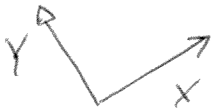
General Problem Solving Guide

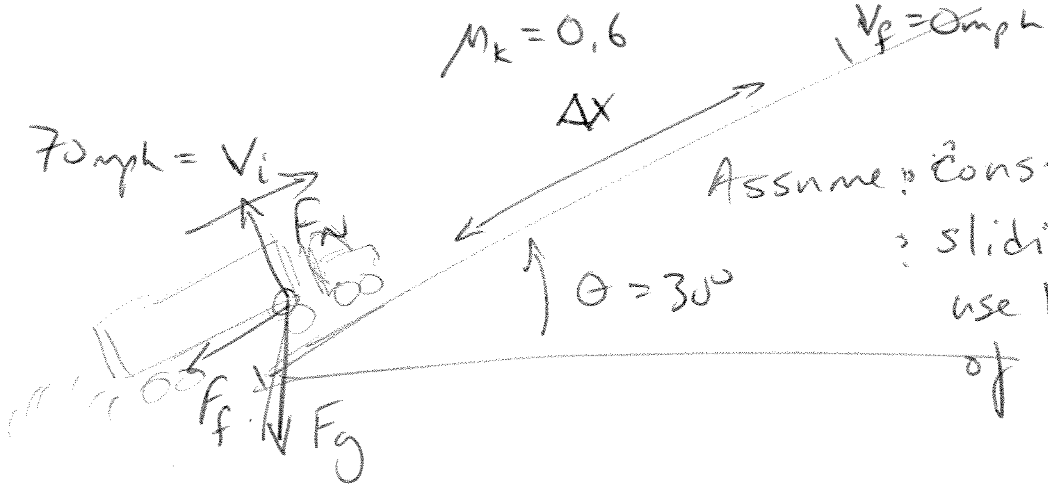
Date:
Recorder: LINDAAS
Skeptic: NOETHER
Timekeeper: KEPLER
Psychic: DIRAC

List given information, define variables, sketch picture:



$m = 50$ ton

$\mu_k = 0.6$



Assume: constant sloping ramp
: sliding up ramp so use kinetic coefficient of friction

Simplify question, list target quantity:

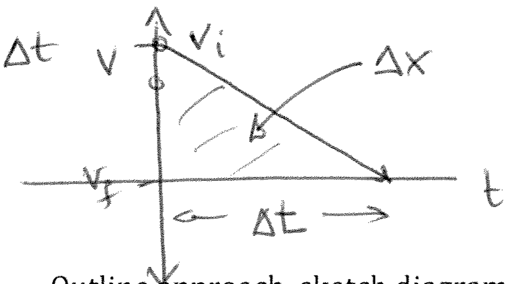
Find length (Δx) of track needed to stop a large fast truck.

List all related quantitative relationships:

$F_g = mg$ $F_f = \mu_k F$ $\sum F = \frac{d}{dt}p = \frac{d}{dt}mv = m\frac{dv}{dt}$

this doesn't help

$\Delta x = \frac{1}{2} v_i \Delta t$



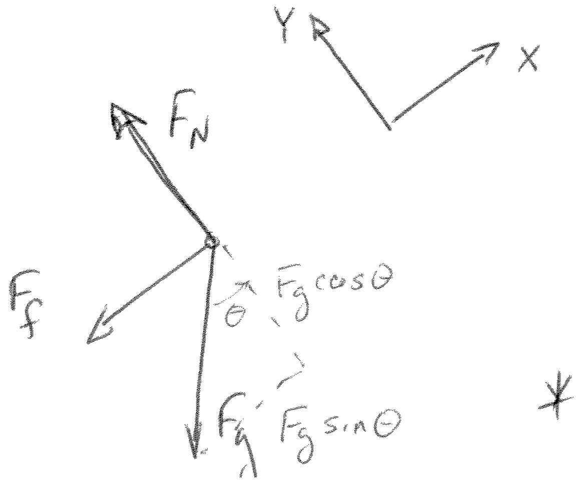
$(v_i + v_f)\frac{1}{2}$ but $v_f = 0$

$v_{avg} = \frac{\Delta x}{\Delta t} = \frac{v_f}{2}$

$\Delta x = \frac{v_i \Delta t}{2}$

$a = \frac{dv}{dt} = \frac{\Delta v}{\Delta t}$

Outline approach, sketch diagrams if needed (or sketch next to pictures above):



$\sum F_x = m\frac{dv_x}{dt} = m\frac{\Delta v_x}{\Delta t}$ *

$\sum F_y = m\frac{dv_y}{dt} = m\frac{\Delta v_y}{\Delta t} = 0$

* you can do this since Force is constant ! (linear change in v)

Obtain a general solution:

$$Y: \quad F_N - F_g\cos\theta = 0$$

$$F_N = F_g\cos\theta$$

$$X: \quad -F_f - F_g\sin\theta = m\frac{\Delta v}{\Delta t}$$

$$F_f = \mu_K F_N = \mu_K F_g\cos\theta$$

$$-F_g(\mu_K\cos\theta + \sin\theta) = m\frac{\Delta v}{\Delta t}$$

$$-\cancel{m}g(\mu_K\cos\theta + \sin\theta) = \cancel{m}\frac{\Delta v}{\Delta t}$$

mass cancels!

$$\Delta v = v_f - v_i = -v_i$$

$$\Delta t = \frac{2\Delta x}{v_i} \qquad \left(\Delta x = \tfrac{1}{2}v_i\Delta t\right)$$

$$-g(\mu_K\cos\theta + \sin\theta) = \frac{-v_i}{\frac{2\Delta x}{v_i}}$$

simplify and solve for Δx

$$\Delta x = \frac{v_i^2}{2g(\mu_K\cos\theta + \sin\theta)}$$

$$v_i = 70\frac{\text{miles}}{\text{hour}}\cdot\frac{1\text{ hour}}{3600\text{ sec}}\cdot\frac{1609\text{ m}}{1\text{ mile}} = 31.3\text{ m/s}$$

Check Units:

$$[m] = \frac{\left[\frac{m}{s}\right]^2}{\left[\frac{m}{s^2}\right]} = \frac{\cancel{m^2}}{\cancel{s^2}}\cdot\frac{\cancel{s^2}}{\cancel{m}} = m$$

✓

Check Limiting Cases:

$\uparrow v_i \quad \Delta x \uparrow$ ✓

$\uparrow g \quad \Delta x \downarrow$ ✓

$\mu_K = 0$ (ice)

$\theta\uparrow \quad \Delta x \downarrow$ ✓ (steeper slope stops sooner)

$\mu_K\uparrow \quad \Delta x \downarrow$ ✓ (rougher slope stops sooner)

Obtain a numeric solution:
(i.e. plug in the numbers)

$$\Delta x = \frac{(31.3\,m/s)^2}{2(9.8\frac{m}{s^2})(0,6\cos 30 + \sin 30)}$$

$$= 49\text{ m} \qquad \Delta x_{ice} = 100\text{ m}$$

Why is solution reasonable? Explain.

- ✓ Units check
- Limiting cases check
- Length seems reasonable and gets a lot longer with ice (30° is actually quite steep!)

Based on the Univ. of Minn. Cooperative Group Problem Solving Sheet, Modified By H. Cegla and S. Lindaas (2010)