MIDTERM 1

Physics 9A Section A **NAME:** KEY

April 18, 2007 **ID #:**

General Instructions: This examination is closed book. Only a calculator is allowed. Please show all your work and box your answers. Credit will only be given for *complete* solutions. Answers must have correct units. There are four problems on four pages. Note that not all the problems are worth the same number of points. The acceleration due to gravity is g=9.8 m/s^2.

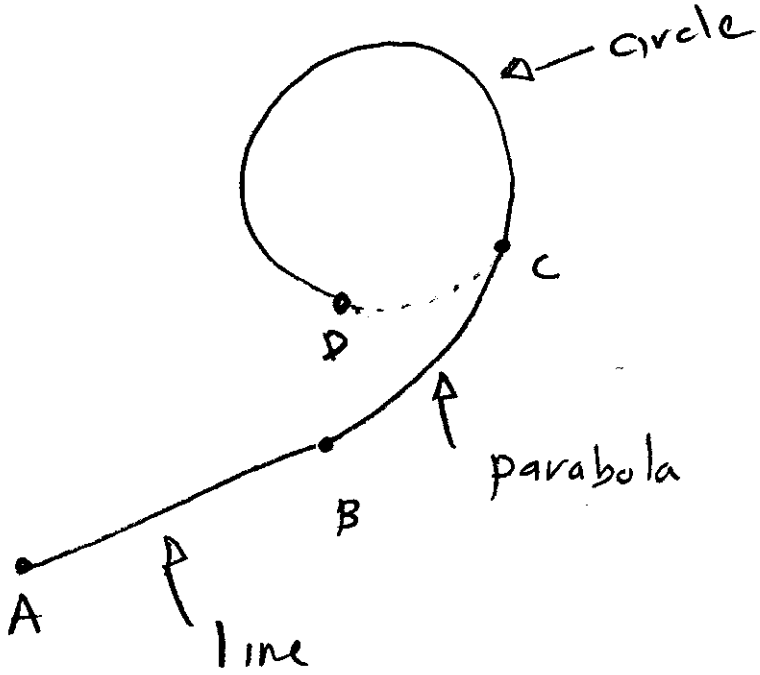
25 points] 1. An ~~object~~ puck moves from point A to point B at constant velocity while under the influence of several forces. (a) What can you say about the forces? (b) Graph the puck's path from A to B. (c) On the graph, continue the path to point C if a new constant force is added to the puck at point B, where the new force is perpendicular to the puck's velocity at point B. (d) Continue the path to point D if at point C the constant force added at B is replaced by one of constant magnitude but in a direction always perpendicular to the path. *Make sure you indicate clearly the nature of each trajectory, if known, i.e. give the name for each segment of the curve: ellipse, parabola, etc.*

a) $\vec{v}$ = const $\rightarrow$ $\vec{a}=0$ $\rightarrow$ $\vec{F}^{NT}=0$ (forces sum to zero)

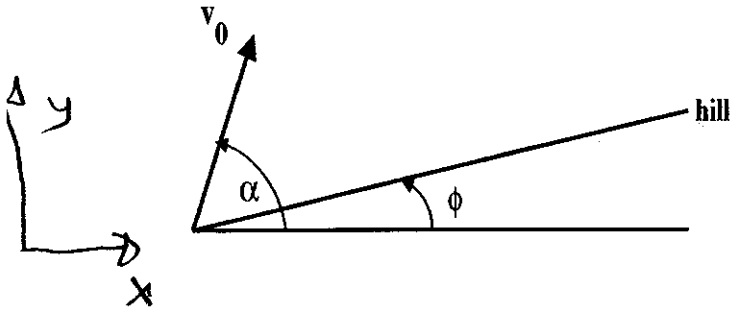
b) since $\vec{v}$ = const trajectory is straight line

c) If $\vec{F}$ = const and $\perp$ to $\vec{v}_0$ puck will follow parabola
(const $\dot{v}$ along $\vec{v}_0$ and v increasing/mcreasing with t $\perp$ to $\vec{v}_0$)

d) puck will travel in circle since $\vec{F}$ = $\perp$ to Path and $|\vec{F}|$=const



[25 points] 2. A person stands at the base of a hill that is a straight incline making an angle ϕ with the horizontal. (See figure.) A ball is thrown with initial speed v_0 at an angle α with the horizontal. What are the x and y coordinates of the ball as a function of time? At what time t will the ball hit the hill?



$$x = x_0 + v_{x0}t + \tfrac{1}{2}a_x t^2 \qquad y = y_0 + v_{y0}t + \tfrac{1}{2}a_y t^2$$

$$= 0 + v_0\cos\alpha\, t + 0 \qquad = 0 + v_0\sin\alpha\, t - \tfrac{1}{2}g t^2$$

Hits hill when $\frac{Y}{X} = \tan\phi$ $\qquad y = x\tan\phi$

$$= v_0\cos\alpha\, t\tan\phi$$

$$v_0\cos\alpha\tan\phi\, t = v_0\sin\alpha\, t - \tfrac{1}{2}g t^2$$

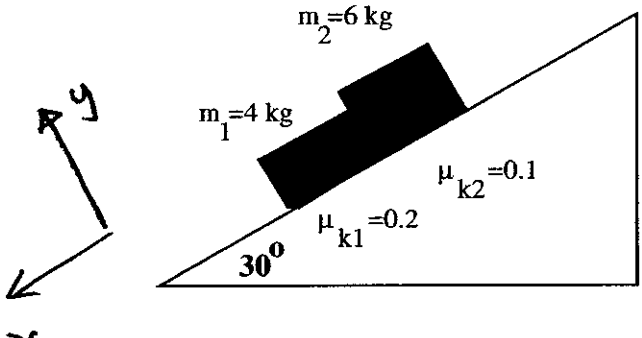
$t = 0$ or $\tfrac{1}{2}g t = (v_0\sin\alpha - v_0\cos\alpha\tan\phi)$

$$t = \frac{2v_0}{g}\left[\sin\alpha - \cos\alpha\tan\phi\right]$$

NOTE has soln only if $\alpha > \phi$, $\cos\alpha\left[\tan\alpha - \tan\phi\right]$

Interesting problem: What α maximizes distance up hill?
SOLN: plug t into eqn for x and then set $dx/d\alpha = 0$.

30 points] 3. Two blocks $m_1 = 4$ kg and m_2=6 kg are sliding down an inclined plane tilted at an angle of 30 degrees as shown in the figure. (a) Compute the acceleration of the masses when the coefficients of kinetic friction are $\mu_{k1} = 0.2$ between m_1 and the plane and $\mu_{k2} = 0.1$ between m_2 and the plane. What is the force (magnitude and direction) of block 2 on block 1? (b) What is the force (magnitude and direction) of block 2 on block 1 if the coefficients of friction are reversed, $\mu_{k1} = 0.1$ and $\mu_{k2} = 0.2$? Hint: To do this part of the problem does not require any equations. To receive credit, however, you must *explain* your answer clearly.



(b) Since $\mu_{k2} < \mu_{k1}$ upper block can slide faster than lower, so it will bump into lower and push it along

If $\mu_{k2} > \mu_{k1}$ upper block is slower. Lower block races ahead, no contact, and force between them is zero,

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Consider 2 blocks as single unit

a) $\rightarrow$ $m_1 g \sin\theta + m_2 g \sin\theta$

components of gravity forces down plane

$- \mu_{k1} m_1 g\cos\theta - \mu_{k2} m_2 g\cos\theta = (m_1 + m_2)a$

$\mu_{k1} m_1 g\cos\theta$: N_1; $\mu_{k2} m_2 g\cos\theta$: N_2

$\leftarrow$ Friction forces up plane

Plugging in numbers

$$a = \frac{16.62}{10} = 3.71\ m/s^2$$

Consider only block 1:

$$F_{2on1} + m_1 g\sin\theta - m_1 g\cos\theta\,\mu_{k1} = m_1 a$$

$$F_{2on1} = 2.03\ N$$

check block 2: $F_{1on2} + m_2 g\sin\theta - m_2 g\cos\theta\,\mu_{k2} = m_2 a$

$F_{1on2} + 29.40 - 5.09 = 22.26$

$F_{1on2} = -2.05$ $\checkmark$ $= -F_{2on1}$

[20 points] 4. The largest helicopter ever built in the United States was the Sikorski CH-53E "Super Stallion". The four blades of its main rotors each has a radius of 24.1 m. If the rotors are turning at 50 rpm, what is the velocity at the tip of the blade? What is the acceleration? Give your answer for the acceleration both in m/s^2 and as a multiple of g.

50 rpm $\Rightarrow$ $T = 1.2$ sec to do 1 revolution

$$v = \frac{2\pi r}{T} = \frac{2\pi(24.1)}{1.2} = 126.2 \text{ m/s}$$

$$a = v^2/r = (126.2)^2/24.1 = 660.7 \text{ m/s}^2$$

$$= 67.4\, g$$