PHYSICS 2110
EXAM I SPRING 2006

NAME (PRINT) I. M. Perfect

INSTRUCTORS: AYIK CLASS MEETING TIME: 11:15 AM
MURDOCK CLASS MEETING TIME: 10:10 AM

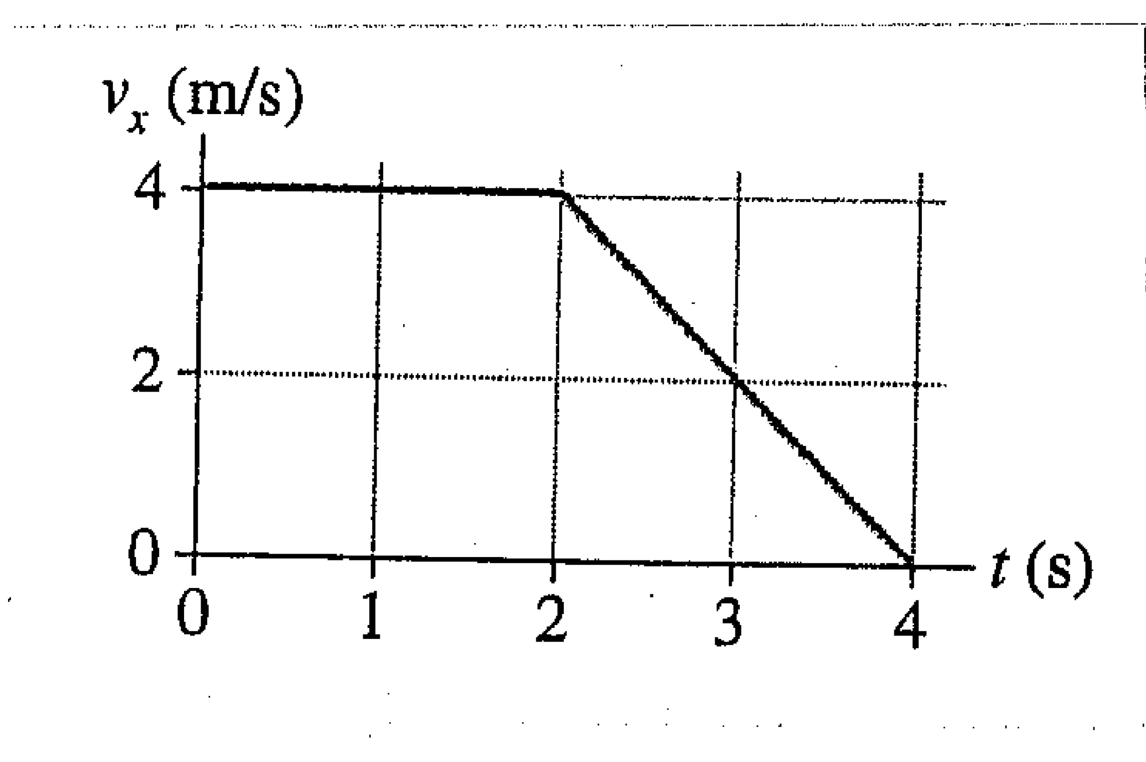
YOU MUST SHOW YOUR WORK AND EXPLAIN YOUR REASONING TO RECEIVE CREDIT

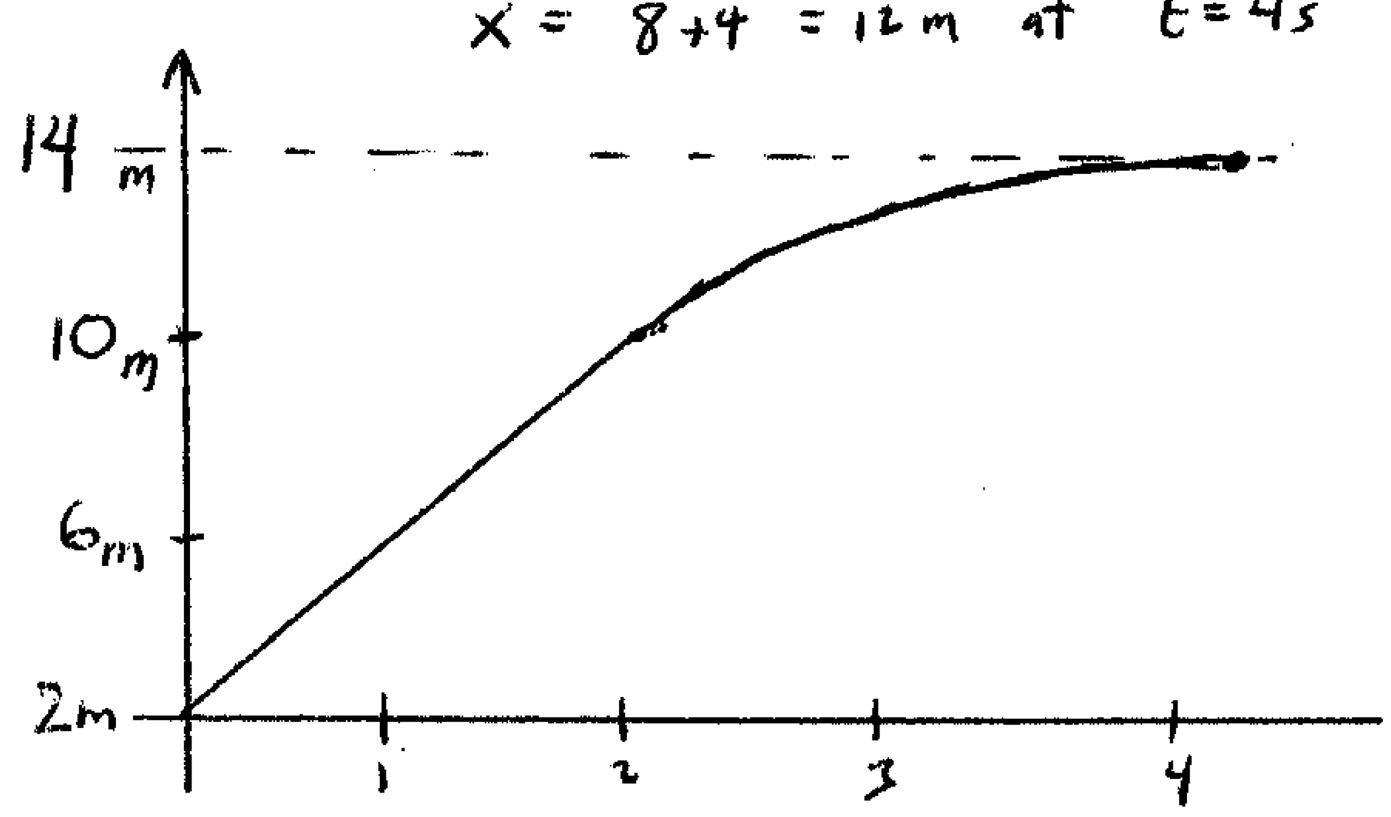
PROBLEM	POINT VALUE	YOUR SCORE
Problem # 1	7	------
Problem # 2	8	-------
Problem # 3	10	-------
Problem # 4	10	--------
Problem # 5	15	--------
Problem # 6	10	--------
Problem # 7	20	---------
Problem # 8	20	---------
TOTAL	100	--------

---

1. The velocity-versus-time graph is shown for a particle moving along the x-axis. The initial position is $x_0 = 2.0$ m at $t_0 = 0$ second.
(a) Draw position-versus-time graph of the particle. (2 pts)

Slope of x vs t is 4 m/s from 0 to 2s
Slope of x vs t is 0 at t = 4s
x = 8+4 = 12 m at t = 4s





(b) Determine the position, velocity and acceleration of the particle at $t = 3.0$ seconds. (5 pts)

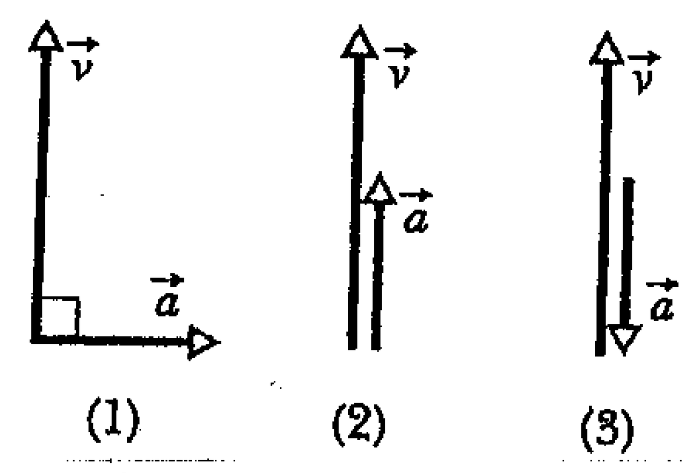
At t = 3s,

$x = 2m + (8m + 4m) = 14m$ (Find area under curve)

$v = 2\ \frac{m}{s}$ (From graph)

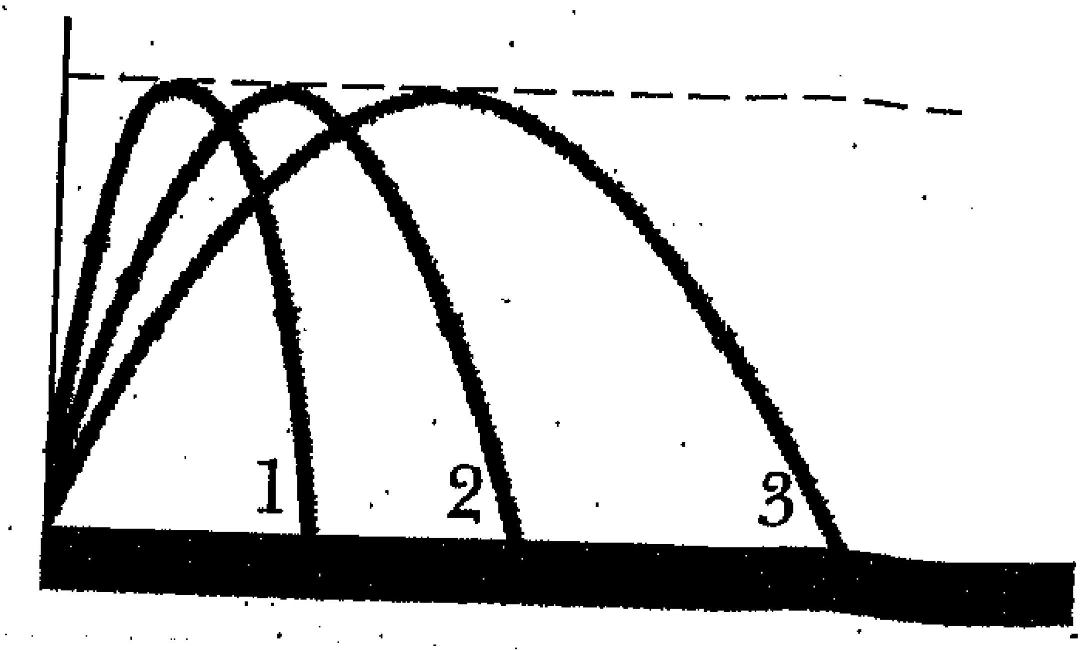
$a = \frac{dv}{dt} = -2.0\ \frac{m}{s^2}$ (slope of v vs. t graph)

2. (a) Figures 1, 2 and 3 show the velocity and acceleration of a particle at a particular instant. In which situation is (i) the speed of the particle increasing, (ii) the speed of the particle increasing, and (iii) the speed not changing. (3 pts)



i Increasing in (2)
ii Decreasing in (3)
iii Not changing in (1)

(b) The shows three paths for a football kicked from ground level. Ignoring the effects of air resistance, rank the paths according to (i) initial vertical velocity component, (ii) time of flight, and (iii) initial horizontal velocity component, greatest first. (5 pts)



i) V_{iy} : $1 = 2 = 3$
ii) t : $1 = 2 = 3$
iii) V_{ix} : $3 > 2 > 1$

3. The velocity of a rocket during the launch stage is directed upward and its speed is given by the equation

$$v = kt - ct^2$$

where v is in m/s and t is in units of s. Numerical values of the constants are $k = 20.0$ and $c = 3.00$.
(a) What are the units for constants k and c? (2 pts)

k : m/s^2 $\quad$ c : m/s^3 $\quad$ (Both must give overall units of m/s on both sides of eqn)

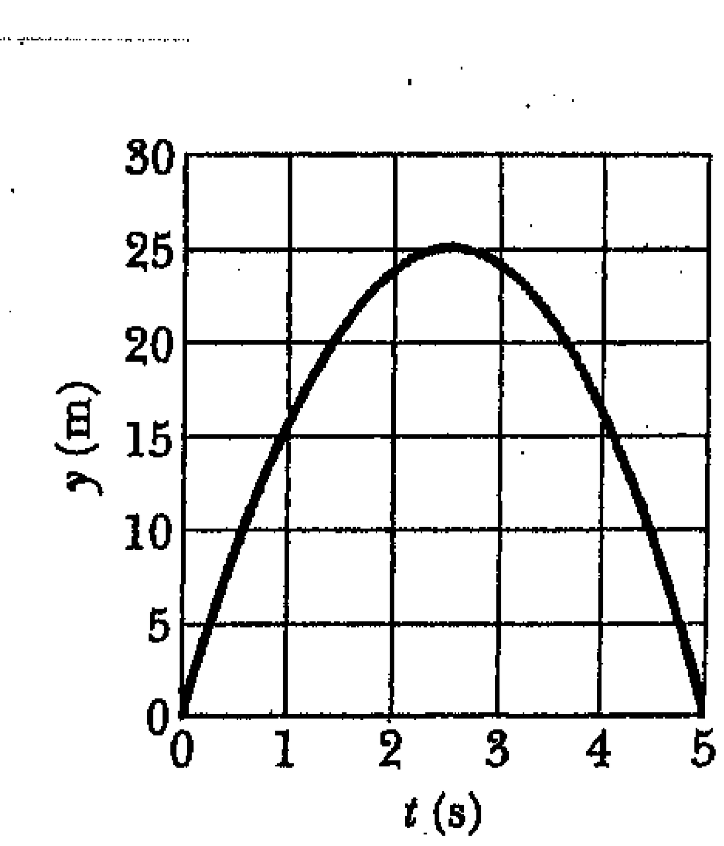
(b) Calculate the instantaneous acceleration of the rocket 3.00 s after launch. (4 pts)

$$a = \frac{dv}{dt} = k - 2ct$$
$$= 20\tfrac{m}{s} - 2(3.0\tfrac{m}{s^3})(3.0s) = 2.0\ m/s^2$$

(c) Calculate the displacement of the rocket during time interval from $t_0 = 0$ s to $t = 4.00$ s. (4 pts)

$$\Delta x = \int_0^4 v(t)\,dt = \int_0^4 [20t - 3t^2] = 10t^2 - t^3 \Big|_0^4$$
$$= 160 - 64 = 96\ m$$

4. A ball is vertically shot upward from the surface of a planet. 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 at the instant that the ball is shot.
(a) Find the free-fall acceleration on the planet. (5 pts)



Consider the time interval from 2.5s to 5s.
Then $\Delta t = 2.5s$, $\Delta x = -25m$, $V_i = 0$, then:

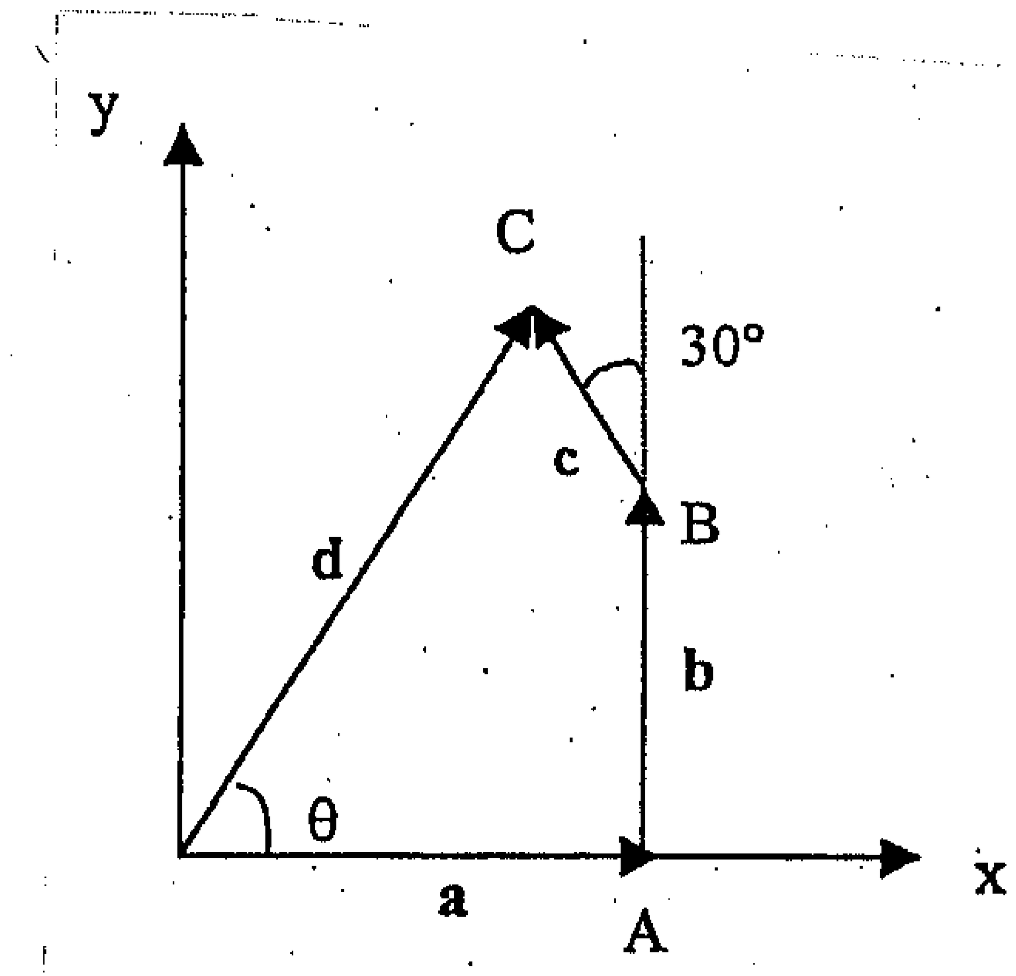
$$\Delta x = -\tfrac{1}{2}g(\Delta t)^2 \implies g = \frac{2(25\ m)}{(2.5s)^2} = 8.0\ m/s^2$$

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

Consider the interval from $t = 0s$ to $t = 2.5s$, then

$$V_f = 0 = V_i - gt \quad \text{So} \quad V_i = gt = (8.0\tfrac{m}{s^2})(2.5s)$$
$$= 20\ m/s$$

5. In a road rally, you are given the following instructions: From the starting point (the origin), drive 30 km due east to checkpoint A, then 40km due north to B, and then 20 km at the direction of of 30^0 west of north to checkpoint C. The figure shows the corresponding displacement vectors $\vec{a}$, $\vec{b}$ and $\vec{c}$.



(a) Determine the magnitude of the resultant displacement vector $\vec{d}$. (10 pts)

Geometry gives:

$a_x = 30 \text{ km} \quad a_y = 0$

$b_x = 0 \quad b_y = 40 \text{ km}$

$c_x = -20 \text{ km} \sin 30^\circ = -10 \text{ km} \quad c_y = 20 \text{ km} \cos 30^\circ = 17.3 \text{ km}$

$d_x = a_x + b_x + c_x = 20 \text{ km}$

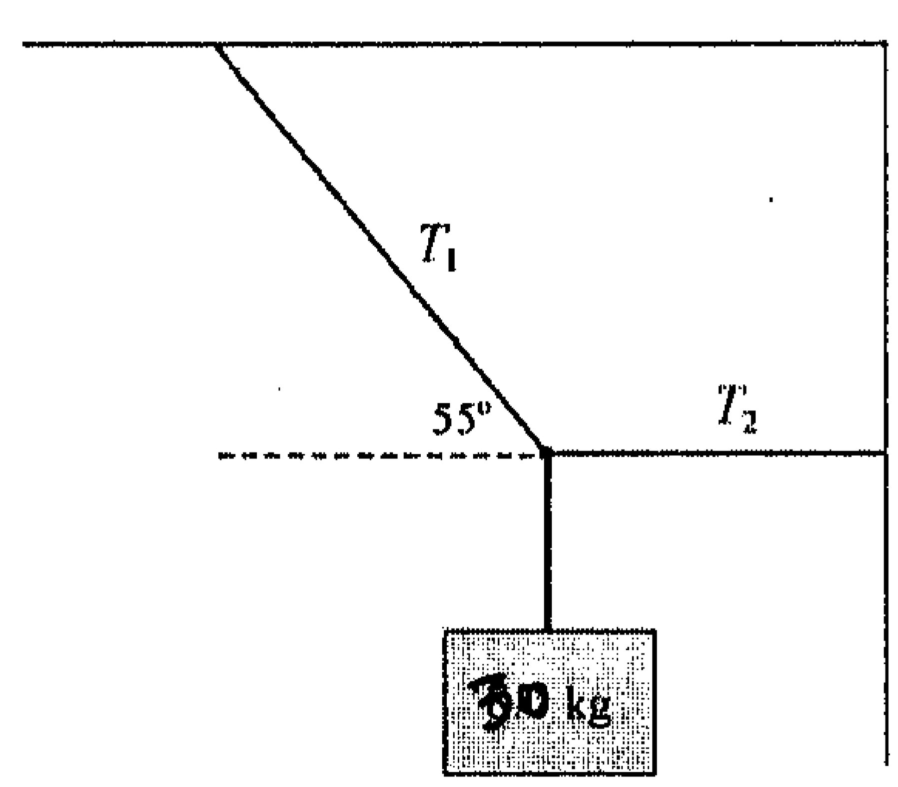
$d_y = a_y + b_y + c_y = 57.3 \text{ km}$

$d = \sqrt{d_x^2 + d_y^2} = 60.7 \text{ km}$

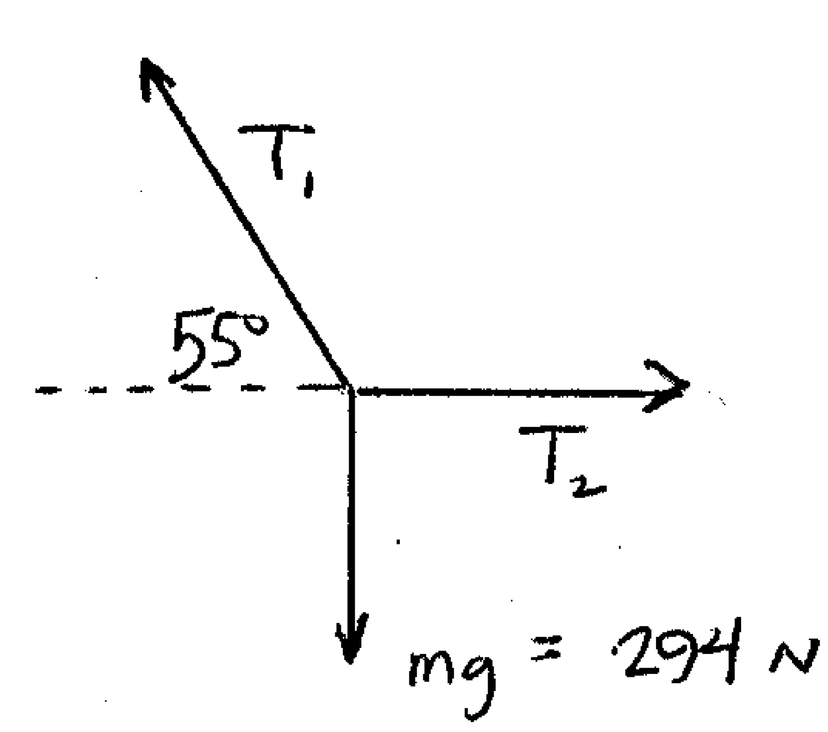
(a) Find the angle θ that the displacement vector $\vec{d}$ makes with +x-axis. (5 pts)

$\tan\theta = \frac{d_y}{d_x} = 2.86 \implies \theta = 70.8^\circ$

6. A 30 kg mass is supported by three ropes joined together at one point. One of the upper ropes is inclined at 55° to the vertical and the other is horizontal. Find the tensions in the two upper ropes. (10 pts)



Forces acting at the knot are shown. The forces must sum to zero since knot is motionless.



$y: \quad T_1 \sin 55^\circ - 294 \text{ N} = 0$

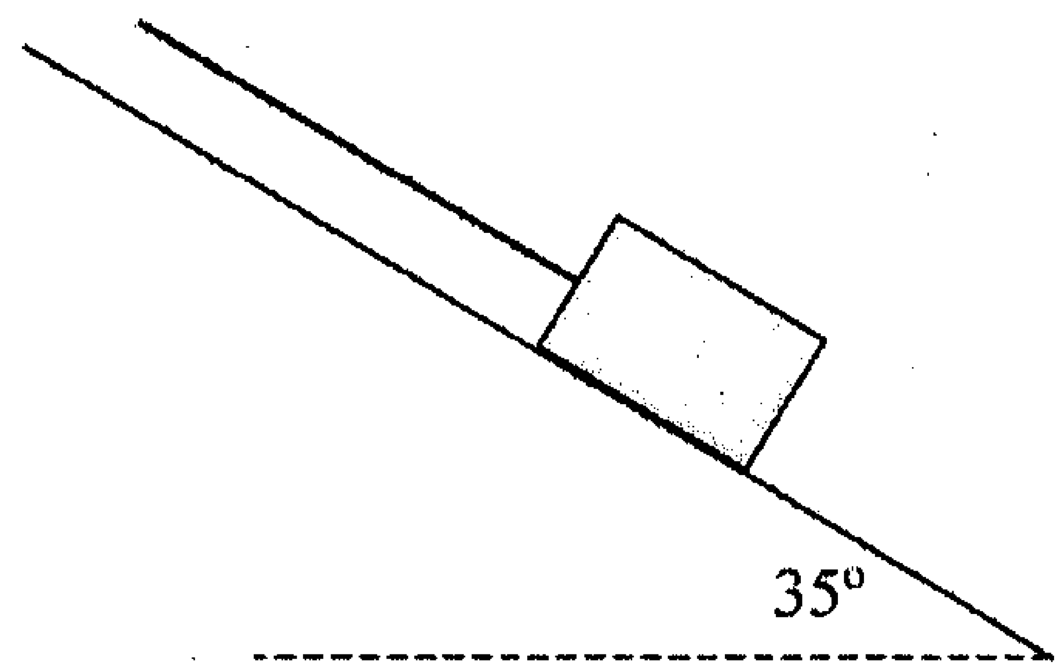
$\implies T_1 = 359 \text{ N}$

$x: \quad -T_1 \cos 55^\circ + T_2 = 0$

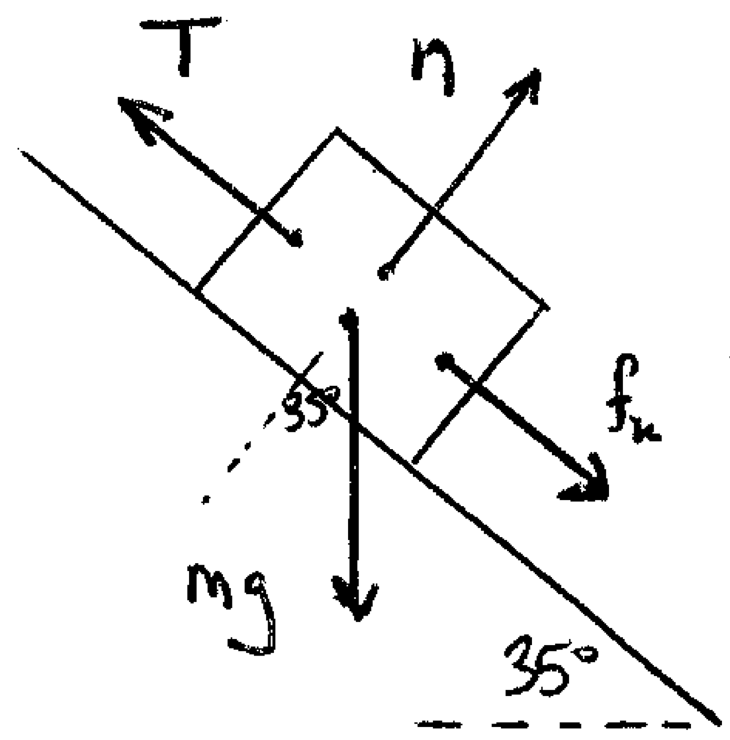
$T_2 = T_1 \cos 55^\circ = (359 \text{ N})(\cos 55^\circ)$

$= 206 \text{ N}$

7. A 5.0 kg mass is pulled up a *rough* 35° slope by a rope parallel to the slope. The tension in the rope is 47.0 N and the acceleration of the mass is $2.00 m/s^2$ (up the slope).



(a) Draw a free-body diagram showing all the forces acting on the block. (5 pts)



T = tension in rope
mg = weight
n = normal force ⊥ surface
f_k = kinetic friction force

(b) What is the magnitude of the normal force (between surface and block)? (5 pts)

Forces perp to surface sum to zero:

$$n - mg\cos 35° = 0$$

$$\longrightarrow \quad n = mg\cos 35° = 40.1\ N$$

(c) What is the magnitude of the friction force which acts on the mass? (5 pts)

Apply N's 2nd Law to forces along slope:

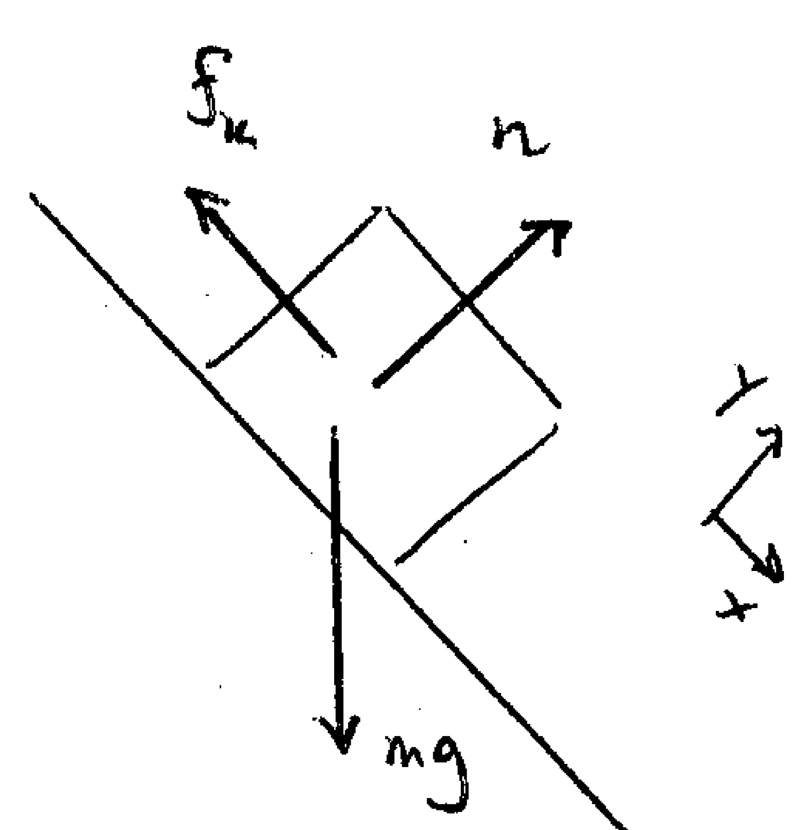
$$T - mg\sin\theta - f_k = ma$$

$$f_k = T - mg\sin\theta - ma = 47\,N - (5\,kg)(9.8\,\tfrac{m}{s^2})\sin 35° - (5\,kg)(2.0\,\tfrac{m}{s^2})$$

$$= 8.89\ N$$

(d) Suddenly the rope snaps and the block slides down the slope! What is the magnitude of the block's acceleration during its descent? (5 pts)

On the slide down kinetic friction force is directed uphill! But f_k has same magnitude as before (normal force is the same, etc.) Forces down the slope are now:



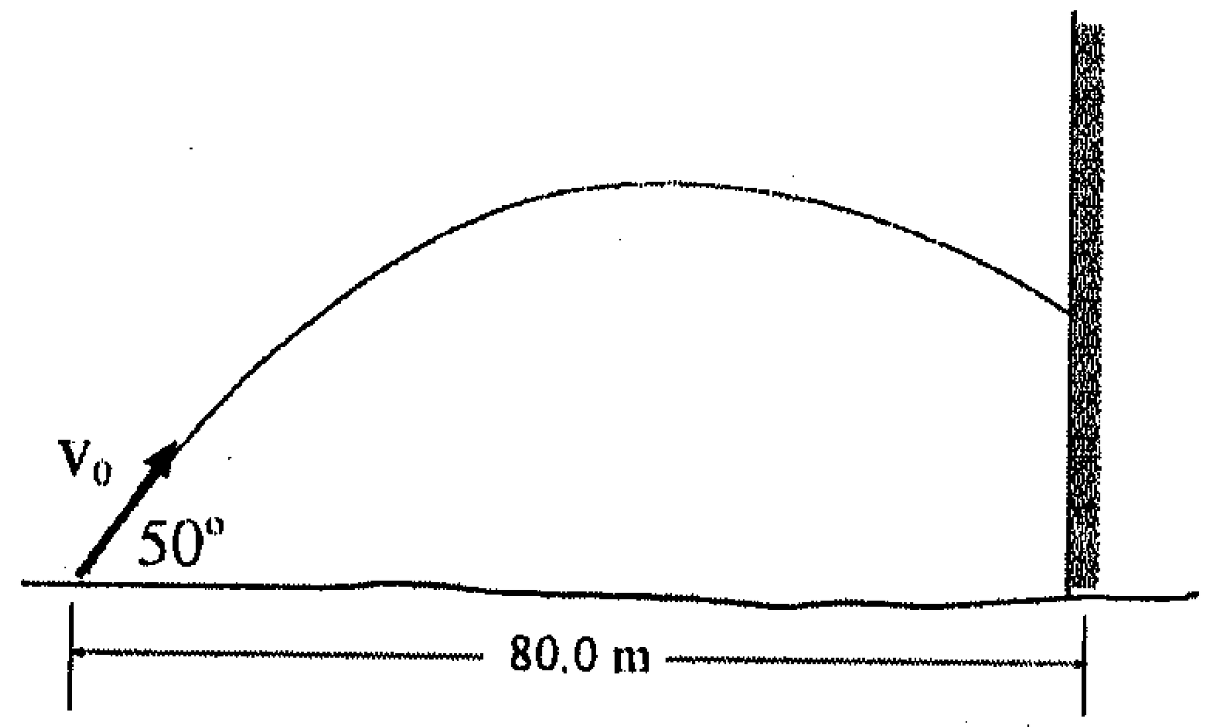
$$F_{x,net} = mg\sin\theta - f_k$$

$$= (5\,kg)(9.8\,\tfrac{m}{s^2})\sin 35° - 8.89\,N$$

$$= 28.1\,N - 8.89\,N = 19.2\ N = ma_x$$

$$a_x = \frac{19.2\,N}{5\,kg} = 3.84\,\tfrac{m}{s^2}$$

8. A projectile is fired from ground level toward a very high wall which is 80 m from the firing point. The projectile is fired at 50° above the horizontal; it strikes the wall 3.5s later.



(a) What is the initial speed v_0 of the projectile? (5 pts)
(Hint: the x equation of motion could be useful!)

with $V_{ix} = V_0 \cos\theta$ we have

$$\Delta X = V_{ix}\Delta t = (V_0 \cos\theta)\Delta t$$ Solve for V_0:

$$V_0 = \frac{\Delta X}{(\cos\theta)(\Delta t)} = \frac{80\ m}{(\cos 50^\circ)(3.5s)} = 35.6\ \frac{m}{s}$$

(b) At what height did it strike the wall? (5 pts)

Find the value of y at $\Delta t = 3.5s$. With $V_{iy} = V_0 \sin 50°$, set

$$y = V_{iy}\Delta t - \frac{1}{2}gt^2 = (V_0 \sin 50^\circ)\,3.5s - \frac{1}{2}(9.8\ \tfrac{m}{s^2})(3.5s)^2$$
$$= 35.3\ m$$

(c) What were the components of the velocity when it struck the wall? (6 pts)

At $\Delta t = 3.5s$,

$$V_{fx} = V_{ix} = V_0 \cos\theta = 22.9\ \frac{m}{s}$$
$$V_{fy} = V_{iy} - gt = V_0 \sin\theta - (9.8\ \tfrac{m}{s^2})(3.5s) = -7.06\ \frac{m}{s}$$

d) What was the speed of the projectile when it struck the wall? (4 pts)

At $\Delta t = 3.5s$,

$$V = \sqrt{V_x^2 + V_y^2} = 24.0\ \frac{m}{s}$$