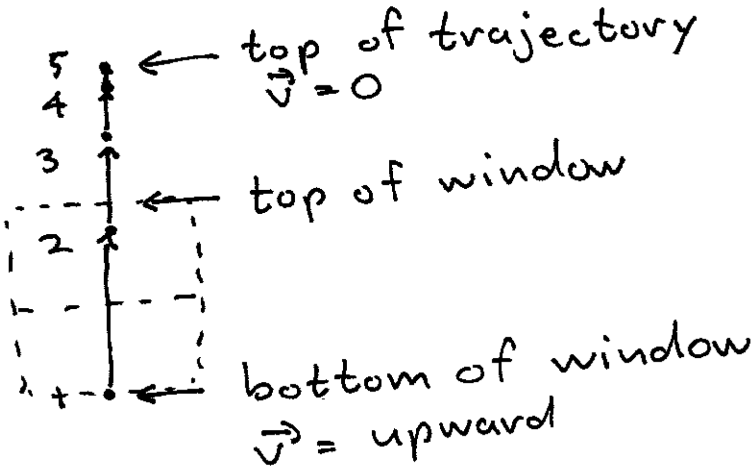
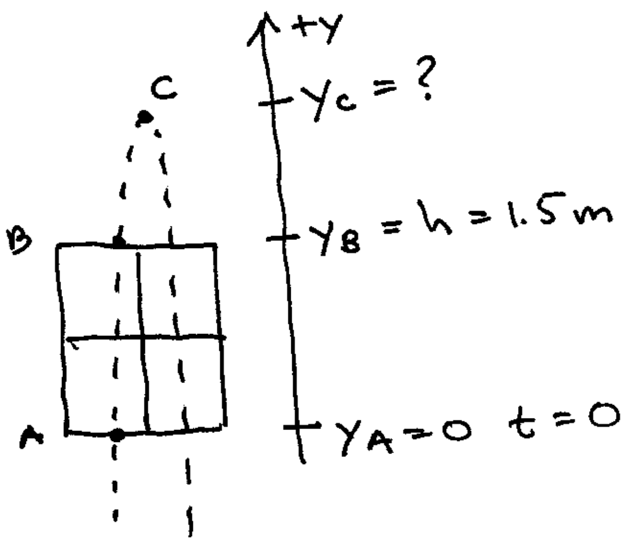
Sample Exam 1 Soln

Problem 1

(a) Motion diagram:



(b) Draw picture w/ coord sys:



$a_y = -g = -9.8\,m/s^2$

$\Delta t_{AB} = 0.1\,s$

A → B: "$\Delta y = v_{iy}\,\Delta t + \frac{1}{2} a_y \Delta t^2$"

$$\underbrace{y_B - y_A}_{= h} = v_A\,\Delta t_{AB} - \frac{1}{2} g\,\Delta t_{AB}^2$$

Solve for v_A: $\quad v_A = \dfrac{h + \frac{1}{2} g \Delta t_{AB}^2}{\Delta t_{AB}} = 15.5\,m/s$

A → C: "$v_{fy}^2 = v_{iy}^2 + 2a_y \Delta y$"

$$\cancelto{0}{v_{Cy}^2} = v_A^2 - 2g(y_c - \cancelto{0}{y_A})$$

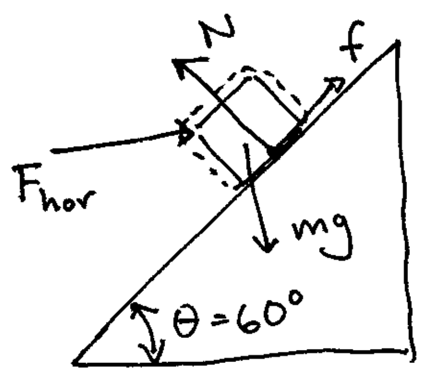
$$v_A^2 = 2g y_c$$

$$y_c = \frac{v_A^2}{2g} = 12.2\,\text{m}$$

This is distance from <u>bottom</u> of window.
Distance from top = 12.2m − 1.5m = 10.7m

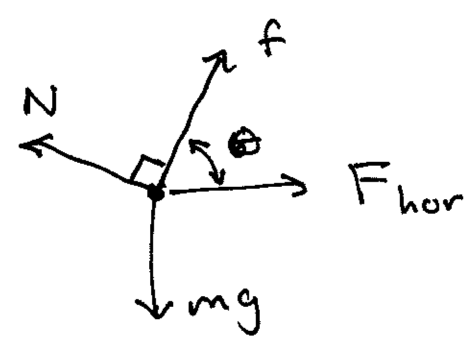
<u>Problem 2</u>

(a)



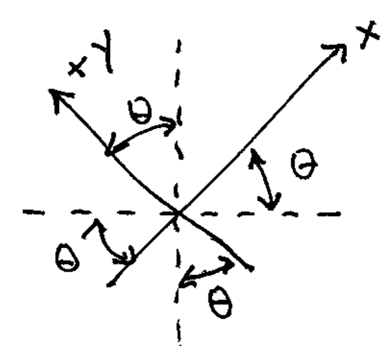
N = force of plane on block
f = friction

sys = block. Free body:



(b) Block not slipping
⇒ static friction
⇒ $\vec{F}_{net} = 0$

Use "tilted" coord sys



$$F_{net,x} = \boxed{f + F_{hor}\cos\theta - mg\sin\theta = 0}$$

$$F_{net,y} = \boxed{N - F_{hor}\sin\theta - mg\cos\theta = 0}$$

$$F_{hor} = \min \Rightarrow f = \max$$

$$\Rightarrow f = \mu_k N$$

$$N = F_{hor}\sin\theta + mg\cos\theta$$

Plug in

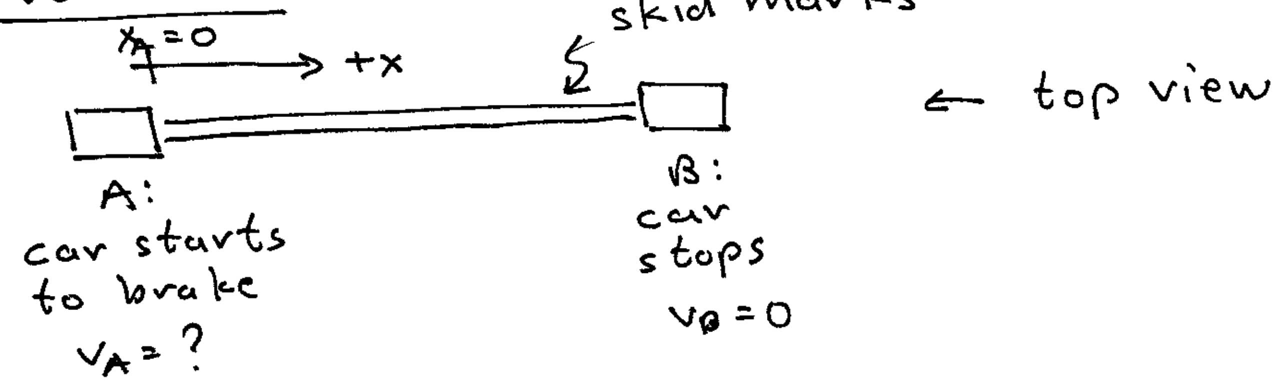
$$\mu_k\left(F_{hor}\sin\theta + mg\cos\theta\right) + F_{hor}\cos\theta - mg\sin\theta = 0$$

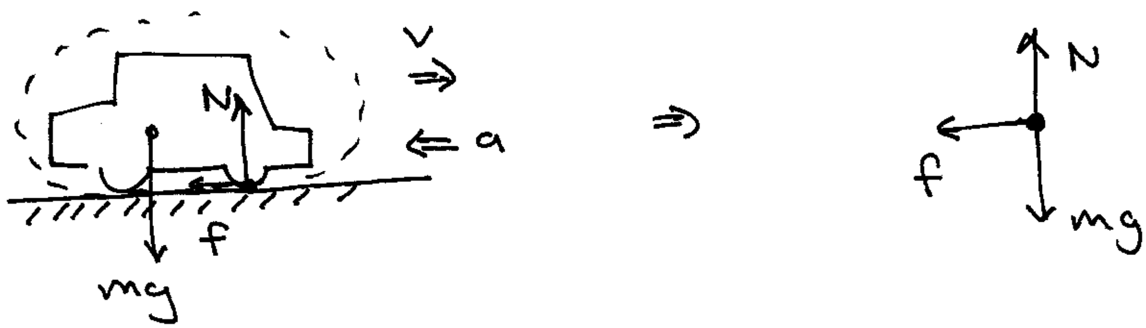
Solve for F_{hor}:

$$\left[\mu_k\sin\theta + \cos\theta\right]F_{hor} = mg\sin\theta - \mu_k mg\cos\theta$$

$$F_{hor} = mg\,\frac{\sin\theta - \mu_k\cos\theta}{\cos\theta + \mu_k\sin\theta} = 1.63\,N$$

Problem 3





$$F_{net,y} = \boxed{N - mg = 0} \Rightarrow N = mg$$

$$F_{net,x} = \boxed{-f = m a_x}$$

$$f = \mu_k N = \mu_k mg$$

$$a_x = -\frac{f}{m} = -\frac{\mu_k \cancel{m} g}{\cancel{m}} \leftarrow \text{m cancels!}$$

$$\boxed{a = -\mu_k g}$$

$\mu_k = 0.3 \Rightarrow a_x = -2.94 \text{ m/s}^2$

$\mu_k = 0.4 \Rightarrow a_x = -3.92 \text{ m/s}^2$

A → B: const accel

$$\text{"} v_{fx}^2 = v_{ix}^2 + 2 a_x \Delta x \text{"}$$

$$\cancel{v_B}^2 = v_A^2 + 2 a_x d \qquad d = 3.5 \text{ m}$$

($v_B \to 0$)

$$v_A^2 = -2 a_x d \qquad (a_x < 0 \Rightarrow v_A^2 > 0)$$

$$\boxed{v_A = \begin{cases} 4.5 \text{ m/s} & \mu_k = 0.3 \\ 5.2 \text{ m/s} & \mu_k = 0.4 \end{cases}}$$