Physics 200 Name KEY 72pts possible

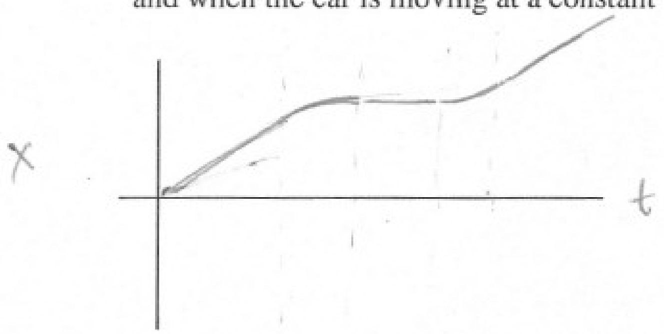
Exam 1 – Kinematics and Force

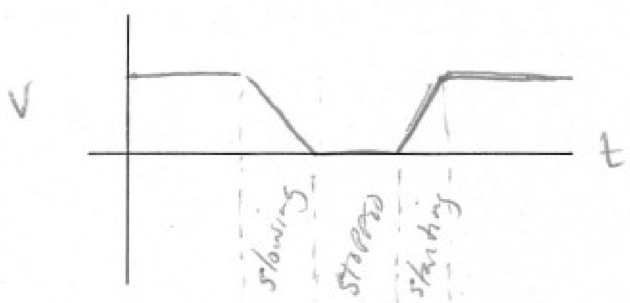
September 29, 2005

This is a closed book examination. There is extra scratch paper available.

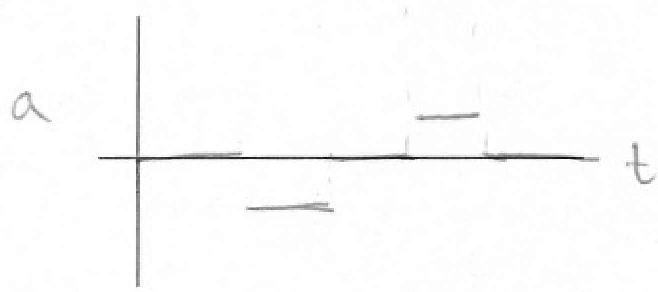
A general reminder about problem solving:
1. Draw a picture then create a simplified free body diagram with all forces
2. Write down what you know including coordinate frame
3. Write down what you don't know and/or want to know
4. List mathematical relationships
5. Simplify and solve
6. Check your answer – Is it reasonable? Are units correct?
- Show all work!

1. [12 PTS] You are driving down the street at a constant velocity and approach a stop sign. You slow down, stop and then resume driving down the street at the same constant velocity. The magnitude of your acceleration when you are stopping and starting is the same. Neglecting friction, draw $y(t)$, $v_y(t)$ and $a_y(t)$. Indicate when the car is stopped and when the car is moving at a constant velocity on each graph.





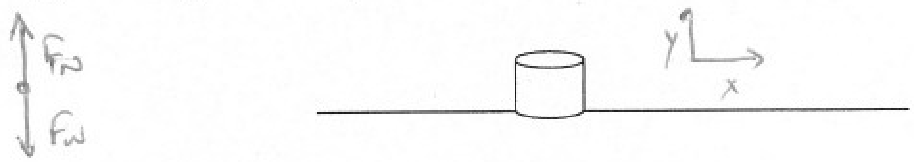
$$V(t) = \frac{d}{dt}x(t)$$



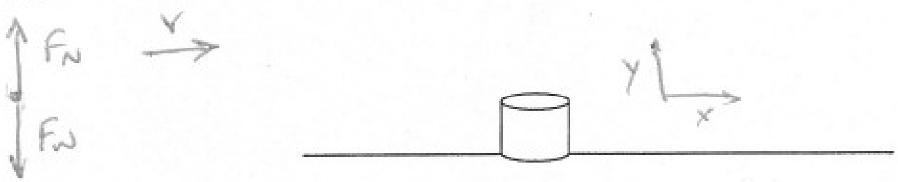
$$a(t) = \frac{d}{dt}v(t)$$

Draw free body diagrams (i.e. label all forces) for the following situations.

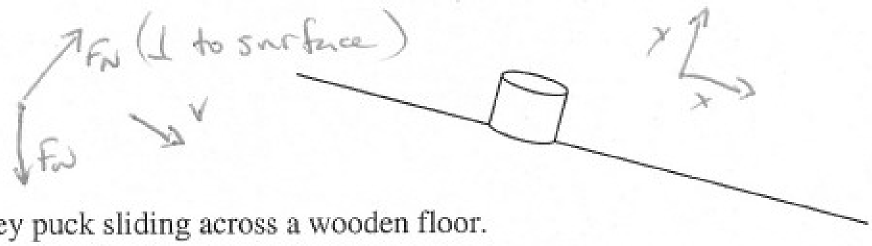
2. [2 PTS] A hockey puck sitting on the ice (assume frictionless surface)



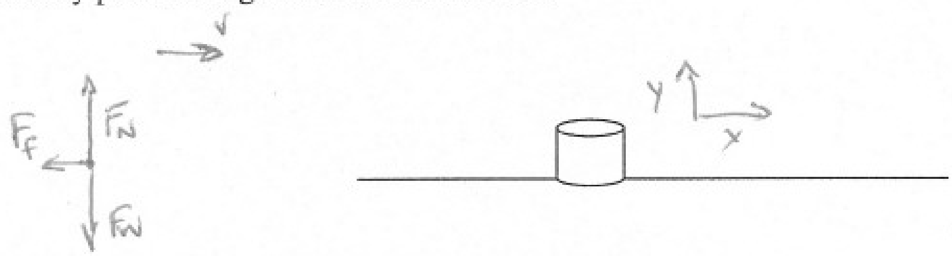
3. [2 PTS] A hockey puck sliding across the ice at a constant velocity (assume frictionless surface)



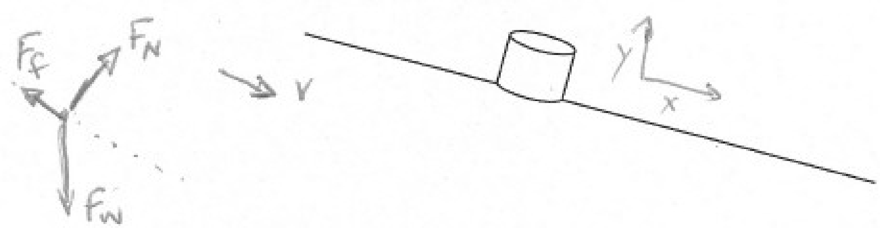
4. [2 PTS] A hockey puck sliding down an inclined ice sheet (assume frictionless surface)



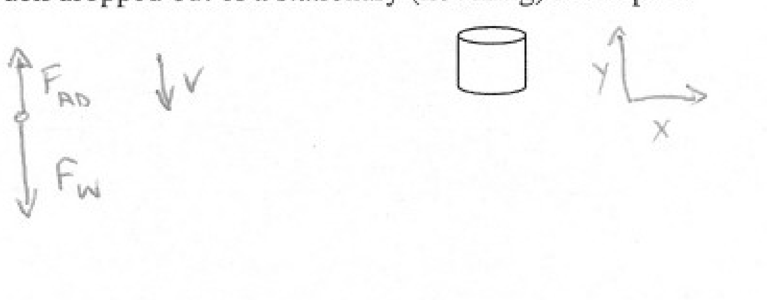
5. [2 PTS] A hockey puck sliding across a wooden floor.



6. [2 PTS] A hockey puck sliding down an inclined wooden floor.



7. [2 PTS] A hockey puck dropped out of a stationary (hovering) helicopter.



F_N = Normal Force
F_W = Weight (gravitational force)
F_f = Friction
F_{AD} = Air Drag

You throw a rather old black and white soccer ball as hard as you can straight up into the air. Assume up is the positive direction. The next six questions refer to this ball after it has left your hand. Please explain your answers (your explanation is worth 2/3 of the points).

8. [3 PTS] The acceleration of the ball on the way up is
   a) 9.81 m/s2 in the upward direction.
   b) zero (no acceleration).
   c) 9.81 m/s2 in the downward direction.
   d) Can not tell. It depends on the initial velocity.

* Acceleration is constant and negative

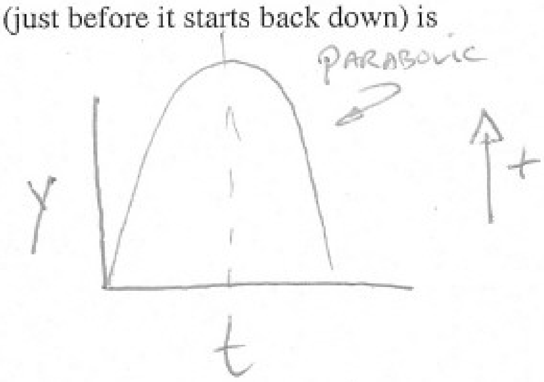
* Velocity ~~start~~ positive, momentarily ϕ at top of trajectory and negative on the way back down.

* Graphs say it all

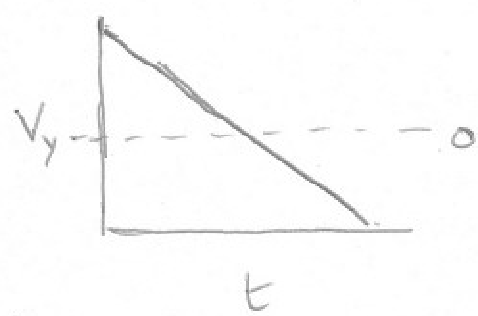
9. [3 PTS] The velocity of the ball on the way up is
   a) positive (in the upward direction).
   b) zero (~~no accelerati~~on).
   c) negative (in the downward direction).
   d) Can not tell. It depends on the initial position.

10. [3 PTS] The acceleration of the ball at the very top of its throw (just before it starts back down) is
    a) 9.81 m/s2 in the upward direction.
    b) zero (no acceleration).
    c) 9.81 m/s2 in the downward direction.
    d) Can not tell. It depends on how high it was thrown.

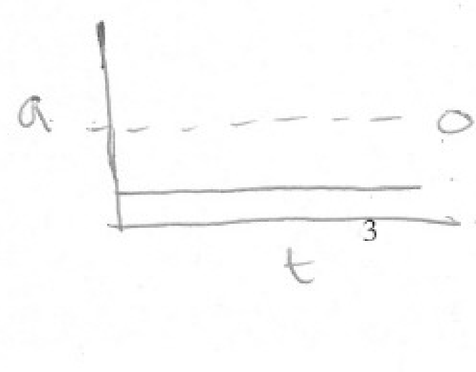
11. [3 PTS] The velocity of the ball at the very top of its throw (just before it starts back down) is
    a) positive (in the upward direction).
    b) zero (~~no accelerati~~on).
    c) negative (in the downward direction).
    d) Can not tell. It depends on the initial position.



12. [3 PTS] The acceleration of the ball on the way down is
    a) 9.81 m/s2 in the upward direction.
    b) zero (no acceleration).
    c) 9.81 m/s2 in the downward direction.
    d) Can not tell. It depends on where you catch it.



13. [3 PTS] The velocity of the ball on the way down is
    a) positive (in the upward direction).
    b) zero (~~no accelerati~~on).
    c) negative (in the downward direction).
    d) Can not tell. It depends on the initial position.



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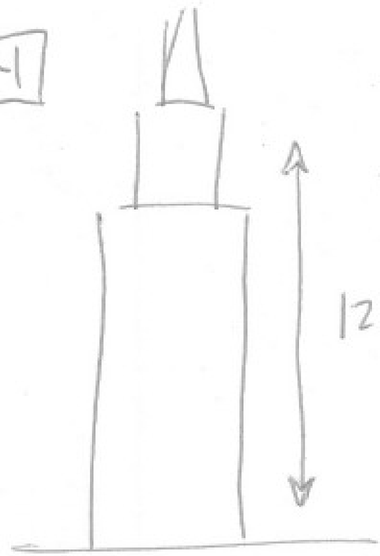
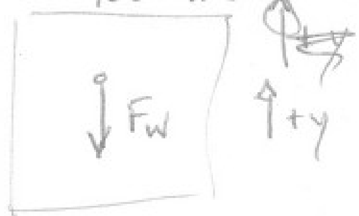


$y_0 = 373m$
$V_{oy} = 0m/s$

$\downarrow g$

NO AIR DRAG



$1224ft = 373\,m = |y - y_0| = h$

$y = 0m$
$t = ?$
$V_y = ?$

$v = \cancel{v_o} - gt$
$y = y_0 + v_{oy} - \frac{1}{2}gt^2$

Since $v_{oy} = 0$

$t^2 = \frac{2h}{g}$ $\boxed{t = 8.7s}$

$g = 9.81m/s^2$

* Equations of motion do not depend on mass.

$v = -gt$ $\boxed{v = 85\,m/s}$

This is quite fast – clearly air drag is significant. Time is reasonable – count how long it takes for a ball to be thrown up and down – and it is not even close to 373m. Units check. As distance decreases, time decreases.

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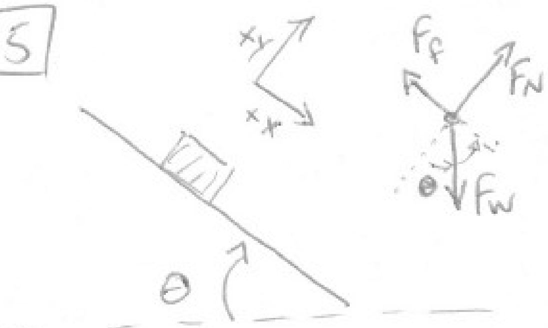

$\sum\vec{F} = m\vec{a}$ $F_f = \mu_s F_N$

$F_N - F_W\cos\theta = 0$ NOT MOVING

$F_W\sin\theta - F_f = 0$

$F_W\sin\theta = \mu_s F_N$ AND $F_N = F_W\cos\theta$

$\cancel{F_W}\sin\theta = \mu_s \cancel{F_W}\cos\theta$

$\boxed{\tan\theta = \mu_s}$ $\mu_s = 0.65$

NOTE: does not depend on mass only on θ

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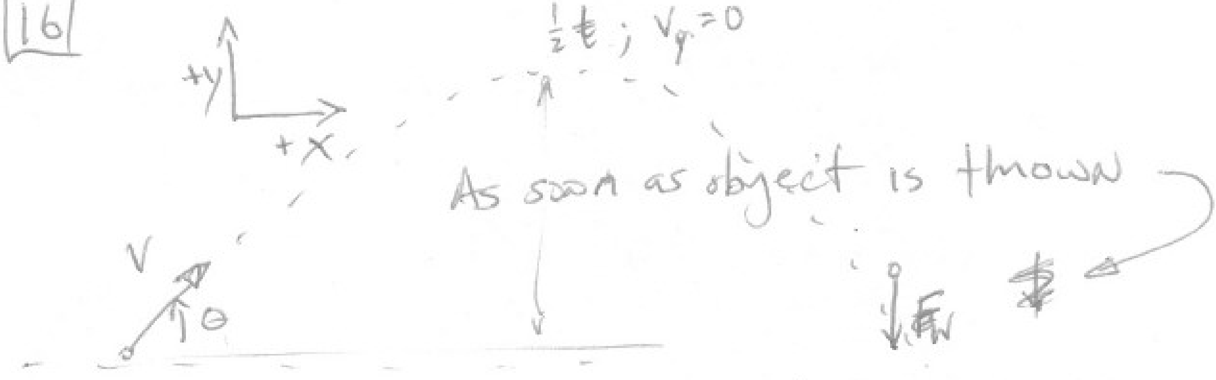

so $\quad x = x_0 + v_{0x} t + \cancel{\tfrac{1}{2} a_x t^2} \quad 0 = a_x \qquad v_x = v_{0x} + \cancel{a_x t} \quad a_x = 0$

$\quad y = y_0 + v_{0y} t - \tfrac{1}{2} g t^2 \qquad v_y = v_{y0} - g t$

$v_{0x} = v\cos\theta \qquad R = x - x_0$ (range)

$v_{0y} = v\sin\theta$

$R = v_{0x} t = v\cos\theta(t)$

@ top of trajectory $v_y = 0$

so $0 = v_{y0} - g t'$

$0 = v\sin\theta - g t'$

$\dfrac{v\sin\theta}{g} = t'$

$t = 2t'$

$R = \left(\dfrac{v\cos\theta\sin\theta}{g}\right)2$

use trig. relation ...

$R = \dfrac{v}{g}\sin(2\theta)$ this is max when $\sin(2\theta) = 1$

so $\theta = \frac{1}{2}(\sin^{-1} 1) = 45°$

MAX range is at 45°, does not matter ~~how~~ what initial height ~~is~~ (assuming no air drag)

[You can also see this w/o trig relationship. max of $\cos\theta\sin\theta$ can not be at $\theta = 0$ or at $\theta = 90°$ where each is 0 so ... max is when each is ~~as large~~ equally large]