Name Key Seat Number ______

PHYSICS 2110
Exam I – Fall 2010

INSTRUCTORS (Circle ONE):	CLASS MEETING TIME
Shriner	MWF 8:00 AM
Ayik	MWF 10:10 AM
Murdock	MWF 12:20 AM

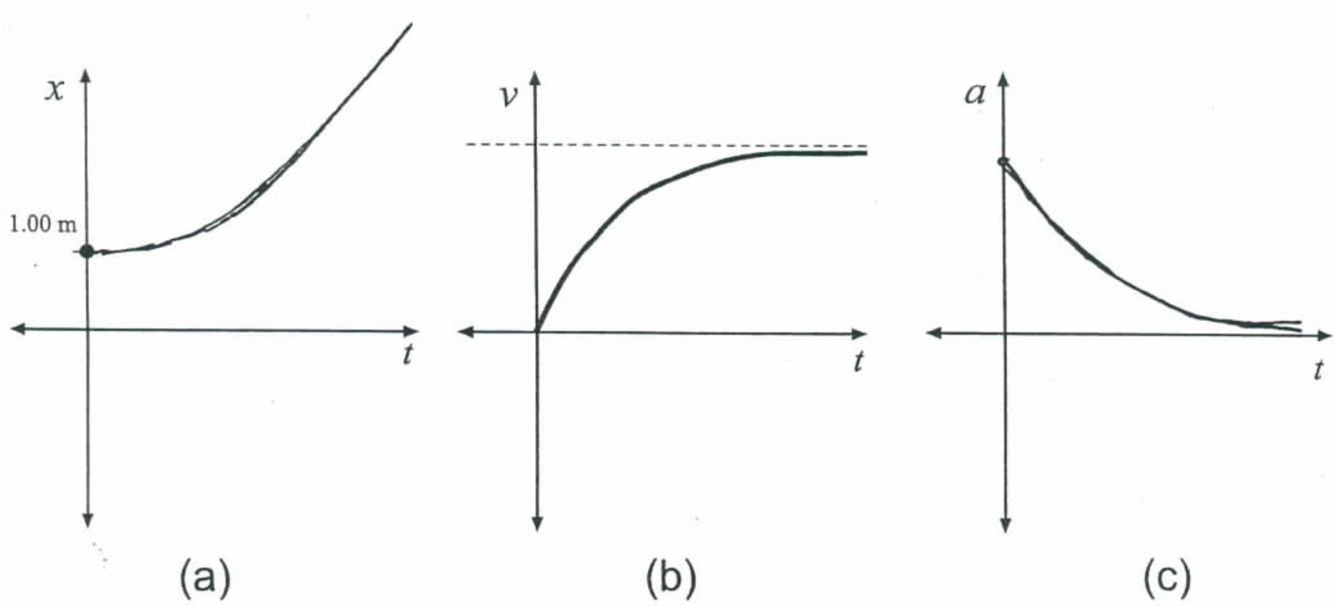
YOU MUST SHOW YOUR WORK **AND** EXPLAIN YOUR REASONING TO RECEIVE CREDIT. ALL CELL PHONES AND OTHER COMMUNICATION DEVICES MUST BE TURNED OFF AND STORED OUT OF SIGHT. NO EXTRA PAPERS ARE ALLOWED OTHER THAN THE PROVIDED FORMULA SHEET.

Free-body diagrams are ***required*** for problems involving forces. For problems involving free-fall, you may ignore air resistance.

PROBLEM	POINT VALUE	YOUR SCORE
1	10	
2	12	
3	11	
4	11	
5	12	
6	11	
7	8	
8	12	
9	13	
TOTAL	100	

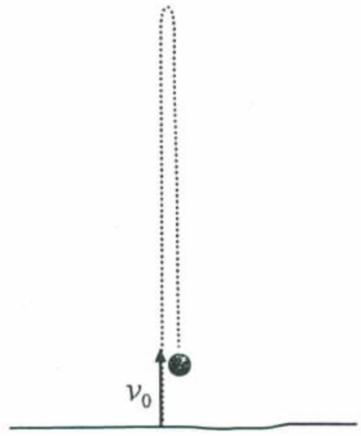
1. A particle moves along the x axis; the plot of v vs. t is given in (b) below.

In the spaces provided, make sketches of the curves for x vs t and a vs t for the same time interval as the first graph; the particle's position at t=0 is 1.00 m. (You just need to give the *appearance* of these curves.) (10 pts)



2.

(a) At what speed must you shoot a projectile straight up so that its *total* time of flight is 10.0 s? (6 pts)



At $t = 10.0\,s$, $x = 0$ so $x(t)$ eqn gives:

$0 = v_0(10.0\,s) - \frac{1}{2}g(10.0\,s)^2$ Solve:

$v_0 = \frac{g(10.0\,s)}{2} = \boxed{49.0\,m/s}$

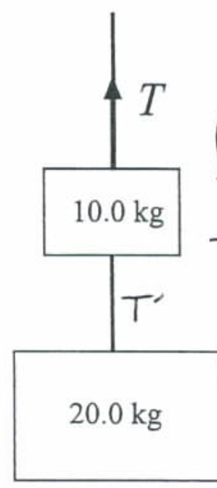
(b) At the firing speed given in (a), what is the maximum height that the projectile will reach? (6 pts)

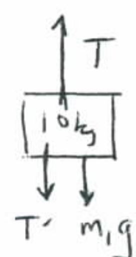
On the trip up, $v_0 = +49.0\,\frac{m}{s}$, $v = 0$, $a_y = -g$

$v^2 = v_0^2 + 2ay$ $0 = (49.0\,\frac{m}{s})^2 - 2(9.8\,\frac{m}{s^2})\,y$

$\rightarrow y = \boxed{123\,m}$

3. Two masses (10.0 kg and 20.0 kg) are connected by a string and are pulled upwards as shown by a string connected to the top mass. The string connecting the masses can only withstand a tension of 300.0 N.





(a) What is the maximum possible tension in the top string so that the connecting string doesn't break? (8 pts)

Draw FBD's; newton's 2nd law gives

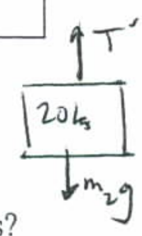
$T - T' - m_1 g = m_1 a$

$T' - m_2 g = m_2 a$ (same accel)

Set $T' = 300\,N$ then 2nd eqn gives

$a = \frac{300\,N - (20\,kg)(9.8\,m/s^2)}{20\,kg} = 5.2\,\frac{m}{s^2}$ and the first eqn gives

$T = T' + m_1 g + m_1 a = \boxed{450\,N}$

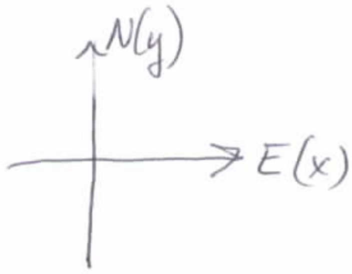


(b) Under the conditions of part (a), what is the magnitude of the acceleration of the masses? (3 pts)

a was found in part (a) and it hasn't changed since then

It is: $\boxed{a = 5.2\,\frac{m}{s^2}}$

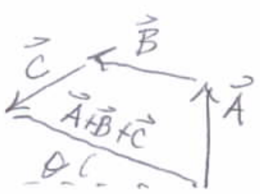
4. A hiker travels 1.5 km north, then turns to a heading 20.° north of west and travels 1.8 km in that direction, then finally turns to a heading 25.° south of west and travels 1.2 km in that direction. Find both the magnitude and direction of the hiker's displacement vector. (11 pts)



$\vec{A} = 1.5\hat{j}$ km

$\vec{B} = -1.8\text{ km}\cos 20^\circ\,\hat{i} + 1.8\text{ km}\sin 20^\circ\,\hat{j} = (-1.7\hat{i} + 0.62\hat{j})$ km

$\vec{C} = -1.2\text{ km}\cos 25^\circ\,\hat{i} - 1.2\text{ km}\sin 25^\circ\,\hat{j} = (-1.1\hat{i} - 0.51\hat{j})$ km

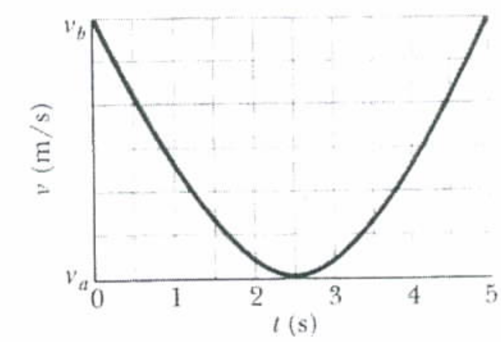


$\vec{A}+\vec{B}+\vec{C} = (-2.8\hat{i} + 1.6\hat{j})$ km

$|\vec{A}+\vec{B}+\vec{C}| = \sqrt{(-2.8)^2 + (1.6)^2}$ km $= 3.2$ km

θ (shown in figure at left) $= \tan^{-1}\frac{1.6}{2.8} = 30^\circ$

5. A golf ball is struck at ground level. Its speed as a function of time is shown in the figure to the right, where t = 0 is the time at which the ball is struck. The numerical values on the vertical axis are v_b = 31 m/s and v_a = 19 m/s.



(a) How far does the ball travel horizontally before returning to ground level? (6 pts)

High point occurs at $t = 2.5$ s

There $v_y = 0 \Rightarrow v_x = 19$ m/s. Since v_x is constant, $v_{ox} = 19$ m/s

$x = x_o + v_{ox}t + \frac{1}{2}a_x t^2 = 0 + (19\text{ m/s})(5\text{ s}) + \frac{1}{2}(0\text{ m/s}^2)(5\text{ s})^2$

$= 95$ m

(b) What is the maximum height above ground level attained by the ball? (6 pts)

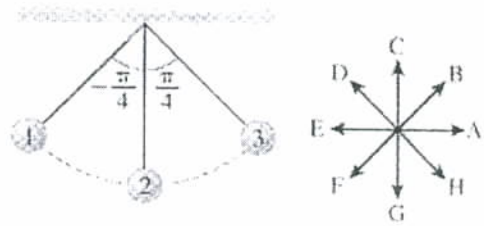
$v_o = 31$ m/s, $v_{ox} = 19$ m/s $\Rightarrow v_{oy} = \sqrt{(31\text{ m/s})^2 - (19\text{ m/s})^2} = 24$ m/s

$y = y_o + v_{oy}t + \frac{1}{2}a_y t^2$

$y(t=2.5\text{ s}) = 0\text{ m} + (24\text{ m/s})(2.5\text{ s}) + \frac{1}{2}(-9.80\text{ m/s}^2)(2.5\text{ s})^2$

$= 31$ m

6. A pendulum bob swings back and forth between positions 1 and 3, as shown in the left part of the figure to the right. (11 pts)



(a) For each of the following statements, indicate true or false.

(i) The acceleration of the pendulum has a magnitude equal to g. F not in free fall
(ii)

(iii) The acceleration of the pendulum is equal to the instantaneous rate of change of its velocity. T
definition of acceleration

(iv) The acceleration of the pendulum is equal to the instantaneous rate of change of its speed. F
speed ≠ velocity, acceleration is vector

(v) The acceleration of the pendulum is everywhere perpendicular to the bob's trajectory. F
not uniform circular motion

(vi) The acceleration of the pendulum is everywhere tangential to the bob's trajectory. F
circular motion

(b) For each quantity below, write the letter of the arrow (choices A-H) above that best indicates the direction of the quantity requested. If you believe the value should be zero, use the letter Z to indicate that. One of the directions B, D, F, or H should be used to indicate directions that are neither purely horizontal nor purely vertical. Take the origin to be where the string attaches to the ceiling.

(i) The position vector when the pendulum is at position 3. H

(ii) The displacement vector as the pendulum moves from position 2 to position 3. B

(iii) The velocity vector at position 1. Z

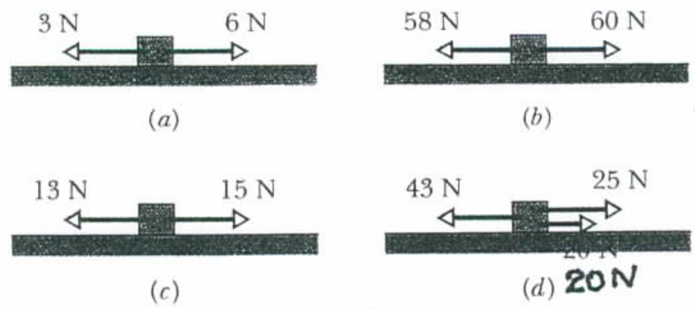
(iv) The acceleration vector at position 3. ~~Could~~ F

(v) The velocity vector at position 2 when moving toward position 3. A

(vi) The acceleration vector at position 2. C

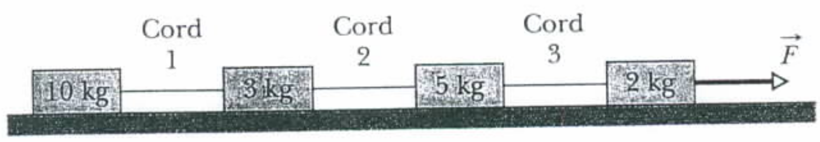
7.

(a) The figure shows the same breadbox in four situations where horizontal forces are applied. Rank the situations according to the magnitude of the box's acceleration, greatest first. (4 pts)



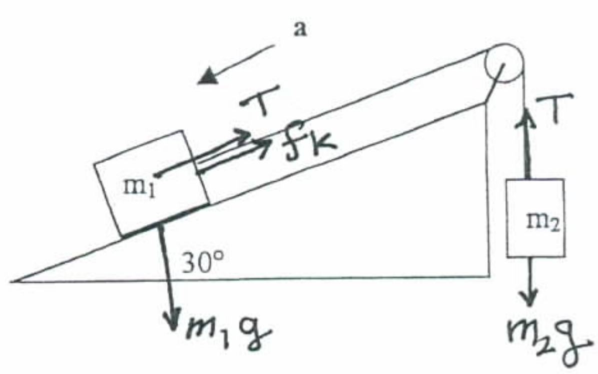
a, b=c=d

(b) A train of four blocks is pulled across a frictionless floor by a force $\vec{F} = 50.0\hat{i}$ N. Rank the cords according to the magnitudes of their tensions, greatest first. (4 pts)



T_3, T_2, T_1

8. A block of mass m_1 = 40. kg on an inclined plane is connected by a cord which runs over a massless, frictionless pulley to a second (hanging) block of unknown mass m_2, as shown. When the system is released, m_1 accelerates down the incline with an acceleration of 2.2 m/s^2. The incline makes an angle of θ = 30.° with the horizontal, and there is friction between m_1 and the incline. The tension in the cord is T = 60. N.



(a) Determine the **mass m_2** of the second block. (5 pts)

$$T - m_2 g = m_2 a$$

$$m_2 = \frac{T}{g+a} = \frac{60}{9.8+2.2} = 5.0 \text{ kg}$$

(b) Calculate the **frictional force** (not the friction coefficient) acting on the **block m_1**. (7 pts)

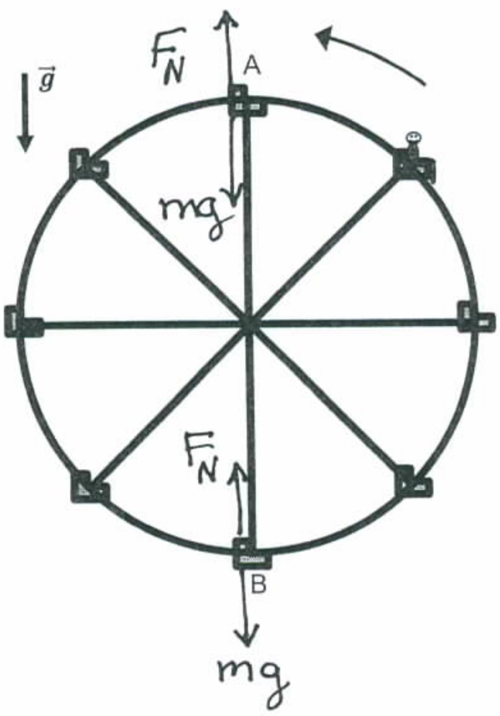
$$m_1 g \sin 30° - T - f_k = m_1 a$$

$$40*9.8*0.5 - 60 - f_k = 40*2.2$$

$$196 - 60 - f_k = 88$$

$$f_k = 48 \text{ N}$$

9. A 30. kg child is riding at constant speed on a Ferris wheel of radius 8.0 m. The magnitude of her acceleration is $2.0 \mathrm{m/s^2}$



(a) Calculate the speed of the child. (3 pts)

$a = \frac{v^2}{R}$

$v = \sqrt{aR} = \sqrt{2 \times 8}$

$v = 4.0 \ m/s$

(b) Calculate the **force exerted on the child** by the seat of the Ferris wheel for each of the following positions. You should draw a free body diagram for the child in each case.

i. Position A (5 pts)

$mg - F_N = ma$

$F_N = mg - ma$

$F_N = 30(9.8 - 2.0) = 234N$

ii. Position B (5 pts)

$F_N - mg = ma$

$F_N = mg + ma$

$F_N = 30(9.8 + 2.0) = 354N$