Name:_____ ID:_____ Lab (day/time)_____

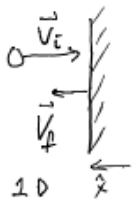
Physics 201

Midterm Exam 1

10/21/2015

Collaboration is not allowed. Allowed on your desk are: up to ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating/graphing scientific calculator, 1 page of scratch paper, writing utensils, and the exam. You will have 80 minutes to complete this exam.

1. (4 points) A racquetball strikes a wall with a speed of 30 m/s and rebounds with a speed of 26 m/s. The collision takes 20 ms. What is the magnitude of the average acceleration of the ball during the collision? How many times greater is this than the acceleration of gravity, i.e. how many **g**'s is this?

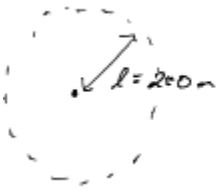


$$\vec{a} = \frac{\Delta \vec{v}}{\Delta t} = \frac{\vec{v}_f - \vec{v}_i}{\Delta t}$$

$$a_x = \frac{(26 - (-30))\ m/s}{0 \times 10^{-3}\ s} = 2800\ m/s^2 = |\vec{a}|$$

"g's" $\Rightarrow$ $|\vec{a}| = 286\ g$

2. (5 points) One of the problems Superman has is that he keeps rescuing people from impending tragedies only to find they've died during the rescue due to the extreme accelerations caused as he flies them away from the scene. Through trial and error he determines that the maximum acceleration they can safely sustain is about 9 times that of gravity or 9***g***'s. A set of bombs will explode everything within 200 m of Lois in 5 seconds. Does superman have enough time to rescue her? Explain.



K	uk	eq
$\Delta t = 5s$	v_f	(i) $\Delta x = v_i \Delta t + \frac{1}{2} a \Delta t^2$
$\Delta x = \ell$	a	(ii) $v_f = v_i \Delta t + \frac{1}{2} \vec{a} \Delta t^2$
$v_i = 0$		(iii) $v_f^2 = v_i^2 + 2a\Delta x$

(i) $\ell = \cancel{v_i^{\,0} \Delta t} + \frac{1}{2} a \Delta t^2 \Rightarrow a = \frac{2\ell}{\Delta t^2} = 16\ m/s^2$

Since 16 m/s^2 is the acceleration required to save Lois, and this is less than 9g's, superman does save Lois. Even if there was not enough time, Superman would spin around her at an incredible rate, creating a small tornado with her at the eye, protecting and saving Lois.

For questions 3 through 5 circle all correct answers, a given problem may have more than one correct answer. Each correctly circled answer will receive two points. There are **6** correct answers in this section and only the first **6** circled answers will be graded. There is no partial credit.

3. In which of the following situations does the car have a eastward acceleration?

[T] (a) The car travels westward and is slowing down.
[F] (b) The car travels westward and is speeding up.
[T] (c) The car starts from rest and moves toward the east.
[F] (d) The car starts from rest and moves toward the west.
[F] (e) The car travels eastward at a constant speed.

4. A car is traveling with a speed ***V*** when it uniformly slows to rest. If the acceleration of the car while coming to rest had been three times as large, which of the following statements are true?

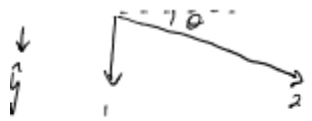
[F] (a) The car would travel 3 times as far.
[F] (b) The car would travel 9 times as far.
[F] (c) The car would travel one ninth the distance.
[T] (d) The car would travel one third the distance.
[F] (e) The car would travel for 3 times longer in time.
[F] (f) The car would travel for 9 times longer in time.
[F] (g) The car would travel for one ninth the time.
[T] (h) The car would travel for one third the time.

5. Pressure is equal to force per area. Energy has the same dimensions as force times length. Knowing this, which of the following statements are true?

[T] (a) Force has the same dimensions as pressure times area.
[F] (b) Force has the same dimensions as pressure.
[F] (c) Energy has the same dimensions as pressure divided by force.
[T] (d) Pressure has the same dimensions as energy per volume.
[F] (e) Pressure has the same dimensions as energy per area.

---

6. (5 points) Bob and Biff throw identical rocks off a tall building at the same time. Bob throws his rock straight downward. Biff throws his rock downward and outward such that the angle between the initial velocity of the rock and the horizon is 30 degrees. Biff throws the rock with a speed twice that of Bob's rock. Which rock hits the ground first? Explain.



$V_{i,y} = V$, $V_{i,2y} = 2V \sin 30$
$= V$

same initial y-component of velocity,

w/ $\Delta y = V_{iy}\Delta t + \frac{1}{2}a_y\Delta t^2$, Δy & a_y the same, they hit simultaneously

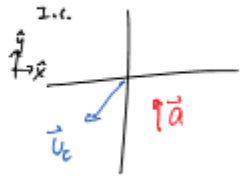
7. (10 points) An object, at the origin, is traveling at 7 m/s in a direction 45° from the negative ***y*** axis towards the negative ***x*** axis when it feels a constant acceleration of 4 m/s² in the positive ***y*** direction. Sketch the ***x*** and ***y*** components of the position and velocity as a function of time for the next 20 s. For the same time interval, also sketch the trajectory ***y*** vs. ***x***. Roughly scale each plot appropriate to the initial conditions and the numbers given. Show any work used to determine the appropriate scaling.

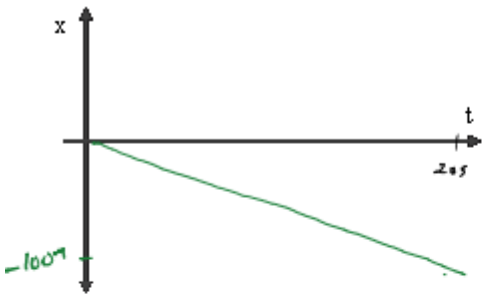
$v_{ix} = v_{iy} = -7\ m/s \sin(45) = -5\ m/s$, $a_x = 0$, $a_y = 4$, $\Delta t = 20\ s$

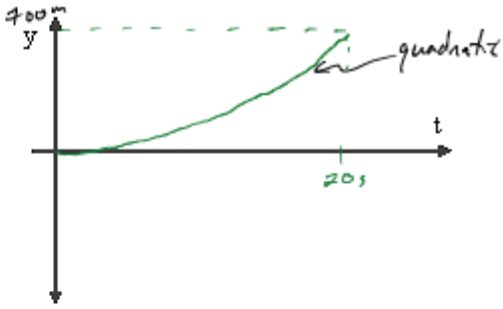
$v_{fy} = v_{iy} + a_y \Delta t = -5\ m/s + (4\ m/s^2)(20\ s) = 75\ m/s$

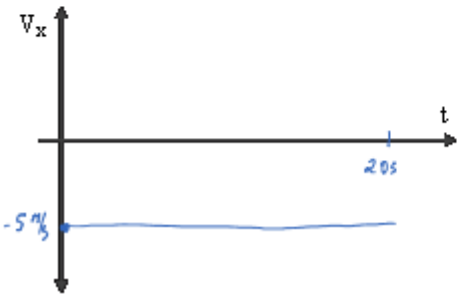
$\Delta x = v_{ix} \Delta t + \frac{1}{2} a_x \Delta t^2 = -100\ m$

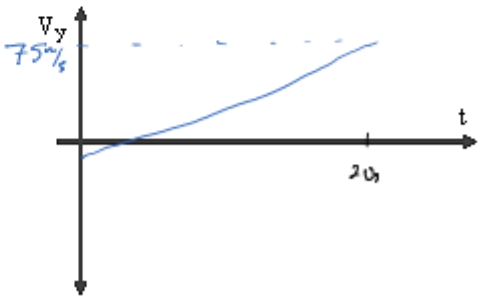
$\Delta y = v_{iy} \Delta t + \frac{1}{2} a_y \Delta t^2 = 700\ m$

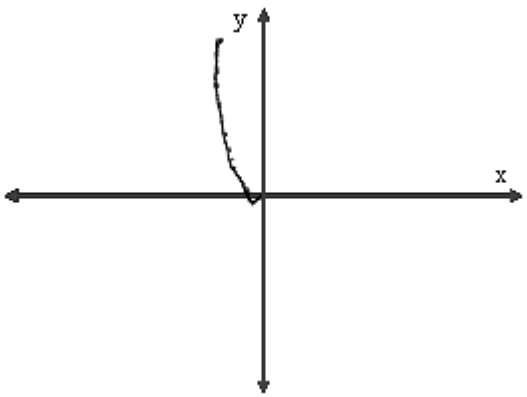












8. (9 points) A computer programmer is working on a computer chess game. Her task is to program the animation of the piece moving from one position to the next. She needs the knight shown below to take 1.5 s to move up two squares and to the left one square, and to do so in a direct path to the final location. The knight must start and stop directly in the middle of a square and the origin is in the bottom left corner of the board. (a) What is the final position vector in units of *squares*. (b) What speed (in squares/second) and direction must she program into the animation to achieve her task? (c) If Carol from accounting sabotages her code by multiplying her average velocity by pi, will the knight even stay on the board during the 1.5 s? Explain

a) $\vec{r}_i = \langle 6.5, 2.5 \rangle_{sq}$, $\Delta\vec{r} = \langle -1, 2 \rangle_{sq}$

$\vec{r}_f = \vec{r}_i + \Delta\vec{r} = \langle 5.5, 4.5 \rangle_{sq}$

b.) speed $|\vec{v}| = \frac{|\Delta\vec{r}|}{\Delta t} = \frac{\sqrt{5}}{3/2} = 1.49\ ^{sq}/_{s}$

direction $\tan\theta = \frac{|\Delta y|}{|\Delta x|} \Rightarrow \theta = 63.4°$

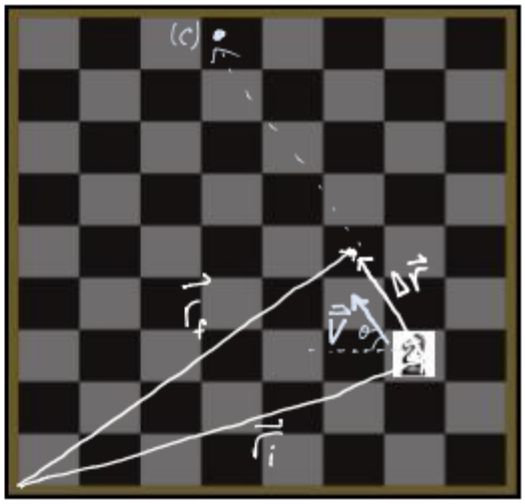
c.) w/ $\vec{r}_f = \vec{r}_i + \vec{v}\Delta t$, if $v \Rightarrow \pi v$

$= \vec{r}_i + \pi\vec{v}\Delta t$

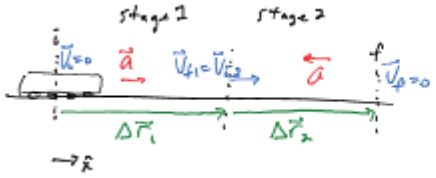
$= \vec{r}_i + \pi\frac{\Delta\vec{r}}{\Delta t}\Delta t$

$\vec{r}_f = \vec{r}_i + \pi\Delta\vec{r} = \langle 3.36, 8.78 \rangle_{sq}$

on this table yes



9. (12 points) Two train stations are 800 m apart. The maximum acceleration that feels comfortable in a train is 1.2 m/s². (a) What is the fastest speed the train could attain between the stations and still pick/drop passengers at both. (b) What is the shortest time between the stations?



K

$V_{i_1} = 0$

[1] $a_1 = +1.2\ m/s^2$

$\Delta x_1 = 400m$

uk

$\Delta t_1 = \Delta t$

$V_{f_1} = V$

eq

(i) $\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$

(ii) $V_f = V_i + a\Delta t$

(iii) $V_f^2 = V_i^2 + 2a\Delta x$

Symmetry

$V_{f_1} = V_{i_2} = V$, $|\vec{a}_1| = |\vec{a}_2| = a$

[1] $V = V_{i_1}^{\nearrow 0} + a\Delta t_1$

[2] $V_{f_2}^{\nearrow 0} = V - a\Delta t_2$

$\Delta t_1 = \Delta t_2 = \Delta t$

Similarly

[1] $V^2 = V_{i_1}^{2\ \nearrow 0} + 2a\Delta x_1$

[2] $V_{f_2}^{2\ \nearrow 0} = V^2 + 2(-a)\Delta x_2$

$\Delta x_1 = \Delta x_2 = \Delta x$

4 $\Delta x_1 + \Delta x_2 = 800m$

$2\Delta x = 800m$

$\Delta x = 400m$

[2] $a_2 = -1.2\ m/s^2$

$V_{f_2} = 0$

$\Delta x_2 = 400m$

$\Delta t_2 = \Delta t_1$

$V_{i_2} = V_{f_1}$

[1]

(a) (iii) $V_{f_1}^{2\ \nearrow 0} = V_{i_1}^{2\ \nearrow 0} + 2a_1\Delta x_1$

$V_{f_1} = \sqrt{2a_1\Delta x_1} = 31.0\ m/s$

(b) $\Delta x_1 = V_{i_1}^{\nearrow 0}\Delta t + \frac{1}{2} a_1 \Delta t^2$

$\Delta t = \sqrt{\frac{2\Delta x_1}{a_1}} = 25.8s$

So $\Delta t_{tot} = 2\Delta t = 51.6s$

Scores:

Problems

1	2	3-8	9	10	11	12

Exam Total
