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

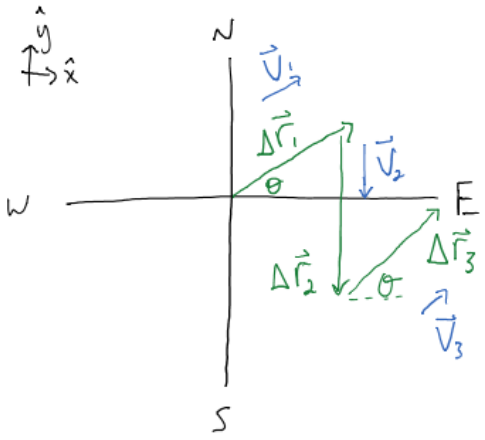
Physics 201

Midterm Exam 1

10/18/2017

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. (8 points) A car travels for 10 mins at a rate of 25 m/s, along a trajectory north of east by 30°. Afterward, it travels due south at a rate of 30 m/s for another 12 mins. If it then travels at a rate of 15 m/s along the same initial 30° north of east trajectory, how long will it take to be due east of the initial location?



w/ $\vec{a}=0$, $\Delta\vec{r} = \vec{V}\Delta t$

$$\Sigma \Delta\vec{r} = \langle \Delta x_{tot}, 0 \rangle$$

$$= \Delta\vec{r}_1 + \Delta\vec{r}_2 + \Delta\vec{r}_3$$

$$= \vec{V}_1 \Delta t_1 + \vec{V}_2 \Delta t_2 + \vec{V}_3 \Delta t_3$$

[y] $\Sigma \Delta y = 0$

$$V_{1y}\Delta t_1 + V_{2y}\Delta t_2 + V_{3y}\Delta t_3 = 0$$

$$|\vec{V}_1|\sin\theta\,\Delta t_1 - |\vec{V}_2|\Delta t_2 + |\vec{V}_3|\sin\theta\,\Delta t_3 = 0$$

$$\Delta t_3 = \frac{|\vec{V}_2|\Delta t_2 - |\vec{V}_1|\sin\theta\,\Delta t_1}{|\vec{V}_3|\sin\theta} = \boxed{1880\,s}$$

or $31.\overline{3}$ mins

Rubric

+2pts - physical Representation

+2pts - $\Sigma\Delta\vec{r} = \langle \Delta x, 0\rangle$ or $\Sigma\Delta y = 0$

+1pt - $\Delta\vec{r} = \vec{V}\Delta t$

+1pt - components (V_y)

+1.5pt - algebra

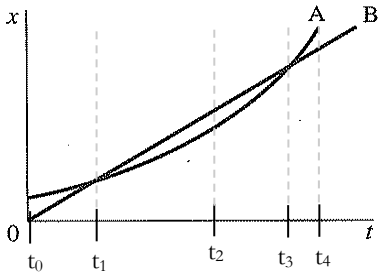
+0.5pts - answer + units

For questions 2 through 6 circle all correct answers, a given problem may have more than one correct answer. Each correctly circled answer will receive two points. There are **8** correct answers in this section and only the first **8** circled answers will be graded. There is no partial credit.

2. A certain physical quantity, **Q**, is calculated using the formula $Q = 4\pi a^2(b - c)$. Here ***a*** is a distance per time, while ***b*** and ***c*** are both distances. Which of the following statements are true?

[F] (a) **Q** must be an acceleration.
[F] (b) **Q** must be an area per time squared.
[T] (c) **Q** must be a volume per time squared.
[F] (d) **Q** must be a speed.
[F] (e) **Q** must be a distance.

3. The figure to the right shows the position vs. time graph for two bicycles, **A** and **B**, which are traveling along a straight line. Which of the following statements are true regarding the bicycles.



[F] (a) The velocity of A is less than B at t_2.
[F] (b) The velocity of A is equal to B at t_3.
[T] (c) The average velocity of A is equal to B between the t_1 and t_3.
[T] (d) The acceleration of A is greater than B at t_1.
[F] (e) The acceleration of A is equal to that of B at t_3.

4. Ball **A** is launched from a table at an angle 30° up from the horizontal and the initial vertical component of its velocity is equal to 4 m/s. At the same time, ball **B** is fired from the same height, straight upward with an initial speed of 4 m/s. Which of the following statements about ball A and B during the time they are undergoing free-fall are true?

[T] (a) Both balls will take the same amount of time to hit the floor.
[F] (b) Ball A will hit the floor before ball B
[F] (c) Both balls will travel the same distance.
[T] (d) Both balls will undergo the same acceleration.
[F] (e) Both balls will have the same speed at some time during their motion.
[T] (f) Ball A will always be traveling faster than ball B.

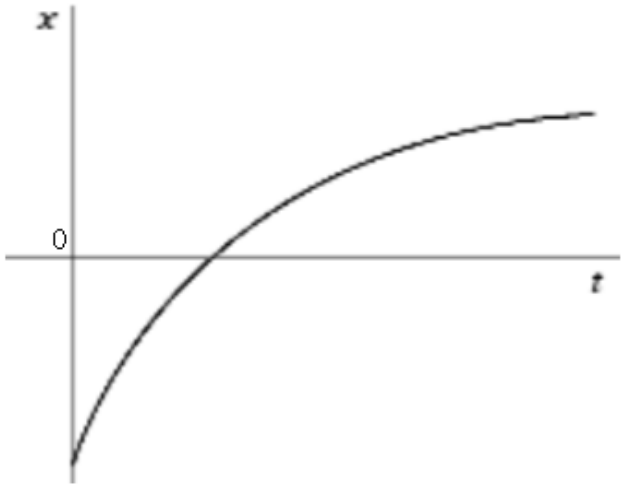
5. The speed of a wave pulse on a string depends on the tension, F, in the string and the mass per unit length, μ, of the string. Tension has SI units of $kg \cdot m \cdot s^{-2}$ and the mass per unit length has SI units of $kg \cdot m^{-1}$. What combination of F and μ must the speed of the wave be proportional to?

(a) $\frac{\mu}{F}$ (b) $\frac{F}{\mu}$ (c) $\sqrt{\frac{F}{\mu}}$ (d) $\sqrt{\mu F}$ (e) $\sqrt{\frac{\mu}{F}}$

6. Two balls are dropped from the roof of a tall building and undergo free-fall. They are not dropped at the same time, one is dropped a short moment after the first. As time progresses, the *difference* in their speeds

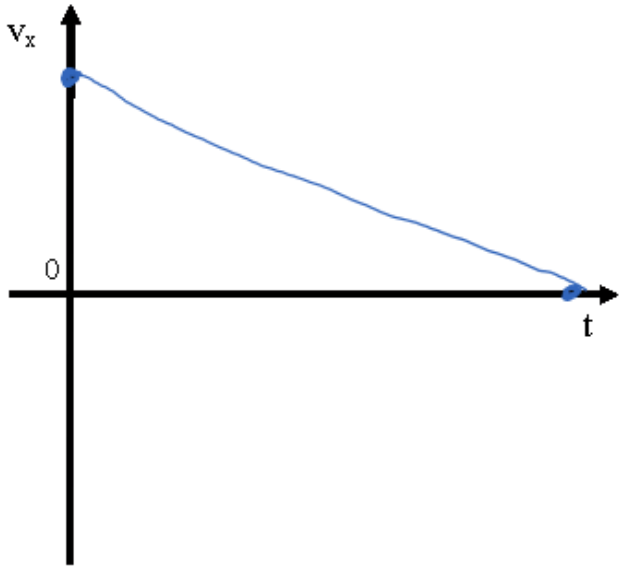
[F] (a) decreases.
[F] (b) increases.
[T] (c) remains constant.
[F] (d) decreases initially, but then remains constant.
[F] (e) increases initially, but then remains constant.

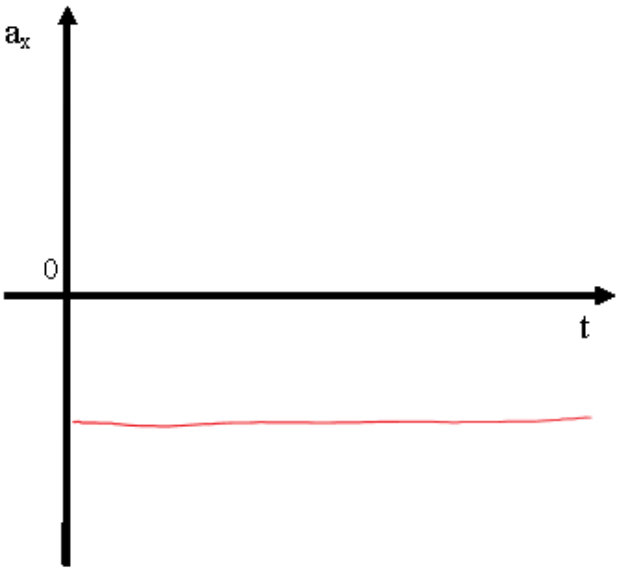
7. (6 points) The position as a function of time is plotted for an object traveling along a straight line. (a) Sketch the corresponding velocity and acceleration as a function of time on the provided plots. (b) Write a description of this motion using a real-world example of something that travels in this manner.



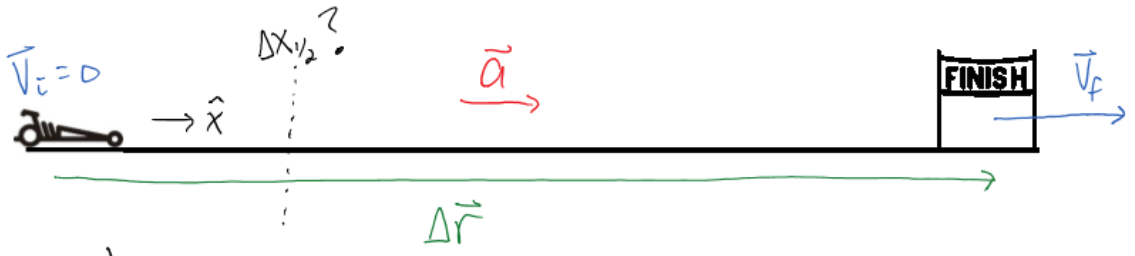
(c) Any object that is moving in the positive direction, slowing down to a stop, and going past x = 0.

Example: Hammy the hamster, running the positive x direction, slows down uniformly to a stop. His acceleration points in the negative x direction and he comes to rest at a positive x location.





8. (10 points) A dragster racing car accelerates uniformly from rest on a straight 400-m-long track. When it crosses the finish line it is traveling at a speed of 500 kph. (a) Where along the track is the car traveling at half its final speed? (b) Where along the track is the car after half the time it takes to finish?



To the finish

K	u/k	eq's
$V_i = 0$	a	(i) $\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$
$V_f = 500\,\text{kph} = 138.\bar{8}\ \text{m/s}$	Δt	(ii) $V_f = V_i + a\Delta t$
$\Delta x = 400\,\text{m}$		(iii) $V_f^2 = V_i^2 + 2a\Delta x$

find a (iii) $V_f^2 = \cancel{V_i^2}^{\,0} + 2a\Delta x \Rightarrow a = \frac{V_f^2}{2\Delta x} = 24.113\ \text{m/s}^2$

(a) @ $V_{1/2} = \frac{V_f}{2} \Rightarrow \left(\frac{V_f}{2}\right)^2 = \cancel{V_i^2}^{\,0} + 2a\Delta x_{1/2} \Rightarrow \Delta x_{1/2} = \frac{V_f^2}{4}\left(\frac{1}{2a}\right) = 100\ \text{m}$

(b) @ $\Delta t_{1/2} = \frac{\Delta t}{2} \Rightarrow \Delta x_{1/2} = \cancel{V_i \Delta t}^{\,0} + \frac{1}{2} a \left(\frac{\Delta t}{2}\right)^2 = 100\ \text{m}$

alternatively: proportional reasoning

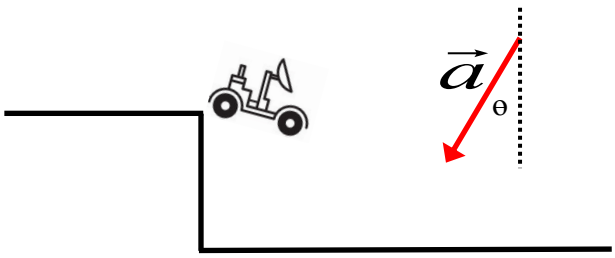
(a) w/ $\Delta x = \frac{V_f^2}{2a}$, $\Delta x \propto V_f^2$, if $V_f \to \frac{V_f}{2}$, then $\Delta x \to \frac{1}{(2)^2}\Delta x$

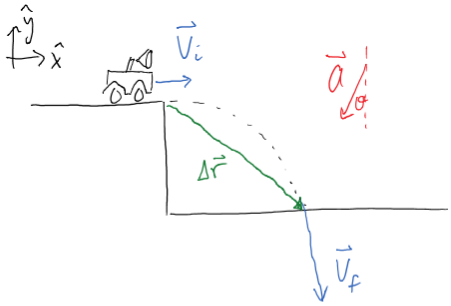
(b) w/ $\Delta x = \frac{1}{2} a \Delta t^2$, $\Delta x \propto \Delta t^2$, if $\Delta t \to \frac{\Delta t}{2}$, then $\Delta x \to \frac{1}{(2)^2}\Delta t$

Rubric

+ 1pt - physical Rep.
+ 1pt - Knowns + Unknowns
+ 1pt - Identifying a is same throughout
+ 2pts - finding a
+ 2.5pts - (a)
+ 2.5pts - (b)

9. (12 points) While exploring a distant asteroid, you drive your rover off a 20-m-high cliff, moving at a speed of 6 m/s. Due to irregularities in the shape of the asteroid the acceleration of gravity does not point straight down but rather a bit towards you at a 30° angle from the vertical. The asteroid is also not very big so the magnitude of the acceleration of gravity is equal to 1.5 m/s². (a) What is the distance you travel before hitting the ground below? (b) With what initial speed should you have been traveling if you wanted your final velocity vector to point straight downward?





K		uk	eq's
(x)	$V_{ix} = 6$ m/s	Δx	(i) $\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$
	$a_x = -\lvert\vec{a}\rvert \sin\theta = -0.75$ m/s²	Δt	(ii) $V_f = V_i + a\Delta t$
		V_{fx}	(iii) $V_f^2 = V_i^2 + 2a\Delta x$
(y)	$V_{iy} = 0$ m/s		
	$a_y = -\lvert\vec{a}\rvert \cos\theta = -1.2990$ m/s²	Δt	
	$\Delta y = -20$ m	V_{fy}	

(a)

(y) (i) $\Delta y = \cancel{V_{iy}}^{0} \Delta t + \frac{1}{2} a_y \Delta t^2$

$\Delta t = \sqrt{\frac{2\Delta y}{a_y}} = 5.549$ s

(x) (i) $\Delta x = V_{ix} \Delta t + \frac{1}{2} a_x \Delta t^2 = 21.747$ m

so $\Delta\vec{r} = \langle 21.747, -20 \rangle$ m

& $|\Delta\vec{r}| = 29.5$ m

(b) if $V_{fx} = 0$, Δt comes from y-dir & is unchanged

but w/ (ii) $\cancel{V_{fx}}^{0} = V_{ix} + a_x \Delta t \Rightarrow V_{ix} = -a_x \Delta t = 4.16$ m/s

Rubric

+1.5 pts - physical rep.
+2 pts - Knowns, Unknowns a_x & a_y
+1.5 pts - eq (i) in y-dir
+1 pt - finding time
+2 pts - using time & eq(i) to find Δx
+1 pts - answer (a) + units
+2.5 pts - using eq (ii) for (b)
+0.5 pts - answer (b) + units

extra space if needed

Scores:

Problems

1	2-6	7	8	9

Exam Total