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

Physics 201

Midterm Exam 1

10/22/2014

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. (3 points) 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. (a) What are the dimensions of energy in terms of the fundamental dimensions, mass [M], length [L], and time [T]? (b) The SI unit for energy is called a Joule, what are the SI units of a Joule?

a) $[D]_E = [D]_F [D]_L$ + $[D]_F = [D]_M [D]_a = [M]\frac{[L]}{[T]^2}$

b) $[D]_E = \frac{[M][L]^2}{[T]^2}$

b) $J = \frac{kg \cdot m^2}{s^2}$

2. (3 points) The following conversion equivalents are given:
   1 kg = 1000g 1 in = 2.54 cm 12 in = 1 ft
   The density of a liquid is 0.83 g/cm^3. What is the density of the liquid, in kg/ft^3.

$$\frac{0.83\,g}{cm^3}\left|\frac{1\,kg}{1000\,g}\right|\left[\frac{2.54\,cm}{1\,in}\right]^3\left|\left[\frac{12\,in}{1\,ft}\right]^3\right. = 23.5\,\frac{kg}{ft^3}$$

For questions 3 through 8 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.

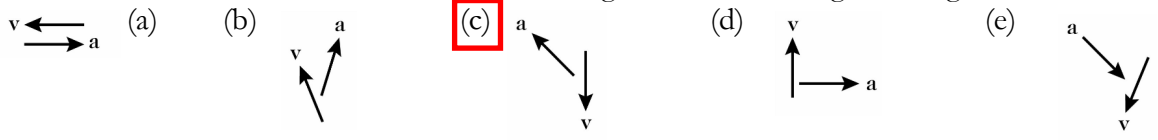
3. A person in a car is driving down a straight road. The instantaneous acceleration is decreasing with time, but is directed in the direction of the car's motion. The speed of the car is
   [T] (a) increasing with time.
   [F] (b) decreasing with time.
   [F] (c) constant.

4. A person in a car is driving down a straight road. The instantaneous acceleration is decreasing with time, but is directed opposite the direction of the car's motion. The speed of the car is
   [F] (a) increasing with time.
   [T] (b) decreasing with time.
   [F] (c) constant.

5. A car maintains 25 mph around a circular track of radius **r**. Which of the following statements about the car are false?
   [F] (a) The velocity is constant.
   [F] (b) The displacement after 1 revolution is $\mathbf{2\pi r}$.
   [T] (c) The distance traveled after 1 revolution is $\mathbf{2\pi r}$.
   [F] (d) The acceleration is zero.
   [T] (e) The car travels an equal distance over equal time periods, e.g. same meters each second.

6. An object is dropped from rest into a pit, and accelerates due to gravity at roughly 10 m/s^2. It hits the ground in 5 seconds. A rock is then dropped from rest into a second pit, and hits the ground in 10 seconds. How much deeper is the second pit, compared to the first pit? Neglect air resistance.
   [T] (a) four times deeper
   [F] (b) two times deeper
   [F] (c) three times deeper
   [F] (d) five times deeper

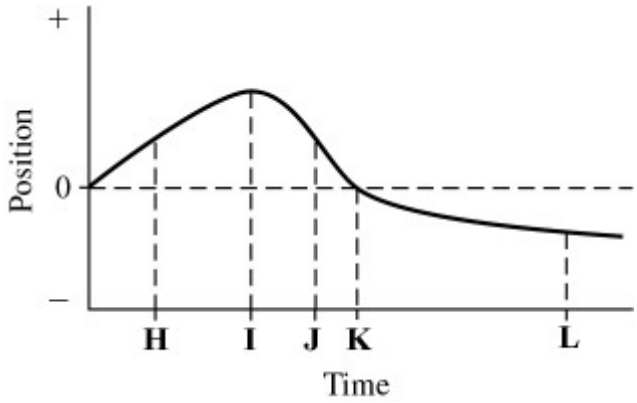
7. Shown here are the velocity and acceleration vectors for an object in several different types of motion. In which of the cases is the object slowing down and turning to ***its*** right?



8. A certain physical quantity, **Q**, is calculated using the formula below, where a and b are distances, and c is a time. What of the following statements are true.
   [T] (a) **Q** must be an acceleration.
   [F] (b) **Q** could be an area.
   [F] (c) **Q** must be a volume.
   [F] (d) **Q** could be a speed.
   [F] (e) **Q** could be a distance.

$$Q = \frac{4\pi}{(a-b)c^2}\left(a^2 + b^2 - 2ab\right)$$

9. (12 points) The plot shows the position (1D) of an object as a function of time. The letters H-L represent particular moments of time that you are asked to rank in various physical quantities. If two options appear very close, then comment that they appear approximately equal.



(a) Rank the displacement from zero of the object, starting with the most negative.

$L < K < H = J < I$

(zero)

(b) Rank the total distance traveled by the object, starting with the least distance value.

$H < I < J < K < L$

(c) Rank the velocity of the object, starting with the most negative.

$J < K < L < I < H$

(zero)

(d) Rank the acceleration of the object, starting with the most negative.

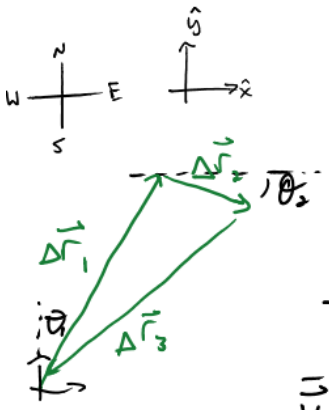
$I < H = J = L < K$

all approx = 0

10. (2 points) What is the direction (positive or negative) of the velocity and acceleration at point **K** in the previous problem, #9?

$v(-)$, $a(+)$

11. (10 points) While studying a flock of African Swallows you observe them fly from their nest and first take a hour to travel 12 km in a direction 20° east of north. Then they take a half hour to travel 5 km in a direction 20° south of east. Finally, they take one hour to fly back to the nest. What was the average velocity of the final leg of their journey? Feel free to answer in kilometers per hour.



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

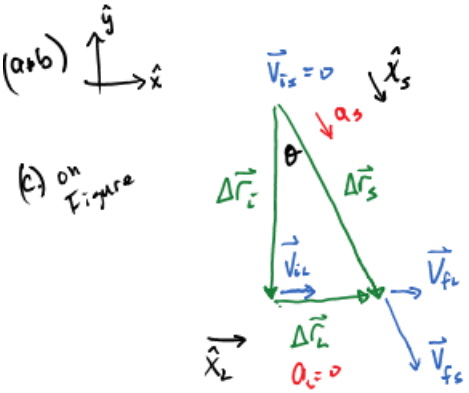
$$-|\Delta\vec{r}_1|\langle \sin\theta_1, \cos\theta_1\rangle - |\Delta\vec{r}_2|\langle \cos\theta_2, -\sin\theta_2\rangle = \Delta\vec{r}_3$$

$$\vec{v}_3 = \frac{\Delta\vec{r}_3}{\Delta t} = \boxed{\langle -8.80, -9.57\rangle \frac{km}{hr}}$$

12. (14 points) Superman is at rest when he spots Lois, 100 m south of him, traveling east on a runaway magnetic levitation (maglev) train at a speed of 100 m/s. His best option to save her is to fly along a straight street that makes an angle of 30.0° from south towards east. (a) What is the displacement vector from Superman's initial location to the point where the street crosses the maglev tracks? (b) What is the displacement vector from Lois's initial location to where the maglev tracks cross the street? (c) If Superman accelerates at a constant rate, what minimum magnitude acceleration must he achieve to just barely save Lois?

Part (c) hint: treat Superman and Lois's motion as separate 1-Dimensional motions.

(a+b) $\hat{y}$, $\hat{x}$



(c) on Figure

a) $|\Delta\vec{r}_s| = \frac{|\Delta\vec{r}_i|}{\cos\theta} = 115.47\,m$

$\Delta\vec{r}_s = |\Delta\vec{r}_s| \langle \sin\theta, -\cos\theta \rangle$

$\boxed{\Delta\vec{r}_s = \langle 57.7, -100 \rangle\, m}$

b.) $\Delta\vec{r}_L = |\Delta\vec{r}_s| \langle \sin\theta, 0 \rangle$

$\boxed{\Delta\vec{r}_L = \langle 57.7, 0 \rangle\, m}$

c.) Both 1D

K

$V_{is} = 0\,m/s$

$\Delta x_s = |\Delta\vec{r}_s| = 115.5\,m$

S

UK

Δt_s

a_s

V_{fs}

eqs

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

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

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

L $V_{iL} = 100\,m/s = V_{fs}$

$a_L = 0\,m/s^2$

$\Delta x_L = |\Delta\vec{r}_L| = 57.7\,m$

Δt_L

Connections

for a_s^{min}

$\Delta t_L = \Delta t_s \equiv \Delta t$

L eq(i) $\Delta x_L = V_{iL}\Delta t + \frac{1}{2}\cancel{a_L}^{0}\Delta t^2 \Rightarrow \Delta t = \frac{\Delta x_L}{V_{iL}} = 0.577\,s$

S eq(i) $\Delta x_s = \cancel{V_{is}}^{0}\Delta t + \frac{1}{2}a_s^{min}\Delta t^2 \Rightarrow a_s^{min} = \frac{2\Delta x_s}{\Delta t^2} = \boxed{693\,m/s^2}$

or 71 g's

Scores:

Problems

1	2	3-8	9	10	11	12

Exam Total
