Name ______________________________ Seat Number ______________

PHYSICS 2110
Exam I – Spring 2007

INSTRUCTORS (Circle ONE): CLASS MEETING TIME
Shriner 9:05 AM
Murdock 10:10 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.

PROBLEM	POINT VALUE	YOUR SCORE
1	4	
2	24	
3	8	
4	6	
5	8	
6	4	
7	4	
8	4	
9	6	
10	6	
11	8	
12	18	
TOTAL	100	

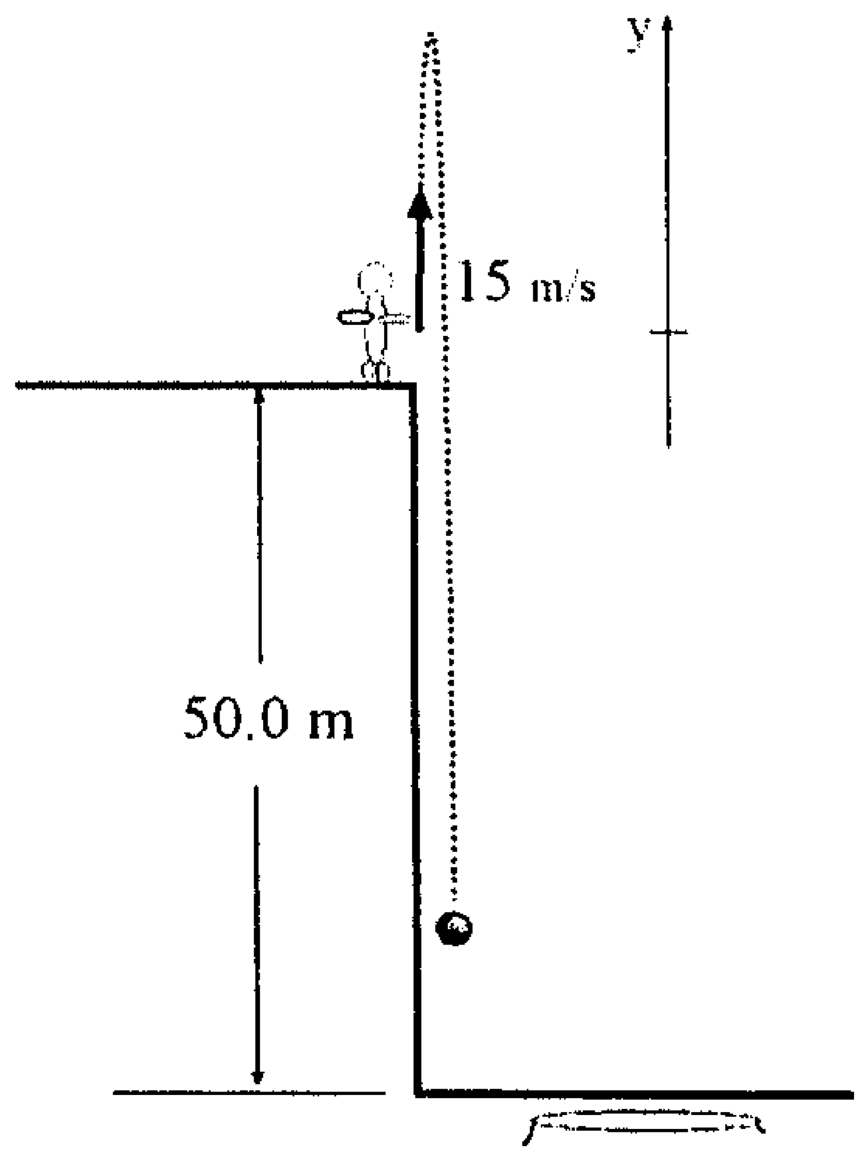
1. If m is a mass, v is a speed and r is a length, what are the SI ("mks") units of the quantity L=mvr? (4 pts)

m is in $\underline{kg}$, v is in $\underline{\frac{m}{s}}$, r is in $\underline{m}$,

so L must be in:

$$[L] = kg \cdot \frac{m}{s} \cdot m = \boxed{\frac{kg\, m^2}{s}}$$

2. An astronaut stands at the edge of a 50.0-m cliff on a strange planet and throws a rock straight up with a speed of 15.0$\frac{m}{s}$. The rock strikes the ground below 8.0 s later.



(a) What is the value of g (the acceleration of gravity) on this planet? (5 pts)

Here, $v_{iy} = 15\frac{m}{s}$, $a_y = -g$

We know:

$$-50.0\,m = 0 + (15\tfrac{m}{s})(8.0s) + \tfrac{1}{2}(-g)(8.0s)^2$$

Solve for g, get:

$$\boxed{g = 5.31\ \tfrac{m}{s^2}}$$

(b) What was the speed of the rock when it struck the ground below? (5 pts)

We can use $\Delta y = \frac{1}{2}(v_{iy} + v_y)\Delta t$, so

$$v_{iy} + v_y = \frac{2\Delta y}{\Delta t} = \frac{2(-50m)}{8.0s} = -12.5\ \tfrac{m}{s}$$

Since $v_{iy} = +15\frac{m}{s}$, $v_y = -12.5\frac{m}{s} - 15\frac{m}{s} = -27.5\frac{m}{s}$

So speed is $\boxed{27.5\ \frac{m}{s}}$!

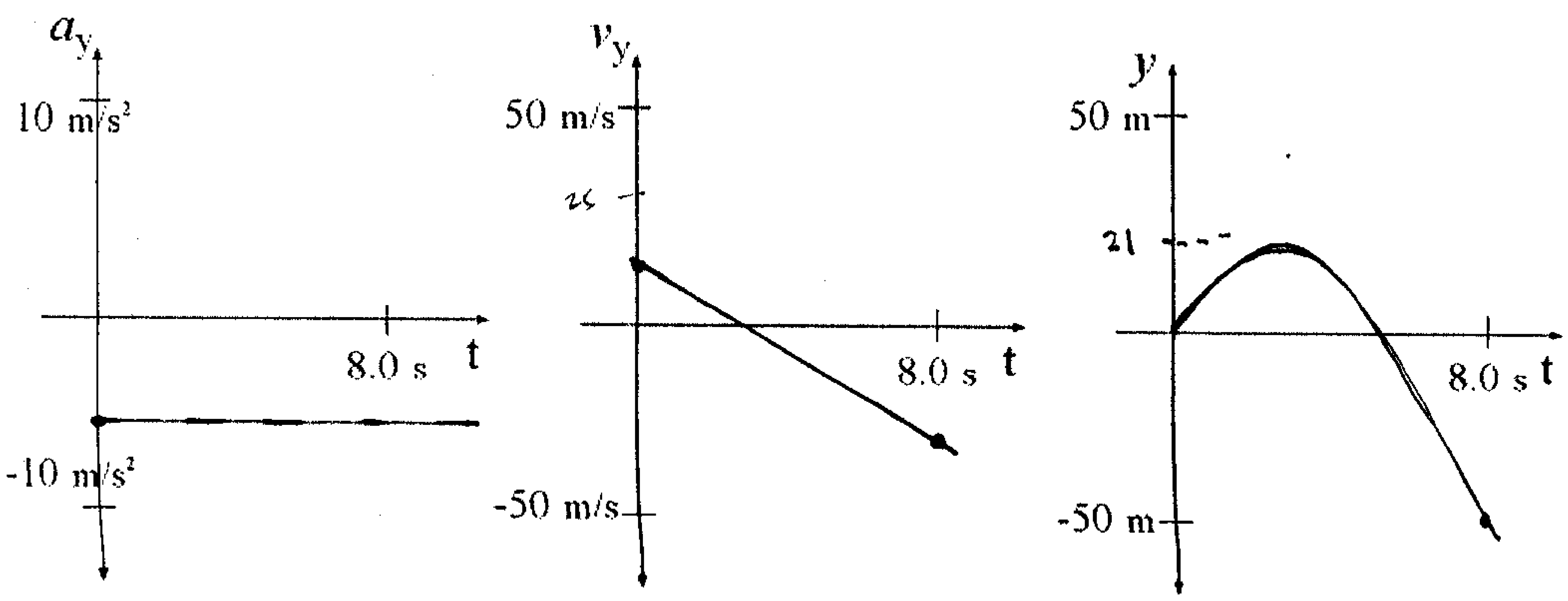
(c) What was the maximum height above the starting point attained by the rock? (5 pts)

Use

$$v_y^2 = 0 = v_{iy}^2 + 2a_y\Delta y$$

Then $$\Delta y = \frac{-v_{iy}^2}{2a_y} = \frac{-(15\frac{m}{s})^2}{2(-5.31\frac{m}{s^2})} = \boxed{+21.2\,m}$$

(d) On the axes below give plots of the acceleration, velocity and y-coordinate of the rock versus time. Assume that the rock starts at y=0. (9 pts)

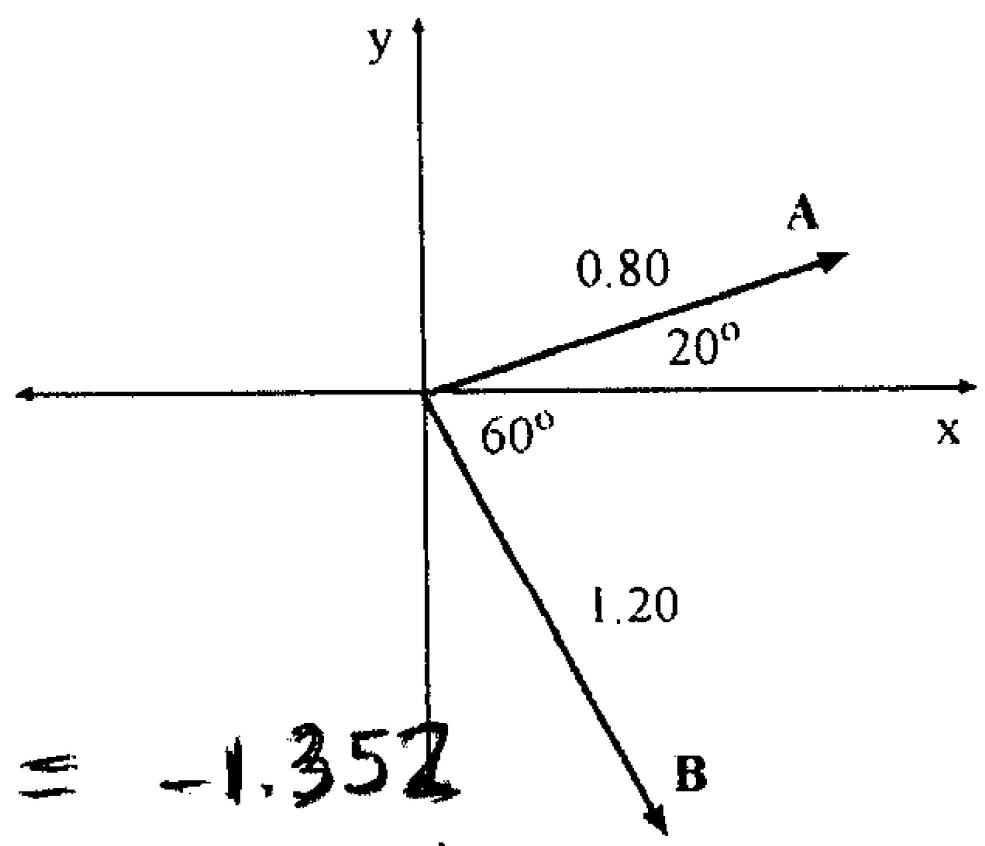


a_y is always $-5.31\frac{m}{s^2}$!

v_y changed from $+15\frac{m}{s}$ to $-27.5\frac{m}{s}$

y has got to look like this !

3. Vector $\vec{A}$ has magnitude 0.80 and it is directed at 20 deg above the +x axis. Vector $\vec{B}$ has magnitude 1.20 and is directed at 60 deg below the +x axis.



Find the vector $\vec{C}$ which gives $\vec{A}+\vec{B}+\vec{C}=0$. Give the magnitude and direction of $\vec{C}$. (8 pts)

We need

$$C_x = -A_x - B_x = -(0.80 \cos 20^\circ) - (1.20 \cos 60^\circ) = -1.352$$

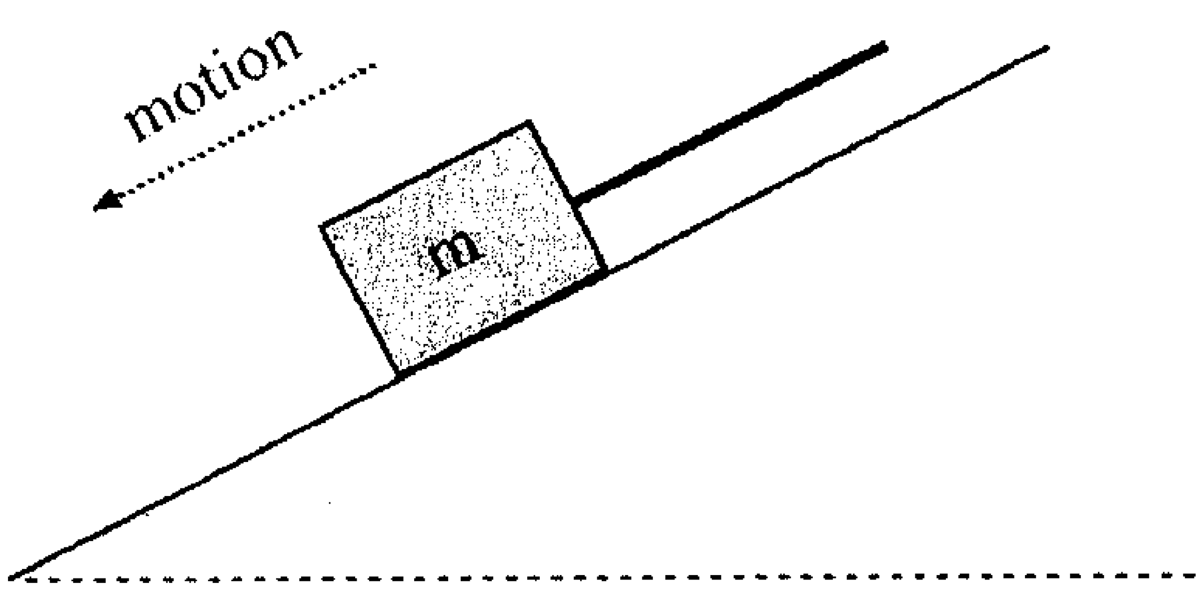
$$C_y = -A_y - B_y = -(0.80 \sin 20^\circ) - (-1.20 \sin 60^\circ) = 0.766$$

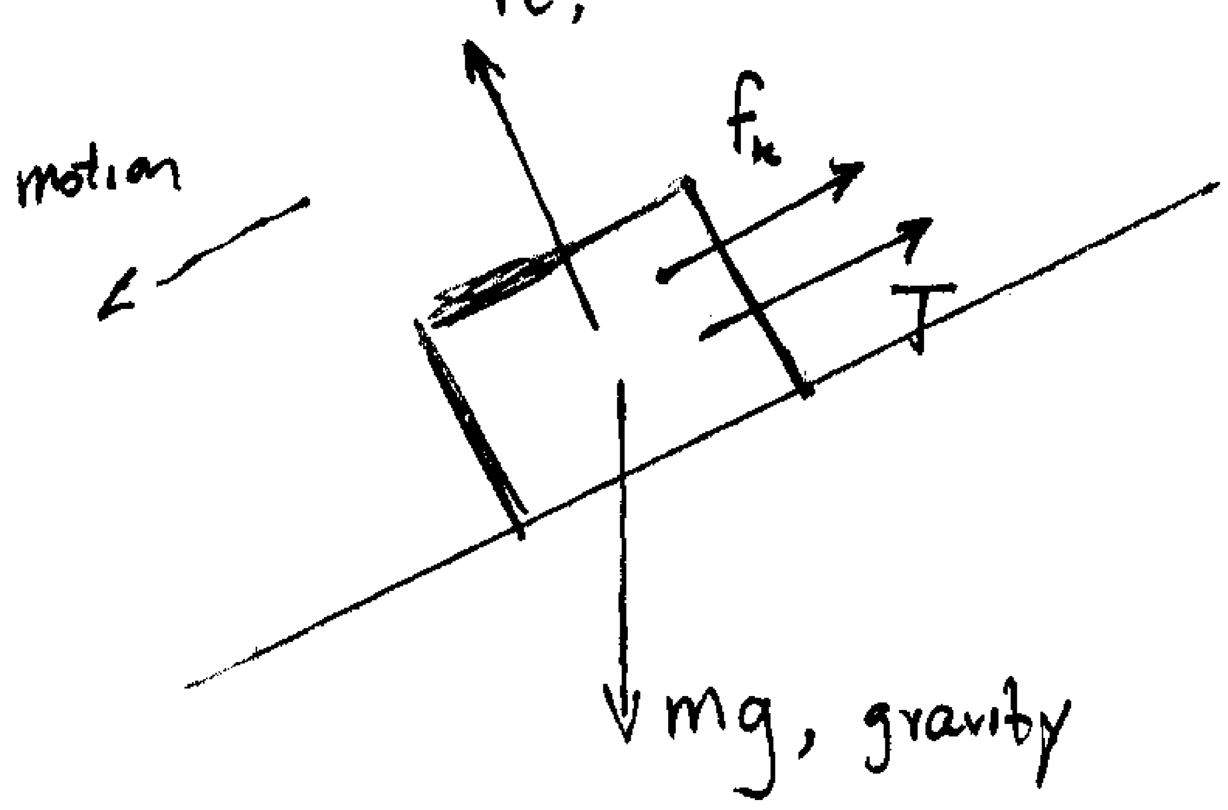
$$C = \sqrt{C_x^2 + C_y^2} = \boxed{1.55} \qquad \tan\theta = \frac{C_y}{C_x} = -0.567$$

$$\Rightarrow \theta = -29.5^\circ + 180^\circ = \boxed{150.4^\circ}$$

4. A mass slides on a *rough* inclined plane. It is attached to a taut string; it is moving *down* the slope.

In the space below, give a free-body diagram showing the forces acting on the mass. (Don't split them into components; just show and label the forces.) (6 pts)



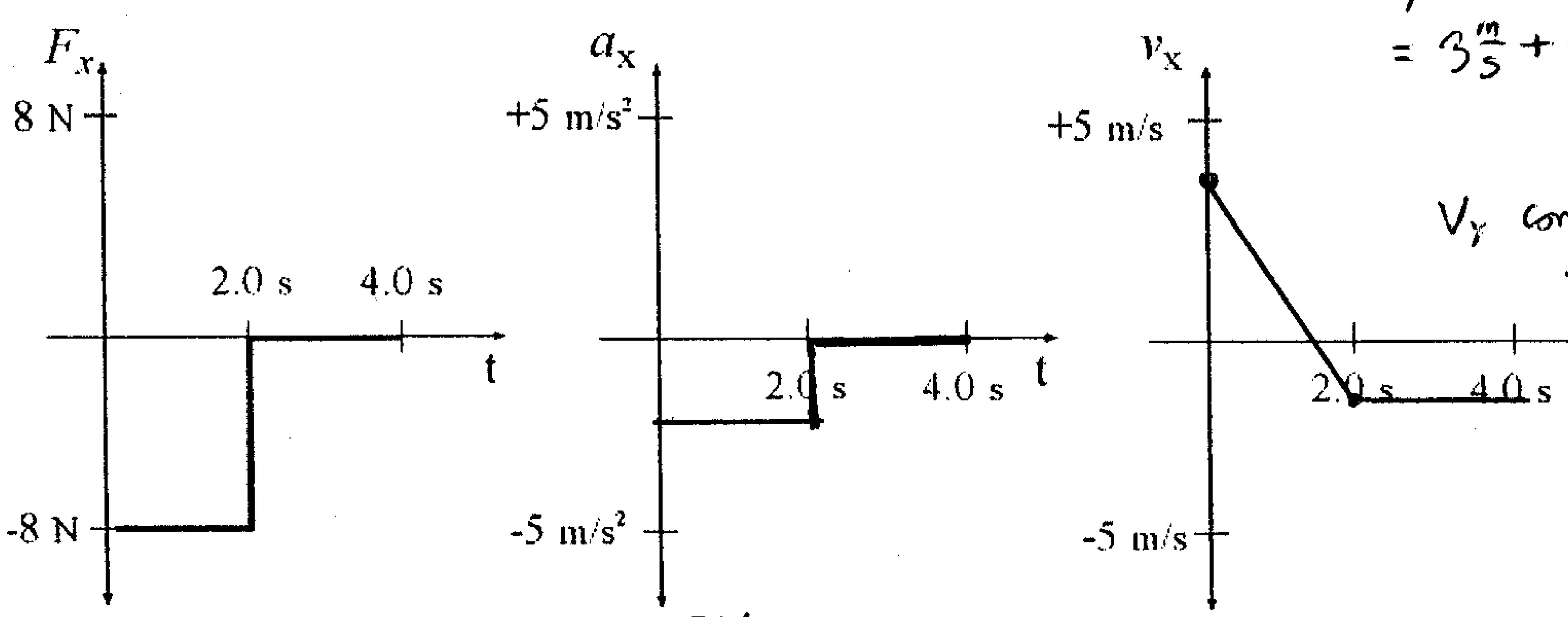


Force of friction goes up the slope since the block is moving down the slope.

5. A 4.0 kg mass moves in one dimension (along the x axis). It is acted upon by a single force F_x, plotted versus time in (a). If the velocity of the mass at t=0 is $+3.0\frac{m}{s}$, plot a_x and v_x on axes (b) and (c). (8 pts)

V_x at 2 s is
$= 3\frac{m}{s} + (-2\frac{m}{s^2})(2s)$
$= -1\frac{m}{s}$

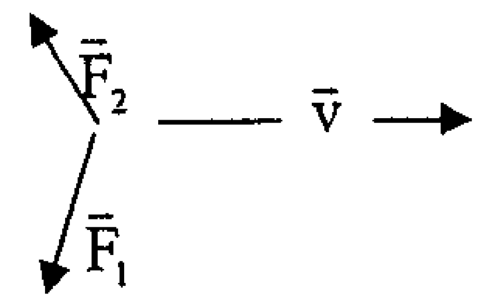
V_x constant thereafter



(a) $a_x = \frac{F_x}{m} = \frac{-8N}{4kg} = -2\frac{m}{s^2}$ (b) (c)

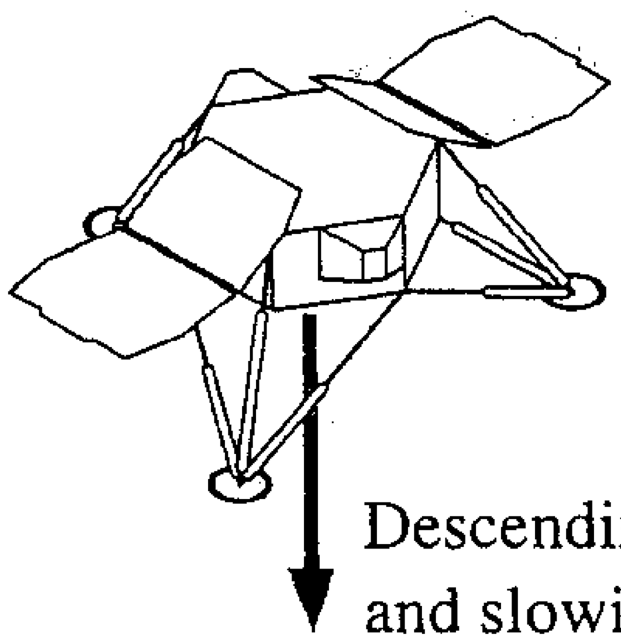
(for 1st 2 seconds)

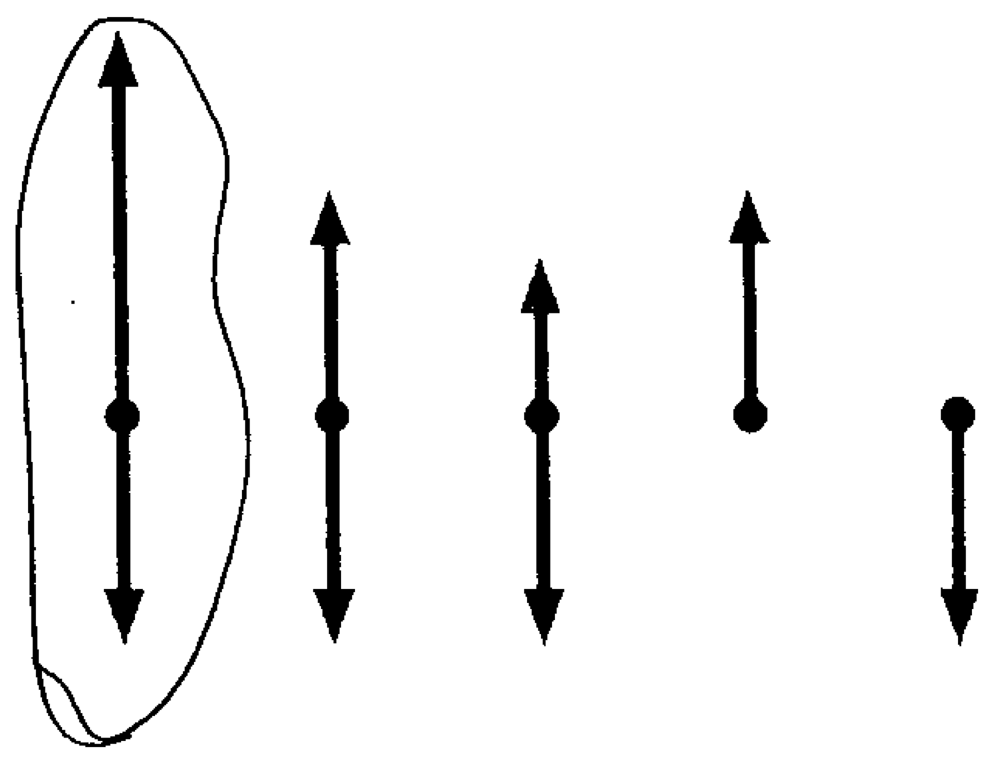
6. At some instant in time, an object has the velocity vector shown to the right and is acted upon by the two forces shown. How will the object move in its very near future? (4 pts)



(a) It will continue in a straight line.
(b) It will speed up and deflect to its right.
(c) It will slow down and deflect to its right.
(d) It will speed up and deflect to its left.
(e) It will slow down and deflect to its left.

7. A Martian lander is approaching the surface of the planet. It is slowing its descent by firing its rockets. Circle the free-body diagram on the right that correctly represents the forces acting on the lander and their magnitudes. (4 pts)





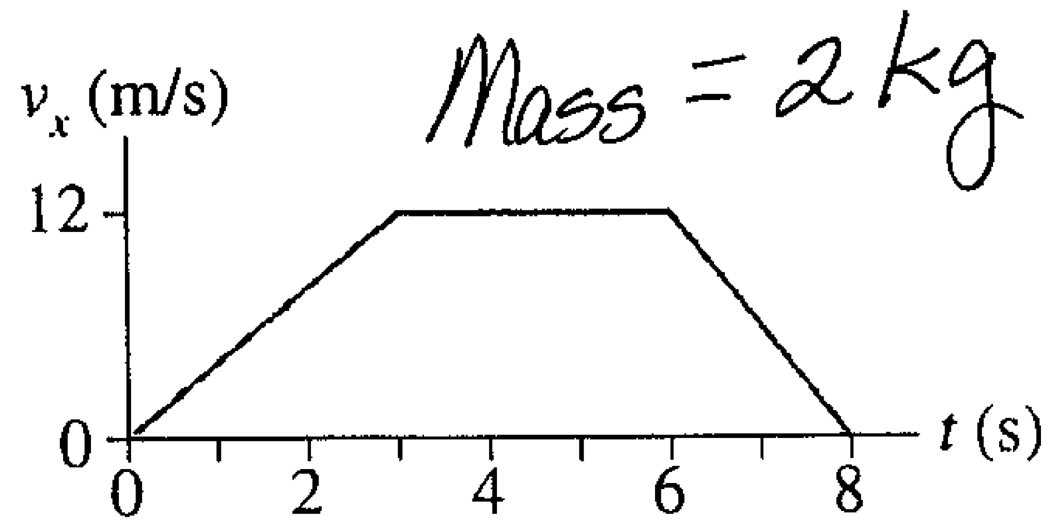
8. A shopper gives a grocery cart an initial push along a horizontal floor and then lets go of the cart. The cart continues to roll forward, gradually slowing as it moves. Consider only the horizontal forces on the cart while it is moving forward and slowing. Which of the following statements is correct? (4 pts)

(a) Both a forward and a backward force are acting on the cart, but the forward force is larger.
(b) Both a forward and a backward force are acting on the cart, but the backward force is larger.
(c) Only a forward force is acting, and it gets smaller in magnitude as time passes.
(d) Only a backward force is acting.

9. An object is moving to the right in a straight line. The net force on the object is also acting to the right but is decreasing in magnitude as time passes. Describe the subsequent motion of the object (be sure to explain your answer). (6 pts)

Net force is to right ⇒ acceleration is to right.
So object continues to move to the right and speeds up.

10. The figure shows the velocity vs. time graph of an object as it moves along the x-axis. Determine the net force acting on the object at t = 1 s and at t = 7 s. (6 pts)



Mass = 2 kg

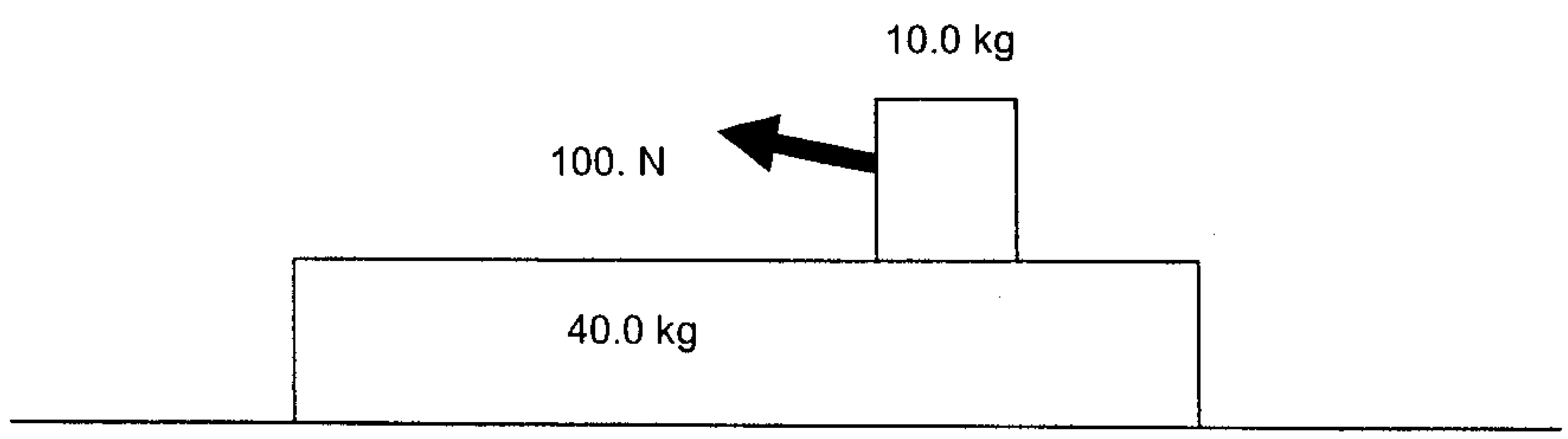
a_x = slope of V_x vs time graph

$\vec{F}_{net} = m\vec{a}_x$

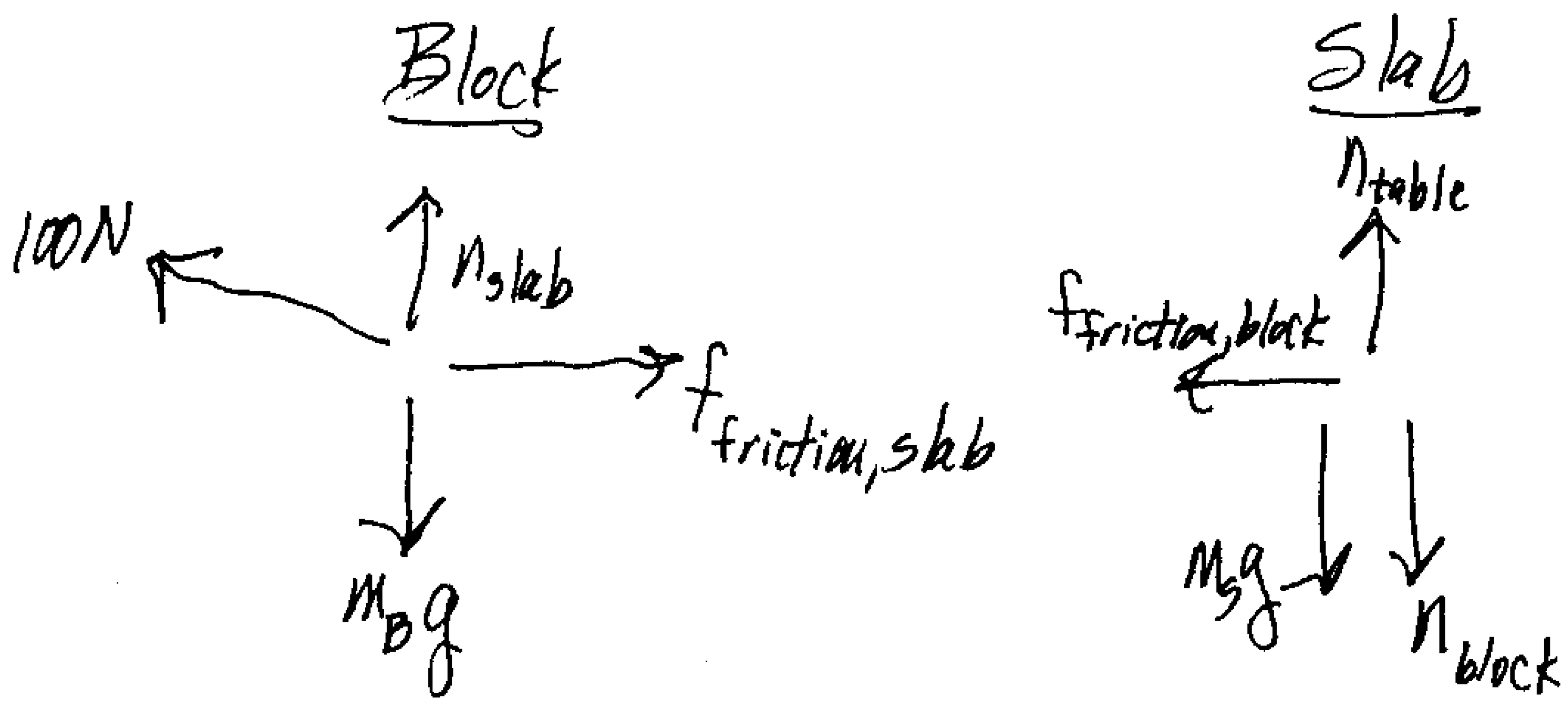
$t = 1 \Rightarrow a_x = \frac{12\,m/s}{3s} = 4\,m/s^2 \Rightarrow \vec{F}_{net} = 8N$ toward positive x

$t = 7 \Rightarrow a_x = \frac{-12\,m/s}{2s} = -6\,m/s^2 \Rightarrow \vec{F}_{net} = 12N$ toward negative x

11. A 40.0 kg slab rests on a horizontal, frictionless floor. A 10.0 kg block rests on top of the slab. The coefficient of static friction between the block and the slab is 0.600, whereas their coefficient of kinetic friction is 0.400. The block is pulled by a force with a magnitude of 100. N directed at 15.0° above the horizontal.



(a) Draw clearly labeled free-body diagrams for the slab and the block. (4 pts)



(b) Find the resulting acceleration of the block. (4 pts)

Block $\Sigma F_y = n_{slab} - m_B g + 100.N \sin 15° = m_B a_y$ $\qquad a_y = 0$

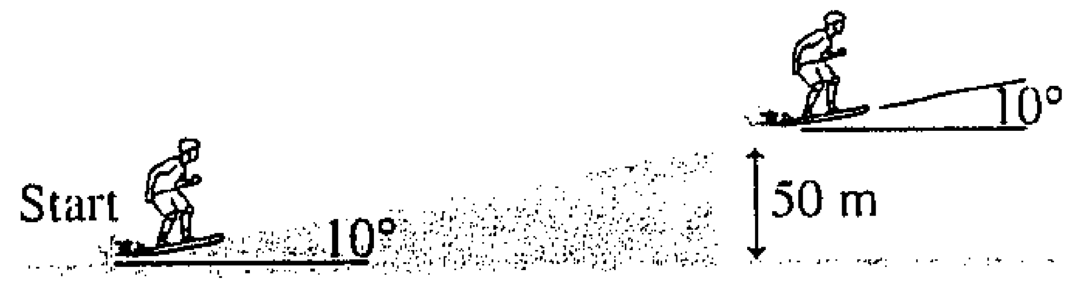
$n_{slab} = (10.0\,kg)(9.80\,m/s^2) - 100.N \sin 15° = 72.1N$

Friction will be kinetic friction (compare forces) so

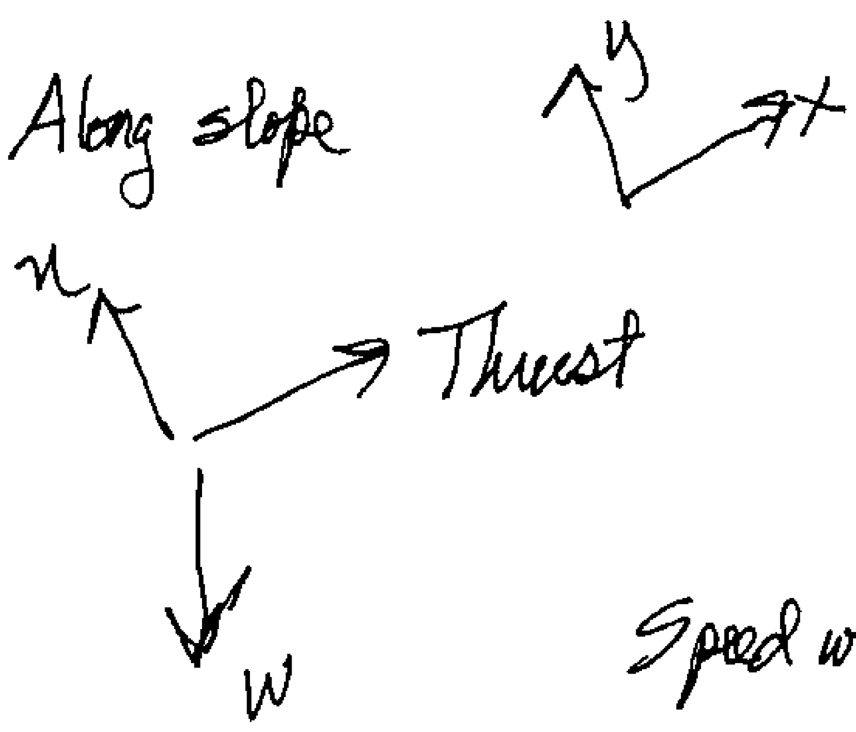
$\Sigma F_x = \mu_k n_{slab} - 100.N \cos 15° = m_{block} a_x$

$\Rightarrow a_x = \frac{(.400)(72.1N) - 100N.\cos 15°}{10.0\,kg} = -6.77\,m/s^2$ (to left)

12. Sam (mass 75 kg) takes off up a slope of 10.° with an ultimate height of 50. m on his jet- powered skis. The skis have a thrust of 200. N. He keeps his skis tilted at 10.° even after becoming airborne, as shown in the figure. How far does Sam land from the base of the cliff? (18 pts)



Along slope



$$\Sigma F_x = \text{Thrust} - w \sin 10^\circ = ma_x$$

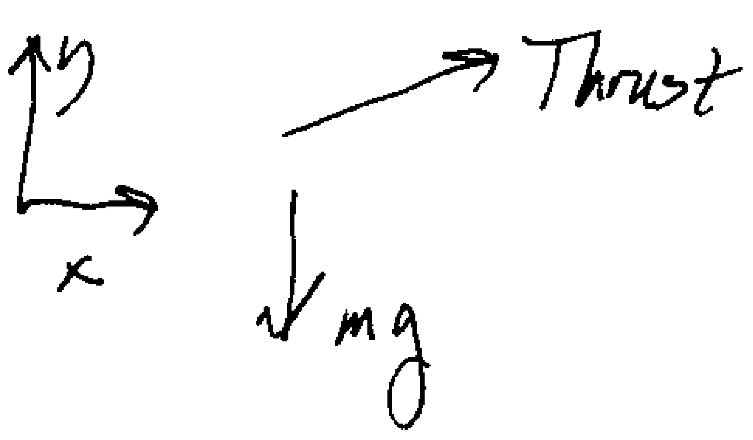
$$\Rightarrow a_x = \frac{200\,N - (75\,kg)(9.80\,m/s^2)\sin 10^\circ}{75\,kg} = 0.96\,m/s^2$$

Speed when leaving slope:

$$v_{fx}^2 = v_{ix}^2 + 2a_x(x - x_0) = (0\,m/s)^2 + 2(0.96\,m/s^2)\left(\frac{50\,m}{\sin 10^\circ}\right)$$

$$\Rightarrow v_{fx} = 24\,m/s$$

In air



$$\Sigma F_x = 200\,N \cos 10^\circ = ma_x$$

$$\Rightarrow a_x = 2.6\,m/s^2$$

$$\Sigma F_y = 200\,N \sin 10^\circ - (75\,kg)(9.80\,m/s^2) = ma_y$$

$$\Rightarrow a_y = -9.3\,m/s^2$$

Time in air (choose origin where Sam leaves slope)

$$y_f = y_i + v_{iy}t + \tfrac{1}{2}a_y t^2$$

$$-50\,m = 0\,m + 24\,m/s \sin 10^\circ t + \tfrac{1}{2}(-9.3\,m/s^2)t^2$$

$$\Rightarrow t = 3.7\,s \text{ (from quadratic formula)}$$

Horizontal distance

$$x_f = x_i + v_{ix}t + \tfrac{1}{2}a_x t^2$$

$$= 0\,m + (24\,m/s)(\cos 10^\circ)(3.7\,s) + \tfrac{1}{2}(2.6\,m/s^2)(3.7\,s)^2$$

$$= 100\,m$$