi}

$$V_{gi} = V_{gp} + V_{pi}$$

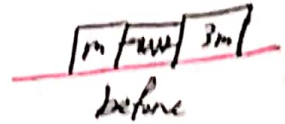
$$= V_{gp} + \frac{m_g V_{gp}}{m_g + m_p} = \frac{(m_g + m_p) V_{gp} - m_g V_{gp}}{m_g + m_p}$$

$$V_{gi} = \frac{m_p V_{gp}}{m_g + m_p}$$

(1)

9.11)

$$V_{br(2m)} = 2m/s$$

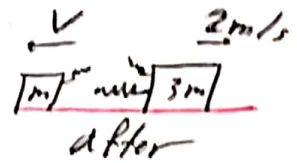


a) $V_{br\ m}$

$$P_i = P_f$$

$$0 = mV_m + (3m \times 2)$$

$$-mV_m = 6m \Rightarrow \boxed{V_m = -6m/s}$$



b) U_s $m = 0.35\ kg$

$$U_s = \frac{1}{2} kx^2 = \frac{1}{2} m V_m^2 + \frac{1}{2} (3m) V_{3m}^2$$

$$= \left(\frac{1}{2} \times 0.35 \times (-6)^2 \right) + \left(\frac{1}{2} \times (3 \times 0.35) \times (2)^2 \right)$$

$$\boxed{= 8.4\ J}$$

$$E_i = E_f$$

$$k + U = k + U^0$$

c) The original energy is in the spring.

d) the work must be force and displacement and the cord doesn't give displacement.

e) the momentum is conserved

9.22)

$$m_c = 1200 \text{ kg}$$

$$V_{ci} = 25 \text{ m/s } \hat{i}$$

$$V_{ci} = 20 \text{ m/s } \hat{i}$$

$$m_t = 9000 \text{ kg}$$

$$V_{cf} = 18 \text{ m/s } \hat{i}$$

$$a) V_{tf}$$

$$P_i = P_f$$

$$P_{ci} + P_{ti} = P_{cf} + P_{tf}$$

$$m_c V_{ci} + m_t V_{ti} = m_c V_{cf} + m_t V_{tf}$$

$$(1200 \times 25) + (9000 \times 20) = (1200 \times 18) + (9000 V_{tf})$$

$$V_{tf} = 20.93 \text{ m/s } \hat{i}$$

$$b) \Delta E$$

$$U = 0$$

$$= E_f - E_i$$

$$= K_f - K_i$$

$$\left[\frac{1}{2} m_c V_{cf}^2 + \frac{1}{2} m_t V_{tf}^2 \right] - \left[\frac{1}{2} m_c V_{ci}^2 + \frac{1}{2} m_t V_{ti}^2 \right]$$

$$= \left[(1200 \times 18^2) + (9000 \times 20.93^2) \right] - \left[1200 \times 25^2 + 9000 \times 20^2 \right]$$

$$= -8.68 \times 10^3 \text{ J}$$

c) the energy loss is ~~is~~ transferred into internal energy and sound.

9.23)

$$\left. \begin{aligned} m_b &= 10g \\ m_w &= 5kg \\ v_f &= 0.6 m/s \\ v_b &= ?? \end{aligned} \right\}$$

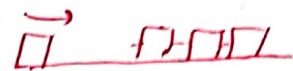
$$\begin{aligned} P_i &= P_f \\ (m_b v_b + m_w v_w) &= (m_b + m_w) v_f \\ 0.01 v_b &= (0.01 + 5) 0.6 \\ v_b &= 300.6 m/s \end{aligned}$$

9.25)

$$\left. \begin{aligned} m &= 2.5 \times 10^4 kg \\ v_{mi} &= 4 m/s \\ v_{3mi} &= 2 m/s \\ v_f &= ?? \end{aligned} \right\}$$

$$\begin{aligned} P_i &= P_f \\ m v_m + 3m v_{3m} &= (4m) v_f \\ 4 + (3 \times 2) &= 4 v_f \end{aligned}$$

$$\boxed{v_f = 2.5 m/s}$$



b) $\Delta K = ??$

$$\Delta K = K_f - K_i$$

$$= -\left(\frac{1}{2} m v_i^2 + \frac{1}{2} 3m v_{3i}^2\right) + \left(\frac{1}{2} (4m) v_f^2\right)$$

$$= \left(4 \times 2.5 \times 10^4 \times 2.5^2\right) - \left(2.5 \times 10^4 \times 4^2\right) + \left(3 \times 2.5 \times 10^4 \times 2^2\right)$$

$$\boxed{= -3.75 \times 10^4 J}$$

4

9.30)

$$V_{min} = 2.2$$

$$P_i = P_f$$

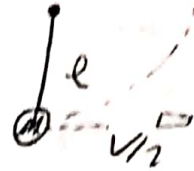
$$mV + 0 = MV_m + m \frac{1}{2} V$$

$$mV - \frac{1}{2} mV = M \times 2gl$$

$$\frac{1}{2} mV = M \times 2gl$$

$$V = \frac{4M \sqrt{gl}}{m}$$

$$\frac{m}{M}$$



$$\text{but } V_m = \sqrt{2gl}$$

$$= \sqrt{2gl}$$

$$= \sqrt{4gl}$$

$$= 2\sqrt{gl}$$

9.31)

$$m_c = 12g$$

$$m_w = 100g$$

$$d = 25m$$

$$V_f = 0$$

$$\mu_k = 0.65$$

$$V_c = 2.2$$

$$P_i = P_f$$

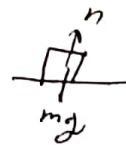
$$m_c V_c + m_w V_w = (m_c + m_w) V_f$$

we need to find V_f first

$$F_k = \mu_k m$$

$$= 0.65 \times (0.112 \times 9.8)$$

$$= 0.713 N$$



$$F = ma$$

$$0.713 = 0.112 a \Rightarrow$$

$$a = 6.37 m/s^2$$

$$(12 \times 10^{-3}) \times V_c = (0.112 \times 9.77)$$

$$V_c = 91.23 m/s$$

$$V_f^2 = V_i^2 + 2ad$$

$$0 = V_i^2 + 2 \times (-6.37) \times 7.5$$

$$V_i = 9.77 m/s$$

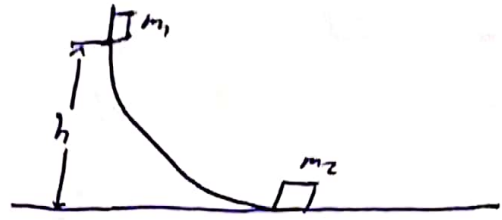
5

9.33)

$$m_1 = 5 \text{ kg}$$

$$m_2 = 10 \text{ kg}$$

$$h = 5 \text{ m}$$



after the elastic collision.

$$P_i = P_f$$

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

$$5 \times 9.9 = 5 v_{1f} + 10 v_{2f}$$

$$49.5 = 5 v_{1f} + 10 v_{2f} \quad (1)$$

$$\left. \begin{aligned} v_{1i} &= \sqrt{2gh} \\ &= \sqrt{2 \times 9.8 \times 5} \\ &= 9.9 \text{ m/s} \end{aligned} \right\}$$

$$\text{or } v_{1i} + v_{1f} = v_{2f} + v_{2i}$$

$$9.9 + v_{1f} = v_{2f} + 0$$

$$v_{2f} = 9.9 + v_{1f} \quad (2) \text{ into } (1)$$

$$49.5 = 5 v_{1f} + 10(9.9 + v_{1f})$$

$$= 5 v_{1f} + 99 + 10 v_{1f}$$

$$-49.5 = 15 v_{1f}$$

$$\Rightarrow v_{1f} = -3.3 \text{ m/s}$$

$$\text{So, } h = \frac{v_{1f}^2}{2g}$$

$$h = 0.55 \text{ m}$$

6

9.35)

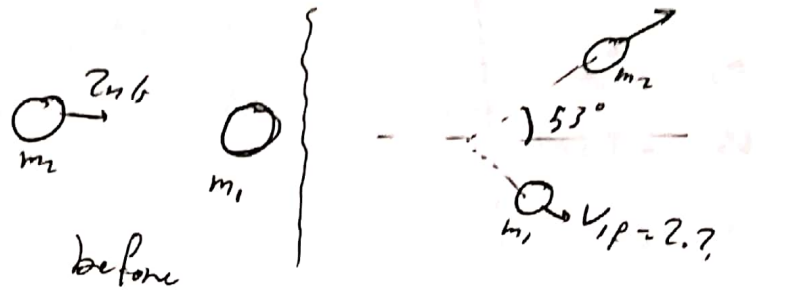
$$m_1 = 0.3 \text{ kg}$$

$$v_1 = 0$$

$$m_2 = 0.2 \text{ kg}$$

$$v_2 = 2 \text{ m/s } \hat{i}$$

$$v_{2f} = 1 \text{ m/s } \quad \theta = 53^\circ$$



a) $v_{1f} = 2.2$

$$P_{ix} = P_{fx}$$

$$P_{1ix} + P_{2ix} = P_{1fx} + P_{2fx}$$

$$0 + m_2 v_{2x} = m_1 v_{1fx} + m_2 v_{2fx}$$

$$(0.2 \times 2) = 0.3 v_{1fx} + 0.2 \times 1 \cos 53^\circ$$

$$v_{1fx} = 0.93 \text{ m/s } \hat{i}$$

$$P_{iy} = P_{fy}$$

$$0 = m_2 v_{2fy} + m_1 v_{1fy}$$

$$= 0.2 \times 1 \sin(53^\circ) + 0.3 v_{1fy} \Rightarrow v_{1fy} = 0.53 \text{ m/s } (-\hat{j})$$

$$\boxed{v_{1f} = 1.07 \text{ m/s}} \quad \text{at } \theta = 29.67^\circ \text{ under the } (x)$$

b) ~~energy~~ ratio of energy loss:-

$$\text{ratio} = \frac{\Delta K}{K_i}$$

$\Rightarrow$

$$\frac{0.27 - 0.4}{0.4} = \boxed{-3.25 \text{ J}}$$

$$K_f = \frac{1}{2} m_1 v_{1f}^2 + \frac{1}{2} m_2 v_{2f}^2 = 0.27 \text{ J}$$

$$K_i = \frac{1}{2} m_1 v_{1i}^2 + \frac{1}{2} m_2 v_{2i}^2 = 0.4 \text{ J}$$

9.37)

$$\left. \begin{aligned} m_1 &= 3 \text{ kg} \\ v_{1i} &= 5 \text{ m/s} \\ m_2 &= 2 \text{ kg} \\ v_{2i} &= -3 \text{ m/s} \\ v_f &= ?? \end{aligned} \right\}$$

$$P_i = P_f$$

$$m_1 v_{1i} + m_2 v_{2i} = (m_1 + m_2) v_f$$

$$(3 \times 5) + (2 \times -3) = (3 + 2) v_f$$

$$v_f = \frac{15 - 6}{5} = (3 - 1.2) \text{ m/s}$$

9.41)

$$\left. \begin{aligned} v_i &= 5 \text{ m/s} \\ m_1 &= m_2 \\ v_{1f} &= 4.33 \text{ m/s } \theta = 30^\circ \\ v_{2f} &= ?? \end{aligned} \right\}$$

$$P_{ix} = P_{fx}$$

$$m_1 v_{1ix} + m_2 v_{2ix} = m_1 v_{1fx} + m_2 v_{2fx}$$

$$5 + 0 = 4.33 \cos(30^\circ) + v_{2fx}$$

$$v_{2fx} = 1.25 \text{ m/s}$$

$$P_{iy} = P_{fy}$$

$$0 = 4.33 \sin(30^\circ) + v_{2fy}$$

$$v_{2fy} = -2.165 \text{ m/s}$$

$$\boxed{v_2 = 2.5 \text{ m/s}} \quad \theta = 60^\circ \text{ under the (x)}$$

9.45)

$$\left. \begin{aligned} m_1 &= 2 \text{ kg at } +3 \text{ m} \\ m_2 &= 3 \text{ kg at } +2.5 \text{ m} \\ m_3 &= 2.5 \text{ kg at } 0 \text{ m} \\ m_4 &= 4 \text{ kg at } -0.5 \text{ m} \end{aligned} \right\}$$

all the masses on the y-axis
find r_{cm}

$$x_{cm} = 0$$

$$y_{cm} = \frac{(2 \times 3) + (3 \times 2.5) + (2.5 \times 0) + (4 \times -0.5)}{2 + 3 + 2.5 + 4}$$

$$= 1 \text{ m}$$

$$\vec{r}_{cm} = (0\hat{i} + 1\hat{j}) \text{ m}$$



9.49)

$$l = 30 \text{ cm}$$

$$\lambda = 50 + 20x$$

$$\lambda (\text{gm/centimeter})$$

a) the mass

b) the center of mass

$$a) \lambda = \frac{m}{l}$$

$$m = \lambda l$$

$$m = \int_0^{0.3} \lambda dx = 50x + 10x^2 \Big|_0^{0.3} = 15.9 \text{ g}$$

$$b) x_{cm} = \frac{1}{m} \int x dm$$

$$= \frac{1}{m} \int_0^{0.3} \lambda x dx$$

$$= \frac{1}{m} \int_0^{0.3} [50x + 20x^2] dx$$

$$= \frac{1}{15.9} \left[25x^2 + \frac{20x^3}{3} \right]_0^{0.3} = \boxed{0.153 \text{ m}}$$

9.55)

$$m_1 = 0.2 \text{ kg}$$

$$v_1 = 1.5 \text{ m/s}$$

$$m_2 = 0.3 \text{ kg}$$

$$v_2 = -0.4 \text{ m/s}$$

elastic collision

$$a) v_{1f} = ?$$

$$v_{2f} = ?$$

$$a) P_i = P_f$$

$$m_1 v_{1i} + m_2 v_{2i} = m_1 v_{1f} + m_2 v_{2f}$$

$$0.2 \times 1.5 + 0.3 \times (-0.4) = 0.2 v_{1f} + 0.3 v_{2f}$$

$$\boxed{0.18 = 0.2 v_{1f} + 0.3 v_{2f}} \quad \text{--- (1)}$$

$$v_{1i} - v_{2i} = -(v_{1f} - v_{2f})$$

$$1.5 - (-0.4) = v_{2f} - v_{1f}$$

$$1.9 = v_{2f} + v_{1f} \quad \text{--- (2)}$$

from (1) and (2)

$$2.8 = 2.5 v_{2f}$$

$$\boxed{v_{2f} = 1.12 \text{ m/s}}$$

$$\boxed{v_{1f} = -0.78 \text{ m/s}}$$

$$v_{cm} = \frac{(0.2 \times 1.5) + (0.3 \times -0.4)}{0.2 + 0.3}$$

$$v_{cm} = 0.36 \text{ m/s}$$

and after is the same

⑧

9.67)

$m = 3 \text{ kg}$
 $V_i = 10 \text{ m/s}$
 $\theta = 60^\circ$
 $V_f = 10 \text{ m/s}$
 $\Delta t = 0.2$
 $F = ?$

$$P_{ix} = P_{fx}$$

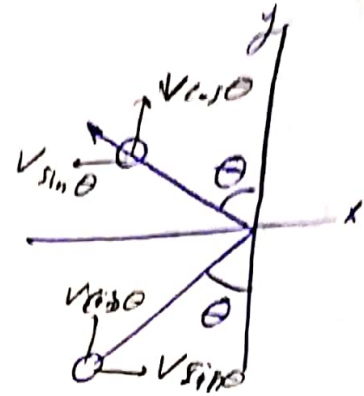
$$m_1 V_{ix} + m_2 V_{ix} = m_1 V_{fx} + m_2 V_{fx}$$

$$F = \frac{I}{\Delta t} = \frac{\Delta P}{\Delta t} = \frac{m(V_f - V_i)}{\Delta t}$$

$$F = \frac{3(-V \sin \theta - V \sin \theta)}{\Delta t}$$

$$= \frac{3(-2 \times 10 \times \sin 60)}{0.2}$$

$$= -259.8 \text{ N}$$



$$\Delta P_y = m(V_{fy} - V_{iy})$$

$$= m(V \sin \theta - V \sin \theta)$$

$$= 0$$

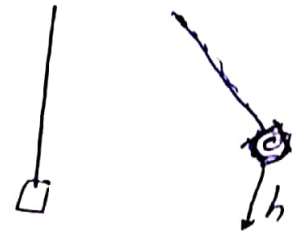
9.68)

a) Prove that $\frac{K_f}{K_i} = \frac{m_1}{m_1 + m_2}$

$$K_f = \frac{1}{2} (m_1 + m_2) V_f^2$$

$$= \frac{1}{2} \frac{m_1 V_i^2}{(m_1 + m_2)}$$

$$\left\{ \begin{array}{l} P_i = P_f \\ m_1 V_i = (m_1 + m_2) V_f \\ V_f = \frac{m_1 V_i}{m_1 + m_2} \end{array} \right.$$



$$K_i = \frac{1}{2} m_1 V_i^2$$

$$\frac{K_f}{K_i} = \frac{m_1}{m_1 + m_2}$$

b) the ratio of momentum

$$\frac{P_f}{P_i} = 1 \quad (\text{the momentum is conserved})$$

9.69)

$m_p = 60 \text{ kg}$ a) V_{ey}

$V_p = 4 \text{ m/s}$

$m_c = 120 \text{ kg}$

$V_{ci} = 0$

$\mu_k = 0.4$

$P_i = P_f$

$m_p V_{pi} + m_c V_{ci} = (m_p + m_c) V_f$

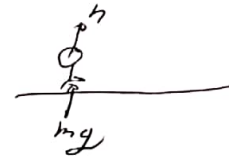
$60 \times 4 + 0 = (60 + 120) V_f$

$V_f = 1.33 \text{ m/s}$

b) $F_k = ?$

$F_k = \mu_k n$

$n = 60 \times 9.8$
 $= 588 \text{ N}$



$= 0.4 \times 588$

$F_k = 235.2 \text{ N}$

c) the time of friction.

$F \Delta t = \Delta P$

$F \Delta t = m V_f - m V_i$

$-235.2 \Delta t = 60(1.33 - 4) \Rightarrow \Delta t = 0.68 \text{ s}$

d) ΔP for person and cart.

$\Delta P_p = m(V_f - V_i)$

$= 60(1.33 - 4) = -160.2 \text{ kg} \cdot \text{m/s}$

$\Delta P_c = 120(1.33 - 0) = 159.6 \text{ kg} \cdot \text{m/s}$

e) the displacement of the person.

$\Delta x = (V_f - V_i) t = (1.33 - 4) \times 0.68 = 1.8 \text{ m}$

f) the displacement of the cart.

$\Delta x = \frac{1}{2} (V_i + V_f) \Delta t = 0.454 \text{ m}$

g) $\Delta K_p = -427 \text{ J}$

h) $\Delta K_c = 107 \text{ J}$

9.70)

$$k = 2 \times 10^4 \text{ N/m}$$

$$m_p = 200 \text{ kg}$$

$$v_p = 125 \text{ m/s } @ 45^\circ$$

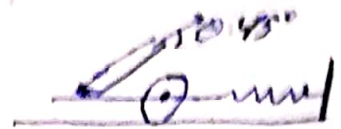
$$m_c = 5000 \text{ kg}$$

a) $v_p = 0$

$$a) \quad P_{ix} = P_{fx}$$

$$5200 \times 0 = (200 \times 125 \cos 45^\circ) + 5000 v_p$$

$$v_p = -3.54 \text{ m/s}$$



$$b) \quad x = ??$$

$$E_i = E_f \quad \text{or } W = \Delta K$$

$$K_i + U_i = K_f + U_f$$

$$\frac{1}{2} m v^2 = \frac{1}{2} k x^2 \Rightarrow x = \sqrt{\frac{m}{k}} v$$

$$= \sqrt{\frac{5000}{2 \times 10^4}} 3.54 = 1.77 \text{ m}$$

$$c) \quad F_s$$

$$F_s = kx$$

$$= 2 \times 10^4 \times 1.77 = 3.54 \times 10^4 \text{ N}$$

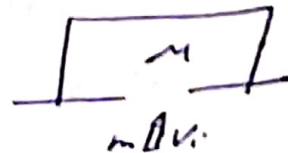
$$d) \quad N_o$$

9.71)

$$M = 1.25 \text{ kg}$$

$$m = 5 \text{ g}$$

$$h = 22 \text{ cm}$$



(a) (b) find the initial velocity

$$P_i = P_f$$

$$m v_i + M V_{i1} = (m + M) V_f$$

$$5 \times 10^{-3} v_i + 0 = (1.255) V_f$$

$$v_i = \frac{1.255 \times 2.07}{5 \times 10^{-3}}$$

$$v_i = 521.2 \text{ m/s}$$

$$\text{but } V_f = \sqrt{2gh}$$

$$= \sqrt{2 \times 9.8 \times 0.22}$$

$$= 2.07 \text{ m/s}$$

7.73)

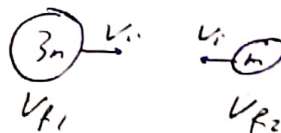
$$m_1 = m$$

$$m_2 = 3m$$

$$V_f = 2?$$

$$P_i = P_f$$

$$-m v_i + 3m v_i = 3m v_{f1} + m v_{f2}$$



$$2v_i = 3v_{f1} + v_{f2} \quad \text{--- (1)}$$

$$v_i - v_{i2} = -(v_{f1} - v_{f2})$$

$$v_i - -v_i = v_{f2} - v_{f1}$$

$$2v_i = v_{f2} - v_{f1} \quad \text{--- (2)}$$

from (1) and (2)

$$8v_i = 4v_{f2}$$

$$v_{f2} = 2v_i \quad \text{for the mass } m$$

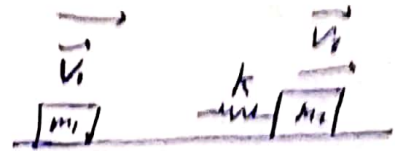
$$v_{f1} = 0 \quad \text{for the mass } 3m$$

(15)

75

9.75) in terms of V_1, V_2, m_1, m_2 and k

find a) the speed V at max. compression.
the same speed



$$P_i = P_f$$

$$m_1 V_1 + m_2 V_2 = (m_1 + m_2) V$$

$$V = \frac{m_1 V_1 + m_2 V_2}{m_1 + m_2}$$

b) X_{max} .

$$E_i = E_f$$

$$\frac{1}{2} m_1 V_1^2 + \frac{1}{2} m_2 V_2^2 = \frac{1}{2} (m_1 + m_2) V^2 + \frac{1}{2} k X^2$$

$$k X^2 = \frac{m_1 V_1^2 + m_2 V_2^2}{m_1 V_1 + m_2 V_2}$$

$$X = \sqrt{\frac{m_1 V_1^2 + m_2 V_2^2}{k(m_1 V_1 + m_2 V_2)}}$$

c) V_{1f} and V_{2f}

$$m_1 V_1 + m_2 V_2 = m_1 V_{1f} + m_2 V_{2f} \quad \text{--- (1)}$$

$$V_1 - V_2 = V_{2f} - V_{1f} \quad \text{--- (2)}$$

From (1) and (2)

$$V_{2f} = \frac{2m_1 V_1 + (m_2 - m_1) V_2}{m_1 + m_2}$$

$$V_{1f} = \frac{(m_1 - m_2) V_1 + 2m_2 V_2}{m_1 + m_2}$$

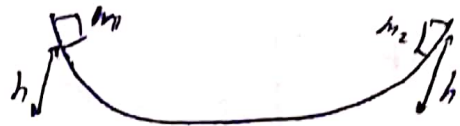
9.77)

$$m_1 = 2 \text{ kg}$$

$$m_2 = 4 \text{ kg}$$

$$h = 5 \text{ m}$$

y_{max} for m_1 and m_2



$$P_i = P_f$$

$$m_1 V_{1i} + m_2 V_{2i} = m_1 V_{1f} + m_2 V_{2f}$$

$$2 \times 9.9 + 4 \times (-9.9) = 2V_{1f} + 4V_{2f}$$

$$\boxed{-19.8 = 2V_{1f} + 4V_{2f}} \quad (1)$$

$$V_i = \sqrt{2gh}$$

$$= \sqrt{2 \times 9.8 \times 5}$$

$$\boxed{V_i = 9.9 \text{ m/s}}$$

$$V_{1i} - V_{2i} = -(V_{1f} - V_{2f})$$

$$9.9 - (-9.9) = V_{2f} - V_{1f}$$

$$\boxed{19.8 = V_{2f} - V_{1f}} \quad (2)$$

$$19.8 = +6V_{1f} = \cancel{V_{2f} = 9.9 \text{ m/s}}$$

$$\boxed{V_{2f} = 3.3 \text{ m/s}}$$

$$\boxed{V_{1f} = -16.5 \text{ m/s}}$$

y_{max} for m_1

$$h = \frac{V^2}{2g} = \frac{(-16.5)^2}{2 \times 9.8} = \boxed{13.89 \text{ m}}$$

y_{max} for m_2

$$h = \frac{V^2}{2g} = \frac{3.3^2}{2 \times 9.8} = \boxed{0.55 \text{ m}}$$

9.80)

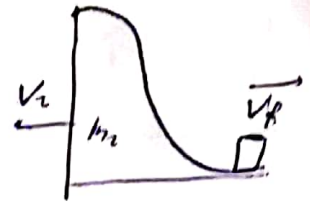
$$m_1 = 0.5 \text{ kg}$$

$$m_2 = 3 \text{ kg}$$

$$V_{1i} = 4 \text{ m/s}$$

$$a) V_{1f} = ?$$

$$b) h = ?$$



$$a) P_i = P_f$$

$$m_1 V_{1i} + m_2 V_{2i} = m_1 V_{1f} + m_2 V_{2f}$$

$$0 = 0.5 \times 4 + 3 V_{2f}$$

$$V_{2f} = -\frac{2}{3} \text{ m/s}$$

b) the high of the wedge

$$E_i = E_f$$

$$U + K_{1i} + K_{2i} = U_f + K_{1f} + K_{2f}$$

$$m_1 g h = \frac{1}{2} m_1 V_{1f}^2 + \frac{1}{2} m_2 V_{2f}^2$$

$$0.5 \times 9.8 h = \left(\frac{1}{2} \times 0.5 \times 4^2 \right) + \frac{1}{2} \times 3 \times \left(-\frac{2}{3} \right)^2$$

$$h = 0.952 \text{ m}$$

9.81)

$$m = 8g$$

$$M = 250g$$

$$h = 1m$$

$$d = 2m$$

$$V_i = ?$$

$$P_i = P_f$$

$$m V_i + (M \times 0) = (m + M) V_f$$

$$8 \times 10^{-3} V_i = (0.258) V_f$$

$$\text{but } d = V_f t$$

$$\text{and } h = \cancel{V_f t} - \frac{1}{2} g t^2$$

$$-h = -\frac{1}{2} \times 9.8 \times t^2$$

$$t = \sqrt{\frac{2h}{g}} = \sqrt{\frac{2 \times 1}{9.8}} = \boxed{0.455}$$

$$d = V_f t$$

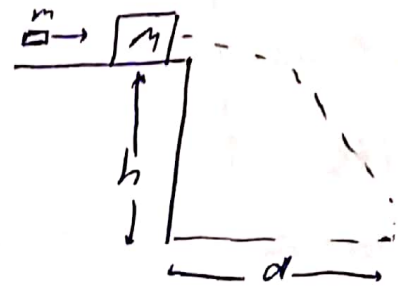
$$2 = V_f \times 0.455$$

$$\boxed{V_f = 4.42 \text{ m/s}}$$

So,

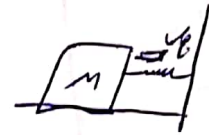
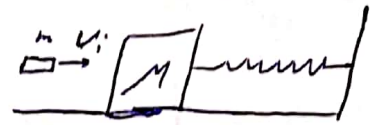
$$V_i = \frac{0.258 \times 4.42}{8 \times 10^{-3}}$$

$$\boxed{V_i = 142.77 \text{ m/s}}$$



9.87)

$$\left. \begin{aligned} m_p &= 5g \\ V_{pi} &= 400 \text{ m/s} \\ M &= 1 \text{ kg} \\ k &= 900 \text{ N/m} \\ d &= 5 \text{ cm} \end{aligned} \right\}$$



$$P_i = P_f$$

$$m_p V_p = m_p V_{pf} + M V_{mf}$$

$$\text{From } E_i = E_f$$

$$\frac{1}{2} m_p V_p^2 = \frac{1}{2} k x^2$$

$$V = \sqrt{\frac{k}{m}} x = \sqrt{\frac{900}{1}} \times 0.05 = 1.5 \text{ m/s}$$

So,

$$m_p V_p = m_p V_{pf} + M V$$

$$V_{pf} = \frac{m_p V_p - M V}{m_p}$$

$$= \frac{5 \times 10^{-3} \times 400 - 1 \times 1.5}{5 \times 10^{-3}} = 100 \text{ m/s}$$

b)

$$\Delta E_{int} = 2.1$$

$$E_i = E_f + \Delta E_{int}$$

$$\Delta E_{int} = E_i - E_f$$

$$= \frac{1}{2} m_p V_{pi}^2 - \frac{1}{2} M V^2 - \frac{1}{2} m_p V_{pf}^2$$

$$= \left(\frac{1}{2} \times 5 \times 10^{-3} \times 400^2 \right) - \left(\frac{1}{2} \times 1 \times 1.5^2 \right) - \left(\frac{1}{2} \times 5 \times 10^{-3} \times 100^2 \right)$$

$$= 374 \text{ J}$$

(18)