Steps for solving a related rates problem:

1. Read and understand the problem (understand the story)
2. Draw a picture.
   - What is changing in the picture and what is constant?
3. List the information given (write information in “math”, not English).
   - What rates have you been given and what rates do you need to find?
4. Find an equation relating the quantities.
5. \( \frac{d}{dt} \)
   - Use the chain rule!
6. Solve for the rate you want to find.
7. Plug in.

**Warm-up Problems**

**Lecture Problems**

1. Air is being pumped into a spherical balloon at a rate of 20 in\(^3\)/min. How fast is the radius of the balloon increasing when the radius is 6 inches?

   **Solution:** \( \frac{5}{36\pi} \) inches per minute.

2. A 25 foot ladder is leaning against a vertical wall. The bottom of the ladder slips away from the wall at a rate of 0.2 inches per second. How fast is the top of the ladding sliding down the wall when the top is 20 feet above the floor?

   **Solution:** \(-\frac{3}{20}\) inches per second

3. A conical water tank with vertex pointed down, has radius of 10 feet at the top and is 24 feet high. The tank starts full and water flows out at a rate of 20 cubic feet per minute. How fast is the depth of the water decreasing when the water is 16 feet deep.

   (Volume of a cone is \( V = \frac{1}{3} \pi r^2 h \))

   **Solution:** \(-\frac{9}{20\pi}\) feet per minute

4. Ship A is 32 miles north of ship B. Ship A is sailing due south at 16 miles per hour. Ship B is sailing due east at 12 miles per hour. At what rate is the distance between them changing at the end of 1 hour?

   **Solution:** \(-\frac{224}{40}\) mph

5. Two sides of a triangle have lengths 12 meters and 15 meters. The angle between them is increasing at a rate of 2 degrees per minute. How fast is the area of the triangle changing when the angle between the sides of fixed length is 60°.

   **Solution:** \( 90 \cdot (\cos(60°)) \cdot (0.035) \approx 1.575 \) square meters per minute.
6. Sand is falling from a chute and forms a conical pile of sand whose height is always equal to $4/3$ the radius of the base. The radius of the base is increasing at a rate of 3 inches per minute. How fast is the volume of the pile changing when the radius of the base is 3 feet?

**Solution:** $3\pi$ cubic feet per minute

7. A lighthouse is located on a small island 3 km away from the nearest point P on a straight shoreline. If the lighthouse beacon rotates at a constant rate of 4 revolutions per minute, how fast is the beam of light moving along the shoreline when it is 1 km from the nearest point P?

**Solution:** $80\pi/3$