Your Name ______________________

PY132 Physics of Motion
First Exam (**Practice**)
Monday, October 2, 2006

This is a closed book exam, with no notes allowed. You may use (but not share) a calculator. Do not talk or otherwise communicate with the other students. If you have a question about the interpretation of a question on the exam, raise your hand and ask the proctor; he will come over to you. He will answer only if appropriate.

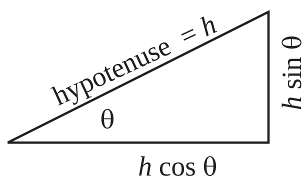
Show the mathematical steps that lead you to your answers. Without them, a "right" answer is unjustified. With them, a "wrong" answer may be worth partial credit.

Some equations and constants that you might need to be reminded of:

$x(t) = x_0 + v_0 t + \frac{1}{2} a t^2$ $\qquad v(t) = v_0 + at$

$\sum \vec{F} = m\vec{a}$ $\qquad |f| = \mu |N|$ $\qquad g = 10 \, {}^{m}\!/_{s^2}$

$\tan\theta = \dfrac{opposite}{adjacent} = \dfrac{\sin\theta}{\cos\theta}$



1. ________/ 30

2. ________/ 25

3. ________/ 25

4. ________/ 20

__________ Total

Problem 1. [30 points] Conceptual Questions (1a-d; see also next page)

1a) If you graph velocity versus time, the slope of the graph at any point may be identified with

A. instantaneous velocity.
B. average velocity.
C. instantaneous speed.
D. instantaneous acceleration.
E. average acceleration.

1a continued) What does the area under the curve considered in 1a represent?

1b) You stand high up on a seaside cliff and want to throw a lemon as far as possible to the beach below. You should throw the lemon at an angle [GREATER THAN 45 DEGREES] [EQUAL TO 45 DEGREES][LESS THAN 45 DEGREES].

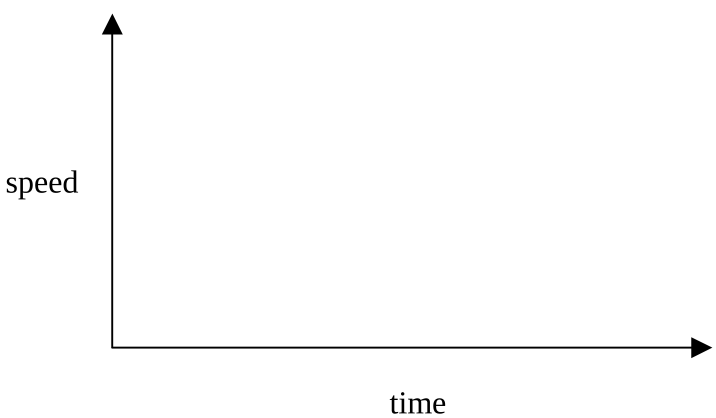
Problem 1 continued (see also previous page).

1c) The magnitude of two force vectors **A** and **B** are 24 N and 16 N respectively, but I have not specified their directions.

i) What are the largest and smallest magnitudes for the net force **F** = **A** + **B**?

ii) Now, let **A** be directed along the *x*-axis
and **B** be directed at plus thirty degrees from the *x*-axis.
Sketch this situation below and construct (draw) the vector **F´**=2**A**-**B**.
Express the vector mathematically by the *x* and *y* components.

1d) Sketch a graph of speed versus time for a ball dropped from a very tall building for two cases: (A) ignoring air resistance and (B) considering air resistance. Put the two curves on one graph and label which one is which.



Problem 2. [25 points] Squirrel Peril

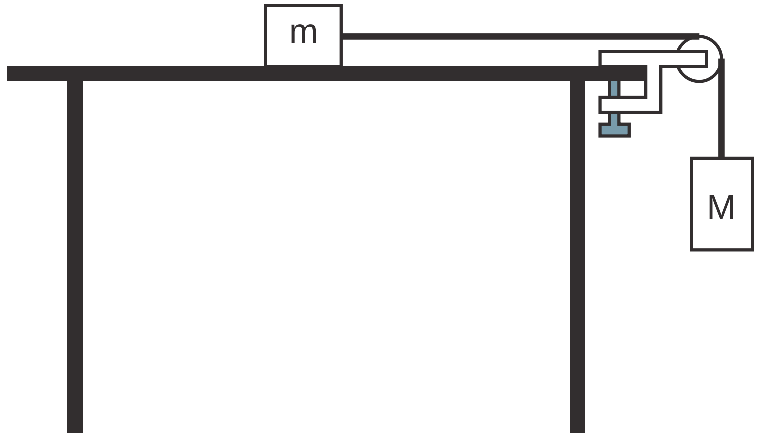
You are driving home at 60 mph, talking on the cell phone and not paying attention to the road. Five hundred feet ahead a squirrel runs into the road and stops to eat an acorn. After 2 seconds, you finally notice, hit the brakes, and come uniformly to a stop in 10 seconds.

HINT: first convert your speed into feet per second and use that throughout.
The acceleration due to gravity in English units is: $g = 32$ ft s^{-2}.

- **(a)** How big an instantaneous acceleration do your passengers feel? Express in units of g.
- **(b)** How far do you travel before coming to a stop? (Do you hit the squirrel?)
- **(c)** Carefully draw on the graph paper your position, velocity, and acceleration as a function of time. Label your axes, put numbers by your tick marks.

Problem 3. **[25 points] Slowly falling masses.**

You have a lab setup with two masses, a smaller one (*m*) of 2 kg and a larger one (*M*) of 8 kg. They are connected by a light string and frictionless pulley. The table has a coefficient of friction of 0.4. You release the system and measure the motion.



(a) Draw proper free body diagrams for each mass (when the system is moving). Show all forces.
(b) Calculate the acceleration.
(c) Calculate the tension in the string (when the system is moving).
~~(d) How much work is done by friction on the small mass when it moves 0.1 m?~~

Problem 4. **Landing on a jet plane. [20 pts]**

While landing, during the period of time when the plane slows down to a near stop on the runway by applying powerful reverse engine thrust, some passenger, who shall remain nameless, dangles his computer mouse to estimate the acceleration. If the angle of the mouse is 15 degrees from the vertical, what is the acceleration?

Draw a free body diagram for the mouse. Show your work in the calculation. State any assumptions you feel are important about this experimental setup.

Problem 1. [30 points] Conceptual Questions (1a-d; see also next page)

1a) If you graph velocity versus time, the slope of the graph at any point may be identified with

A. instantaneous velocity.
B. average velocity.
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(D) instantaneous acceleration.
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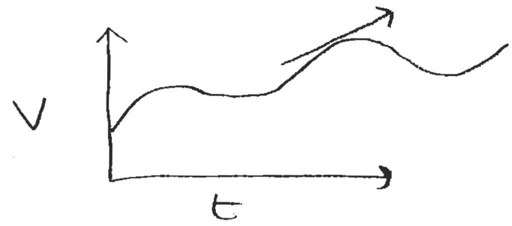


1a continued) What does the area under the curve considered in 1a represent?

DISTANCE TRAVELLED

area ~ V × t = d   units of distance

1b) You stand high up on a seaside cliff and want to throw a lemon as far as possible to the beach below. You should throw ~~the lemon at an angle~~ [GREATER THAN 45 DEGREES] [EQUAL TO 45 DEGREES] ([LESS THAN 45 DEGREES]).

LIKE IN the LAB

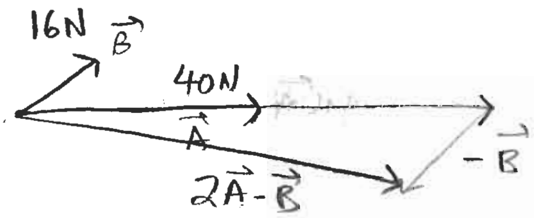
Problem 1 continued (see also previous page).

1c) The magnitude of two force vectors **A** and **B** are 24 N and 16 N respectively, but I have not specified their directions.

i) What are the largest and smallest magnitudes for the net force **F** = **A** + **B**?

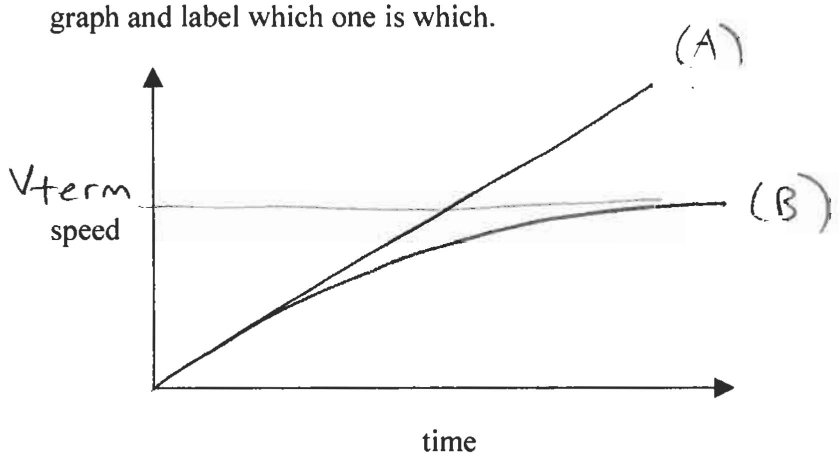
largest : 40N
smallest : 8 N

ii) Now, let **A** be directed along the x-axis
and **B** be directed at plus thirty degrees from the x-axis.
Sketch this situation below and construct (draw) the vector **F′**=2**A**-**B**.
Express the vector mathematically by the x and y components.



$2A = (80, 0)$
$-B = (13.9, 8)$
$(66.1, -8) = 2\vec{A} - \vec{B}$

1d) Sketch a graph of speed versus time for a ball dropped from a very tall building for two cases: (A) ignoring air resistance and (B) considering air resistance. Put the two curves on one graph and label which one is which.



some students thought braking was 8 s

Problem 2. [25 points] Squirrel Peril

You are driving home at 60 mph, talking on the cell phone and not paying attention to the road. Five hundred feet ahead a squirrel runs into the road and stops to eat an acorn. After 2 seconds, you finally notice, hit the brakes, and come uniformly to a stop in 10 seconds.

HINT: first convert your speed into feet per second and use that throughout.
The acceleration due to gravity in English units is: $g = 32 \text{ ft s}^{-2}$.

- **(a)** How big an instantaneous acceleration do your passengers feel? Express in units of g.
- **(b)** How far do you travel before coming to a stop? (Do you hit the squirrel?)
- **(c)** Carefully draw on the graph paper your position, velocity, and acceleration as a function of time. Label your axes, put numbers by your tick marks.

HINT: $v = \left(60 \frac{mi}{h}\right)\left(5280 \frac{ft}{mi}\right)\left(\frac{hr}{3600\ s}\right) = 88\ ft/s$

(6) (a) $a = \frac{\Delta v}{\Delta t} = \frac{88\ ft/s - 0\ ft/s}{10\ s} = 8.8\ ft/s$

12s → −2

$= 0.275\ g's$

÷10 ⇒ −2

(10) (b) $x(t) = x_0 + v_0 t + \frac{1}{2} a t^2$

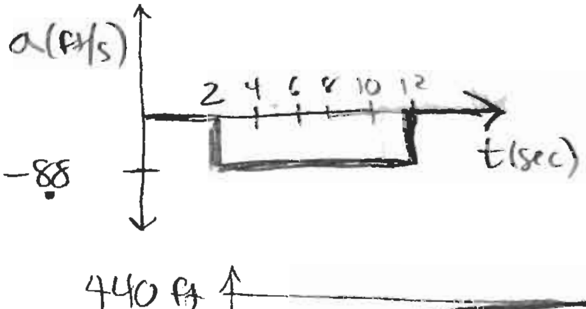
constant speed part: $d = vt = (88\ ft/s)(2s) = 176\ ft$

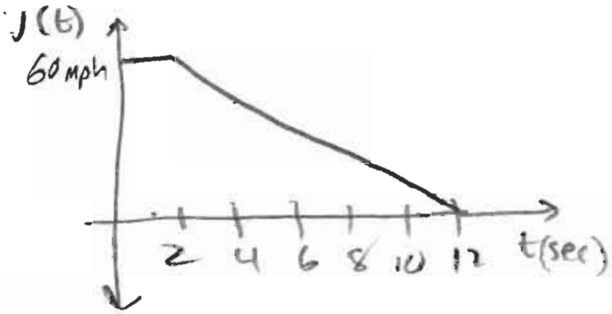
constant accel part: $d = v_0 t - \frac{1}{2} a t^2 = \left(88 \frac{ft}{s}\right)(10s) - \frac{1}{2}\left(8.8 \frac{ft}{s^2}\right)(10s)^2$

$= 880\ ft - 440\ ft = 440\ ft$

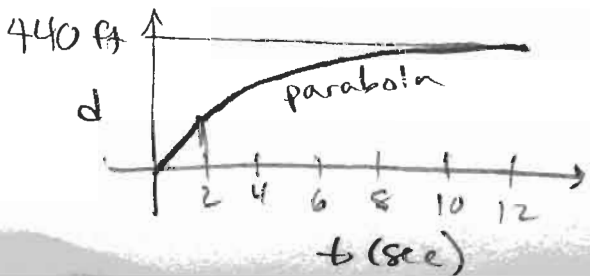
TOTAL = 176 ft + 440 ft = 616 ft

YOU HIT THE SQUIRREL!!



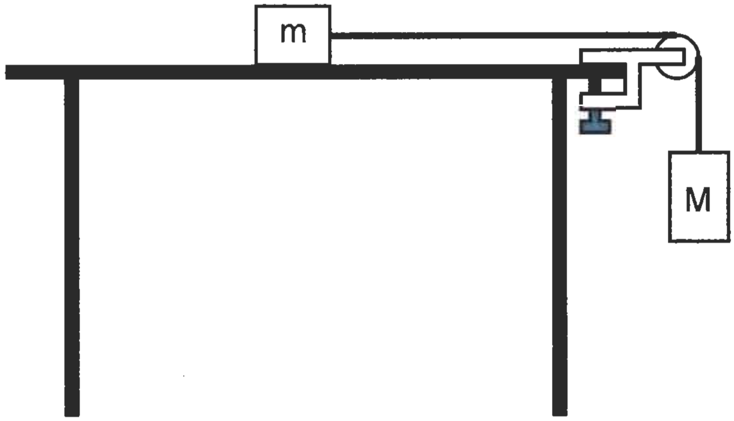


(3) each



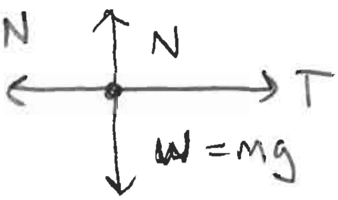
Problem 2. [25 points] Slowly falling masses.

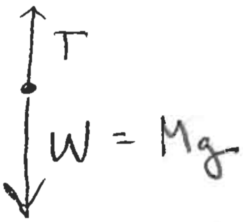
You have a lab setup with two masses, a smaller one (m) of 2 kg and a larger one (M) of 8 kg. They are connected by a light string and frictionless pulley. The table has a coefficient of friction of 0.4. You release the system and measure the motion.



(a) Draw proper free body diagrams for each mass (when the system is moving). Show all forces.
(b) Calculate the acceleration.
(c) Calculate the tension in the string (when the system is moving).
~~(d) How much work is done by friction on the small mass when it moves 0.1 m?~~

(8) a)



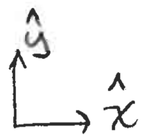


$W = Mg = 80\,N$

$f = \mu mg = 8\,N$

$N = 20\,N = w$

b) $\Sigma \vec{F} = m\vec{a}$



$\Sigma F_x = T - f = ma_x$ $\qquad \Sigma F_x = 0$

$\Sigma F_y = 0$ ← eliminate T — $\Sigma F_y = T - W = Ma_y$

(12) NOTE: $a_x = -a_y = a$

or use down as + motion from start $\Sigma F = W - T$

$W + Ma_y - f = ma_x$

$W - Ma - f = ma$

$W - F = (M+m)a$

$a = \frac{W-f}{m+M} = \frac{72\,N}{10\,kg} = \boxed{7.2\ m/s^2}$

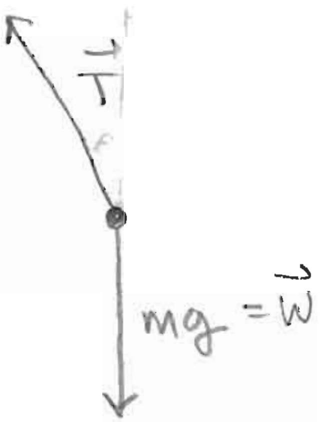
c) $T = W - Ma = 80N - 8kg \cdot 7.2\,m/s^2 = \boxed{22.4\ N}$

(5) d) need next chapter

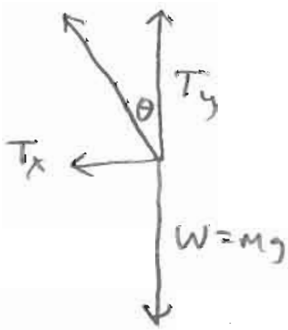
Problem 3. Landing on a jet plane. [20 pts]
(slowing down on runway)

While landing, some passenger, who will remain nameless, dangles his computer mouse to estimate the acceleration. If the angle of the mouse is 15 degrees from the vertical, what is the acceleration?

Draw a free body diagram for the mouse. Show your work in the calculation. State any assumptions you feel are important about this experimental setup.



No force in x-direction ⇒ $\vec{a} = \dfrac{\vec{T} + \vec{W}}{m}$



$T_y = mg$

$T_x = ma_x$

$\tan\theta = \dfrac{ma_x}{mg} = \dfrac{a}{g}$

$(10\ m/s^2)(\tan 15°) = \boxed{2.68\ m/s^2}$

(in the −x direction)

$= 0.27\ g$'s

Assumption: motion is steady — no bumps, hand is still
camera is ⊥ to plane of motion