PHYSICS 1A

Midterm 1

Winter, 2017 Dr. Coroniti

There are 100 points on the exam, and you have 50 minutes. To receive full credit, show all you work and reasoning. No credit will be given for answers that simply "appear". The exam is closed notes and closed book. You do not need calculators, so please put them, and all cell phones, away. If you need more space, use the backside of the page.

Deven Patel
Your Full Name - Printed

Your Normal Signature

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Your Student ID Number

Problem	**Score**
1	25
2	30
3	25
4	15
Total	100

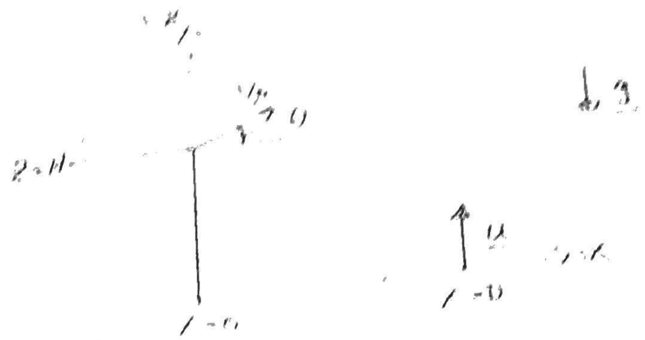
(25 Pts)

1. At time t = 0, a ballistic missile is launched from the top of a mountain of height $z = H$ located at $x = 0$ with an initial velocity v_0 that makes an angle θ with respect to the horizontal as shown. At $t = 0$, a gunner on the ground is located at a distance D from the base of the mountain, and fires a shell vertically upward with an initial speed u

(9) a. Write the equations for the position $x_M(t)$ and $z_M(t)$ for the missile, and $z_s(t)$ for the shell

(6) b. Now express the height of the missile and the height of the shell as a function of the x position of the missile.

(10) c. Show that for the shell to hit the missile, the shell should be fired with an initial vertical speed given by



$$u = \frac{[H\cos\theta + D\sin\theta]}{D} v_0$$

a) $X_m(t) = X_{initial} + V_{ox} t$ $Z_m(t) = Z_{initial} + V_{oz} t - gt^2/2$

$\boxed{X_m(t) = V_0 \cos\theta t}$ $\boxed{V_0 \sin(\theta) t - gt^2/2 + H}$

$Z_s(t) = Z_{initial} + V_0 t - gt^2/2$

$= \boxed{ut - gt^2/2}$

+6

b) height of missile: same base - will call $X_m(t)$ just x

$Z_m(t) = V_0 \sin\theta t - gt^2/2 + H$ $X_m(t) = V_0 \cos\theta t$ $t = \frac{X_m(t)}{V_0 \cos\theta}$

$Z_m(t) = V_0 \sin\theta \left(\frac{x}{V_0 \cos\theta}\right) - g\left(\frac{x}{V_0 \cos\theta}\right)^2 + H$

$$\boxed{Z_m(x) = x\tan\theta - \frac{gx^2}{2V_0^2\cos^2\theta} + H}$$

+6

height of shell:

$Z_s(t) = ut - gt^2/2$ $X_m(t) = V_0 \cos\theta t$ $t = \frac{x}{V_0 \cos\theta}$

$$\boxed{Z_{(s,x)} = \frac{ux}{V_0\cos\theta} - \frac{gx^2}{2V_0^2\cos^2\theta}}$$

c) z val should be same at some x to show they hit.   +9

$$H + x\tan\theta - \cancel{\frac{gx^2}{2V_0^2\cos^2\theta}} = \frac{ux}{V_0\cos\theta} - \cancel{\frac{gx^2}{2V_0^2\cos^2\theta}}$$

$$\frac{V_0\cos\theta(H + x\tan\theta)}{x} = u \quad \boxed{V_0\left(\frac{H\cos\theta + x\sin\theta}{x}\right) = u}$$ ✓

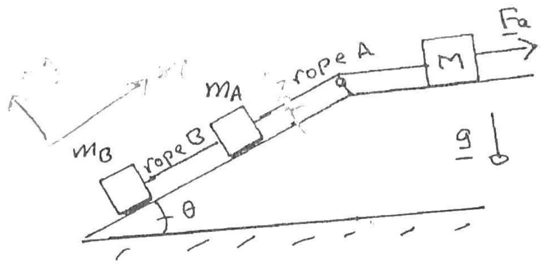
(30 Pts)

2. A block with mass M is pulled along a frictionless horizontal surface by an applied horizontal force F_a as shown. Block M is connected to a massless rope (A) that passes over a massless pulley and connects to a block with mass m_A located on an inclined plane with inclination angle θ as shown. Block m_A is connected to a third block with mass m_B on the inclined plane by a second massless rope (B) as shown.

(9) a. Draw free body diagrams for each of the three blocks.

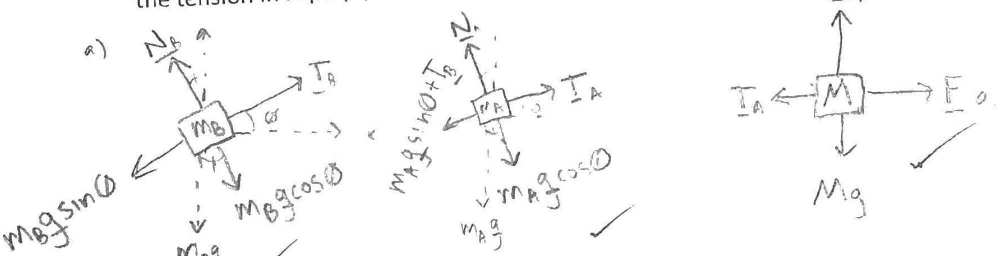
(15) b. Assuming that the three blocks accelerate together, prove that the acceleration is given by

$$a = \frac{F_a-(m_A+m_B)g\sin\theta}{m_A+m_B+M}$$



(6) c. Suppose that rope (A) breaks. Find the acceleration of m_A and m_B and the tension in rope (B).

a)



b) $\Sigma F_x = m_B a$ $\quad$ $\Sigma F_x = m_a a$ $\quad$ $\Sigma F_x = Ma$

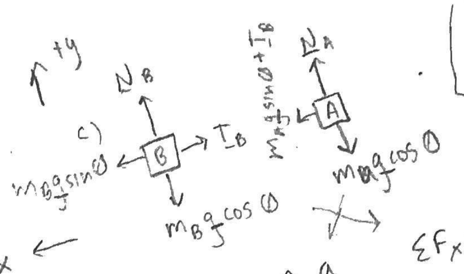
$T_B - m_Bg\sin\theta = m_B a$ $\quad$ $T_A - m_ag\sin\theta - T_B = m_a a$ $\quad$ $F_a - T_a = Ma$

$T_a - m_ag\sin\theta - m_Bg\sin\theta = m_Ba + m_aa$

$F_a - m_ag\sin\theta - m_Bg\sin\theta = m_Ba + m_aa + Ma$

$$\boxed{\frac{F_a-(m_a+m_B)g\sin\theta}{m_a+m_B+M} = a}$$

c)



$\Sigma F_x = m_a a$

$T_B + m_ag\sin\theta = m_a a$

$\Sigma F_x = m_B a$

$m_Bg\sin\theta - T_B = m_B a$

$m_Bg\sin\theta + m_ag\sin\theta = (m_B+m_a)a$

$m_Bg\sin\theta$

$\frac{\cancel{(m_B+m_a)}g\sin\theta}{\cancel{(m_B+m_a)}} = a$ $\quad$ $\boxed{a = g\sin\theta}$

$T_B = m_a a - m_ag\sin\theta$

$\boxed{T_B = 0N}$

$m_Bg\sin\theta - 0 = m_Bg\sin\theta$

25

(30 Pts)

3. A block with mass M is pushed along a rough horizontal surface, with a coefficient of <u>kinetic</u> friction μ_k, by an applied horizontal force F_a as shown. A second block with mass m sits on top of block M. The coefficient of <u>static</u> friction between the surfaces of m and M is μ_s.

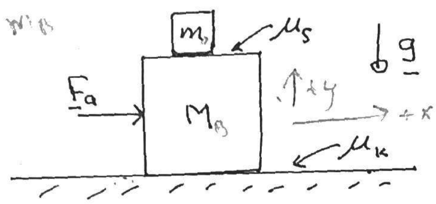
(10) a. Draw free body diagrams for the two blocks.

(10) b. If m does <u>not slip</u> relative to M, find the acceleration of the system.

(10) c. Show that the <u>maximum</u> value of the applied force for which m remains at rest relative to M is given by

m m_a

M = m_B

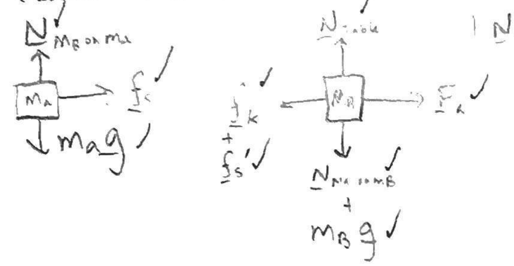


$$(F_a)_{MAX} = (m_A + M_B)(\mu_K + \mu_s)g$$

$|N_{MB\ on\ ma}| = |N_{ma\ on\ MB}|$

a)

10



b)

5

$\Sigma F_x = m_a a$ $\quad$ $\Sigma F_x = m_B a$

$f_s = m_a a$ $\quad$ $F_a - f_k - f_s' = m_B a$

If no slip, the blocks travel together so...

$\frac{f_s}{m_a} = a$ $\quad$ $\cancel{\frac{\mu_s m_a g}{m_a}} = a$ $\quad$ $\boxed{\cancel{a = \mu_s g}}$

c) $f_s = m_a a$ $\quad$ $F_a - f_k - f_s' = m_B a$

10

$(m_B + m_a)a = F_a - f_k$ $\quad$ $f_K = \mu_K N_{Table}$

$\Sigma F_y = 0N$

$F_a = (m_B + m_a)\mu_s g + f_k$

$N_{Table} = N_{mB\ on\ Ba} + m_B g$

$= (m_B + m_a)\mu_s g + (m_B + m_a)\mu_K g$

$= m_a g + m_B g$

$\boxed{= (m_a + m_B)(\mu_K + \mu_s)g}$

$f_k = \mu_K(m_a g + m_B g)$

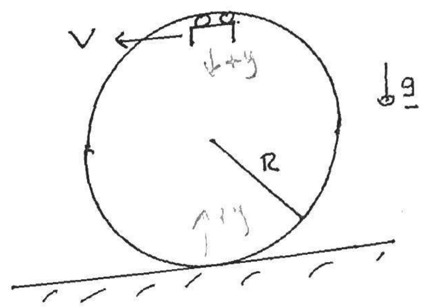
15

(15 Pts)

4. A thrilling roller coaster has a vertical circular loop with a radius R as shown.

(10) a. Find the minimum circular speed at which the roller coaster must be traveling in order that an un –seat-belted passenger does not fall out at the top of the loop.

(5) b. If the roller coaster travels at this same speed when it is at the bottom of the loop, show that a passenger's weight would be double its normal value.



a) min v occurs at top when N = 0N.

$\Sigma F = \frac{mv^2}{R}$ $\quad N + mg = \frac{mv^2}{R}$ $\quad \cancel{m}g = \frac{\cancel{m}v^2}{R}$ $\quad \boxed{v = \sqrt{g \cdot R}}$

10

b) $\Sigma F = \frac{mv^2}{R}$

$N - w = \frac{mv^2}{R}$

$N - \frac{mv^2}{R} = w$ normal value is at v = 0 m/s so N = w

$N - \frac{mg\cancel{R}}{\cancel{R}} = w$ now we plug in $\sqrt{gR}$ for v

5

$N = w + mg$

$\boxed{N = 2w}$ ✓