KEY

PHYSICS 2110 – EXAM #1
October 6, 2011

SEAT NO._______________ **NAME (PRINT)**____________________________

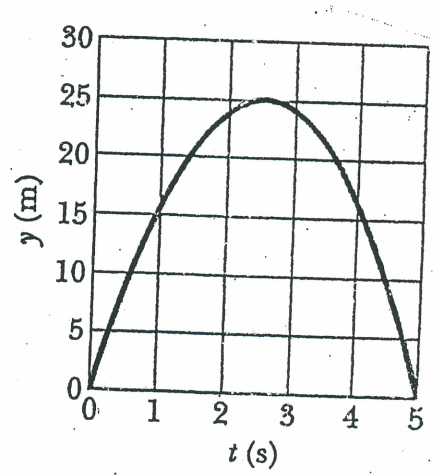
YOU MUST SHOW YOUR WORK **AND** EXPLAIN YOUR REASONING TO RECEIVE CREDIT. ALL CELL PHONES AND OTHER COMMUNICATION DEVICES MUST BE TURNED OFF AND STORED OUT OF SIGHT. NO EXTRA PAPERS ARE ALLOWED OTHER THAN THE PROVIDED FORMULA SHEET. STANDARD SCIENTIFIC CALCULATORS MAY BE USED.

Free-body diagrams are ***required*** for problems involving forces.

INSTRUCTORS (Circle ONE):	CLASS MEETING TIME
Shriner	8:00 AM
Kozub	9:05 AM
Ayik	10:10 AM
Murdock	12:20 PM

PROBLEM	POINT VALUE	YOUR SCORE
1	10	
2	5	
3	10	
4	12	
5	13	
6	10	
7	15	
8	18	
9	7	
TOTAL	100	

1. A ball is vertically shot upward from the surface of a planet. The plot shows y versus t for the ball, where y is the height of the ball above its starting point and time $t = 0$ is the instant that the ball is shot.



(a) Find the free-fall acceleration on the planet. (5 points)

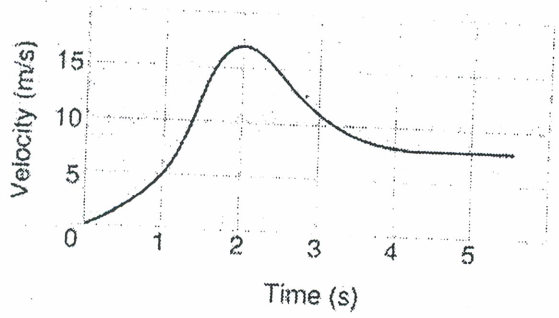
$y_m = \frac{1}{2} g t^2$

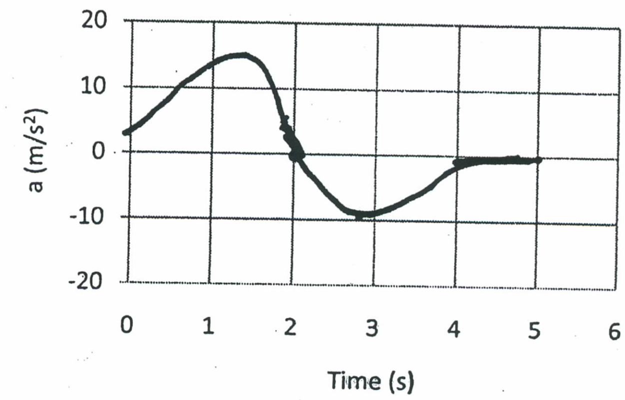
$g = \frac{2 y_m}{t^2} = \frac{2 * 25}{(2.5)^2} = \boxed{8.0 \ m/s^2}$ $\boxed{\text{down}}$

(b) What is the initial velocity of the ball? (5 points)

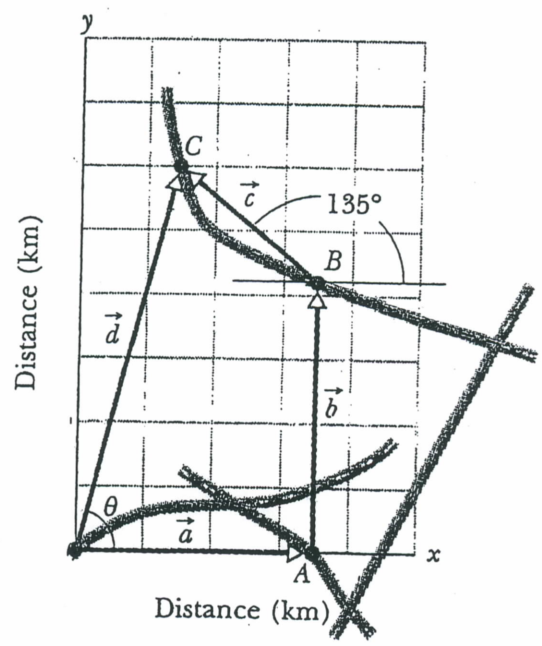
$V_{y_0} = g t = 8.0 \times 2.5 = \boxed{20 \ m/s}$ $\boxed{\text{up}}$

2. An object moves in a straight line as described by the velocity vs. time graph shown below. Sketch the acceleration vs. time graph for this object. (5 points)





3. The figure on the right gives an incomplete map of a road rally. From the starting point (at the origin), you must use the available roads to go through the following displacements:
(i) $\vec{a}$ to checkpoint Able, magnitude 36.0 km, due east.
(ii) $\vec{b}$ to checkpoint Baker, due north.
(iii) $\vec{c}$ to checkpoint Charlie, magnitude 25.0 km, at the angle shown. Your net displacement $\vec{d}$ from the starting point has a magnitude of 62.0 km.
(a) Calculate the direction θ of the net displacement $\vec{d}$. (5 points)



$$d_x = a_x + b_x + c_x$$

$$62 \cos\theta = 36 + 0 + 25 \cos 135°$$

$$\cos\theta = \frac{36 + 25\cos 135°}{62} \Rightarrow \boxed{\theta = 72.8°}$$

(b) Calculate the magnitude of the displacement $\vec{b}$. (5 points)

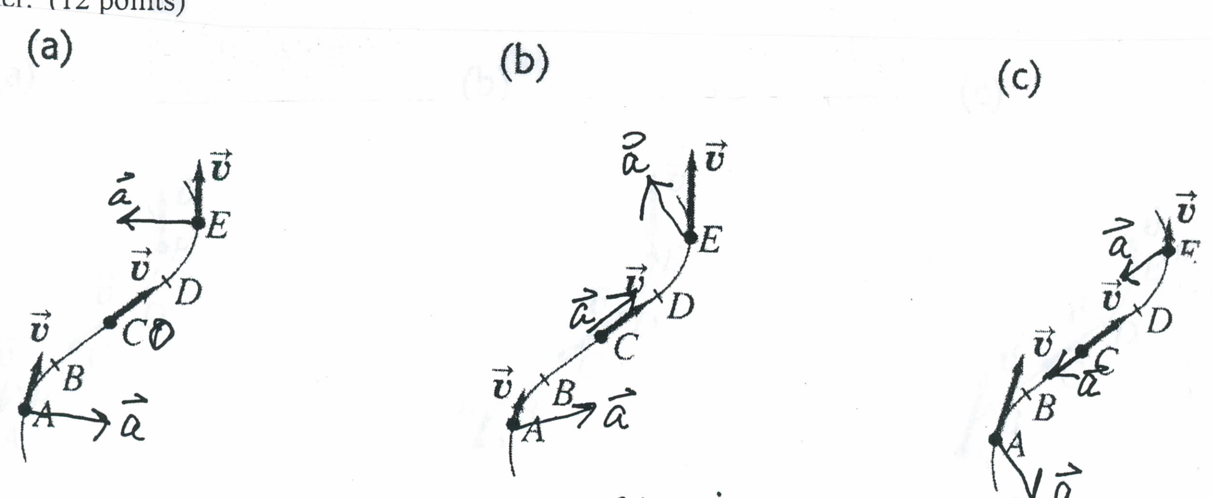
$$d_y = a_y + b_y + c_y$$

$$62 \sin\theta = 0 + b + c \sin 135°$$

$$b = 62 \sin 72.8 - 25 \sin 135° \Rightarrow \boxed{b = 41.5 m}$$

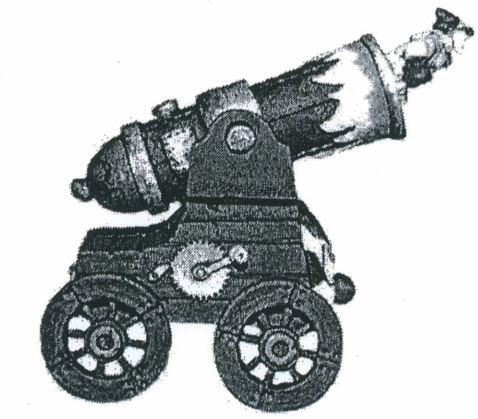
4. A particle moves along a path as shown in the three drawings below. Between points B and D, the path is a straight line. In drawing (a), the particle has constant speed as indicated by the three velocity vectors' having the same magnitude. In drawing (b), the particle is speeding up all along the path, while in drawing (c) the particle is slowing down all along the path.

In **each** drawing, indicate the direction of the acceleration vector at points A, C, and E. If the acceleration is zero at any of these points, indicate that by placing a "0" next to the appropriate letter. (12 points)



Component of $\vec{a} \perp \vec{v}$ necessary to change direction
Component of $\vec{a} \parallel \vec{v}$ necessary to change speed

5. A circus clown is shot out of a cannon and flies across the big top to a waiting net. The clown leaves the cannon at a height of 1.5 m above the floor. The cannon is aimed at 39° above horizontal, and the speed with which the clown leaves the cannon is 11 m/s (relative to the ground).



(a) Find the maximum vertical distance above the floor of the clown. (6 points)

What is y when $v_y = 0$? Put $y=0$ at ground

$v_{y0} = 11\,m/s \sin 39° = 6.9\,m/s$, $y_0 = 1.5\,m$

$v_y^2 = v_{y0}^2 + 2a_y(y-y_0)$

$(0\,m/s)^2 = (6.9\,m/s^2) + 2(-9.80\,m/s^2)(y-1.5\,m)$

$\Rightarrow y = 3.9\,m$

(b) The center of the net is located a horizontal distance of 11.3 m from the mouth of the cannon. How high should the center of the net be so that the clown hits that central point? (7 points)

Find time to travel $x - x_0 = 11.3\,m$: $x = x_0 + v_{x0}t + \frac{1}{2}a_x t^2 \Rightarrow 11.3\,m = (11\,m/s \cos 39°)t + \frac{1}{2}(0)t^2$

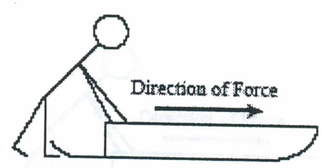
$\Rightarrow t = 1.32\,s$

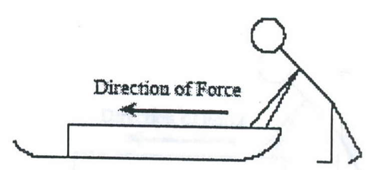
Find y at $t = 1.32\,s$

$y = y_0 + v_{y0}t + \frac{1}{2}a_y t^2 = 1.5\,m + (11\,m/s \sin 39°)(1.32\,s) + \frac{1}{2}(-9.80\,m/s^2)(1.32\,s)^2$

$= 2.1\,m$

6. A sled on ice moves in the ways described in the questions below. Friction is so small that it can be ignored. A person wearing spiked shoes standing on the ice can apply a force to the sled and push it along the ice. Circle the number corresponding to the best answer to each of the following. (2 points each)





(a) Which force would keep the sled moving toward the right and speeding up at a steady rate (constant acceleration)?

1. The force is toward the right and is increasing in strength (magnitude).
2. The force is toward the right and is of constant strength (magnitude).
3. The force is toward the right and is decreasing in strength (magnitude).
4. The force is toward the left and is decreasing in strength (magnitude).
5. The force is toward the left and is increasing in strength (magnitude).
6. The force is toward the left and is of constant strength (magnitude).
7. The applied force is zero.

(b) Which force would keep the sled moving toward the right at a steady (constant) velocity?

1. The force is toward the right and is increasing in strength (magnitude).
2. The force is toward the right and is of constant strength (magnitude).
3. The force is toward the right and is decreasing in strength (magnitude).
4. The force is toward the left and is decreasing in strength (magnitude).
5. The force is toward the left and is increasing in strength (magnitude).
6. The force is toward the left and is of constant strength (magnitude).
7. The applied force is zero.

(c) The sled is moving toward the right. Which force would slow it down at a steady rate (constant acceleration)?

1. The force is toward the right and is increasing in strength (magnitude).
2. The force is toward the right and is of constant strength (magnitude).
3. The force is toward the right and is decreasing in strength (magnitude).
4. The force is toward the left and is decreasing in strength (magnitude).
5. The force is toward the left and is increasing in strength (magnitude).
6. The force is toward the left and is of constant strength (magnitude).
7. The applied force is zero.

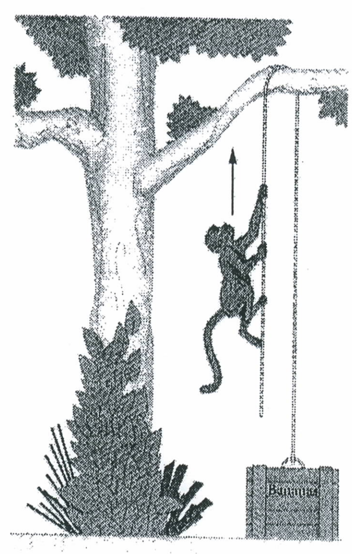
(d) The sled is accelerating to the right. The force exerted on the sled by the person

1. is greater in magnitude than the force exerted on the person by the sled.
2. is less in magnitude than the force exerted on the person by the sled.
3. is equal in magnitude to the force exerted on the person by the sled.
4. is equal to the force exerted on the person's shoes by the ice.
5. is equal to the normal force exerted on the person by the ice.
6. is equal to the normal force exerted on the ice by the sled.
7. is zero.

(e) The sled is accelerating to the left. The reaction to the normal force exerted on the sled by the ice is

1. the weight of the sled.
2. the weight of the person.
3. the normal force exerted on the person.
4. the attractive gravitational force exerted on the earth by the sled.
5. the normal force exerted on the ice by the sled.
6. the normal force exerted on the sled by itself.
7. is zero.

7. A 12.0-kg monkey climbs up a massless rope that runs over a frictionless tree limb. The other end of the rope is connected to a 16.0-kg box of bananas on the ground.



(a) Draw carefully labeled free body force diagrams for the box and the monkey for the situation when the box is still on the ground. (5 points)

(b) Calculate the minimum acceleration that the monkey must have in order to lift the box off the ground. (5 points)

$\vec{n} = 0$ and $T = Mg = (16.0\,kg)(9.80\,\frac{m}{s^2}) = 157\,N$ to lift box. $a_{box} = 0$

Then for monkey, $F_{net} = ma$:

$T - mg = ma$

$$a = \frac{T - mg}{m} = \frac{157\,N - (12.0\,kg)(9.80\,m/s^2)}{12.0\,kg} = 3.27\,\frac{m}{s^2}$$

(c) After the box is lifted, the monkey stops climbing and just hangs on to the rope. What will be the tension in the rope under these conditions (before the box hits the ground again)? (5 points)

$a_{box} = a_{monkey} = a$.

Monkey: $T - mg = ma$

Box: $Mg - T = Ma$

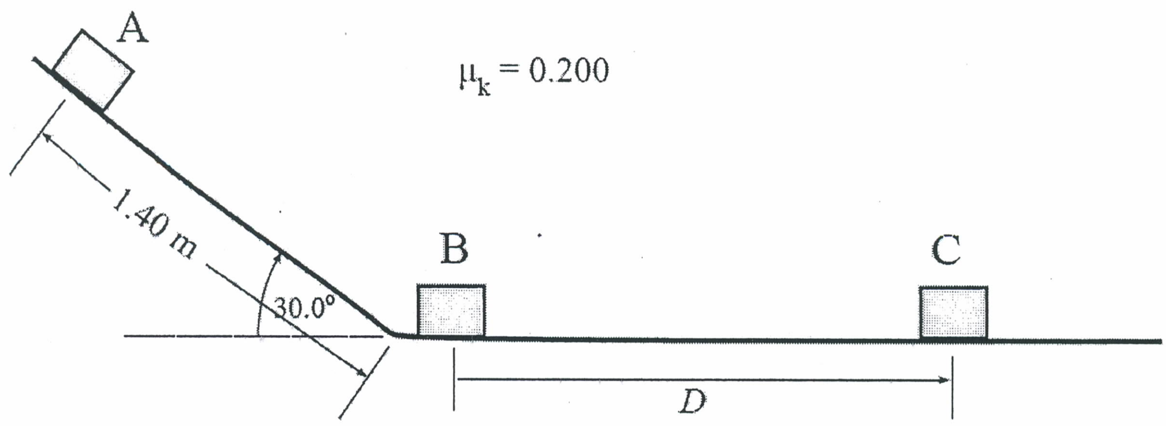
$Mg - mg = (M+m)a$

$$a = \frac{g(M-m)}{M+m} = \frac{4g}{28} = 1.40\,m/s^2$$

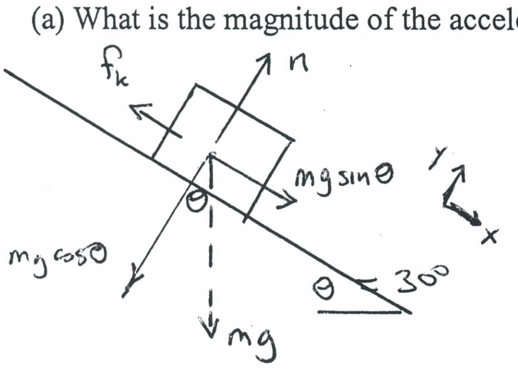
$\therefore T = m(g+a) = (12\,kg)(9.80 + 1.40)\,\frac{m}{s^2}$

$T = 134\,N$

8. A 1.50-kg block slides 1.40 m down a 30.0° slope, starting from rest at point A; at the bottom, it smoothly moves onto a level surface. For *both* the slope and the level surface the surface/block coefficient of kinetic friction is 0.200.



(a) What is the magnitude of the acceleration of the block as it slides down the slope? (8 points)



$\Sigma y \text{ forces} = 0 \rightarrow n = mg\cos\theta$

$\Sigma x \text{ forces} = mg\sin\theta - f_k$

$= mg\sin\theta - \mu_k n = mg\sin\theta - \mu_k mg\cos\theta$

$= ma_x$

$a_x = g\sin\theta - \mu_k g\cos\theta = g(\sin\theta - \mu_k\cos\theta)$

$= \boxed{3.20 \text{ m/s}^2}$

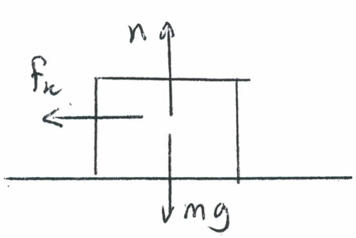
(b) What is the speed of the block when it reaches the bottom of the slope (B)? (3 points)

Use $V_x^2 = V_{0x}^2 + 2a_x(x - x_0)$

$= 0 + 2(3.20 \frac{m}{s^2})(1.40\, m) = 8.97 \frac{m^2}{s^2}$

$\rightarrow \boxed{V_x = 2.99 \frac{m}{s}}$

(c) Taking your answer to (b) as the initial speed when the block starts its motion on the level part, how far does the block travel before coming to rest? (7 points)



On flat part net force is (with $n = mg$)

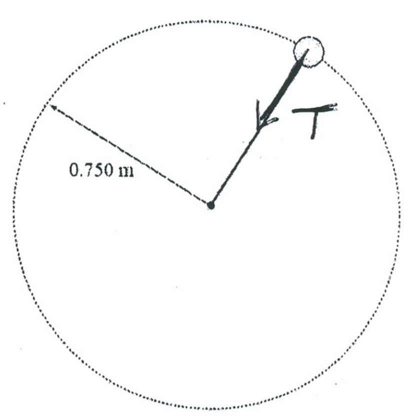
$F_x = -f_k = -\mu n = -\mu mg$

$= ma_x$ so $a_x = -\mu g = -1.96 \frac{m}{s^2}$

With $V_{0x} = 2.99 \frac{m}{s}$, $V_x = 0$,

$V_x^2 = V_{0x}^2 + 2a(x - x_0)$ $0 = (2.99\frac{m}{s})^2 + 2(-1.96\frac{m}{s^2})\Delta x$ $\rightarrow \boxed{\Delta x = 2.3\, m}$

9. A small mass is attached to a string of length 0.750 m which is attached to a fixed point on a horizontal frictionless table. The mass undergoes circular motion such that it makes one revolution every 0.800 seconds. A bird's-eye-view is shown at the right.



The string (which is parallel to the table surface) will break if its tension exceeds 20.0 N. What is the maximum possible value of m? (7 points)

$V = \frac{2\pi r}{T} = \frac{2\pi(0.750\, m)}{(0.800\, s)} = 5.89 \frac{m}{s}$

$F_c = T = \frac{mv^2}{r}$. With T at critical value 20.0 N,

$m = \frac{rT}{v^2} = \frac{(0.750\, m)(20.0\, N)}{(5.89\frac{m}{s})^2} = \boxed{0.432\, kg}$