



- 4) A spherical balloon is inflated so that its radius ( $r$ ) increases at a rate of  $\frac{2}{r}$  cm/sec. How fast is the volume of the balloon increasing when the radius is 4 cm?
- 5) A 7 ft tall person is walking away from a 20 ft tall lamppost at a rate of 5 ft/sec. Assume the scenario can be modeled with right triangles. At what rate is the length of the person's shadow changing when the person is 16 ft from the lamppost?
- 6) An observer stands 700 ft away from a launch pad to observe a rocket launch. The rocket blasts off and maintains a velocity of 900 ft/sec. Assume the scenario can be modeled as a right triangle. How fast is the observer to rocket distance changing when the rocket is 2400 ft from the ground?

## Related Rates

**Solve each related rate problem.**

- 1) Water leaking onto a floor forms a circular pool. The radius of the pool increases at a rate of 4 cm/min. How fast is the area of the pool increasing when the radius is 5 cm?

$A$  = area of circle    $r$  = radius    $t$  = time

Equation:  $A = \pi r^2$    Given rate:  $\frac{dr}{dt} = 4$    Find:  $\frac{dA}{dt} \Big|_{r=5}$

$$\frac{dA}{dt} \Big|_{r=5} = 2\pi r \cdot \frac{dr}{dt} = 40\pi \text{ cm}^2/\text{min}$$

- 2) Oil spilling from a ruptured tanker spreads in a circle on the surface of the ocean. The area of the spill increases at a rate of  $9\pi$  m<sup>2</sup>/min. How fast is the radius of the spill increasing when the radius is 10 m?

$A$  = area of circle    $r$  = radius    $t$  = time

Equation:  $A = \pi r^2$    Given rate:  $\frac{dA}{dt} = 9\pi$    Find:  $\frac{dr}{dt} \Big|_{r=10}$

$$\frac{dr}{dt} \Big|_{r=10} = \frac{1}{2\pi r} \cdot \frac{dA}{dt} = \frac{9}{20} \text{ m/min}$$

- 3) A conical paper cup is 10 cm tall with a radius of 10 cm. The cup is being filled with water so that the water level rises at a rate of 2 cm/sec. At what rate is water being poured into the cup when the water level is 8 cm?

$V$  = volume of material in cone    $h$  = height    $t$  = time

Equation:  $V = \frac{\pi h^3}{3}$    Given rate:  $\frac{dh}{dt} = 2$    Find:  $\frac{dV}{dt} \Big|_{h=8}$

$$\frac{dV}{dt} \Big|_{h=8} = \pi h^2 \cdot \frac{dh}{dt} = 128\pi \text{ cm}^3/\text{sec}$$

- 4) A spherical balloon is inflated so that its radius ( $r$ ) increases at a rate of  $\frac{2}{r}$  cm/sec. How fast is the volume of the balloon increasing when the radius is 4 cm?

$V$  = volume of sphere    $r$  = radius    $t$  = time

Equation:  $V = \frac{4}{3}\pi r^3$    Given rate:  $\frac{dr}{dt} = \frac{2}{r}$    Find:  $\left. \frac{dV}{dt} \right|_{r=4}$

$$\left. \frac{dV}{dt} \right|_{r=4} = 4\pi r^2 \cdot \frac{dr}{dt} = 32\pi \text{ cm}^3/\text{sec}$$

- 5) A 7 ft tall person is walking away from a 20 ft tall lamppost at a rate of 5 ft/sec. Assume the scenario can be modeled with right triangles. At what rate is the length of the person's shadow changing when the person is 16 ft from the lamppost?

$x$  = distance from person to lamppost    $y$  = length of shadow    $t$  = time

Equation:  $\frac{x+y}{20} = \frac{y}{7}$    Given rate:  $\frac{dx}{dt} = 5$    Find:  $\left. \frac{dy}{dt} \right|_{x=16}$

$$\left. \frac{dy}{dt} \right|_{x=16} = \frac{7}{13} \cdot \frac{dx}{dt} = \frac{35}{13} \text{ ft/sec}$$

- 6) An observer stands 700 ft away from a launch pad to observe a rocket launch. The rocket blasts off and maintains a velocity of 900 ft/sec. Assume the scenario can be modeled as a right triangle. How fast is the observer to rocket distance changing when the rocket is 2400 ft from the ground?

$a$  = altitude of rocket    $z$  = distance from observer to rocket    $t$  = time

Equation:  $a^2 + 490000 = z^2$    Given rate:  $\frac{da}{dt} = 900$    Find:  $\left. \frac{dz}{dt} \right|_{a=2400}$

$$\left. \frac{dz}{dt} \right|_{a=2400} = \frac{a}{z} \cdot \frac{da}{dt} = 864 \text{ ft/sec}$$