Sept. 26, 2000

Name________________________________

Instructor (circle only one): **Robinson** **Murdock**

Physics 121, Exam #1

1. ____________________ (10)

2. ____________________ (14)

3. ____________________ (8)

4. ____________________ (16)

5. ____________________ (8)

6. ____________________ (8)

7. ____________________ (16)

Mult Choice ____________________ (20)

Total ____________________ (100)

$A_x = A\cos\theta \quad A_y = A\sin\theta \quad A = \sqrt{A_x^2 + A_y^2} \quad \theta = \tan^{-1}\left(\frac{A_y}{A_x}\right)$

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

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

$\sum \mathbf{F} = \mathbf{F}_{\text{net}} = m\mathbf{a} \quad \sum F_x = ma_x \quad \sum F_y = ma_y \quad F = G\frac{m_1 m_2}{r^2}$

$g = 9.80\,\frac{\text{m}}{\text{s}^2} \quad G = 6.67\times10^{-11}\,\frac{\text{N}\cdot\text{m}^2}{\text{kg}^2} = 6.67\times10^{-11}\,\frac{\text{m}^3}{\text{kg}\cdot\text{s}^2} \quad \text{Weight} = mg$

$f_{\text{stat}}^{\text{Max}} = \mu_s F_N \quad f_{\text{kin}} = \mu_k F_N \quad 1\,\text{m} = 10^2\,\text{cm} \quad 1\,\text{km} = 10^3\,\text{m}$

For all projectile problems, neglect air resistance.

Multiple Choice (2 pts each)

1. How many cubic centimeters (cm^3) are there in a cubic meter (m^3)?

(A) 10^2
(B) 10^4
(C) 10^6
(D) 10^9

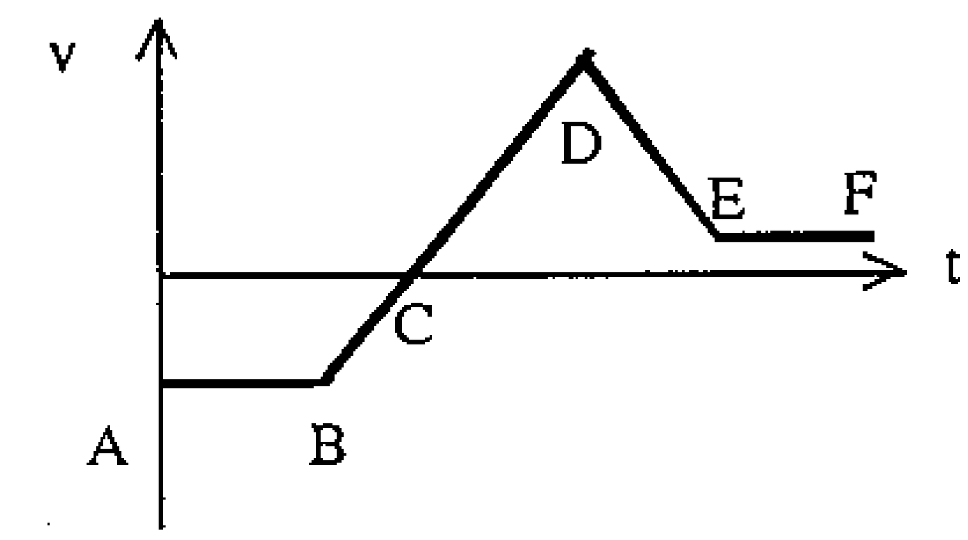
A small ball is tossed straight up into the air. Answer the following three questions about its motion.

2. On the way up,
(A) Its velocity points upward and its acceleration points upward.
(B) Its velocity points upward and its acceleration points downward.
(C) Its velocity points upward and its acceleration is zero.
(D) Its velocity points downward and its acceleration points upward.

3. At its highest point,
(A) Its velocity is zero and its acceleration points upward.
(B) Its velocity is zero and its acceleration points downward.
(C) Its velocity is zero and its acceleration is zero.
(D) Its velocity points downward and its acceleration is zero.

4. On the way back down,
(A) Its velocity points upward and its acceleration points downward.
(B) Its velocity points downward and its acceleration is zero.
(C) Its velocity points downward and its acceleration points downward.
(D) Its velocity points downward and its acceleration points upward.

The sketch to the right shows a velocity-time Graph for a car moving on a straight road. Answer the following three questions, based on this graph.



5. Which of the following statements best describes the motion of the object between points A and B on the graph?
(A) The car is not moving.
(B) The car is moving forward at a constant speed.
(C) The car is moving backward and speeding up.
(D) The car is moving backward at a constant speed.

6. At which point(s) on the graph does the car change direction?
(A) Point D only.
(B) Points B and E only.
(C) Point C only.
(D) Points B, D, E only.

7. On which section(s) of the graph does the acceleration of the car have a negative value?
(A) Sections AB and BC.
(B) Section DE
(C) Sections AB and EF
(D) No sections.

8. In the parking lot at Wal-Mart, while looking for a parking space, an inattentive motorist's car collides with an empty shopping cart. Which of the following statements best describes the forces acting during the collision?
(A) The force exerted by the car on the cart has the same magnitude as the strength of the force exerted by the cart on the car.
(B) The force exerted by the car on the cart is larger than the force exerted by the cart on the car.
(C) The force exerted by the car on the cart is smaller than the force exerted by the cart on the car.
(D) The car exerts a large force on the cart, but the cart does not exert any force on the car.

9. Two lemmings run horizontally off the edge of a cliff, one at twice the speed of the other. The faster lemming will land

(A) Twice as far from the base of the cliff as the slower one.
(B) Four times as far from the base of the cliff as the slower one.
(C) The same distance from the base of the cliff as the slower one.
(D) There is not enough information to tell.

10. Two vectors **A** and **B** have magnitudes of 3 and 4 units respectively, with unspecified directions. What are the minimum and maximum magnitudes of the vector $\mathbf{C} = \mathbf{A} + \mathbf{B}$?

(A) Minimum magnitude = -1 units, Maximum magnitude = 7 units.
(B) Minimum magnitude = 1 unit, Maximum magnitude = 5 units.
(C) Minimum magnitude = 1 units, Maximum magnitude = 7 units.
(D) Minimum magnitude = 5 units, Maximum magnitude = 7 units.

Problems. (Always show your work!)

1. Given that: 1 gallon $= 3.758 \times 10^{-3}\ \text{m}^3$, convert

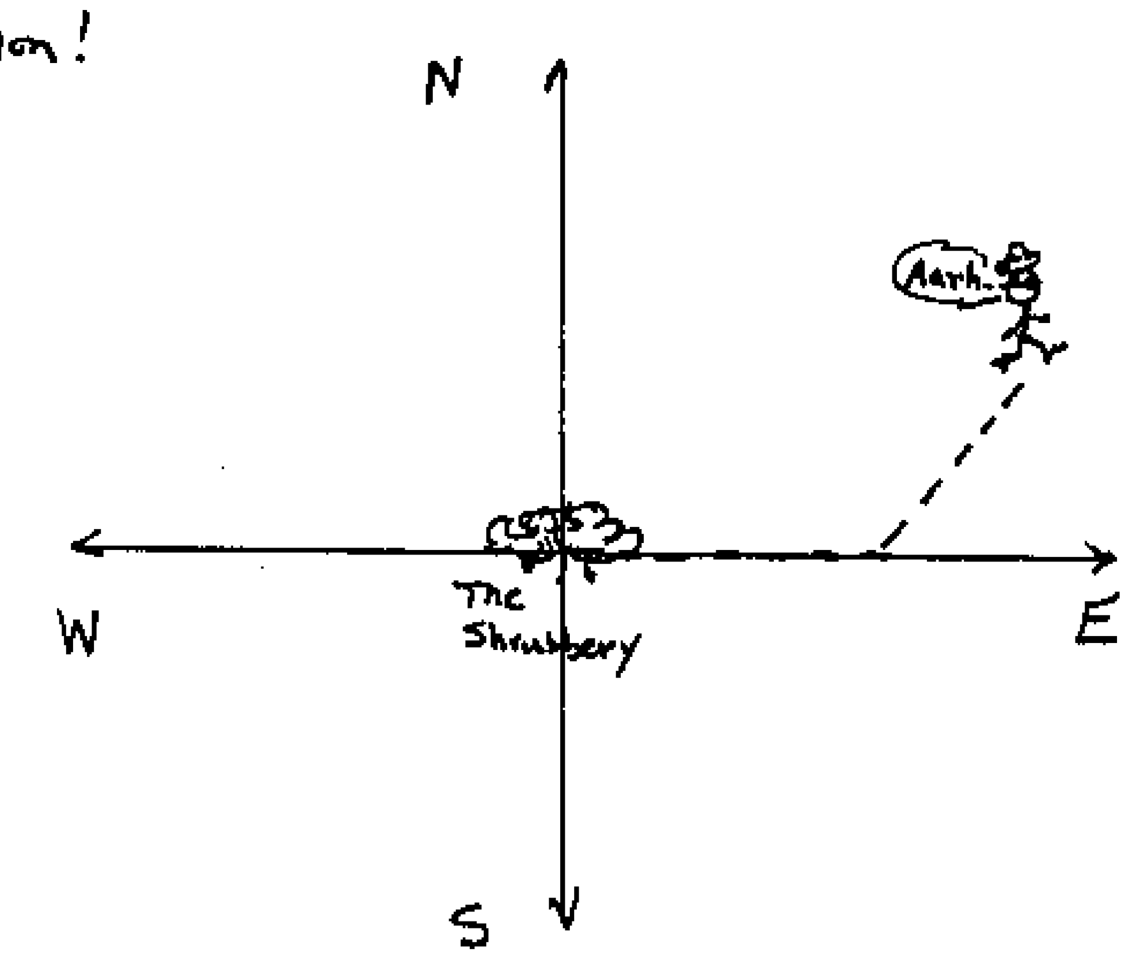
$$2.56 \frac{\text{gallon}}{\text{hour}}$$

to units of cm^3/s. (10)

$$= \left(2.56 \frac{\text{gal}}{\text{hr}}\right)\left(\frac{3.758 \times 10^{-3}\ \text{m}^3}{1\ \text{gal}}\right)\left(\frac{10^2\ \text{cm}}{\text{m}}\right)^3 \left(\frac{1\ \text{hr}}{60\ \text{min}}\right)\left(\frac{1\ \text{min}}{60\ \text{sec}}\right)$$

$$= 2.67 \frac{\text{cm}^3}{\text{s}}$$

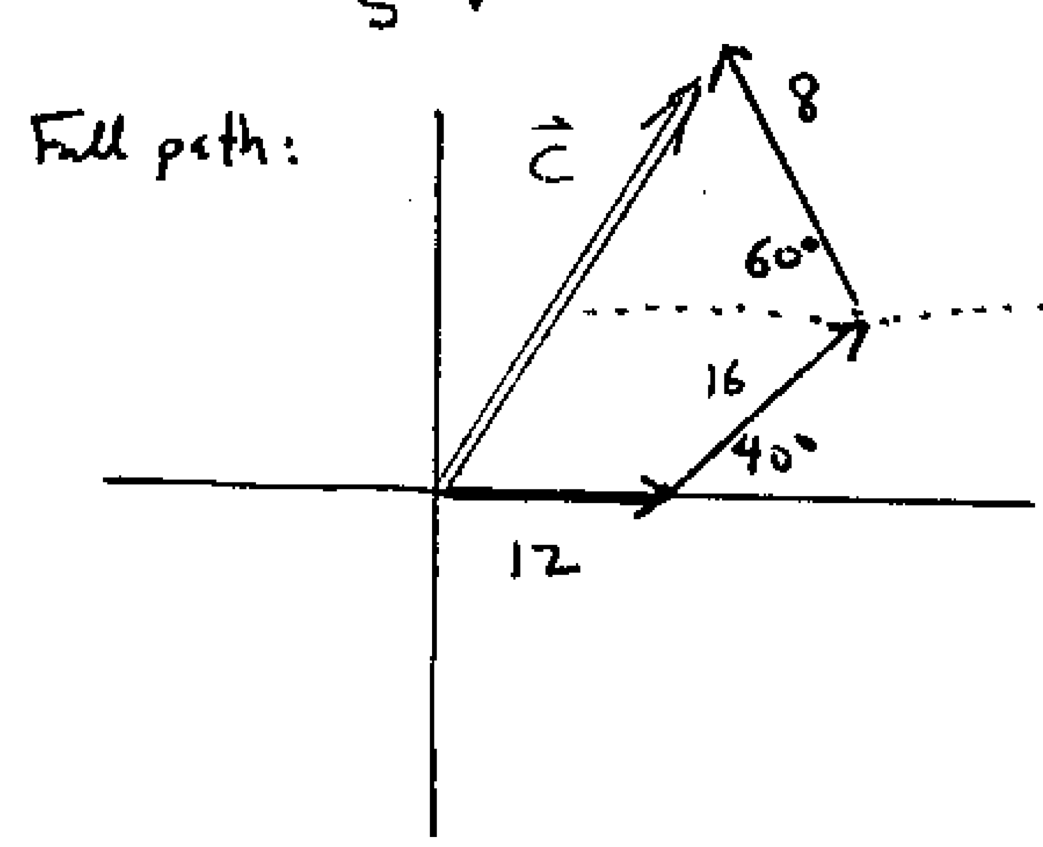
where have used $(10^2)^3$ in the calculation!



2. A pirate in search of buried treasure starts off from a shrubbery and walks 12 paces East, then 16 paces in a direction 40° North of East and then 8.0 paces in a direction 60° North of West.

Find the direction and magnitude (in units of paces) of the net displacement of the pirate from the shrubbery. (14)

If $\vec{C}$ is the net displacement then sum the individual x and y displacements to get:



$$C_x = 12 + 16\cos 40^\circ - 8.0\cos 60^\circ$$
$$= 20.3$$

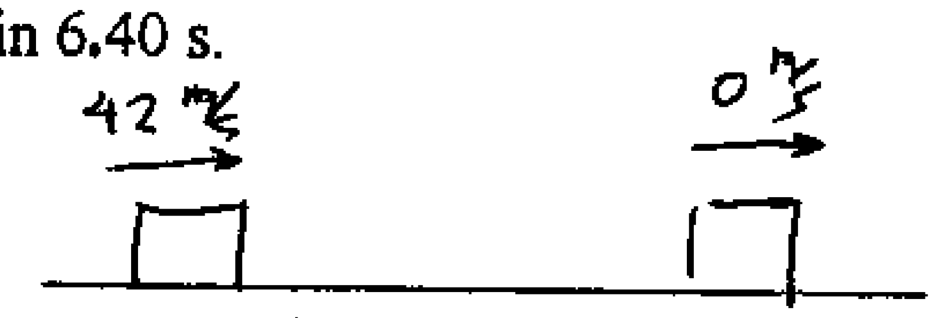
$$C_y = 16\sin 40^\circ + 8\sin 60^\circ$$
$$= 17.2$$

Magnitude of $\vec{C}$ is

$$C = \sqrt{C_x^2 + C_y^2} = 26.6$$

Direction is $\theta = \tan^{-1}\left(\frac{C_y}{C_x}\right) = 40.3^\circ$ (ccwise from +x axis)

3. A truck traveling on a straight road at $42.0\frac{m}{s}$ comes to a halt in 6.40 s.



a) What is the magnitude of the truck's acceleration? (4)

$$a_x = \frac{v - v_0}{\Delta t} = \frac{0\frac{m}{s} - 42\frac{m}{s}}{6.40\,s} = -6.56\frac{m}{s^2}$$

Magnitude of a_x is $6.56\ m/s^2$

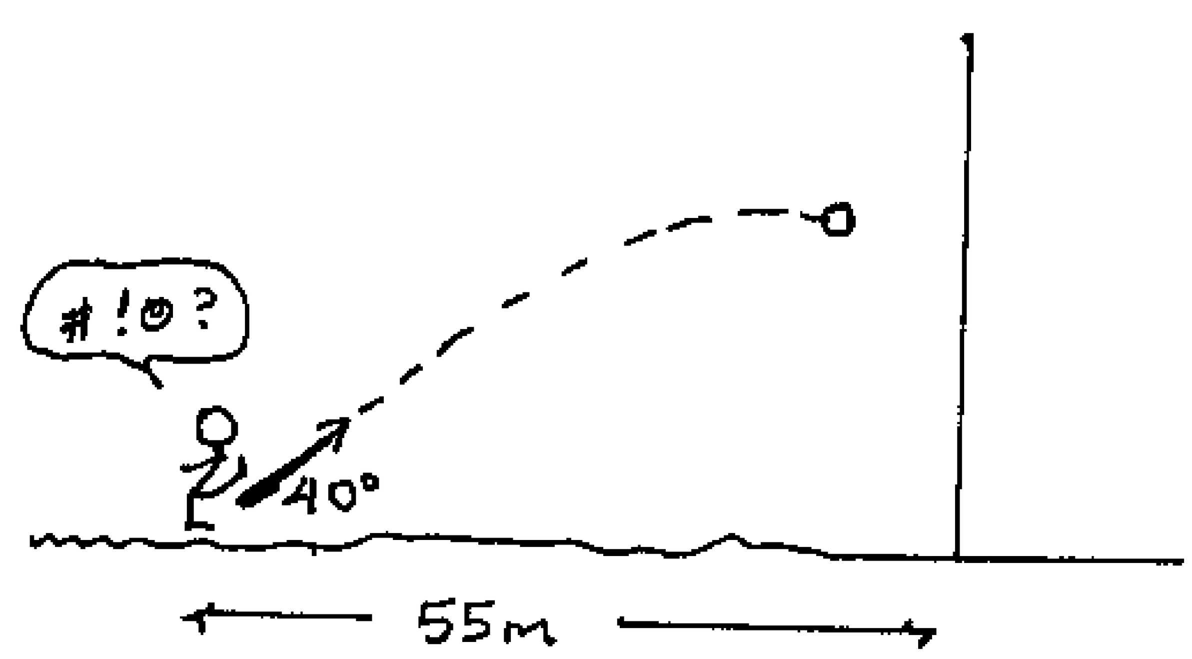
b) How far does the truck travel in the process of stopping? (4)

Use $v^2 = v_0^2 + 2ax$. Then:

$$2ax = v^2 - v_0^2$$

$$x = \frac{v^2 - v_0^2}{2a} = \frac{0 - (42\frac{m}{s})^2}{2(-6.56\frac{m}{s^2})} = 134\ m$$

4. An irate physics teacher kicks a soccer ball toward a neighbouring building. The ball is kicked at an angle of 40°, and 2.15 s later it strikes the building, which is 55.0 m away from the launch point.



a) What was the x-component of the ball's initial velocity? (6)

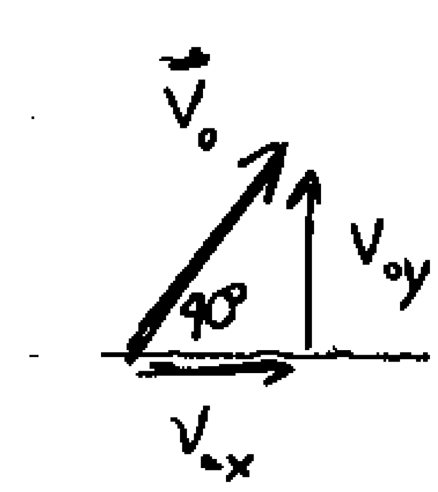
x-eqn of motion for ball is

$x = V_{0x} t$ || No a_x !!

At $t = 2.15\,s$ we know $x = 55.0\ m$, so

$$(55.0\,m) = V_{0x}(2.15\,s) \rightarrow V_{0x} = \frac{(55.0\,m)}{(2.15\,s)} = 25.6\frac{m}{s}$$

b) What was the initial *speed* of the ball? (Speed is the *magnitude* of the velocity vector…) (5)



V_{0x} is the x-component of $\vec{V}_0$.

It related to V_0 by $V_{0x} = V_0 \cos 40°$

So $$V_0 = \frac{V_{0x}}{\cos 40°} = \frac{25.6\frac{m}{s}}{0.766} = 33.4\frac{m}{s}$$

c) At what vertical distance (height) did the ball strike the building? (6)

Then we have $V_{0y} = V_0 \sin 40° = (33.4\frac{m}{s}) \sin 40° = 21.5\frac{m}{s}$

and at $t = 2.15\,s$ the y-coord of the ball is

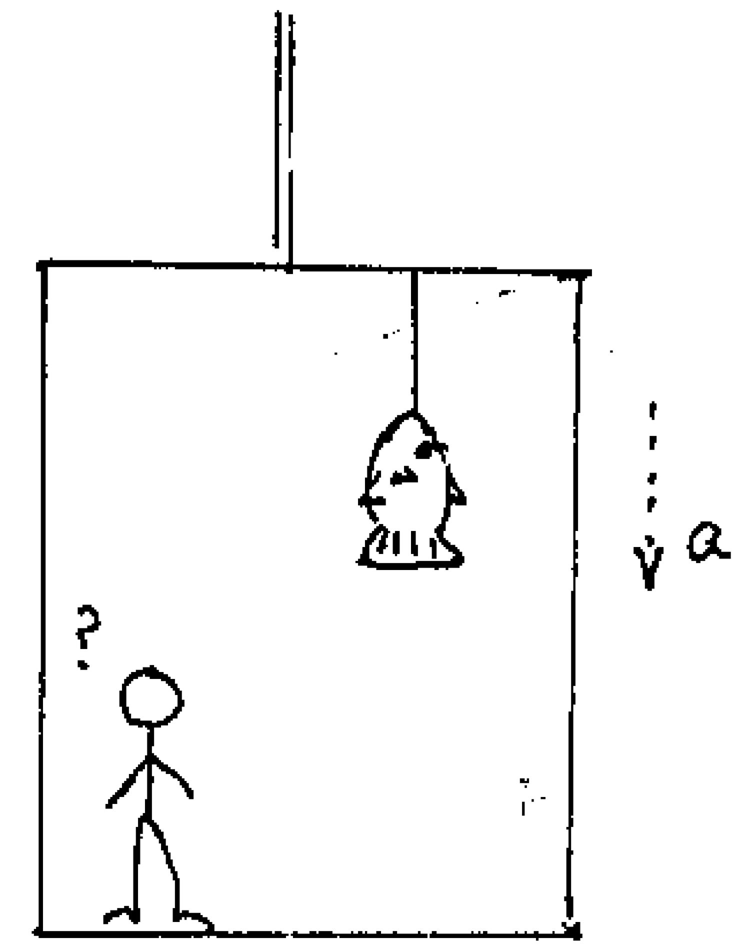
$$y = V_{0y} t + \tfrac{1}{2} a_y t^2 = (21.5\tfrac{m}{s})(2.15\,s) + \tfrac{1}{2}(-9.8\tfrac{m}{s^2})(2.15\,s)^2$$

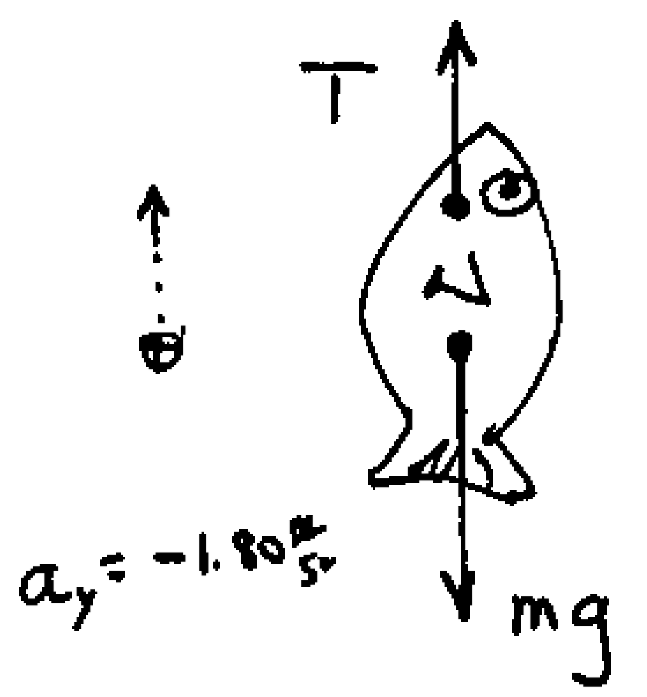
$$= 23.5\,m$$

= height at which building was struck.

5. A 3.30 kg fish hangs from a string inside an elevator which is accelerating downward at a rate of $1.80\frac{m}{s^2}$

What is the tension in the string?





Forces on fish are tension T upward, weight mg downward.

Acceleration is $a_y = -1.80\frac{m}{s^2}$

Newton says:

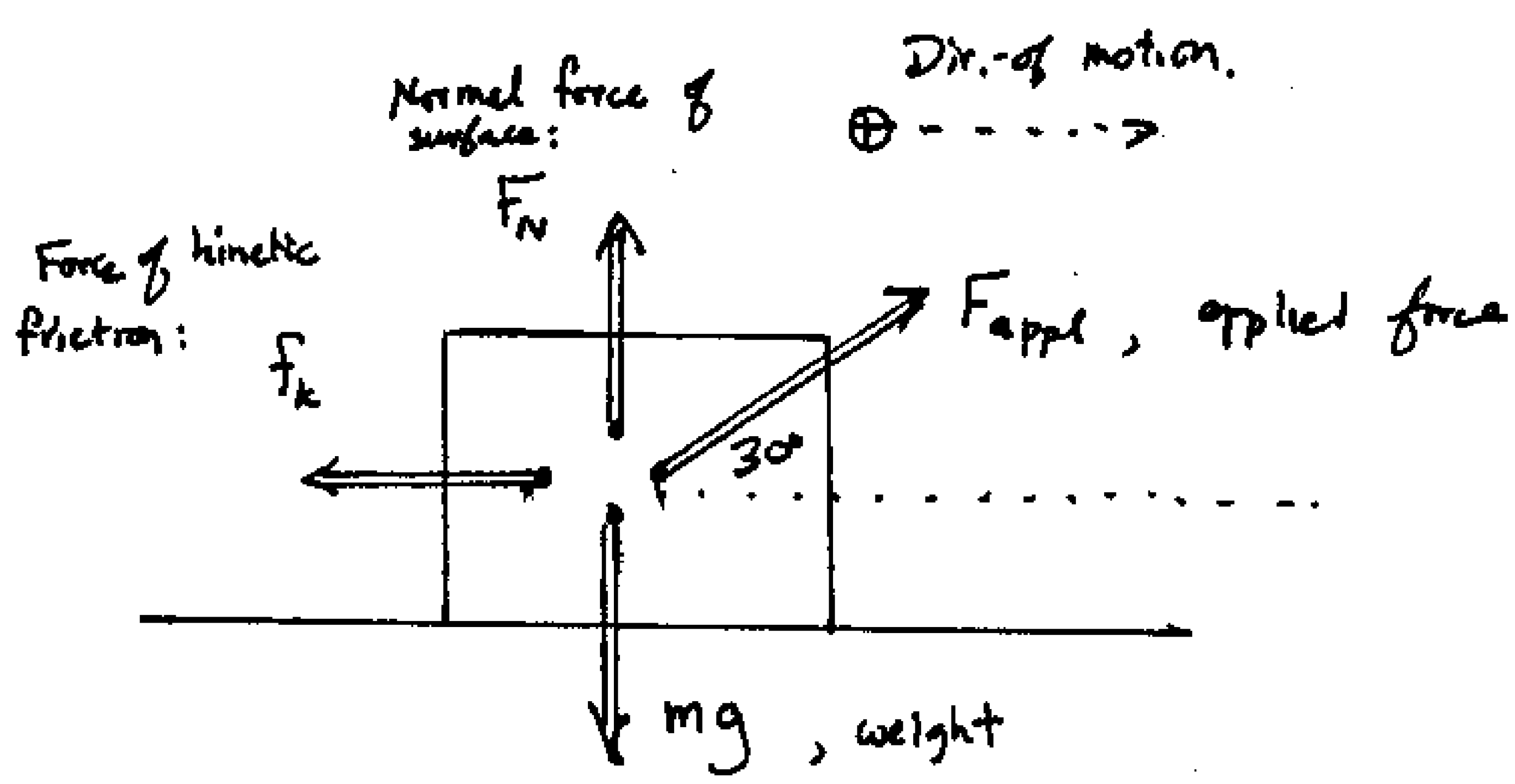
$$\sum F_y = T - mg = ma_y = m(-1.80\tfrac{m}{s^2})$$

Find T:

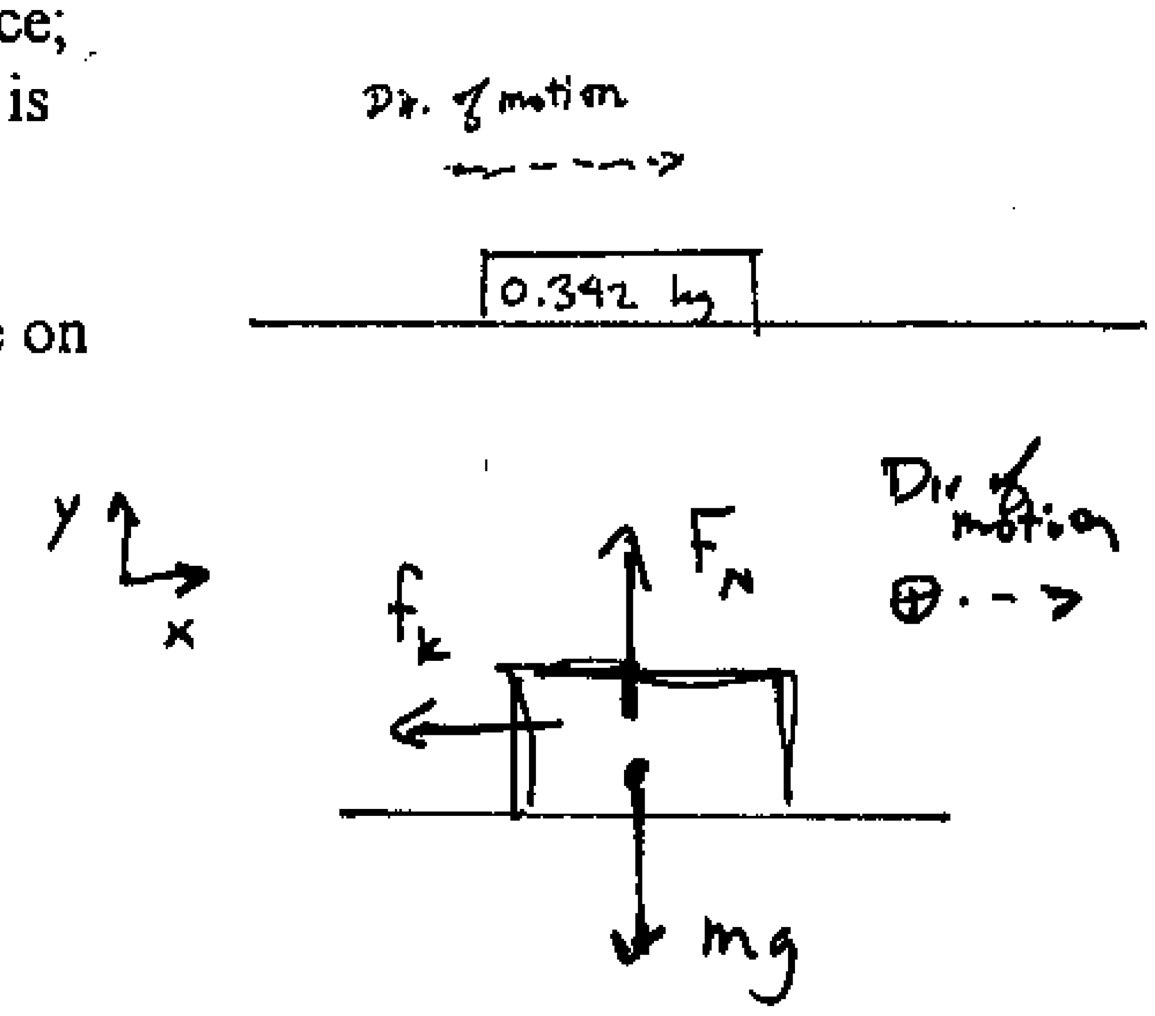
$$T = mg + ma_y = m(g + a_y) = (3.30\text{ kg})(9.80\tfrac{m}{s^2} - 1.80\tfrac{m}{s^2}) = 26.4\text{ N}$$

6. A block of mass m is dragged over a rough horizontal surface by an applied force which is directed at 30° above the horizontal. *(Rough surfaces have friction...)*

Draw a free-body diagram for the mass, labeling *all* the forces and showing their directions.



7. A hockey puck of mass 0.342 kg slides over a flat surface; the coefficient of kinetic friction between puck and surface is 0.114.



a) What is the magnitude of the normal force of the surface on the puck?

Vertical forces sum to zero, so

$$F_N = mg = (0.342\text{ kg})(9.80\tfrac{m}{s^2})$$
$$= 3.35\text{ N}$$

b) What is the magnitude of the force of kinetic friction?

Mag. of force of kin. friction is

$$f_k = \mu_k F_N = (0.114)(3.35\text{ N})$$
$$= 0.382\text{ N}$$

c) What is the magnitude of the puck's acceleration?

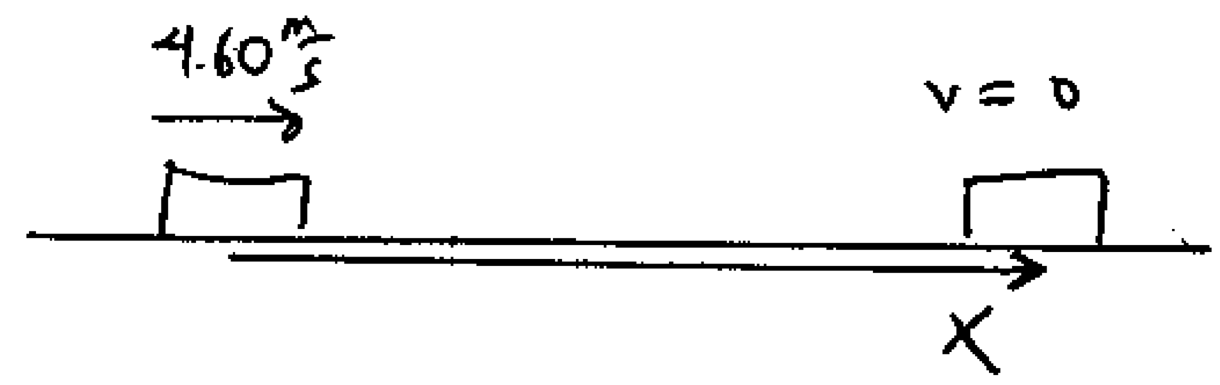
The net x-force is $\sum F_x = -f_k = ma_x$

so $a_x = -f_k/m = -\dfrac{(0.382\text{ N})}{(0.342\text{ kg})} = -1.12\ \frac{m}{s^2}$

(The magnitude of the acceleration is $1.12\ \frac{m}{s^2}$.)

d) If the puck is initially sliding with a speed of $4{,}60\frac{m}{s}$, how far will it slide before coming to rest?

Use: $v^2 = v_0^2 + 2ax$



$2ax = v^2 - v_0^2$

$x = \dfrac{v^2 - v_0^2}{2a} = \dfrac{(0)^2 - (4.60\ \frac{m}{s})^2}{2(-1.12\ \frac{m}{s^2})} = 9.5\text{ m}$