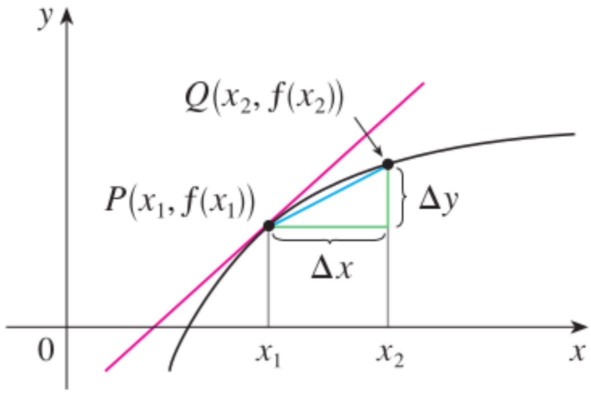
Chapter 2
Derivatives
2.7 Rates of Change.

Average rate of change.



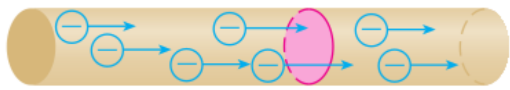
Instantaneous Rate of Change.

Physics.

Velocity and Acceleration.

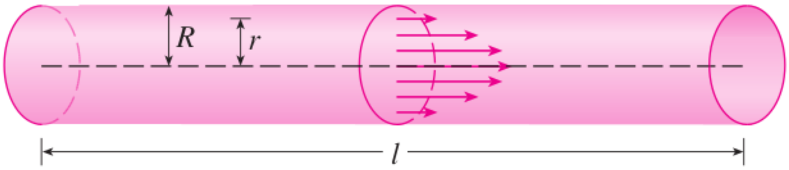
Linear density in a rod.

Current.



Many more examples:
- Heat flow - Rate of Decay of a nuclear substance - Power (rate at which work is done) - Temperature gradient
- Wind chart

EXAMPLE 7 When we consider the flow of blood through a blood vessel, such as a vein or artery, we can model the shape of the blood vessel by a cylindrical tube with radius R and length l as illustrated in Figure 8.



Because of friction at the walls of the tube, the velocity v of the blood is greatest along the central axis of the tube. The velocity decreases as the distance r from the axis increases, until v becomes 0 at the wall. The relationship between v and r is given by the **law of laminar flow** discovered by the French physician Jean-Louis-Marie Poiseuille in 1840. This law states that

$$v = \frac{P}{4\eta l}(R^2 - r^2) \qquad \boxed{1}$$

where η is the viscosity of the blood and P is the pressure difference between the ends of the tube. If P and l are constant, then v is a function of r with domain $[0, R]$.

Velocity Gradient (instanteneous rate of change of the speed of the blood):

For more detailed information, see W. Nichols and M. O'Rourke (eds.), *McDonald's Blood Flow in Arteries: Theoretical, Experimental, and Clinical Principles*, 5th ed. (New York, 2005).