Understanding the Concepts

4.5. You are standing in an elevator that is at rest. The elevator starts moving up. In due course you reach your desired floor, and the elevator slows down and stops. Assume that you are standing on a scale during the whole trip. Describe and explain how the pointer on the scale will move from beginning to end.

4.17. Determining the mass of objects in space, where the motion is that of free fall, can be difficult. How do you think it can be done?

4.22. If you tie a rock to one end of a piece of string and swing it in a circle, you experience a force on your hand. Why?

4.38. In a tug of war, one side is stronger than the other. Assuming that both sides exert themselves to the maximum, discuss the motion of a handkerchief tied to the rope being pulled.

5.15 The speed of the boats (shells) used in scull racing is, to a good approximation, independent of the number of people rowing (provided that the number is larger than three or four). At first, this might appear strange: The more people there are, the larger the forward propelling force available to overcome the drag of the water. Can you explain this seeming contradiction?

5.27. Why is it hard to run when the ground is icy?

Solve yourself problems

4.22. (II) Electrons, mass about \(10^{-30}\) kg, are constituents of atoms and respond to electrical forces. Such forces, of varying strengths, can be generated in the laboratory. Suppose that a constant electrical force of \(5 \times 10^{-14} \text{ N}\) acts on an electron. What is the speed of the electron after \(10^{-10}\) s? After \(10^{-9}\) s?

4.25. (I) A falling automobile, mass 950 kg, has an acceleration of magnitude \(9.8 \text{ m/s}^2\) when only the force of gravity acts on it. What is the magnitude of the upward acceleration of Earth? Take the mass of Earth to be \(6.0 \times 10^{24}\) kg.

4.48. (II) A block of mass \(M\) sits on a rough horizontal surface. A rope inclined upward at an angle \(\theta\) with the horizontal exerts a force of magnitude \(T\) on the block. The block remains stationary. Draw a free-body diagram and express all the forces on the block in terms of \(M, g, \theta, \text{ and } T\).
4.68. (II) A boat is being pulled up the middle of a canal at a steady speed by two horses, one on each side of the canal (Fig. 4–40). The ropes tying the boat to the horses each make an angle of 30° with the lengthwise direction of the canal. (a) Draw a free-body diagram for the boat. Include the friction force due to the boat sliding through the water. (b) If the force exerted on each horse by its rope is 2000 N, what is the force of friction that the boat experiences due to the water?

4.77. (III) As shown in Fig. 4–42, a plumb bob suspended from a frame settles to a steady position as the frame slides down a frictionless inclined plane. What is the angle the plumb bob makes with the vertical during the slide?

5.13. (II) Two blocks of masses $M$ and $m$ are connected by a light rope that passes over a frictionless pulley. Mass $M$ sits on an inclined plane with an angle of inclination of $\theta = 30^\circ$ (Fig. 5–34). The coefficient of static friction between mass $M$ and the inclined plane is 0.20, while $m = 3.0 \, \text{kg}$. Determine the largest and smallest possible values of $M$ for which the system remains in equilibrium. Calculate the force of static friction on the block of mass $M$ if $M = 6.0 \, \text{kg}$.

**Hand-in Problems**

4.28. (II) A force of magnitude 8.0 N pushes on a horizontally stacked set of blocks on a frictionless surface (Fig. 4–32) with masses $m_1 = 2.0 \, \text{kg}$, $m_2 = 3.0 \, \text{kg}$, and $m_3 = 4.0 \, \text{kg}$. (a) What is the acceleration of the stack? (b) What are the forces on block 1 as well as the net force on this block? (c) Repeat part (b) for block 2. (d) Repeat part (b) for block 3.

4.46. (II) A rope spans a gap by being attached at two points on either side of the gap. The two points are at the same height, and the rope is attached in such a way that the tension in it is 50 N. (See Problem 20 for a discussion of tension.) (a) Can the rope be perfectly horizontal? You can assume here that the rope is so light that you can neglect any mass it has. (b) A mass of 2.0 kg is hung by another (light) rope tied to the gap-spanning rope at its midway point. Can the gap-spanning rope remain horizontal? (c) If your answer to part (a) is no, what is the angle the appropriate parts of the gap-spanning rope make with the horizontal?

4.49. (II) Consider a brick sliding down an inclined plane of 21°. Draw a free-body diagram for the brick that includes the gravity, friction, and normal forces. Choose a coordinate system and give the force components in equation form.

4.71. (II) A parachutist experiences two forces: One is the force of gravity, which is of the form $F_g = -mg \hat{j}$. Here, $m$ is the mass of the parachutist and $g$ is the acceleration due to gravity. The other force is a drag force, and, in contrast to Problem 70, it has the form $F_d = A v^2 \hat{j}$ in this problem, where the velocity of the parachutist is given by $-v \hat{j}$. (a) What are the dimensions (and units) of $A$? (b) Complete the equation $dv/dt = \ldots$. (c) At some point, the parachutist reaches a terminal velocity that is constant. What is it?
An Atwood machine consists of a massless string connecting two masses over a massless, frictionless pulley (Fig. 5–33). In this case, the masses are 1.70 and 1.65 kg. The system is released from rest with the 1.7-kg mass 2.15 m above the floor and the 1.65-kg mass on the floor. (a) What is the acceleration of the 1.7-kg mass? Of the 1.65-kg mass? (b) What is the speed of the 1.7-kg mass just before it hits the floor? (c) How long does it take the 1.7-kg mass to reach the floor?