Name:______________________________ ID:______________________________

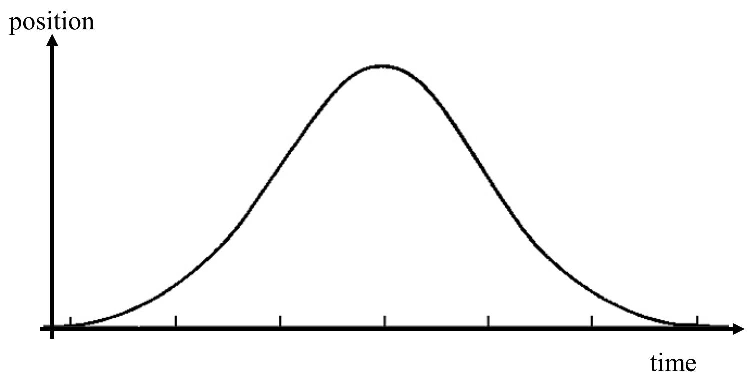
Physics 201

Midterm Exam 1

10/17/2018

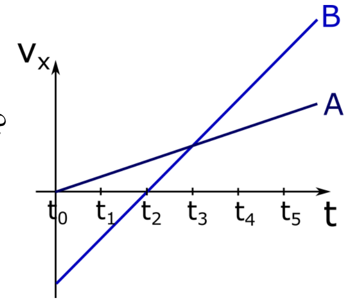
Collaboration is not allowed. Allowed on your desk are: up to ten 8.5 x 11 inch doubled sided sheets of notes that are bound together, non-communicating graphing scientific calculator, 1 page of scratch paper, writing utensils, and the exam. You will have 80 minutes to complete this exam.

1. (5 points) The figure shows the position of Benny as a function of time while he waddles along a straight line. Use words to describe the motion. Include a discussion of position, velocity, and acceleration in your explanation.



Benny starts at the origin from rest and starts to speed up in the positive direction. His acceleration is positive and appears nearly constant, although whether the curve is quadratic is not completely clear. After increasing his speed for a few moments he reaches a period where his speed is mostly a constant positive value. During this time he continues to move further into the positive position. After the period of zero acceleration he begins to decelerate. Since he's moving in the positive direction and slowing down, his acceleration points in the negative direction. Eventually he slows down to a stop. Then, after momentarily being at rest, he begins to speed up in the negative direction, moving back towards the origin. After a period of increasing his speed in the negative direction he reaches a steady speed. The last few moments he slows down again but this time he is moving in the negative direction and so his acceleration must be in the positive direction. When he finally comes to rest he is back to his original location.

For questions 2 through 6 shade in all correct answers ***like a bubble sheet***. A given problem may have more than one correct answer. Each correctly circled answer will receive two points. There are **10** correct answers in this section and only the first **10** circled answers will be graded. There is no partial credit.



2. The figure shows the velocity as a function of time for two objects. Which of the following statements are *necessarily* true regarding the motion of these two objects?

[F] (a) A and B are at the same location at time t_3.
[F] (b) The speed of B is greater than A during the entire motion.
[T] (c) The magnitude of the displacement of A from t_0 to t_3 is greater than B.
[F] (d) The acceleration of B is less than A until t_3 and greater than A after that.
[T] (e) The acceleration of B is greater than A for the entire motion.

3. Energy has the same dimensions as a force multiplied by a distance. The dimensions of force is the same as the dimensions of mass multiplied by acceleration. Which of the following statements are true?

[T] (a) The dimensions of energy are mass times length squared divided by time squared.
[F] (b) The dimensions of energy are mass times length divided by time squared.
[F] (c) The dimensions of energy are mass squared times length squared divided by time.
[T] (d) The S.I. unit for energy is a kilogram meter squared per second squared.
[F] (e) The S.I. unit for energy is a kilogram meter per second squared.
[F] (f) The S.I. unit for energy is a kilogram squared meter squared per second.

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

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

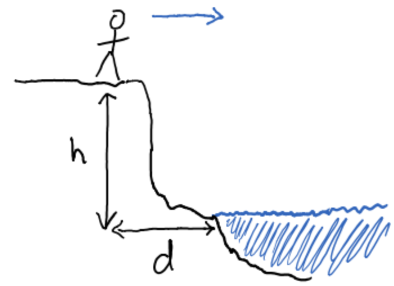
5. At a given instant of time, a car and a truck are traveling in the same direction, side by side in adjacent lanes of a highway. The car has a greater velocity than the truck. Which of the following statements are *necessarily* true about the car and truck.

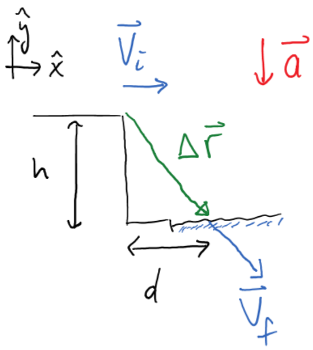
[?] (a) The car has a greater acceleration than the truck.
[?] (b) The truck has a greater acceleration than the car.
[?] (c) The car and the truck have the same acceleration.
[T] (d) Nothing can be determined about their accelerations with the given information.
[T] (e) At the next moment in time the car will be ahead of the truck.

6. Three vectors, $\vec{A}$, $\vec{B}$, and $\vec{C}$ add together to yield zero: $\vec{A}+\vec{B}+\vec{C}=0$. The vectors $\vec{A}$ and $\vec{B}$ point in opposite directions and their magnitudes are related by the expression: 2A = B. Which of the following conclusions are correct?

[F] (a) $\vec{A}$ and $\vec{B}$ have equal magnitudes and point in opposite directions.
[T] (b) $\vec{A}$ and $\vec{C}$ have equal magnitudes and point in the same direction.
[F] (c) $\vec{B}$ and $\vec{C}$ have equal magnitudes and point in opposite directions.
[F] (d) $\vec{A}$ and $\vec{B}$ point in the same direction, but $\vec{A}$ has twice the magnitude of $\vec{B}$
[T] (e) $\vec{B}$ and $\vec{C}$ point in opposite directions, but $\vec{B}$ has twice the magnitude of $\vec{C}$

7. (8 points) A movie stunt women is in a scene where she is running from the bad guys and has to jump off a cliff to the ocean below. There is a ledge she must pass to safely dive into the water. If the height of the cliff **h** is equal to 10 m, and the width of the ledge **d** is equal to 1.7 m, how fast must she be moving when she jumps horizontally off the cliff?





K	UK
[x] $a_x = 0\,m/s^2$	V_{ix} ?
$\Delta X = 1.7m = d$	Δt
	$V_{fx} = V_{ix}$
[y] $a_y = -9.8\,m/s^2 = -g$	Δt
$V_{iy} = 0\,m/s$	V_{fy}
$\Delta y = -10m = -h$	

eq.

(1) $\Delta X = V_{ix}\Delta t + \frac{1}{2}a_x\Delta t^2$

(2) $V_{fx} = V_{ix} + a_x\Delta t$

(3) $V_{fx}^2 = V_{ix}^2 + 2a_x\Delta X$

[y] eq #1, $\Delta y = V_{iy}\Delta t + \frac{1}{2}a_y\Delta t^2 \Rightarrow \Delta y = -\frac{1}{2}g\Delta t^2 \Rightarrow \Delta t = \sqrt{\frac{2h}{g}} = 1.428s$

[x] eq #1, $\Delta X = V_{ix}\Delta t + \frac{1}{2}a_x\Delta t^2 \Rightarrow \Delta X = V_{ix}\Delta t \Rightarrow V_{ix} = d\sqrt{\frac{g}{2h}} = 1.19\,m/s$

use ΔX_{min} for $|\vec{V}|_{min}$

w/ $V_{iy} = 0$, $|\vec{V}_i|_{min} = V_{ix} = 1.19\,m/s$

Rubric

+1 pt - physical rep.

+1pt - Knowns + Unknowns

+1pt - eq #1 in $\hat{y}$

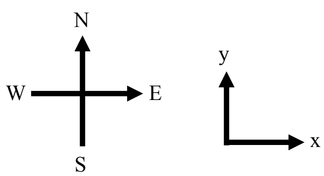
+2pt - finding Δt

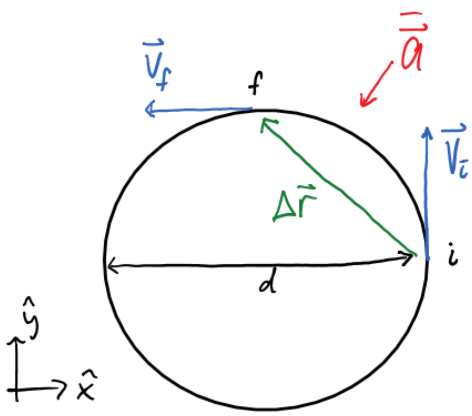
+1pt - eq #1 in $\hat{x}$

+1.5pt - finding $|V_{min}|$

+0.5pt - Answer + units

8. (10 points) On a nice leisurely Sunday you find yourself walking due north, counter-clock-wise around a circular pond that is 100 m across. You walk a quarter of the way around the pond at a speed of 0.5 m/s. (a) Which direction are you now traveling? (b) How long did it take to travel a quarter of the way around the pond? (c) What was your average velocity during that time? (d) What was your average acceleration?





(a) **West**

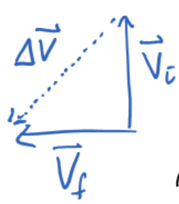
(b) Speed = $\frac{\text{distance}}{\text{time}}$ (distance ~ $\frac{\text{Circumference}}{4}$)

$0.5\,m/s = \frac{\pi d}{4}\frac{1}{\Delta t} \Rightarrow$ **$\Delta t = 157\,s$**

(c) $\bar{V} = \frac{\Delta\vec{r}}{\Delta t}$, $\Delta\vec{r} = \langle -\frac{d}{2}, \frac{d}{2}\rangle$

So, $\bar{V} = \frac{1}{\Delta t}\langle -\frac{d}{2}, \frac{d}{2}\rangle =$ **$\langle -0.318, 0.318\rangle\,m/s$**

(d) $\bar{a} = \frac{\Delta\vec{V}}{\Delta t}$, Vector Op



Sign + Self-consist Sense Making

, Math

$\vec{V}_i = \langle 0, 0.5\rangle\,m/s$, $\vec{V}_f = \langle -0.5, 0\rangle\,m/s$

So, $\bar{a} = \frac{\langle -0.5, 0\rangle\,m/s - \langle 0, 0.5\rangle\,m/s}{\Delta t}$

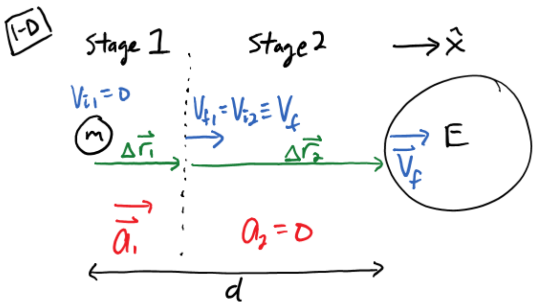
$\bar{a} = \langle -3.18\times10^{-3}, -3.18\times10^{-3}\rangle\,m/s^2$

Both neg $\hat{x}$ + $\hat{y}$ as expected

Rubric

- +1 pt – Answer (a)
- +1 pt – Speed = $\frac{\text{dist}}{\text{time}}$
- +1 pt – dist. = $\frac{\pi d}{4}$
- +0.5 pt – Answer + units (b)
- +1 pt – $\bar{V} = \frac{\Delta\vec{r}}{\Delta t}$ eq.
- +1 pt – $\Delta\vec{r}$
- +0.5 pt – Answer + units (c)
- +1 pt – $\bar{a} = \frac{\Delta\vec{V}}{\Delta t}$ eq.
- +1.5 pt – $\vec{V}_i$ + $\vec{V}_f$
- +1 pt – application
- +0.5 pt – Answer + units (d)

9. (10 points) The Ruthless Ruler Lrrr from the Planet Omicron Persei 8 desires a new galactic highway right through where Earth now lies. He intends to blow up the planet by placing anti-matter rockets on the moon and accelerating it towards Earth. The rockets will provide a constant acceleration for a 1000 seconds and then drop to zero. He figures if the rockets get the moon up to a speed of a hundred thousand meters per second, it will be enough to blow up the Earth upon impact. (a) What is the acceleration, in terms of ***g***, the rockets must achieve to reach the desired final speed? (b) How much time in minutes will elapse from when the rockets fire to when the moon destroys the Earth? The distance from the Earth to the moon on average is 3.84×10^8 m.



	K	UK	eq's
1	$V_{i_1} = 0\ m/s$ $\Delta t_1 = 1000\ s$ $V_f = 1 \times 10^5\ m/s$	ΔX_1 a_1?	(1) $\Delta X = V_{ix}\Delta t + \frac{1}{2}a_x \Delta t^2$ (2) $V_{fx} = V_{ix} + a_x \Delta t$ (3) $V_{fx}^2 = V_{ix}^2 + 2a_x \Delta X$
2	$a_2 = 0\ m/s^2$ $V_{i_2} = V_{f_2} = V_f = 1 \times 10^5\ m/s$	ΔX_2 Δt_2?	

(a) Stage 1, eq #2: $V_f = \cancel{V_{i_1}}^{0} + a_1 \Delta t_1 \Rightarrow a_1 = \frac{V_f}{\Delta t_1} = 100\ m/s^2 = \boxed{10.2\ g}$

(b) Stage 1, eq #1: $\Delta X_1 = \cancel{V_{i_1}}^{0} \Delta t_1 + \frac{1}{2} a_1 \Delta t_1^2$ (i)

Stage 2, eq #1: $\Delta X_2 = V_{i_2} \Delta t_2 + \frac{1}{2}\cancel{a_2}^{0} \Delta t_2^2$ (ii), with $V_{i_2} = V_f$

Combine w/ $\Delta X_1 + \Delta X_2 = d$

So, $\frac{1}{2} a_1 \Delta t_1^2 + V_f \Delta t_2 = d$

$\Delta t_2 = \frac{1}{V_f}\left[d - \frac{1}{2} a_1 \Delta t_1^2\right] = 3340\ s$

finally $\Delta t_{tot} = \Delta t_1 + \Delta t_2 = 4340\ s$ or $\boxed{72.\bar{3}\ min}$

Rubric

+1 pt - physical rep

+1 pt - $V_{f_1} = V_{f_2} \equiv V_f$

+1 pt - Knowns & Unknowns

+1 pt - Stage 1, eq #2

+1 pt - answer (a)

+1 pt - stage 1, eq #1

+1 pt - Stage 2, eq #2

+1 pt - $\Delta X_1 + \Delta X_2 = d$

+1.5 pt - Solving for Δt_2

+0.5 pt - Answer (b) w/ units