Name____________________

Class Time: 10am 11am 1pm

Sept. 25, 2003

Phys 2010 — Fall 2003
Exam #1

1.	__________	(20)
2.	__________	(20)
3.	__________	(6)
4.	__________	(12)
5.	__________	(22)
MC	__________	(20)
Total	__________	(100)

You must show all your work and include the right units with your answers!

$$1\,\text{in} = 2.54\,\text{cm} \qquad 1\,\text{m} = 3.281\,\text{ft} \qquad 1\,\text{mi} = 5280\,\text{ft} \qquad 1\,\text{yd} = 36\,\text{in}$$

$$g_{\text{earth}} = 9.80\,\tfrac{\text{m}}{\text{s}^2} \qquad G = 6.67 \times 10^{-11}\,\tfrac{\text{N}\cdot\text{m}^2}{\text{kg}^2} \qquad M_{\text{earth}} = 5.98 \times 10^{24}\,\text{kg}$$

$$A_x = A\cos\theta \qquad A_y = A\sin\theta \qquad A = \sqrt{A_x^2 + A_y^2} \qquad \tan\theta = (A_y/A_x)$$

$$v_x = v_{0x} + a_x t \qquad x = v_{0x}t + \tfrac{1}{2}a_x t^2 \qquad v_x^2 = v_{0x}^2 + 2a_x x \qquad x = \tfrac{1}{2}(v_{0x} + v_x)t$$

$$v_y = v_{0y} + a_y t \qquad y = v_{0y}t + \tfrac{1}{2}a_y t^2 \qquad v_y^2 = v_{0y}^2 + 2a_y y \qquad y = \tfrac{1}{2}(v_{0y} + v_y)t$$

$$R = \frac{2v_0^2 \sin\theta\cos\theta}{g} = \frac{v_0^2 \sin 2\theta}{g} \qquad H = \frac{v_0^2 \sin^2\theta}{2g} \qquad y = \tan\theta\, x - \frac{gx^2}{2v_0^2\cos^2\theta}$$

$$\mathbf{F} = m\mathbf{a} \qquad f_k = \mu_k F_N \qquad f_s^{\text{MAX}} = \mu_s F_N \qquad F = G\frac{m_1 m_2}{r^2} \qquad g = G\frac{M}{R^2}$$

Multiple Choice

Choose (with a circle around the letter) the best answer from among the four.

1. How many square meters are there in a square kilometer?

a) 10^3
b) 10^4
c) 10^5
d) 10^6

2. Two vectors **A** and **B** have magnitudes 4.0 and 3.0, but their directions are unspecified. What is the smallest possible value for the magnitude of **A + B**?

a) 0.0
b) 1.0
c) 5.0
d) 7.0

3. A ball is thrown straight up in the air. At what time is its acceleration equal to g and directed upward?

a) While it is moving upward.

b) At the very top of the path.

c) While it is moving downward.

d) At no time during the flight.

4. A ball is thrown at an angle of 45° with the horizontal, and eventually reaches the ground. At what point in the trajectory are the ball's velocity and acceleration perpendicular?

a) At the point the ball is thrown.

b) At a point whose height is one–half the maximum height.

c) At the point of maximum height.

d) There is no such point.

5. Two stones are launched from the top of a tall building; one stone is thrown directly upward with a speed of 20 $\frac{m}{s}$ and the other is thrown downward with the same speed. When they hit the street below, how do their speeds compare? Neglect air friction.

a) The one thrown upward will be travelling faster.

b) The one thrown downward will be travelling faster.

c) Both are travelling at the same speed.

d) It is impossible to tell.

6. If the distance between the centers of two objects of given mass is doubled, the gravitational attractive force between them:

a) Reduces to $\frac{1}{4}$ the original amount.

b) Reduces to $\frac{1}{2}$ the original amount.

c) Increases to twice the original amount.

d) Increases to four times the original amount.

7. An object of mass m is suspended by a string from the top of an elevator. The elevator is accelerating *downward*. Which statement best describes the magnitude of the tension in the string?

a) It is equal to mg.

b) It is less than mg.

c) It is greater than mg

d) It is impossible to tell without knowing the acceleration.

8. An object of mass m is suspended by a string from the top of another elevator... This elevator is moving *downward* with a *constant speed* v. Which statement best describes the magnitude of the tension in the string?

a) It is equal to mg.

b) It is less than mg.

c) It is greater than mg

d) It is impossible to tell without knowing v.

9. 1 newton is equal to

a) $1\,\frac{\mathrm{kg \cdot m}}{\mathrm{s}^2}$

b) $1\,\frac{\mathrm{kg \cdot m}^2}{\mathrm{s}^2}$

c) $1\,\frac{\mathrm{kg \cdot m}}{\mathrm{s}}$

d) $1\,\frac{\mathrm{kg}^2\mathrm{\cdot m}}{\mathrm{s}^3}$

10. In the absence of any force, a moving object will:

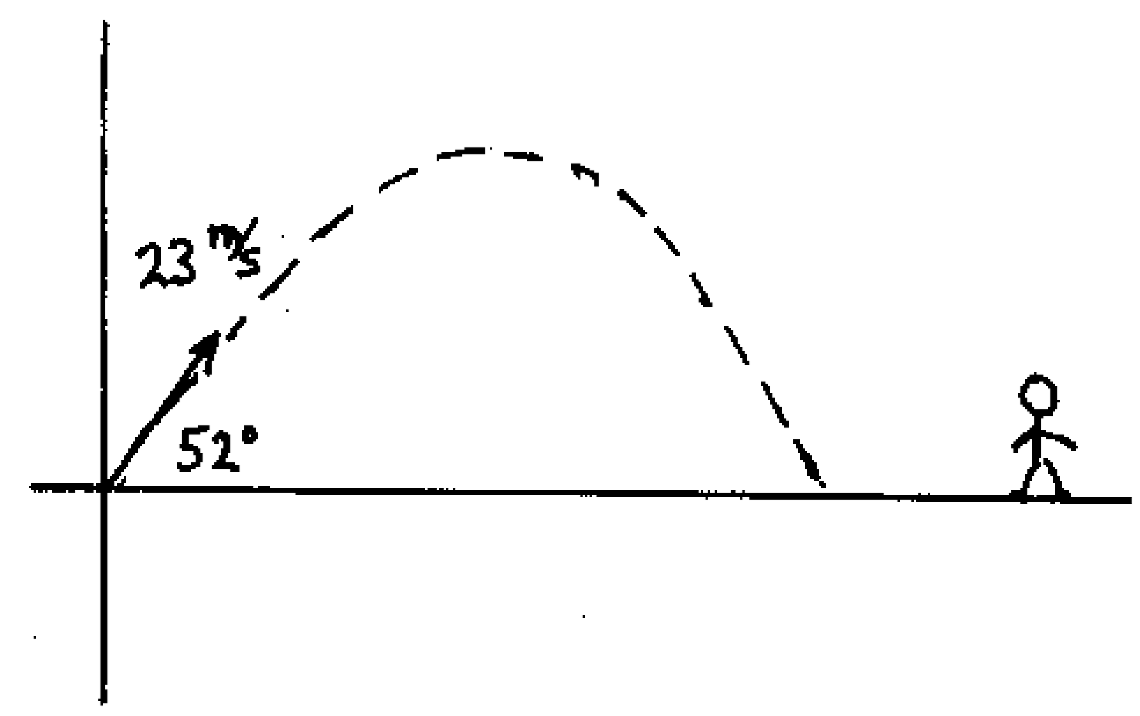
a) Slow down and eventually stop.

b) Maintain a steady speed as it follows a circular path; for example, a satellite in a circular orbit abound the earth.

c) Continue moving in a straight line at a steady speed.

d) Immediately stop moving.

Problems



1. A football is kicked from the ground with a speed of 23.0 $\frac{m}{s}$ at an angle of 52.0° with the horizontal.

a) How far from the point where it is kicked will it land? (5)

we can use the formula for the range R of a ground-to-ground projectile

$$R = \frac{2v_0^2 \sin\theta\cos\theta}{g} = \frac{2(23.0\frac{m}{s})^2 \sin 52^\circ \cos 52^\circ}{(9.8\frac{m}{s^2})}$$

$$= \boxed{52.4\,m}$$

one can also use the formula for the ball's trajectory $y = \tan\theta x - \frac{gx^2}{2v_0^2\cos^2\theta}$ and find the value of x for which $y=0$.

b) How high does the football rise during its flight? (5)

Find the time at which $v_y = 0$:

$$v_y = 0 = v_{0y} + a_y t = (23\tfrac{m}{s}\sin 52^\circ) - (9.8\tfrac{m}{s^2})t = (18.1\tfrac{m}{s}) - (9.8\tfrac{m}{s^2})t$$

Then $t = \frac{(18.1\frac{m}{s})}{(9.8\frac{m}{s^2})} = 1.85\,s$

Find the value of y at this time:

$$y = v_{0y}t + \tfrac{1}{2}a_y t^2 = (18.1\tfrac{m}{s})(1.85s) - \tfrac{1}{2}(9.8\tfrac{m}{s^2})(1.85s)^2 = \boxed{16.8\,m}$$

One can also use the formula for maximum height H given in the formula set.

c) How long is the football in the air? (5)

At what time does $y = 0$? Solve for t:

$$y = (18.1\tfrac{m}{s})t - \tfrac{1}{2}gt^2 = 0$$

$\rightarrow t[18.1\frac{m}{s} - \frac{1}{2}gt] = 0$, so $\frac{1}{2}gt = 18.1\frac{m}{s}$. Then:

$$t = \frac{2(18.1\frac{m}{s})}{g} = \frac{2(18.1\frac{m}{s})}{9.8\frac{m}{s^2}} = \boxed{3.70\,s}$$

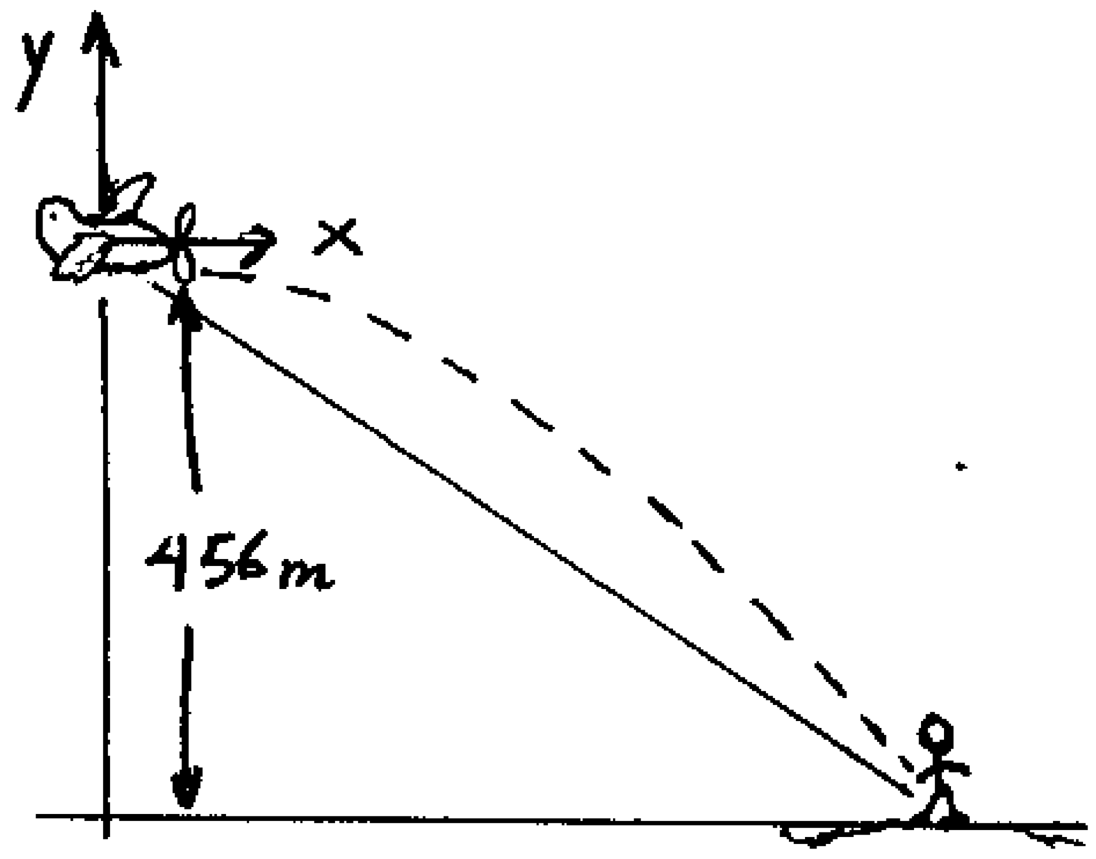
This is also twice the time found in part (b).

d) Suppose a player was standing a distance of 60.0 m from where the ball was kicked. How fast would he have to run (at a constant velocity) in order to catch the ball? (5)

Using part (a), the player is standing $60.0m - 52.4m = 7.6\,m$ from where the ball will land. S/he will need to cover this distance during the time of flight of the ball 3.70 s as found in (c). Then running at constant speed from the instant of the kick the necessary speed is

$$v = \frac{d}{t} = \frac{7.6m}{3.70s} = \boxed{2.1\,\tfrac{m}{s}}$$

2. The pilot of a plane, flying horizontally parallel to the Atlantic Ocean at a speed of 567 $\frac{\text{km}}{\text{h}}$, observes a shipwrecked sailor. The plane's altimeter shows a height of 0.456 km. The pilot knows, from her course in physics that if she drops the survival package when the sailor is directly below, it will be too late! Hence, she releases the package before reaching the sailor (who is at rest with respect to the calm ocean).



a) What is the initial velocity of the package in $\frac{\text{m}}{\text{s}}$? (5)

Initial velocity (speed) of package is same as that of plane,

$$V_0 = \left(567 \frac{\text{km}}{\text{h}}\right)\left(\frac{10^3 \text{ m}}{1 \text{ km}}\right)\left(\frac{1 \text{ h}}{60 \text{ min}}\right)\left(\frac{1 \text{ min}}{60 \text{ s}}\right) = \boxed{158 \text{ m/s}}$$

b) After how much time will the package reach the sailor? (5)

Plane is 456 m above the ground. → At what time does $y = -456$ m?

Since $V_{0x} = 158$ m/s, $V_{0y} = 0$, get:

$y = -456\text{m} = V_{0y}t + \frac{1}{2}a_y t^2 = -\frac{1}{2}gt^2$ Solve for t:

$$t^2 = \frac{2(456\text{m})}{g} = \frac{2(456\text{m})}{(9.8 \text{ m/s}^2)} = 93.1 \text{ s}^2 \longrightarrow \boxed{t = 9.65 \text{ s}}$$

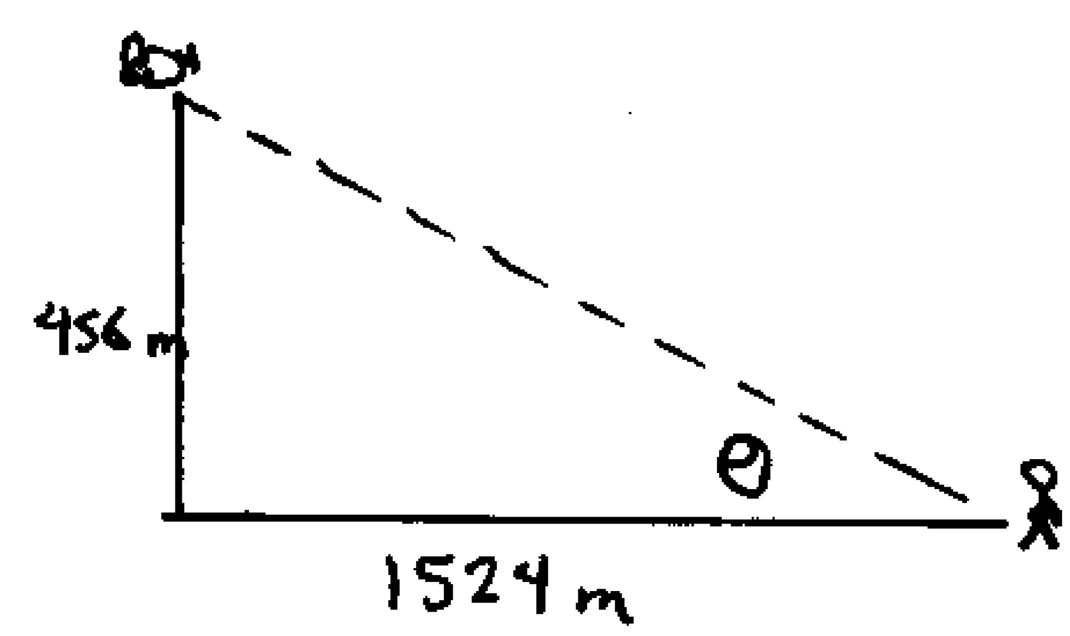
c) What is the horizontal distance travelled by the package? (5)

what is x at the time found in (b)?

$$x = V_{0x}t + \tfrac{1}{2}a_x t^2 = (158 \text{ m/s})(9.65 \text{ s}) = \boxed{1524 \text{ m}}$$

d) At what angle was the line of sight from the plane to the sailor (with respect to the horizontal) when the pilot released the package? (5)

Using the answer from (c) the geometry at the time of the drop was as shown. Then:

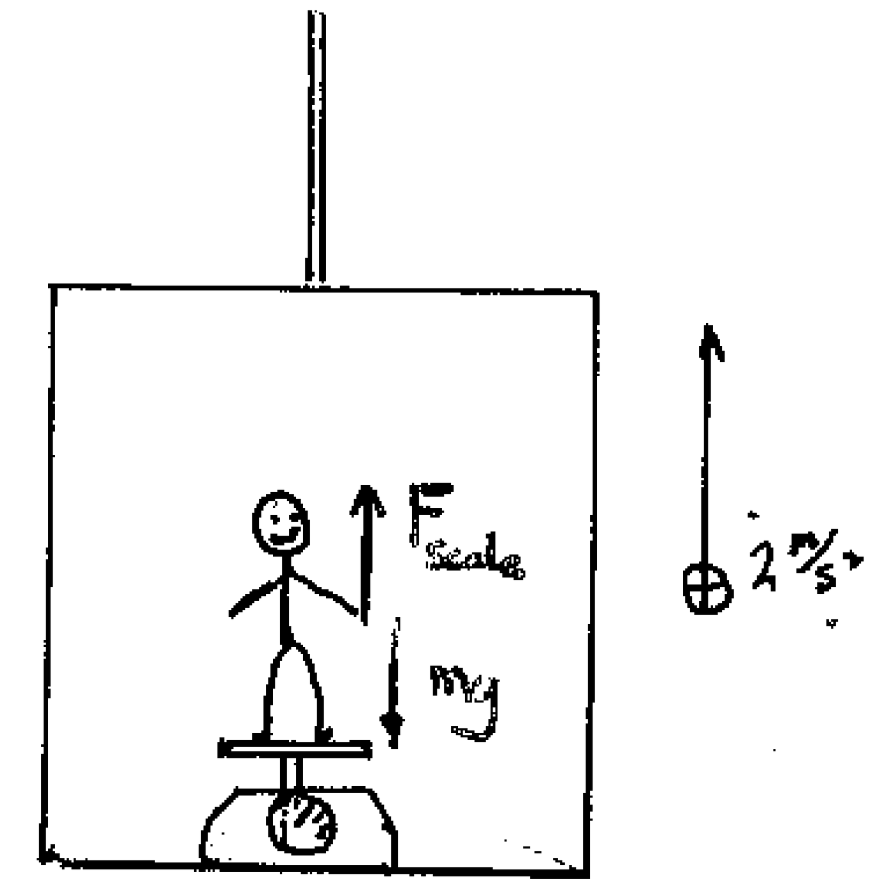


$$\tan\theta = \frac{456\text{m}}{1524\text{m}} = 0.2992$$

$$\longrightarrow \theta = \boxed{16.7°}$$

3. A very thin man stands on a scale inside an elevator which is accelerating upward at 2.00 $\frac{\text{m}}{\text{s}^2}$. The scale reads 1070 N.

What is the mass of the man? (6)

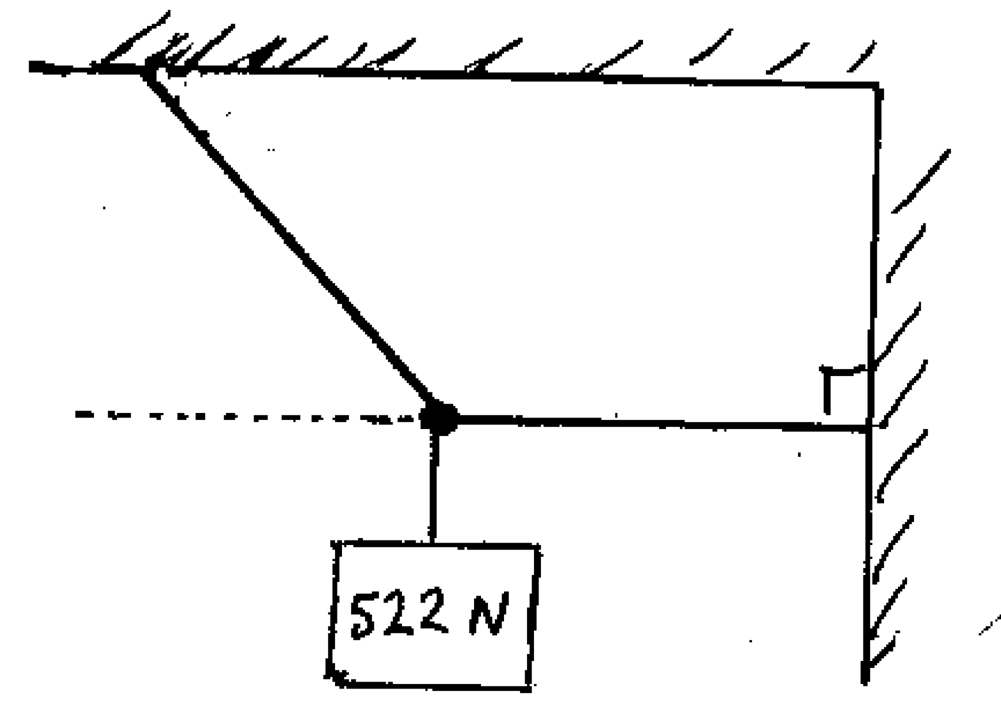


Forces on the man are: Gravity, mg downward and F_{scale}, upward. Newton's 2nd law for the y direction gives:

$$F_{scale} - mg = ma_y$$

$$\rightarrow F_{scale} = mg + ma_y = m(g + a_y) \quad . \quad \text{Then:}$$

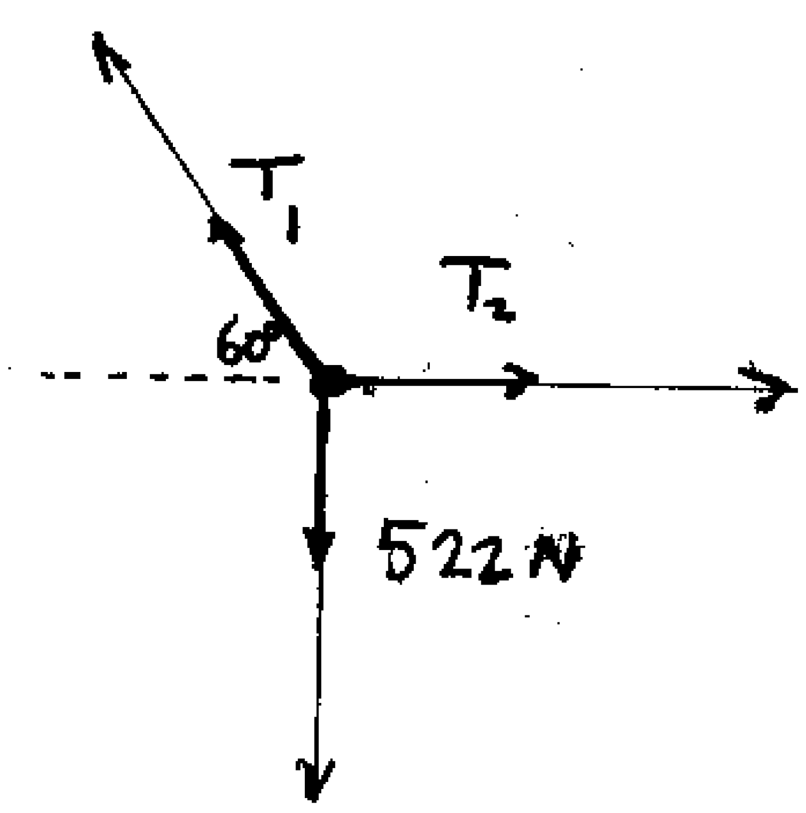
$$m = \frac{F_{scale}}{(g + a_y)} = \frac{(1070\ \text{N})}{(9.8\ \frac{\text{m}}{\text{s}^2} + 2.0\ \frac{\text{m}}{\text{s}^2})} = \boxed{90.7\ \text{kg}}$$



4. Consider the 522 N weight held by two cables, as shown at the right. The left–hand cable makes an angle of 60.0° with the ceiling, while the right–hand cable is horizontal.

a) What is the tension in the left–hand cable? (6)

Forces (from the cables) acting at the junction are as shown. Junction has no motion so the x-forces and the y-forces both sum to zero. For the y-forces we get:



$$T_1 \sin 60^\circ - 522\ \text{N} = 0 \qquad \text{Then:}$$

$$T_1 = \frac{522\ \text{N}}{\sin 60^\circ} = \boxed{603\ \text{N}}$$

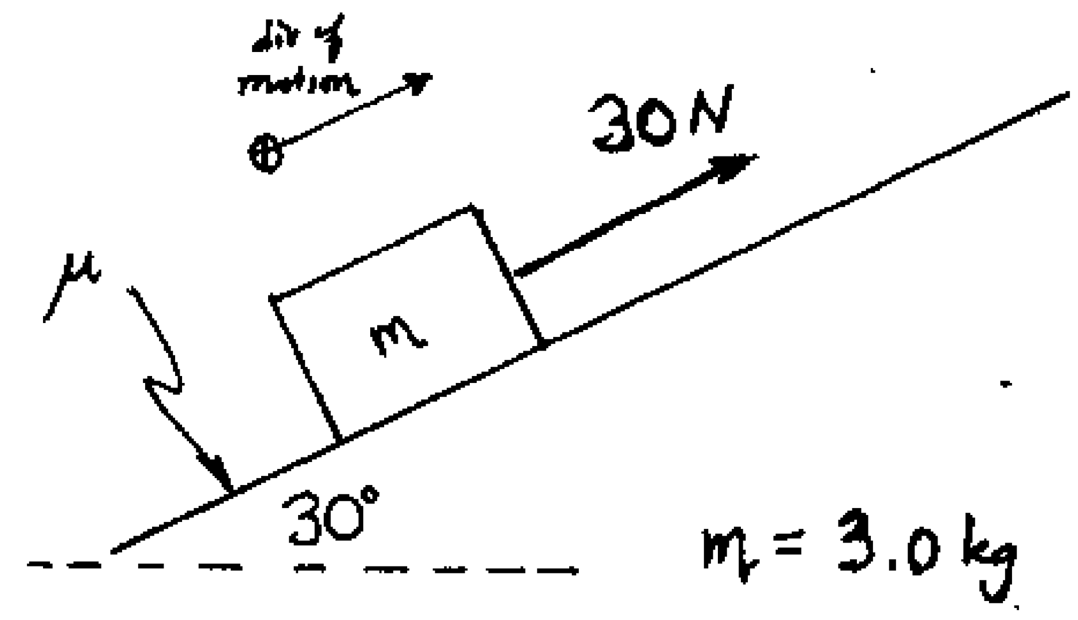
b) What is the tension in the right–hand (horizontal) cable? (6)

The x-forces sum to zero so we get:

$$-T_1 \cos 60^\circ + T_2 = 0$$

$$T_2 = T_1 \cos 60^\circ = (603\ \text{N}) \cos 60^\circ = \boxed{301\ \text{N}}$$

5. A 3.0 kg block is dragged up a rough 30.0° incline by a force of 30.0 N which is applied parallel to the incline. The block accelerates uniformly up the incline; starting from rest, it moves a distance of 2.0 m in 1.13 s.



a) What is the magnitude of the block's acceleration? (3)

$V_0 = 0$, so $x = \frac{1}{2}at^2$. Then:

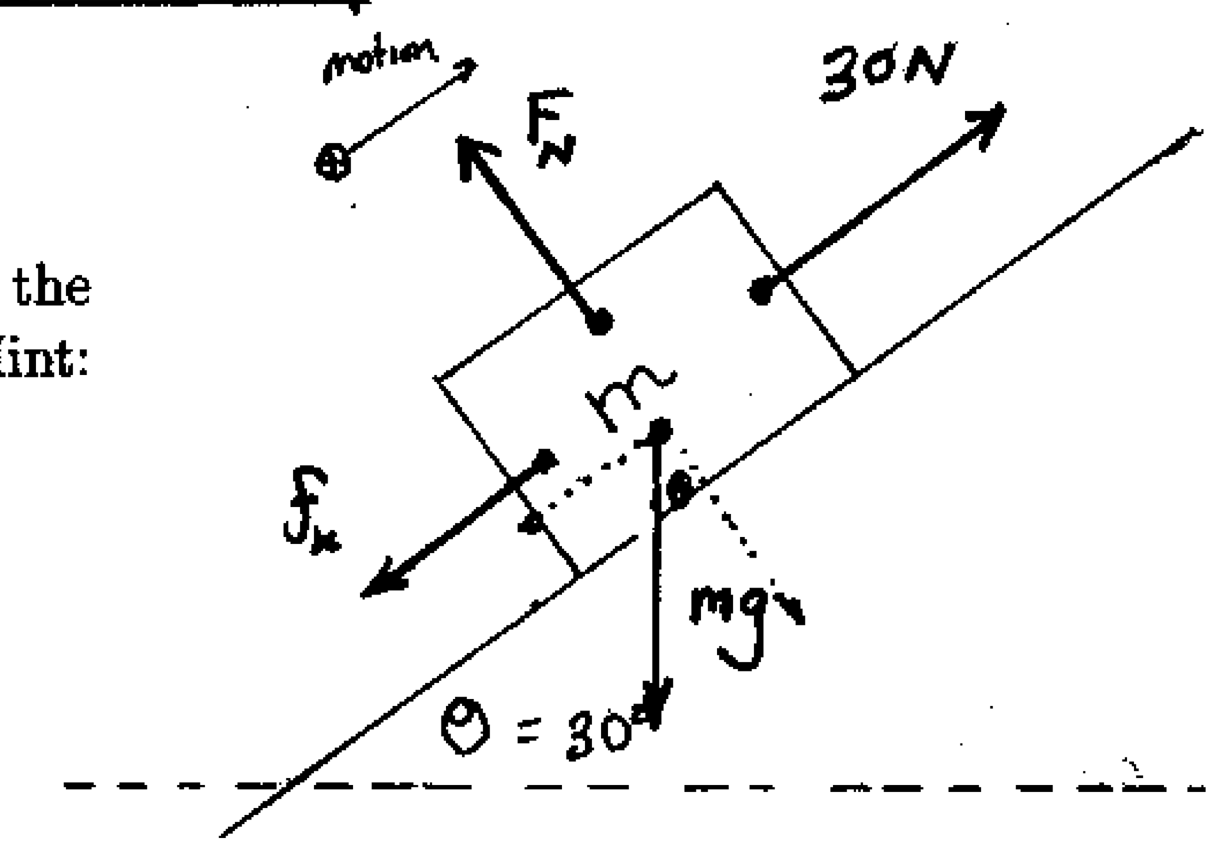
$$a = 2x/t^2 = \frac{2(2.0\,m)}{(1.13\,s)^2} = \boxed{3.13\,m/s^2}$$

b) What is the magnitude of the *net* force which acts on the block? (3)

The net force points in the same direction as the acceleration (up the slope) and has magnitude

$$|\vec{F}| = m|\vec{a}| = (3.0\,kg)(3.13\,m/s^2) = \boxed{9.4\,N}$$

c) On the figure at the right, show all the forces acting on the block, that is, make a (labelled) free-body diagram. (Hint: Friction *opposes* the motion of the block.) (5)



d) What is the magnitude of the normal force from the surface? (3)

The sum of the force components perpendicular to the surface must cancel; this gives:

$$F_N - mg\cos\theta = 0 \quad \longrightarrow \quad F_N = mg\cos\theta = (3.0\,kg)(9.8\,m/s^2)\cos 30° = \boxed{25.5\,N}$$

e) What is the magnitude of the kinetic friction force which acts on the block? (Hint: Use the answer to (b), your diagram in (c) and Newton's 2nd law!) (5)

Sum of forces up the slope is (using (b)),

$$30\,N - f_k - mg\sin\theta = F_{net,x} = 9.4\,N$$

Solve for f_k,

$$f_k = 30\,N - mg\sin\theta - 9.4\,N = 30\,N - (3.0\,kg)(9.8\,m/s^2)\sin 30° - 9.4\,N = \boxed{5.9\,N}$$

f) What is the coefficient of kinetic friction for the block and surface? (3)

Since $f_k = \mu_k F_N$, use result of (d) to get:

$$\mu_k = f_k/F_N = \frac{5.9\,N}{25.5\,N} = \boxed{0.23}$$