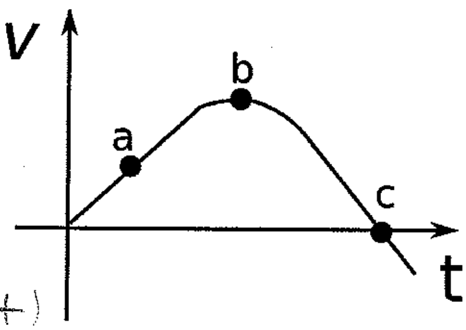
Physics 213H Test 1

Section 1: Dr. Gladden, Sept. 29, 2009

NAME: KEY   UM ID#: ____________

Conceptual Questions (*5 points each*) Answer each of the following questions drawing on and referencing the physical concepts we have covered. Sketches may aid your discussion and no more than 2 - 4 sentences should be required.



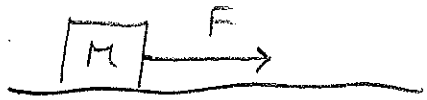
1. Describe the motion of a car (as in acceleration and velocity) which follows the velocity - time graph shown below in the various parts indicated.

a: • Constant acceleration and (+)
• v is linearly increasing with time
• Started from rest

b – • acceleration is 0 (Slope is 0)

c – • acceleration is negative – it has slowed to $v = 0$ at this point. Here it is changing directions.

2. A block of mass M with a string attached rests on a *perfectly frictionless* surface. A student pulls gently on the string and the block accelerates according to $\vec{F} = m\vec{a}$. The student repeats the experiment, but now yanks hard on the string and the string breaks. Use Newton's Laws to explain why this happens.

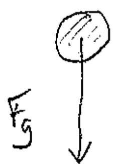


The rope can take a maximum tension of T.

If $F = Ma > T$, then it will break. So upon "yanking", you are trying to accelerate the block faster than $a = \frac{T}{M}$, thus it breaks.

3. We've seen that a more massive object has a larger gravitational force acting on it than a less massive one. Why is it then that all objects accelerate downward with the same acceleration (9.8 m/s^2) regardless of mass?

Consider an object in "free fall" – so only gravity is acting on it. Then $F_g = mg$, but Newton's 2^{nd} Law says $F = ma$.



So $mg = ma$ and mass cancels out meaning all objects accelerate with 9.8 m/s^2 in free fall regardless of weight. By the way, this assumes gravitational mass is the same as inertial mass → true as best as we can test it!

Conceptual Multiple Choice (*4 points each*): Clearly write the letter corresponding to the BEST possible answer in the space provided. You may also circle the answer to be sure.

1. C The position, x, of an object is given by the equation $x = A + Bt + Ct^2$, where t refers to time. What are the dimensions of A, B, and C?
   A) distance, distance, distance
   B) distance, time, time^2
   C) distance, distance/time, distance/ time^2
   D) distance/time, distance/ time^2, distance/ time^3

2. B What is the percent uncertainty in the measurement 2.58 0.15 cm?
   A) 2.9%
   B) 5.8%
   C) 8.7%
   D) 12%

3. C The number of significant figures in 0.01500 is
   A) two.
   B) three.
   C) four.
   D) five.

4. C When is the average velocity of an object equal to the instantaneous velocity?
   A) always
   B) never
   C) only when the velocity is constant
   D) only when the velocity is increasing at a constant rate

5. A If the velocity of an object is zero, does it mean that the acceleration is zero? Support your answer with an example.

A) no, and an example would be an object starting from rest
B) no, and an example would be an object coming to a stop
C) yes, because of the way in which velocity is defined
D) yes, because of the way in which acceleration is defined

6. B Suppose a ball is thrown straight up, reaches a maximum height, then falls to its initial height. Make a statement about the direction of the velocity and acceleration as the ball is going up.

A) Both its velocity and its acceleration point upward.
B) Its velocity points upward and its acceleration points downward.
C) Its velocity points downward and its acceleration points upward.
D) Both its velocity and its acceleration points downward.

7. D The resultant (sum) of two vectors is the smallest when the angle between them is

A) 0°.
B) 45°.
C) 90°.
D) 180°.

8. A Three forces, each having a magnitude of 30 N, pull on an object in directions that are 120 apart from each other. Make a statement concerning the resultant force.

A) The resultant force is zero.
B) The resultant force is greater than 30 N.
C) The resultant force is equal to 30 N.
D) The resultant force is less than 30 N.

9. A You are standing in a moving bus, facing forward, and you suddenly fall forward. You can imply from this that the bus's

A) velocity decreased.
B) velocity increased.
C) speed remained the same, but it's turning to the right.
D) speed remained the same, but it's turning to the left.

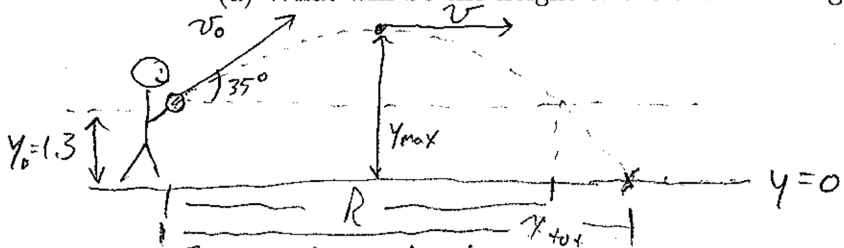
10. C If you blow up a balloon, and then release it, the balloon will fly away. This is an illustration of

A) Newton's first law.
B) Newton's second law.
C) Newton's third law.
D) Galileo's law of inertia.

Problems: Work each of the following problems. Make sure to **show your work** and put a box around your final answer. (*15 points each*)

1. A shot putter launches the shot with an initial velocity of 12 m/s at an angle of 35° from the horizontal and a initial height of 1.3 m off the ground.

   (a) What will be the height of the shot off the ground at its highest point?



$v_{fy} = 0$ at top

$v_{oy} = v_0 \sin\theta$

$= 12\,m/s \sin(35°) = 6.9\,m/s$

Vert. motion $a_y = g$

$v_{fy}^2 = v_{oy}^2 + 2g\Delta y$, $\Delta y = y_{max} - y_0$

$y_{max} = y_0 + \frac{v_{fy}^2 - v_{oy}^2}{2g}$

$= 1.3 + \left[\frac{0 - (6.9\,m/s)^2}{2(-9.8\,m/s^2)}\right]$

$\boxed{y_{max} = 3.7\,m}$

   (b) How far will it have traveled horizontally when it comes back down to its *initial height* (1.3 m off the ground)?

Can use range eqn. here

$$R = \frac{v_0^2}{g}\sin(2\theta) = \frac{(12\,m/s)^2}{9.8\,m/s^2}\sin(70°)$$

$$\boxed{R = 13.8\,m}$$

   (c) Write the equations you would need to figure out how much further horizontal distance the shot would gain by the time it hit the ground. You also need to write a few comments about how you would use those equations.

From horiz. motion

① --- $x_{tot} = v_{ox} t_f + x_0$

$x_0 = 0$, t_f is total time in the air

$v_{ox} = v_0 \cos\theta$

Need t_f from Vert. motion eqns.

From Vert motion:

When it lands, $y_f = 0$

$y_f = y_0 + v_{oy} t_f + \frac{1}{2} g t_f^2$

$v_{oy} = v_0 \sin\theta$

Need to solve for t_f

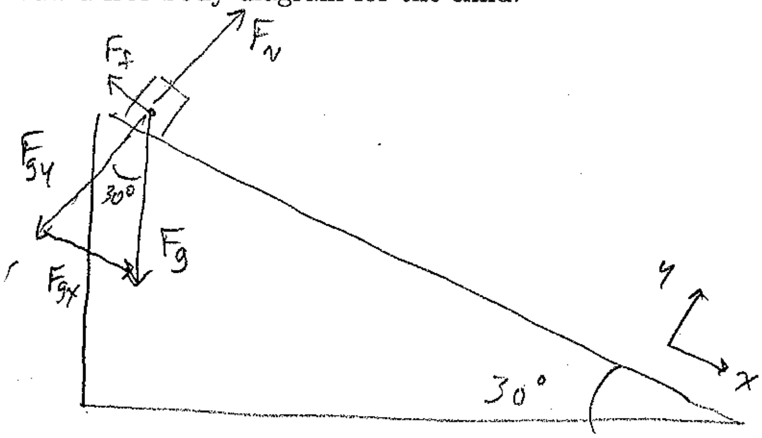
$\frac{1}{2} g t_f^2 + v_{oy} t_f + y_0 = 0$

would need quadratic eqn.

once you have t_f, plug in ① to get total horiz. displacement

2. A child is at the top of a slide which makes and angle of 30° with the ground and is 5.0 m long (not high). The coefficient of kinetic friction is $\mu_k = 0.1$.

(a) Draw a free body diagram for the child.



(b) What will the acceleration of the child be down the slide?

$$\Sigma F_x = m a_x = F_{gx} - F_f \qquad \Sigma F_y = m a_y = F_N - F_{gy} = 0$$

$$= mg \sin\theta - \mu_k F_N \qquad \text{so } F_N = F_{gy} = mg\cos\theta$$

so $m a_x = mg \sin\theta - \mu_k mg \cos\theta$

$$a_x = g \sin\theta - \mu_k g \cos\theta = 9.8 \sin(30°) - 0.1(9.8)(\cos(30°))$$

so $\boxed{a_x = 4.1 \, m/s^2}$

(c) If he starts from rest, what will his final speed be at the bottom of the slide?

use $v_{fx}^2 = v_{oy}^2 + 2a_x \Delta x$, $\Delta x = L$ here, $v_{oy} = 0$ (starts from rest)

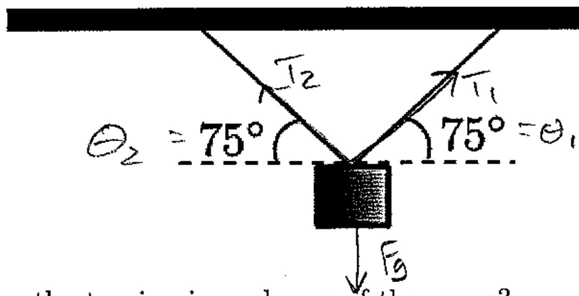
so

$$v_{fx}^2 = 2a_x L$$

$$v_{fx} = \sqrt{2(4.1 \, m/s^2)(5.0 \, m)}$$

$$\boxed{v_{fx} = 6.4 \, m/s}$$

3. A 100.0 kg mass is hung by two ropes, each make an angle of 75° from the horizontal.



$\vec{a} = 0$ here, so all forces cancel each other $\Sigma F = 0$ so $\Sigma F_x = 0$ + $\Sigma F_y = 0$

(a) What will be the tension in each one of the ropes?

$\Sigma F_y = T_{2y} + T_{1y} - mg = 0$

$T_{2y} = T_2 \sin\theta_2$

$T_{1y} = T_1 \sin\theta_1$

$\Sigma F_x = T_{1x} - T_{2x} = 0$

so $T_{1x} = T_{2x}$

$T_1 \cos\theta_1 = T_2 \cos\theta_2$, but $\theta_1 = \theta_2$

so $T_1 = T_2$, call it T

Then $T_y = T_{1y} = T_{2y} = T\sin\theta$

$2T_y = mg \Rightarrow T = \frac{mg}{2\sin\theta}$

so

$T = \frac{mg}{2\sin\theta}$

$= \frac{(100.0)(9.8\ m/s^2)}{2\sin 75°}$

$T = 507\ N$

(b) What would the tension have to be for the angle to 0°? (Show mathematically why this is the case.)

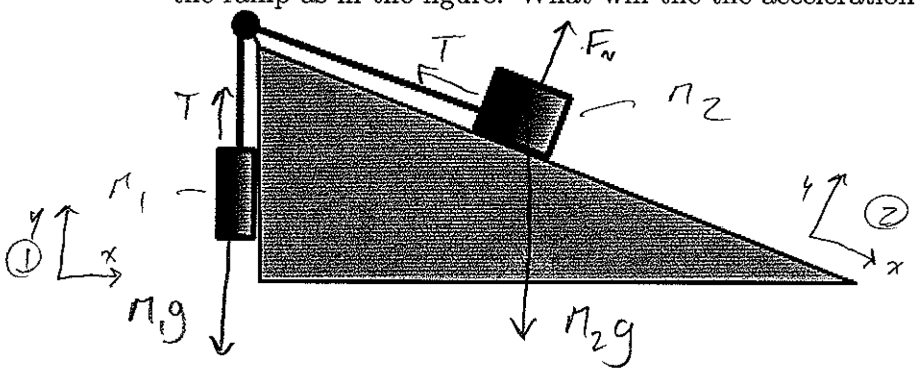
Look at eqn. for the tension: $T = \frac{mg}{2\sin\theta}$

if $\theta = 0$, $\sin\theta = 0$, the $T \to \infty$. You would need an infinite tension to have the ropes perfectly straight across!

This is because you must have some T_y to balance the weight.

Extra Credit(+5 points)

A box of mass 10.0 kg is on a 25° frictionless ramp with a massless rope attached to it. The other end of the rope is attached to to a 12.0 kg mass hanging vertically off the top of the ramp as in the figure. What will the the acceleration of the box on the ramp?



Hint: • use 2 coord. systems, one for each mass
• use $+9.8\,m/s^2$ for g and put in + or − in your force equations

For m_1

Only vertical motion

$$\Sigma F_y = T - m_1 g = m a_1$$

$$T = m_1 a_1 + m_1 g$$

For m_2

$$\Sigma F_x = m_2 g \sin\theta - T = m_2 a_x$$

$$\text{So } T = m_2 g \sin\theta - m_2 a_x$$

Since m_1 + m_2 are joined by a rope, $|a_1| = |a_x|$, call them a

Now

$$m_1 a + m_1 g = m_2 g \sin\theta - m_2 a$$

$$(m_1 + m_2) a = m_2 g \sin\theta - m_1 g$$
$$= g(m_2 \sin\theta - m_1)$$

$$\text{so } a = \frac{g(m_2 \sin\theta - m_1)}{m_1 + m_2} = \frac{9.8\,(10 \sin(25) - 12)}{(10 + 12)}$$

$a = -3.5\,m/s^2$ → accelerating up the ramp