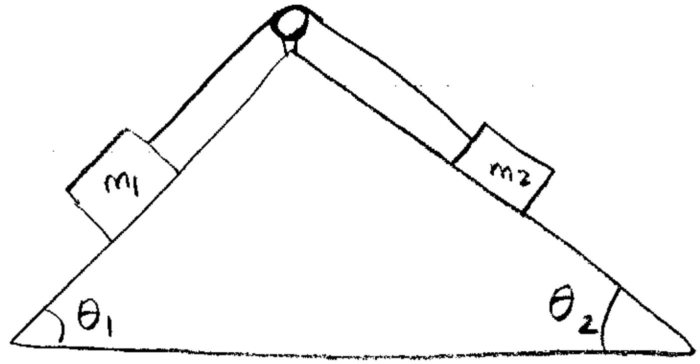
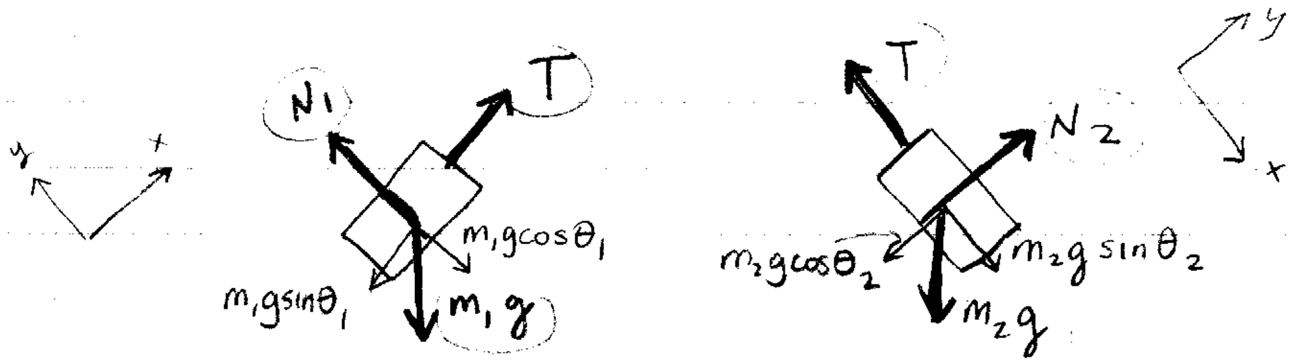
Quiz 1 Solutions

Problem 1:



a) Use tilted coordinate systems



Forces are N_1, T, $m_1 g$ $\qquad$ N_2, T, $m_2 g$

Tension is the same for both blocks

Block 1, x dir

b) (1) $T - m_1 g \sin\theta_1 = m_1 a_1$

(2) $-T + m_2 g \sin\theta_2 = m_2 a_2$

$a_1 = a_2 = a$ if blocks moving together

Add (1) & (2) $\qquad m_2 g \sin\theta_2 - m_1 g \sin\theta_1 = (m_1 + m_2)\, a \qquad (3)$

$$a = \frac{m_2 g \sin\theta_2 - m_1 g \sin\theta_1}{m_1 + m_2}$$

$$= \frac{10 \cdot (9.8) \sin 50^\circ - (8)(9.8) \sin 40^\circ}{(10+8)}$$

$$\underline{\underline{a = 1.4 \ m/s^2}}$$

Since a is pos, blocks slide to right.

c) From ①

$$T = m_1 a + m_1 g \sin\theta_1$$

$$= (8)(1.4) + 8(9.8) \sin 40^\circ$$

$$\underline{\underline{T = 62 \ N}}$$

d) Const a: $d = \frac{1}{2} a t^2 = \frac{1}{2}(1.4)(1)^2 = \underline{\underline{0.7 \ m}}$

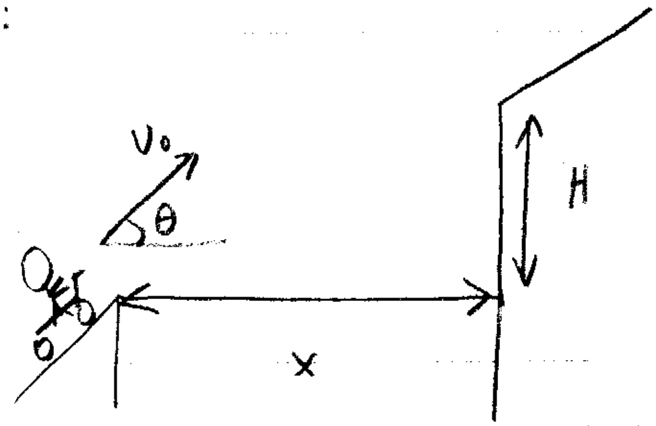
e) $a = 0$ Get ratio of masses

From ③

$$m_2 \cancel{g} \sin\theta_2 = m_1 \cancel{g} \sin\theta_1$$

$$\Rightarrow \frac{m_2}{m_1} = \frac{\sin\theta_1}{\sin\theta_2} = \frac{\sin 40^\circ}{\sin 50^\circ} = \underline{\underline{0.84}}$$

Problem 2 :



a) $X = v_{0x} t = v_0 \cos\theta \, t$

$$\Rightarrow \boxed{t = \frac{x}{v_0 \cos\theta}}$$

b) $y = v_{0y} t - \frac{1}{2} g t^2$

$= v_0 \sin\theta \, t - \frac{1}{2} g t^2$ ← substitute t from part a

$$= v_0 \sin\theta \frac{x}{v_0 \cos\theta} - \frac{1}{2} g \frac{x^2}{v_0^2 \cos^2\theta}$$

$$\boxed{y = x \tan\theta - \frac{1}{2} g \frac{x^2}{v_0^2 \cos^2\theta}}$$

c) The upper limit on H such that Evil has any chance (for given θ, x) is for $v_0 \to \infty$

(Note the bigger v_0, the bigger y)

For $v_0 \to \infty$, the second term in the answer to part b $\to \infty$

and $\boxed{y_{max} = x \tan\theta}$

(Note that this question was not asking for the top of the trajectory where $v = 0$)

d) Use part b, assume $y = H$

$$H = x\tan\theta - \frac{1}{2} g \frac{x^2}{v_0^2 \cos^2\theta}$$

solve for v_0 in terms of the other quantities

$$H - x\tan\theta = -\frac{1}{2} g \frac{x^2}{v_0^2 \cos^2\theta}$$

$$v_0^2 = -\frac{1}{2} g \frac{x^2}{\cos^2\theta} \frac{1}{H - x\tan\theta}$$

$$\boxed{v_0 = \frac{x}{\cos\theta} \sqrt{\frac{g}{2} \frac{1}{x\tan\theta - H}}}$$

3) a) You can solve this either exactly, or using the approximation you used in your experiment analysis.

$$RC = (20\times10^{6}\ \Omega)(10^{-6}\ F) = 20\ s$$

Exact: $(0.160) = 2.2(1 - e^{-t/20})$

$$e^{-t/20} = 1 - \frac{0.16}{2.2}$$

$$-t/20 = \ln\left(1 - \frac{0.16}{2.2}\right)$$

$$\Rightarrow t = \underline{\underline{1.5}}\ s$$

Approx: $e^{-t/20} \sim 1 - \frac{t}{20}$ (Taylor expansion)

$$V_{cap} \sim V_{cell}\left(\cancel{1} - \cancel{(1} - \frac{t}{20})\right)$$

$$V_{cap} \sim \frac{V_{cell}}{20}t$$

$$t \sim \frac{20\ V_{cap}}{V_{cell}} = \frac{20\ (0.160)}{2.2} = \underline{\underline{1.5\ s}}$$

b)

$$d = \frac{1}{2} g t^2$$

$$\frac{d_1}{d_2} = \frac{\frac{1}{2} \cancel{g} t_1^2}{\cancel{\frac{1}{2}} \cancel{g} t_2^2}$$

$V_{cap} \propto t$ for small V, t (as is the case for FO)

$$\Rightarrow \frac{d_1}{d_2} = \frac{V_1^2}{V_2^2}$$

$$V_2 = V_1 \sqrt{\frac{d_2}{d_1}} = (64)\sqrt{\frac{18}{6.5}} = \underline{\underline{107\ mV}}$$