

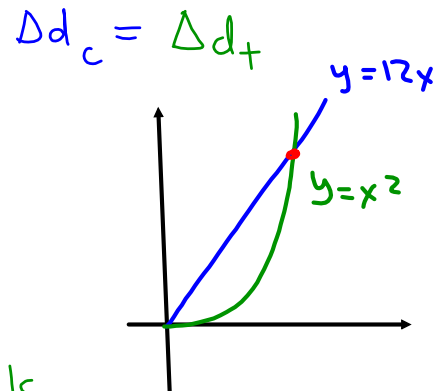
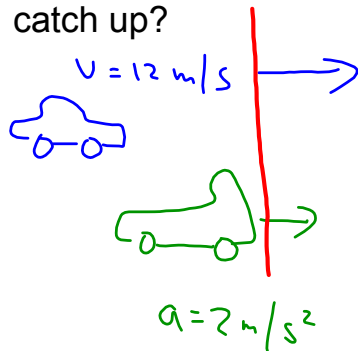
Advanced Kinematics Problems

Goal:

- to be able to solve advanced kinematics problems that may involve more than one object

A car moving at 12 m/s passes a stationary truck. At that instant the truck accelerates at 2 m/s².

If the truck maintains this acceleration, how long will it take to catch up?



Car

$$v = 12 \text{ m/s}$$

$$v = \frac{\Delta d}{\Delta t}$$

$$v \Delta t = \Delta d$$

$$12 \Delta t = \Delta d_c$$

Truck

$$a = 2 \text{ m/s}^2$$

$$v_i = 0$$

$$\Delta d = v_i \Delta t + \frac{1}{2} a (\Delta t)^2$$

$$\Delta d = 0 + \frac{1}{2} (2) \Delta t^2$$

$$\Delta d_t = \Delta t^2$$

$$\Delta d_c = \Delta d_t$$

$$12 \Delta t = \Delta t^2$$

$$0 = \Delta t^2 - 12 \Delta t$$

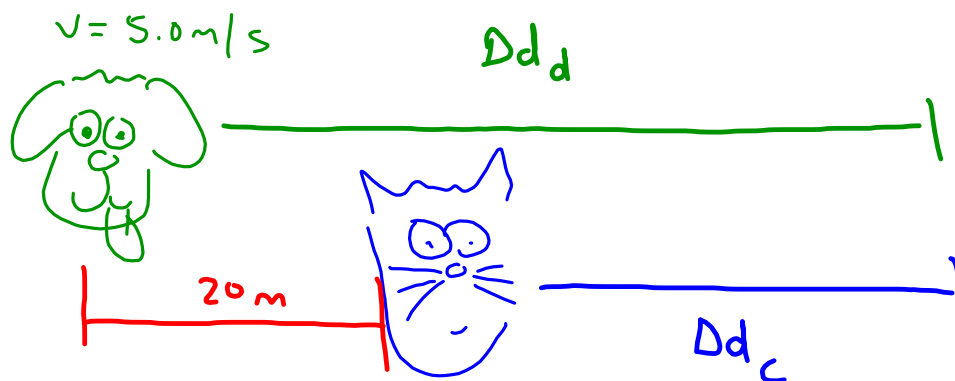
$$0 = \Delta t (\Delta t - 12)$$

$$\Delta t = 0$$

$$\Delta t - 12 = 0$$

$$\underline{\Delta t = 12} \quad \checkmark$$

A dog is running at 5.0 m/s and a cat is running at 3.0 m/s. If the cat has a 20.0 m headstart, how long will it take the dog to catch the cat?



Dog

$$v = 5.0 \text{ m/s}$$

$$v = \frac{\Delta d}{\Delta t}$$

$$\Delta d_d = 5 \Delta t$$

Cat

$$v = 3.0 \text{ m/s}$$

$$v = \frac{\Delta d}{\Delta t}$$

$$\Delta d_c = 3 \Delta t$$

$$\Delta d_c + 20 = \Delta d_d$$

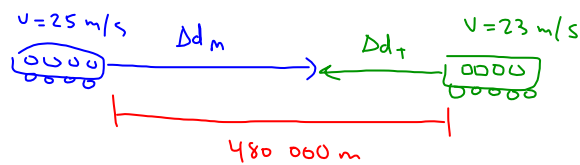
$$3 \Delta t + 20 = 5 \Delta t$$

$$20 = 2 \Delta t$$

$$\Delta t = 10 \text{ s}$$

An electric train leaves Montreal heading towards Toronto with an average velocity of 25 m/s. One hour later, another train leaves Toronto heading to Montreal traveling at 23 m/s. The track connecting Montreal and Toronto is 480 km.

How far has each train traveled when they pass each other?



$$\begin{array}{l} \text{Montreal} \\ v = 25 \text{ m/s} \\ \Delta t = x \end{array}$$

$$v = \frac{\Delta d}{\Delta t}$$

$$\Delta d = 25x$$

Toronto

$$v = 23 \text{ m/s}$$

$$\Delta t = x - \underline{\underline{1 \text{ h}}}$$

$$= x - 3600$$

$$v = \frac{\Delta d}{\Delta t}$$

$$23 = \frac{\Delta d}{x - 3600}$$

$$\Delta d = 23(x - 3600)$$

$$\Delta d_M + \Delta d_T = 480\,000$$

$$25x + 23(x - 3600) = 480\,000$$

$$25x + 23x - 82\,800 = 480\,000$$

$$48x = 562\,800$$

$$\underline{x = 11\,725} \quad \text{montreal train time}$$

$$\Delta d_M = 25x = 293\,125 \text{ m}$$

$$\Delta d_T = 23(x - 3600)$$

$$= 23(11\,725 - 3600) = 186\,875 \text{ m}$$

b) If the wind is traveling at 10 m/s towards Montreal, how fast does the smoke from the train travel?