

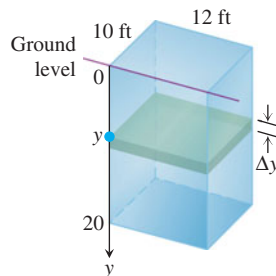
- 6. Bathroom scale** A bathroom scale is compressed $1/16$ in. when a 150-lb person stands on it. Assuming that the scale behaves like a spring that obeys Hooke's Law, how much does someone who compresses the scale $1/8$ in. weigh? How much work is done compressing the scale $1/8$ in.?

Work Done by a Variable Force

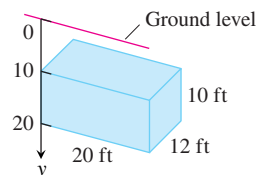
- 7. Lifting a rope** A mountain climber is about to haul up a 50-m length of hanging rope. How much work will it take if the rope weighs 0.624 N/m?
- 8. Leaky sandbag** A bag of sand originally weighing 144 lb was lifted at a constant rate. As it rose, sand also leaked out at a constant rate. The sand was half gone by the time the bag had been lifted to 18 ft. How much work was done lifting the sand this far? (Neglect the weight of the bag and lifting equipment.)
- 9. Lifting an elevator cable** An electric elevator with a motor at the top has a multistrand cable weighing 4.5 lb/ft. When the car is at the first floor, 180 ft of cable are paid out, and effectively 0 ft are out when the car is at the top floor. How much work does the motor do just lifting the cable when it takes the car from the first floor to the top?
- 10. Force of attraction** When a particle of mass m is at $(x, 0)$, it is attracted toward the origin with a force whose magnitude is k/x^2 . If the particle starts from rest at $x = b$ and is acted on by no other forces, find the work done on it by the time it reaches $x = a$, $0 < a < b$.
- 11. Leaky bucket** Assume the bucket in Example 4 is leaking. It starts with 2 gal of water (16 lb) and leaks at a constant rate. It finishes draining just as it reaches the top. How much work was spent lifting the water alone? (*Hint:* Do not include the rope and bucket, and find the proportion of water left at elevation x ft.)
- 12. (Continuation of Exercise 11.)** The workers in Example 4 and Exercise 11 changed to a larger bucket that held 5 gal (40 lb) of water, but the new bucket had an even larger leak so that it, too, was empty by the time it reached the top. Assuming that the water leaked out at a steady rate, how much work was done lifting the water alone? (Do not include the rope and bucket.)

Pumping Liquids from Containers

- 13. Pumping water** The rectangular tank shown here, with its top at ground level, is used to catch runoff water. Assume that the water weighs 62.4 lb/ft³.
- How much work does it take to empty the tank by pumping the water back to ground level once the tank is full?
 - If the water is pumped to ground level with a $(5/11)$ -horsepower (hp) motor (work output 250 ft-lb/sec), how long will it take to empty the full tank (to the nearest minute)?
 - Show that the pump in part (b) will lower the water level 10 ft (halfway) during the first 25 min of pumping.
- d. The weight of water** What are the answers to parts (a) and (b) in a location where water weighs 62.26 lb/ft³?



- 14. Emptying a cistern** The rectangular cistern (storage tank for rainwater) shown has its top 10 ft below ground level. The cistern, currently full, is to be emptied for inspection by pumping its contents to ground level.
- How much work will it take to empty the cistern?
 - How long will it take a $1/2$ -hp pump, rated at 275 ft-lb/sec, to pump the tank dry?
 - How long will it take the pump in part (b) to empty the tank halfway? (It will be less than half the time required to empty the tank completely.)
- d. The weight of water** What are the answers to parts (a) through (c) in a location where water weighs 62.26 lb/ft³?



- 15. Pumping oil** How much work would it take to pump oil from the tank in Example 5 to the level of the top of the tank if the tank were completely full?
- 16. Pumping a half-full tank** Suppose that, instead of being full, the tank in Example 5 is only half full. How much work does it take to pump the remaining oil to a level 4 ft above the top of the tank?
- 17. Emptying a tank** A vertical right-circular cylindrical tank measures 30 ft high and 20 ft in diameter. It is full of kerosene weighing 51.2 lb/ft³. How much work does it take to pump the kerosene to the level of the top of the tank?
- 18. a. Pumping milk** Suppose that the conical container in Example 5 contains milk (weighing 64.5 lb/ft³) instead of olive oil. How much work will it take to pump the contents to the rim?
- b. Pumping oil** How much work will it take to pump the oil in Example 5 to a level 3 ft above the cone's rim?
- 19.** The graph of $y = x^2$ on $0 \leq x \leq 2$ is revolved about the y -axis to form a tank that is then filled with salt water from the Dead Sea (weighing approximately 73 lb/ft³). How much work does it take to pump all of the water to the top of the tank?
- 20.** A right-circular cylindrical tank of height 10 ft and radius 5 ft is lying horizontally and is full of diesel fuel weighing 53 lb/ft³. How much work is required to pump all of the fuel to a point 15 ft above the top of the tank?