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

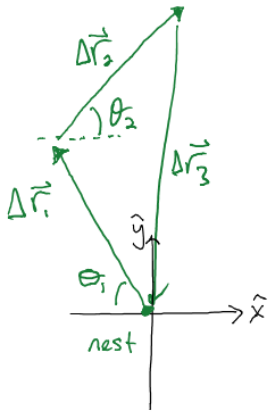
Physics 201

Midterm Exam 1

10/19/2016

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 bird flies from its nest at a constant 12 m/s in a direction 60° north of west for 2 min. It then flies at a constant 18 m/s for another one and a half minutes. Lastly it flies due south for some time, ending up back at the nest. What was the direction the bird flew in the second leg of its journey?



Average Velocity

$$\vec{V} = \frac{\Delta\vec{r}}{\Delta t} \Rightarrow \Delta\vec{r} = \vec{V}\Delta t$$

$$\Delta\vec{r}_1 = \langle -|\vec{V}_1|\cos\theta_1 , |\vec{V}_1|\sin\theta_1 \rangle \Delta t_1$$

$$\Delta\vec{r}_2 = \langle |\vec{V}_2|\cos\theta_2 , |\vec{V}_2|\sin\theta_2 \rangle \Delta t_2$$

$$\Delta\vec{r}_3 = \langle 0 , -|\vec{V}_3| \rangle \Delta t_3$$

$$\Sigma\Delta\vec{r} = 0 \Rightarrow \Delta\vec{r}_1 + \Delta\vec{r}_2 + \Delta\vec{r}_3 = 0$$

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

x-dir $\quad \Delta x_2 = -(\Delta x_1 + \Delta x_3)^{0}$

$$|\vec{V}_2|\cos\theta_2\,\Delta t_2 = |\vec{V}_1|\cos\theta_1\,\Delta t_1 \Rightarrow \cos\theta_2 = \frac{|\vec{V}_1|\cos\theta_1\,\Delta t_1}{|\vec{V}_2|\,\Delta t_2}$$

$$\theta_2 = 63.6^\circ$$

Rubric

1.5pts - physical Rep.
1.5pts - definition $\vec{V}$
1pt - Components
1pt - finding $\Delta\vec{r}_1$
2.5pts - Apply $\Sigma\Delta\vec{r}=0$ or just that $|\Delta x_1| = |\Delta x_2|$
0.5pts - Answer & units

For questions 2 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 **7** correct answers in this section and only the first **7** circled answers will be graded. There is no partial credit.

2. Two cars are traveling the same direction along a straight line. Car A trails car B and is traveling at a slower rate than B. Car B has a slightly smaller constant acceleration in the direction of motion than A. Assuming they continue traveling this way for a very long time, which of the following statements are true regarding this situation?

[F] (a) The distance between the two will increase the entire time.
[F] (b) The distance between the two will decrease the entire time.
[T] (c) The distance between the two will initially increase but eventually Car A will pass B.
[F] (d) The distance between the two will initially decrease but eventually Car B will pull away from A.
[F] (e) The distance between the two will remain a constant value.

3. Which of the following statements regarding the motion of a bird are true?

[F] (a) The change in the position vector of a moving bird is equal to the distance it has moved.
[F] (b) If the bird is moving at 3.5 m/s at a certain instant of time, then it will travel 3.5 m in the next second.
[T] (c) If the final position vector of a moving bird has a smaller magnitude than the initial position vector, then the change in the bird's position vector has a positive magnitude.
[T] (d) If the average speed of a bird is zero, than its average velocity must be zero; but if its average velocity is zero, its average speed is not necessarily zero.

4. Ball **A** is thrown horizontally from a window. At the same instant, ball **B** is thrown straight downward; and ball **C** is thrown straight upward from the same window. All three have the same initial speeds. During the time the balls are in the air, which of the following statements are *necessarily* true. Assume air resistance is negligible.

[F] (a) At some instant after it is thrown, the acceleration of ball **C** is zero.
[F] (b) All three balls strike the ground at the same time.
[F] (c) There is an instant when all three balls have the same velocity.
[T] (d) All three balls have the same acceleration at all times.
[T] (e) Ball **B** and ball **C** reach the ground with the same speed.

5. A ball rolls constantly on a table, eventually falling off and hitting the ground. Which of the following are true regarding the entire time from when the ball was initially rolling to right before the ball hits the ground.

[F] (a) The speed of the ball is constant.
[F] (b) The acceleration of the ball is constant.
[F] (c) The vertical component of the ball's velocity is a constant.
[T] (d) The horizontal component of the ball's velocity is a constant.
[F] (e) The distance the ball travels after leaving the table is independent of the table height.
[T] (f) The distance the ball travels after leaving the table is dependent on the table height.

6. (6 points) Consider that you've been tasked with creating better brakes for a car company. You're specification is to make the car stop in three quarters the distance they currently stop. By what factor then must you make the car's average acceleration change?

Proportional Reasoning

Want $\Delta x \to \frac{3}{4}\Delta x$ w/ same V_i & $V_f = 0$ ... must have greater accel.

So, equation w/ those quantities

$$\cancel{V_f^{\,2}}^{\,0} = V_i^2 + 2a\Delta x \quad \Rightarrow \quad \Delta x = \frac{-V_i^2}{2a}, \text{ or } \Delta x \propto \frac{1}{a}$$

$$\text{if } \Delta x \to \tfrac{3}{4}\Delta x, \text{ then } a \to \boxed{\tfrac{4}{3}}a$$

Rubric

- 2pts - clear understanding of which variables change & which constant
- 1pt - Realizing that a must increase
- 2.5pts - Analysis ... finding $\Delta x(a)$ ... or brute force w/ #'s
- 0.5pt - Answer

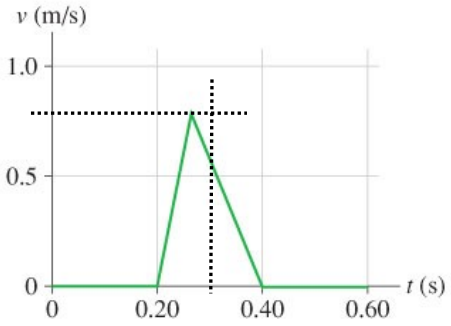
7. (4 points) Electric fields have the same dimensions as a force divided by a charge, where the SI unit for charge is called a Coulomb (C). The dimensions of force are the same as the dimensions of mass multiplied by acceleration. (a) What are the dimensions of an electric field in terms of the fundamental dimensions, charge [Q], mass [M], length [L], and time [T]? (b) What are the SI units of an electric field?

(a) $[D]_E = \frac{[D]_F}{[D]_Q}$, $[D]_F = [D]_m[D]_a$, $[D]_a = \frac{[L]}{[T]^2}$

So $[D]_E = \frac{[D]_m[D]_a}{[D]_Q} \Rightarrow \boxed{[D]_E = \frac{[M][L]}{[Q][T]^2}}$

(b) So E-field SI units ar $\boxed{\frac{kg \cdot m}{C \cdot s^2}}$

8. (8 points) A somewhat idealized graph of the speed of the blood in the ascending aorta during one beat of the heart appears in the figure. (a) Approximate the max acceleration for the blood during one beat. (b) Approximately how far, in cm, does the blood move during one beat? (c) Assuming your brain is 30 cm from your heart, estimate how many beats it will take for that blood to reach your brain. Assume the velocity profile for the blood throughout the entire trip is the same as in the figure.



[10]

(a) $a = \frac{\Delta v}{\Delta t}$ or slope of $v(t)$

$|a|_{max}$ between 0.2 s + 0.25 s

$|a_{max}| \approx \frac{0.75\ m/s}{0.05\ s} = \boxed{15\ m/s^2}$

(b) Δx is area under $v(t)$ curve, Area $\approx \frac{1}{2}(0.05)(0.75) + \frac{1}{2}(0.15)(0.75)$

so $\Delta x \approx 0.075\ m$ or $\boxed{7.5\ cm}$

(c) $\Delta x\ N = \Delta x_{tot}$, where N = # of Beats + $\Delta x_{tot} = 30\ cm$

so $\boxed{N = 4}$

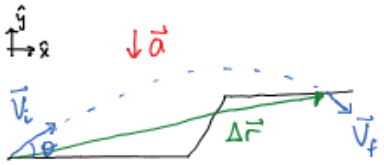
Rubric

(a) 1.5 pts - a is slope of v
1 pts - steepest location
0.5 pts - Reasonable estimate w/ units

(b) 1.5 pts - Δx is area under v
1 pt - Reasonable est. w/ units

(c) 2 pts - $\Delta x N = \Delta x_{tot}$
0.5 pts - Answer

9. (8 points) A golfer hits the ball off the tee at an angle of thirty-five degrees from the horizontal with a speed of 46 m/s. It lands on the green, which is elevated 5.50 m higher than the tee. How much time elapsed from when the ball was hit to when it landed on the green?



k	uk	eq's
$V_{ix} = \lvert\vec{V}_i\rvert \cos\theta = 37.63$ m/s	Δx	(i) $\Delta x = V_i \Delta t + \frac{1}{2} a \Delta t^2$
[x] $a_x = 0$	Δt	(ii) $V_f = V_i + a\Delta t$
$V_{fx} = V_{ix}$		(iii) $V_f^2 = V_i^2 + 2a\Delta x$
[y] $V_{iy} = \lvert\vec{V}_i\rvert \sin\theta = 26.38$ m/s	V_{fy}	
$a_y = -9.8$ m/s^2	Δt	
$\Delta y = 5.5$ m		

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

$5.5 = 26.38\,\Delta t - 4.9\,\Delta t^2 \Rightarrow$ Quadratic!

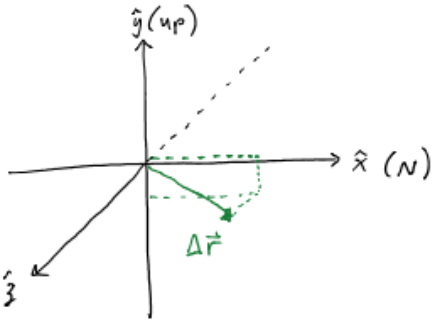
$0 = \underbrace{-4.9}_{\text{"A"}}\Delta t^2 + \underbrace{26.38}_{\text{"B"}}\Delta t \underbrace{-5.5}_{\text{"C"}} \Rightarrow \Delta t = \frac{-B \pm \sqrt{B^2 - 4AC}}{2a}$

$= \frac{-26.38 \pm \sqrt{588.34}}{-9.8} = 0.217\text{ s}$ (on way up) or 5.17 s (on way down)

Rubric

1.5 pts – physical Representation
1.5 pt – known + unknowns
1 pt – V_{ix}, V_{iy} (components)
3.5 pts – Analysis
0.5 pts – Answer w/ units

10. (4 points) A fox runs away from you 5 m in the northern direction, drops straight down a fox-hole 1.5 m, then travels 2 m in the eastern direction. How far away from you is it now?



(E)

$\Delta\vec{r} = \langle 5, -1.5, 2 \rangle$ m

$|\Delta\vec{r}| = \sqrt{\Delta x^2 + \Delta y^2 + \Delta z^2}$

$= 5.59\text{ m}$

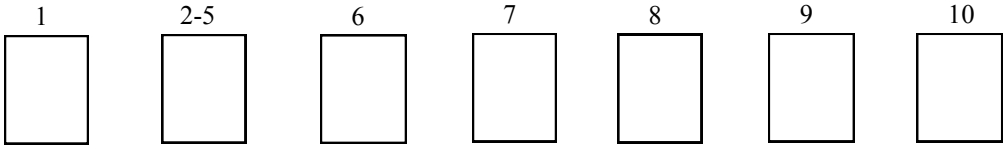
Rubric

+2 pts vector analysis
+1.5 pythagorean
+0.5 Answer + units

extra space if needed

Scores:

Problems



Exam Total