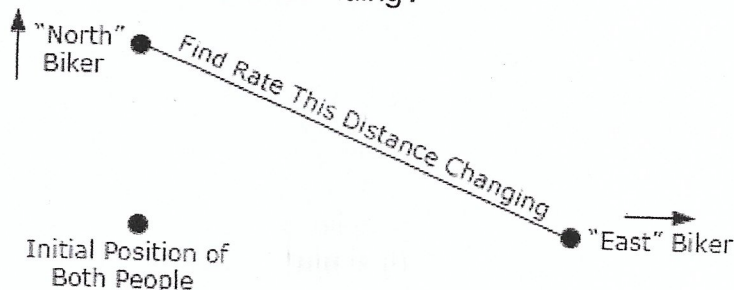
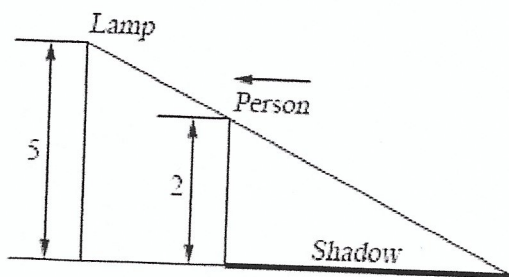


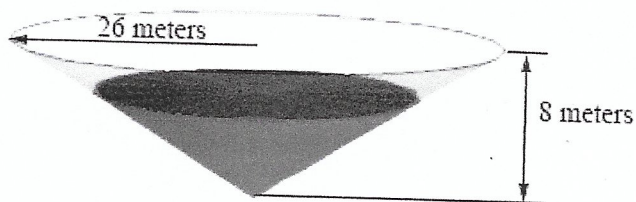
8. Two people on bikes are at the same place. One of the bikers starts riding directly north at a rate of 8 m/sec. Five seconds after the first biker started riding north the second starts to ride directly east at a rate of 5 m/sec. At what rate is the distance between the two riders increasing 20 seconds after the second person started riding?



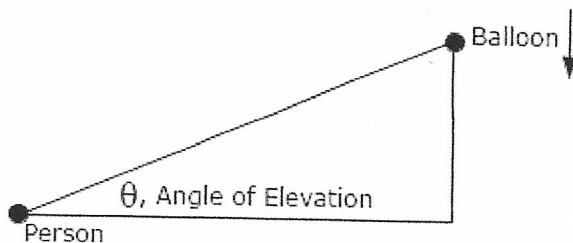
9. A light is mounted on a wall 5 meters above the ground. A 2 meter tall person is initially 10 meters from the wall and is moving towards the wall at a rate of 0.5 m/sec. After 4 seconds of moving is the tip of the shadow moving (a) towards or away from the person and (b) towards or away from the wall?



10. A tank of water in the shape of a cone is being filled with water at a rate of $12 \text{ m}^3/\text{sec}$. The base radius of the tank is 26 meters and the height of the tank is 8 meters. At what rate is the depth of the water in the tank changing when the radius of the top of the water is 10 meters? Note the image below is not completely to scale....



11. The angle of elevation is the angle formed by a horizontal line and a line joining the observer's eye to an object above the horizontal line. A person is 500 feet away from the launch point of a hot air balloon. The hot air balloon is starting to come back down at a rate of 15 ft/sec. At what rate is the angle of elevation, θ , changing when the hot air balloon is 200 feet above the ground. See the (probably bad) sketch below to help visualize the angle of elevation if you are having trouble seeing it.



► EXERCISE SET 3.3

- A metal sphere is heated so that its radius increases at the rate of 1 mm/sec. How fast is its volume changing when its radius is 30 mm?
- The radius of a circle is increasing at the rate of 3 cm/sec. At what rate is the area of the circle increasing when the radius is 20 cm?
- The sides of a square are increasing at the rate of 2 in./min. At what rate is the area of the square increasing when the sides are 4 in.?
- The length of a rectangle is three times its width and the length is increasing at the rate of 9 in./sec. How fast is the area of the rectangle changing?
- The edges of a cube are increasing at the rate of 2 in./min. At what rate is the volume of the cube increasing when the edges are 4 in.?
- Reconsider the cube described in Exercise 5. At what rate is the total surface area of the cube increasing when the edges are 4 in.?
- The sides of an equilateral triangle are increasing at the rate of 1 cm/sec. At what rate is the area of the triangle increasing when the sides are 4 cm?
- The two equal sides of an isosceles triangle are increasing at the rate of 1 cm/sec while the third side is held at 4 cm. At what rate is the area of the triangle increasing when the sides are all 4 cm?
- A stone is dropped into a pool of still water from a height of 150 ft. Circular ripples radiate at the rate of 3 in./sec from the spot where the stone hits the water.
 - What is the area of the disturbed water 4 sec after the stone hits?
 - How fast is the area changing at this time?
- A certain yeast culture grows in a circular colony. As it grows the surface area it covers is directly proportional to its population and contains 10^5 members when the area is 1 cm². How fast is the population increasing when the radius of the circle is 12 cm if the radius of the circle is increasing at the rate of 3 cm/hr?
- Gas is pumped into a spherical balloon at the rate of 1 ft³/min. How fast is the diameter of the balloon increasing when the balloon contains 36 ft³ of gas?
- Flour sifted onto waxed paper forms a conical pile whose radius and height are always equal, although both increase with time (see the figure). The volume of flour on the waxed paper is increasing at the rate of 7.26 in³/sec. How fast is the height of the flour increasing when the volume is 29 in³?
- Find the rate of change of the area of a circle with respect to its radius. Compare this with the circumference of the circle.
- Find the rate of change of the volume of a sphere with respect to its radius. Compare this with the surface area of a sphere.
- Work the problem in Example 5 by first expressing the distance z between the ships explicitly as a function of t .
- A 15-ft ladder is leaning against a wall, and its base is pushed toward the wall at the rate of 2 ft/sec. How fast is the top of the ladder moving up the wall when the top is 9 ft from the ground?
- An 8-ft 2×4 is leaning against a 10-ft wall. The lower end of the 2×4 is pulled away from the wall at the rate of 1 ft/sec. How fast is the top of the 2×4 moving toward the ground (a) when it is 5 ft from the ground and (b) when it is 4 ft from the ground?
- An 8-ft 2×4 is leaning against a 5-ft wall with the remainder of the 2×4 hanging over the wall. The lower end of the 2×4 is pulled away from the wall at a rate of 1 ft/sec. How fast is the top of the 2×4 moving toward the ground when this end is 5 ft from the ground, that is, when the upper end just reaches the wall?
- A rectangular swimming pool 50 ft long and 30 ft wide is being filled with water to a depth of 8 ft at the rate of 3 ft³/min.
 - How long does it take to fill the pool?
 - At what rate is the depth of water in the pool increasing when the pool is half full of water?

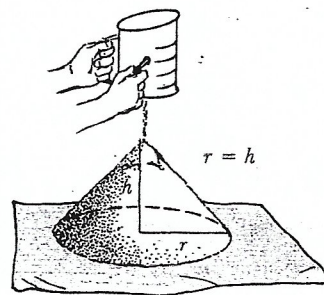
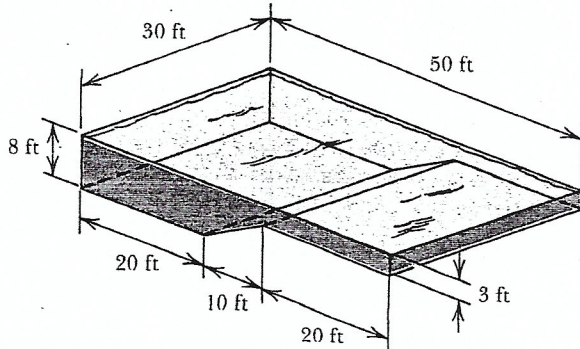
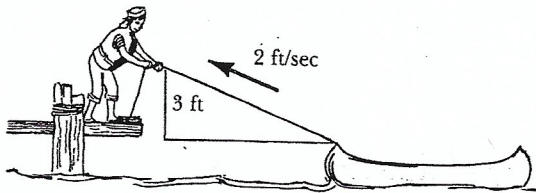


Figure for Exercise 12.

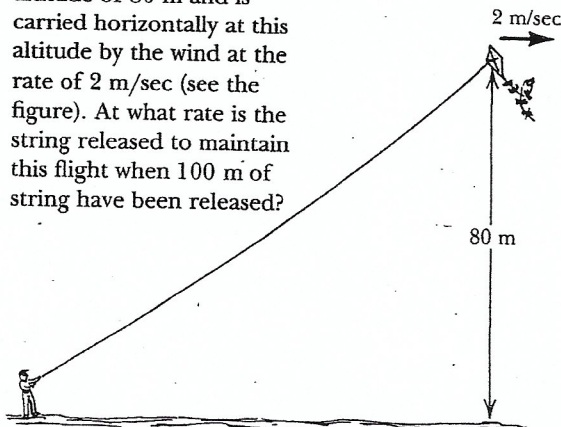
20. A rectangular swimming pool 50 ft long and 30 ft wide has a depth of 8 ft for the first 20 ft of its length and a depth of 3 ft on the last 20 ft of its length, and tapers linearly for the 10 ft in the middle of its length (see the figure). The pool is being filled with water at the rate of $3 \text{ ft}^3/\text{min}$.
- How long does it take to fill the pool?
 - At what rate is the depth of water in the pool increasing when the pool is half full of water?



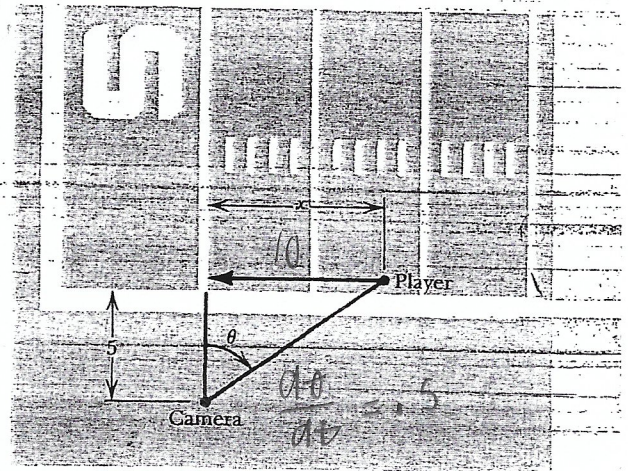
21. A woman on a dock is using a rope to pull in a canoe. The rope is pulled at the rate of 2 ft/sec , 3 ft above the point level with the connection of the rope to the canoe (see the figure). How fast is the canoe approaching the dock when the length of rope from her hands to the canoe is 10 ft?



22. A kite is flying at an altitude of 80 m and is carried horizontally at this altitude by the wind at the rate of 2 m/sec (see the figure). At what rate is the string released to maintain this flight when 100 m of string have been released?



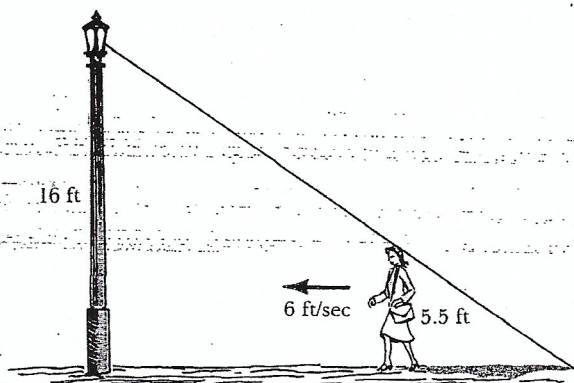
23. A kite is carried horizontally at the rate of 1.5 m/sec and is rising at 2.0 m/sec . How fast is the string released to maintain this flight when 100 m of string have been released and the kite is at an altitude of 80 m?
24. A single-engine airplane passes over a beacon and heads east at the rate of 100 mph. Two hours later a jet passes over the beacon at the same altitude traveling north at 400 mph. Assuming that the planes stay on these courses, how fast are they separating 1 hr after the jet has passed over the beacon?
25. Two ships meet at a point in the ocean with one of the ships traveling south at the rate of 15 mph and the other traveling west at 20 mph. At what rate are the ships separating 2 hr after they meet?
26. Two cars approach an intersection at right angles. One car is traveling at the rate of 50 mph and the other is traveling 40 mph. How fast are the cars approaching each other when the first car is 30 ft from the intersection and the second is 40 ft from the intersection?
27. A fisherman sitting on the end of a pier with his pole 3 m above the water snags what he assumes to be a large fish and reels in his line at the steady rate of 1 m/sec . He does not realize that the object is actually an old log lying just below the surface until the log is 5 m from the end of the rod. How fast is the log approaching the pier at this time?
28. A camera televising the return of the opening kickoff of a football game is located 5 yd from the east edge of the field and in line with the goal line. The player with the football runs down the east edge (just in bounds) for a touchdown. When he is 10 yd from the goal line, the camera is turning at a rate of 0.5 radian/sec . How fast is the player running?



29. A revolving beacon located 1 mi from a straight shoreline turns at 1 revolution per minute. Find the speed of the spot of light along the shore when it is 2 mi away from the point on the shore nearest the light.

30. A metal cylinder contracts as it cools, the height of the cylinder decreasing at 4.5×10^{-4} cm/sec and the radius decreasing at 3.75×10^{-5} cm/sec. At what rate is the volume of the cylinder decreasing when its height is 200 cm and its radius is 10 cm?

31. A woman 5 ft 6 in. tall walks at the rate of 6 ft/sec toward a street light that is 16 ft above the ground.
 a) At what rate is the tip of her shadow moving?
 b) At what rate is the length of her shadow changing when she is 10 ft from the base of the light?



32. Suppose Farmer MacDonald constructs a hog trough to maximize capacity in the manner described in Example 7 of Section 3.2. If the hogs continuously consume the slop at the rate of 1.2 ft^3 per hour, how fast is the height of the slop decreasing when the height of the slop in the trough is 6 in.?

33. A horse trough 10 ft long has a cross section in the shape of an inverted equilateral triangle with an altitude of 2 ft. The trough leaks water through a crack in the bottom at the rate of 1 ft^3 /hour.

- At what rate is the height of the water in the trough decreasing when the depth of the water is 1 ft?
- At what rate is the height of the water in the trough decreasing when the trough contains 10 ft^3 of water?

34. A picture with height 3 ft is placed on a wall with its base 3 ft above an observer's eye level. The observer approaches the wall at the rate of 1 ft/sec. How fast is the angle θ , shown in the figure, changing when the observer is 10 ft from the wall?

35. An object that weighs w_0 lb on the surface of the earth weighs approximately

$$w(r) = w_0 \left(\frac{3960}{3960 + r} \right)^2 \text{ lb}$$

when lifted a distance of r mi from the earth's surface. Find the rate at which the weight of an object weighing 2000 lb on the earth's surface is changing when it is 100 mi above the earth's surface and is being lifted at the rate of 10 mi/sec.

36. The owner of a dog kennel reads in *Dog's Life* that the surface area of a dog is approximately related to its weight by the equation

$$s = 0.1w^{2/3},$$

where the weight w of the dog is measured in kilograms and the surface area s of the dog is measured in square meters. The amount of flea powder the owner must purchase is directly proportional to the surface area of the dogs. If the average pup in the kennel gains weight at the approximate rate of 0.8 kg/wk, at what rate is the purchase of powder increasing when there are 23 dogs, the average dog weighs 20 kg, and a can of powder covers 3 m^2 ?

37. Oil is leaking from an ocean tanker at the rate of 5000 L/sec. The leakage results in a circular oil slick with a depth of 5 cm. (Note: 1 liter = 1000 cm^3 .)

- How fast is the radius of the oil slick increasing when the radius is 300 m?
- How fast is the radius of the oil slick increasing 4 hr after the leakage has begun?

38. In actual practice an oil slick like the one described in Exercise 37 does not have a constant depth; the depth of the slick decreases as the oil moves from the point of spillage and depends primarily on the turbulence of the water and the viscosity of the oil. Suppose the

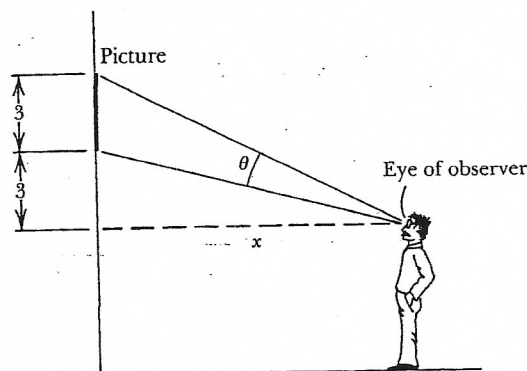


Figure for Exercise 34.