(a) Find the acceleration of the cart. (b) If the car accelerates from rest to 0.3 m s^{-1}, for how long a time is the force applied?

3-42 A box weighing 100 N falls from an airplane. As its speed increases, the air resistance force opposing its motion also increases. How large is the acceleration when the air resistance is 100 N?

3-43 A force **F** acts on a brick of mass m and an acceleration **a** results. If the force is halved and applied to two such bricks, what is the new acceleration?

3-44 What acceleration is produced when a 100-N net force is applied to a 10-kg rock?

3-45 What net force is needed to give a 1000-kg car an acceleration of 3 m s^{-2}?

3-46 A baseball of mass 0.15 kg is struck by a bat with a force of 5000 N. What is the acceleration of the ball?

Section 3.8 | Some Examples of Newton's Laws

3-47 An elevator of mass 900 kg accelerates upward at 3 m s^{-2}. What is the tension in the cable where it is attached to the elevator?

3-48 A horse can exert a horizontal force of 3.5×10^4 N on a rope that passes over a pulley to lift loads vertically. What is the acceleration of a load of weight (a) 3.5×10^4 N; (b) 3×10^4 N? (Neglect the masses of the rope and pulley.)

3-49 An elevator cable that is light in weight compared to the elevator car can support a weight of 10,000 N. If the elevator and occupants weigh 8000 N, what is the maximum possible vertical acceleration of the elevator?

3-50 A 60-kg man hangs from a light cable suspended from a helicopter. Find the tension in the cable if the acceleration is (a) 5 m s^{-2} upward; (b) 5 m s^{-2} downward.

3-51 A human femur will fracture if the compressional force is 2×10^5 N. A person of mass 60 kg lands on one leg, so that there is a compressional force on the femur. (a) What acceleration will produce fracture? (b) How many times the acceleration of gravity is this?

3-52 A 55-kg woman wishes to slide down a stationary rope that will support a force of 400 N. What is the minimum acceleration of the woman if she safely slides down the rope?

3-53 An engine with a mass of 4×10^4 kg pulls a train with a mass of 2×10^5 kg on a level track with an acceleration of 0.5 m s^{-2}. What would the acceleration be if the train had a mass of 10^5 kg?

3-54 In a collision, an automobile of mass 1000 kg stops with constant acceleration in 2 m from an initial speed of 20 m s^{-1}. (a) What is the acceleration of the car? (b) What is the net force on the car during the collision?

3-55 A tennis ball of mass 0.058 kg initially at rest is served at a velocity of 45 m s^{-1}. If the racket is in contact with the ball for 0.004 s, what is the net force on the ball during the serve? (Assume the acceleration is constant.)

Section 3.9 | Gravitational Forces

3-56 The moon is 3.9×10^5 km from the center of the earth. The mass of the moon is 7.3×10^{22} kg, and the mass of the earth is 6.0×10^{24} kg. How far from the earth's center are the gravitational forces on an object due to the earth and moon equal and opposite? (Assume the object is on the line connecting the earth and moon.)

3-57 The mass of the sun is 2.0×10^{30} kg, and the distance from the moon to the sun is 1.5×10^8 km. Using the data of the preceding example, find the ratio of the forces exerted by the earth and the sun on the moon.

3-58 When a rocket ship is at a distance R_E from the surface of the earth, the earth's gravitational attraction on the ship is 144,000 N. What is the earth's gravitational attraction when the ship is at a distance $3R_E$ from the surface? (R_E is the radius of the earth.)

3-59 (a) Find the average density of the earth. (b) Using the data in Table 3.2, explain whether its density is consistent with models that state that the earth has a large iron core.

Section 3.10 | Weight

3-60 Would you prefer to have a piece of gold that weighs 1 N on the earth or one that weighs 1 N on the moon? Explain. (Ignore shipping charges!)

3-61 If the radius of the earth were halved and its mass stayed constant, how would your weight change?

3-81 How can the adjustable inclined plane in Fig. 3.21 be used to measure the coefficient of kinetic friction for an object on the plane?

PROBLEMS

3-82 A planet of radius R is made up of a core of radius $R/2$ and density ρ and an outer shell of density $\rho/2$ (Fig. 3.25). What is the average density of the planet as a whole?

3-83 A 1000-kg automobile is traveling at 15 m s^{-1} and skids to a stop with constant acceleration in 100 m. What is the frictional force on the car?

3-84 A 0.5-kg ball is initially at rest. If a 10-N force is applied for 2 s, what is the final velocity of the ball?

3-85 A hockey player who weighs 800 N comes to rest from 10 m s^{-1} in 1 s. (a) What is his mass? (b) What is his average acceleration? (c) What force is required to provide this acceleration?

3-86 A runner's foot strikes the ground with a velocity of 10 m s^{-1} downward. If the effective mass of the foot and leg that is brought to rest is 9 kg, what is the force on the foot as it comes to rest with constant acceleration in (a) 0.03 m on a soft surface; (b) 0.005 m on a hard surface?

3-87 A woman of mass 55 kg steps off a rock, striking the ground at 5 m s^{-1}. (a) If she lands on her feet with her body held rigid, she stops in 0.15 m. What average force is exerted upward on the woman during the impact? (b) If she flexes her legs and body during impact, she stops in 0.5 m. What average force does she now experience during impact?

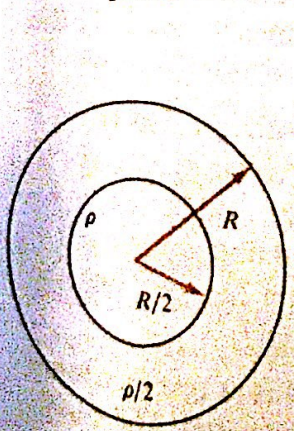

Figure 3.25. Problem 3-82.

3-88 A boy is fishing with a line that will sustain a maximum force of 40 N. If he hooks a 3-kg fish, which can exert a force of 60 N for several seconds, what is the minimum acceleration with which the line must be played out during that time interval?

3-89 A subway train has three cars, each weighing 1.2×10^5 N. The frictional force on each car is 10^3 N, and the first car, acting as an engine, exerts a horizontal force of 4.8×10^4 N on the rails. (a) What is the acceleration of the train? (b) What is the tension in the coupling between the first and second cars? (c) What is the tension between the second and third cars?

3-90 In Fig. 3.26, the string and the pulley are massless, and there is no friction. If $m_1 = m_2 = 5$ kg, find (a) the tension in the string; (b) the acceleration.

3-91 Repeat the preceding problem if the coefficient of kinetic friction between the block and the surface is 0.2.

3-92 In Fig. 3.26, the string and the pulley are massless, and there is no friction. If $m_1 = 10$ kg and $m_2 = 5$ kg, find (a) the tension in the string; (b) the acceleration.

3-93 In Fig. 3.26, the string and the pulley are massless; $m_1 = 10$ kg and $m_2 = 5$ kg. The system remains at rest. Find (a) the tension in the string; (b) the minimum value of the coefficient of static friction between the block and the surface.

3-94 A wagon weighing 5×10^3 N is pulled along a muddy, horizontal road by a 500-kg horse. The coefficient of friction between the wagon wheels and the road is 0.2. (a) If the wagon is pulled at constant speed, what force must the horse exert on the ground to pull the wagon?

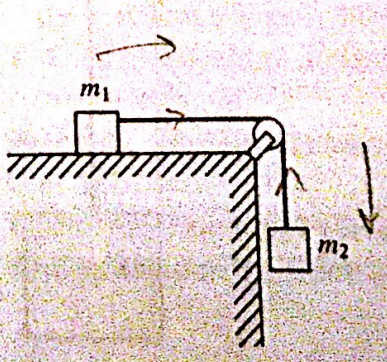

Figure 3.26. Problems 3-90, 3-91, 3-92 and 3-93

(b) If the wagon is accelerated from rest to a velocity of 5 m s^{-1} in 5 s, what force must the horse exert on the ground?

3-95 The radius of the planet Venus is 6.1×10^3 km and that of the earth is 6.4×10^3 km. The mass of Venus is 82 percent of the earth's mass. What is the acceleration of gravity on the surface of Venus?

3-96 Two lead spheres of radius 0.1 m are in contact. (a) What is the mass of each sphere? (b) What is the gravitational force between them?

3-97 Neutron stars with a density comparable to that of atomic nuclei, 10^{17} kg m^{-3}, are believed to exist. Suppose two spheres of radius 0.01 m of such a density were somehow placed 1 m apart on the earth. (a) What would be the weight of each sphere? (b) What would be the gravitational attraction between them?

3-98 A 60-kg man wishes to run on ice. The coefficient of static friction between his shoes and the ice is 0.1. What is his maximum possible acceleration?

3-99 A girl of mass 40 kg skis down a slope, which is at an angle of 37° with the horizontal. (Neglect air resistance.) If the coefficient of kinetic friction between her skis and the snow is 0.1, what is her acceleration?

3-100 In Fig. 3-27, the strings and pulleys are massless, and there is no friction. Find (a) the tensions in the strings; (b) the acceleration of the system.

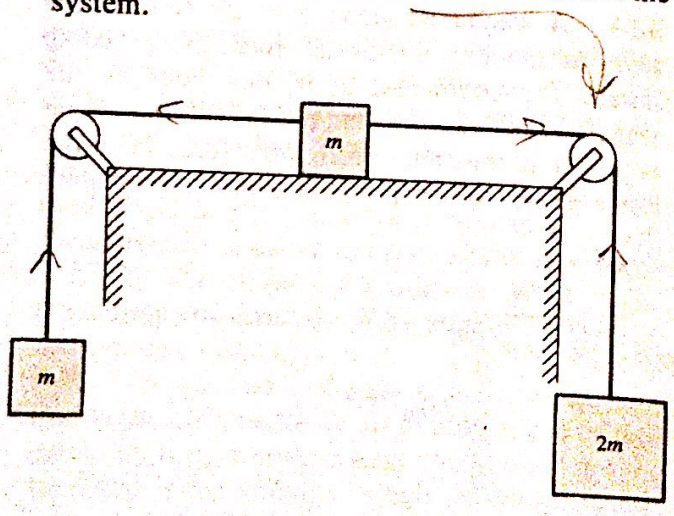

Figure 3.27. Problems 3-100 and 3-101.

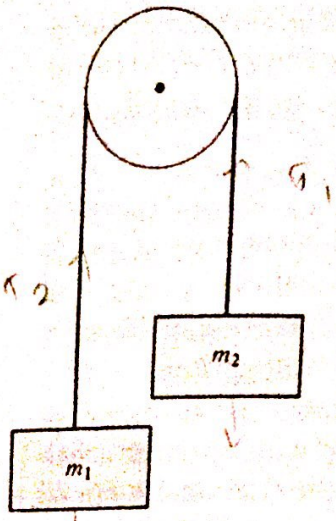

Figure 3.28. Problems 3-102 and 3-103.

3-101 Repeat the preceding problem if the coefficient of kinetic friction between the block on the surface and the surface is 0.1.

3-102 In Fig. 3-28 the string and pulley are massless, and there is no friction. Find (a) the tension in the string; (b) the acceleration.

3-103 In the preceding problem, $m_1 = 2$ kg and $m_2 = 3$ kg. Find (a) the tension in the string; (b) the acceleration. (c) If the system is released from rest, what are its velocity and position after 0.5 s?

***3-104** Two people wish to push a food freezer weighing 2000 N up a ramp inclined at an angle of 37° with the horizontal. The coefficient of sliding friction between the freezer and ramp is 0.5. (a) What minimum force must the people exert to slide the freezer up the ramp? (b) What acceleration will the freezer have if it is released and slides down the ramp? (c) If it slides 4 m down the ramp and strikes a heavy object, coming to rest in 0.5 m, what average force does it exert on the heavy object?

***3-105** A man can exert a force of 700 N on a rope attached to a sled. The rope is at an angle of 30° with the horizontal. If the coefficient of kinetic friction between the sled and ground is 0.4, what is the maximum load on the sled that the man can pull at constant speed?

***3-106** A box weighing 600 N is at rest on a ramp at an angle of 37° with the horizontal. The coefficient of static friction between the box and ramp

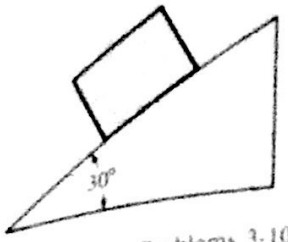

Figure 3.29. Problems 3-108 and 3-109.

is 0.8. Find the minimum force required to move the box down the ramp if the force is applied (a) parallel to the ramp; (b) horizontally.

*3-107 In a ski jump, the slope is initially at an angle of 45° to the horizontal. If the coefficient of kinetic friction between the skis and the snow is 0.1, find (a) a skier's acceleration; (b) the velocity reached after 40 m on the ramp.

3-108 If there is no friction, what is the acceleration of the block in Fig. 3.29?

3-109 If the coefficient of sliding friction is 0.2, what is the acceleration of the block in Fig. 3.29?

ANSWERS TO REVIEW QUESTIONS

Q3-1, contact forces; **Q3-2**, gravitational; **Q3-3**, gravitational acceleration; **Q3-4**, volume; **Q3-5**, water at 0° C; **Q3-6**, no net force; **Q3-7**, stable equilibrium; **Q3-8**, an equal but opposite (reaction) force; **Q3-9**, mass; **Q3-10**, $1/r^2$; **Q3-11**, inertial mass; **Q3-12**, mass, weight; **Q3-13**, free fall; **Q3-14**, contact area, normal force; **Q3-15**, start it moving; **Q3-16**, one, kinetic or sliding friction.

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