Chapter 5 The Laws of Motion

Conceptual Questions

Q5.7
A rubber ball is dropped onto the floor. What force causes the ball to bounce?

Q5.10 A weightlifter stands on a bathroom scale. He pumps a barbell up and down. What happens to the reading on the bathroom scale as this is done? What if he is strong enough to ctually throw the barbell upward? How does the reading on the scale vary now?

Q5.14 Identify the action-reaction pairs in the following situation: a man takes a step; a snowball hits a girl in the back; a baseball player catches a ball; a gust of wind strikes a window

Problems

3. A 3.00-kg object undergoes an acceleration given by $\mathbf{a} = (2.00\hat{\mathbf{i}} + 5.00\hat{\mathbf{j}})\ \text{m/s}^2$. Find the resultant force acting on it and the magnitude of the resultant force.

$\boxed{(6.00\hat{\mathbf{i}} + 15.0\hat{\mathbf{j}})\ \text{N}}$, $\boxed{16.2\ \text{N}}$

5. To model a spacecraft, a toy rocket engine is securely fastened to a large puck, which can glide with negligible friction over a horizontal surface, taken as the *xy* plane. The 4.00-kg puck has a velocity of $3.00\hat{\mathbf{i}}\ \text{m/s}$ at one instant. Eight seconds later, its velocity is to be $(8.00\hat{\mathbf{i}} + 10.0\hat{\mathbf{j}})\ \text{m/s}$. Assuming the rocket engine exerts a constant horizontal force, find (a) the components of the force and (b) its magnitude.

$\boxed{(2.50\hat{\mathbf{i}} + 5.00\hat{\mathbf{j}})\ \text{N}}$, $\boxed{5.59\ \text{N}}$

7. An electron of mass 9.11×10^{-31} kg has an initial speed of 3.00×10^5 m/s. It travels in a straight line, and its speed increases to 7.00×10^5 m/s in a distance of 5.00 cm. Assuming its acceleration is constant, (a) determine the force exerted on the electron and (b) compare this force with the weight of the electron, which we neglected.

(a) $\boxed{3.64 \times 10^{-18}\ \text{N}}$.

(b) $\boxed{4.08 \times 10^{11}\ \text{times the weight of the electron.}}$

11. Two forces $\mathbf{F}_1$ and $\mathbf{F}_2$ act on a 5.00-kg object. If F_1 = 20.0 N and F_2 = 15.0 N, find the accelerations in (a) and (b) of Figure P5.11.

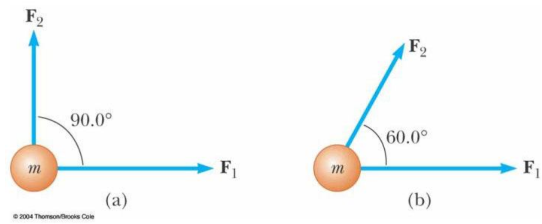


Figure P5.11

Solution

(a) $\boxed{a = 5.00\ \text{m/s}^2 \text{ at } \theta = 36.9°}$

(b) $\boxed{(5.50\hat{\mathbf{i}} + 2.60\hat{\mathbf{j}})\ \text{m/s}^2 = 6.08\ \text{m/s}^2 \text{ at } 25.3°}$

23. A 1.00-kg object is observed to accelerate at 10.0 m/s² in a direction 30.0° north of east (Fig. P5.23). The force $\mathbf{F}_2$ acting on the object has a magnitude of 5.00 N and is directed north. Determine the magnitude and direction of the force $\mathbf{F}_1$ acting on the object.

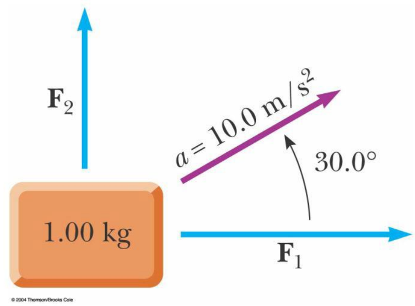


Figure P5.23

$\therefore F_1 = \boxed{8.66\ \text{N (East)}}$

25. A block is given an initial velocity of 5.00 m/s up a frictionless 20.0° incline (Fig. P5.22). How far up the incline does the block slide before coming to rest?

$\boxed{3.73\ \text{m}}$.

31. In the system shown in Figure P5.31, a horizontal force F_x acts on the 8.00-kg object. The horizontal surface is frictionless. (a) For what values of F_x does the 2.00-kg object accelerate upward? (b) For what values of F_x is the tension in the cord zero? (c) Plot the acceleration of the 8.00-kg object versus F_x. Include values of F_x from –100 N to +100 N.

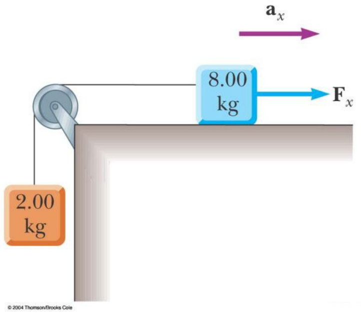


Figure P5.31

(a) $\boxed{19.6\ \text{N}}$
(b) $-78.4\ \text{N}$.

33. A 72.0-kg man stands on a spring scale in an elevator. Starting from rest, the elevator ascends, attaining its maximum speed of 1.20 m/s in 0.800 s. It travels with this constant speed for the next 5.00 s. The elevator then undergoes a uniform acceleration in the negative *y* direction for 1.50 s and comes to rest. What does the spring scale register (a) before the elevator starts to move? (b) during the first 0.800 s? (c) while the elevator is traveling at constant speed? (d) during the time it is slowing down?

(a) $S = \boxed{706\ \text{N}}$.(b) $S = \boxed{814\ \text{N}}$.
(c) $S = \boxed{706\ \text{N}}$.(d) $S = \boxed{648\ \text{N}}$.

41. A 3.00-kg block starts from rest at the top of a 30.0° incline and slides a distance of 2.00 m down the incline in 1.50 s. Find (a) the magnitude of the acceleration of the block, (b) the coefficient of kinetic friction between block and plane, (c) the friction force acting on the block, and (d) the speed of the block after it has slid 2.00 m.

(a) $\boxed{1.78\ \text{m/s}^2}$ (b) $\boxed{0.368}$
(c) $\boxed{9.37\ \text{N}}$ (d) $\boxed{2.67\ \text{m/s}}$

45. Two blocks connected by a rope of negligible mass are being dragged by a horizontal force **F** (Fig. P5.45). Suppose that $F = 68.0$ N, $m_1 = 12.0$ kg, $m_2 = 18.0$ kg, and the coefficient of kinetic friction between each block and the surface is 0.100. (a) Draw a free-body diagram for each block. (b) Determine the tension *T* and the magnitude of the acceleration of the system.

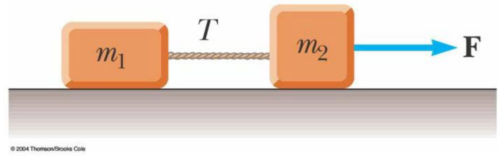
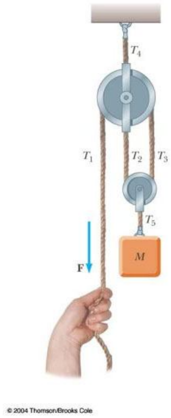


Figure P5.45

$\boxed{1.29\ \text{m/s}^2}$ $\boxed{27.2\ \text{N}}$

55. An object of mass *M* is held in place by an applied force **F** and a pulley system as shown in Figure P5.55. The pulleys are massless and frictionless. Find (a) the tension in each section of rope, T_1, T_2, T_3, T_4, and T_5 and (b) the magnitude of **F**. *Suggestion:* Draw a free-body diagram for each pulley.



(a) $\boxed{T_1 = T_2 = T_3 = \frac{Mg}{2}}$, $\boxed{T_4 = \frac{3Mg}{2}}$, $\boxed{T_5 = Mg}$.

(b) $\boxed{F = \frac{Mg}{2}}$.

61. What horizontal force must be applied to the cart shown in Figure P5.61 in order that the blocks remain stationary relative to the cart? Assume all surfaces, wheels, and pulley are frictionless. (*Hint:* Note that the force exerted by the string accelerates m_1.)

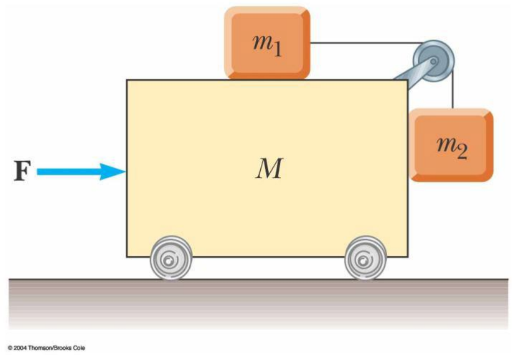


Figure P5.61

$\boxed{(M + m_1 + m_2)\left(\frac{m_2 g}{m_1}\right)}$