Name: SOLUTIONS
Student Number:
Bamfield Number:

Science One Physics Midterm #1

October 10, 2013

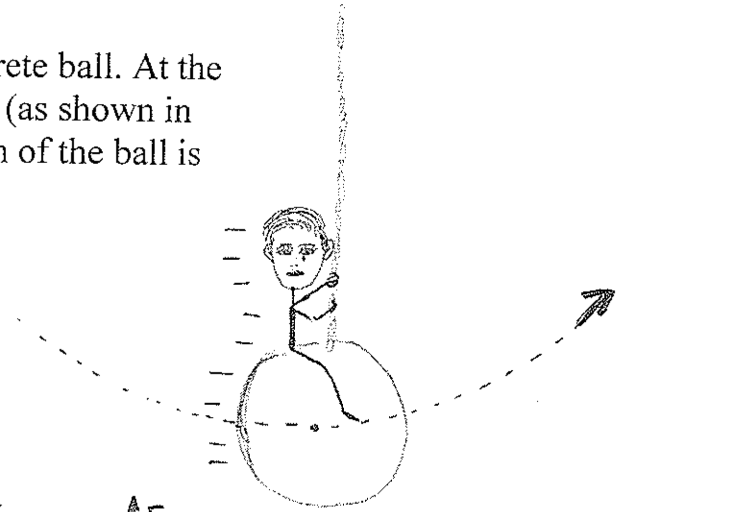
Questions 1-8: Multiple Choice: 2 points each
Questions 9: 2 points
Questions 10-12: Explain your work: 16 points total

Multiple choice answers:

#1	
#2	
#3	
#4	
#5	
#6	
#7	
#8	

Formula sheet at the back (you can remove it)

Question 1: Miley swings on a large concrete ball. At the time when the ball reaches its lowest point (as shown in the figure), we can say that the acceleration of the ball is



A) zero
B) upwards
C) downwards
D) to the right
E) in some other direction

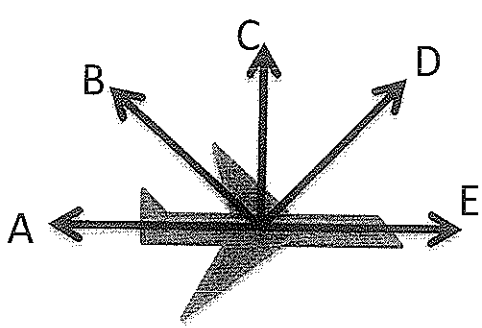
Ignore air drag and Miley for this question.

Forces are tension force + gravity. F_T F_g Thus, acceleration must be up or down. Using $\vec{a} = \frac{\Delta \vec{v}}{\Delta t}$, we see it must be up

$\Delta \vec{v} = \vec{V}_{after} - \vec{V}_{before}$ $\nearrow - \nwarrow = \uparrow$

Question 2: Which statement most accurately describes Conservation of Momentum in a collision of two objects in outer space?

A) Momentum of each object is separately conserved in any collision.
B) Total momentum is conserved during any collision.
C) Total momentum is conserved, but only if the objects don't heat up during the collision. $\longrightarrow$ Mechanical energy not consrved if objects heat up, but $\vec{p}$ is.
D) Total momentum is conserved before and after but not during the collision



Question 3: A jet plane flies at a constant velocity of 900 km/hr. Which of the arrows best represents the net force on the plane?

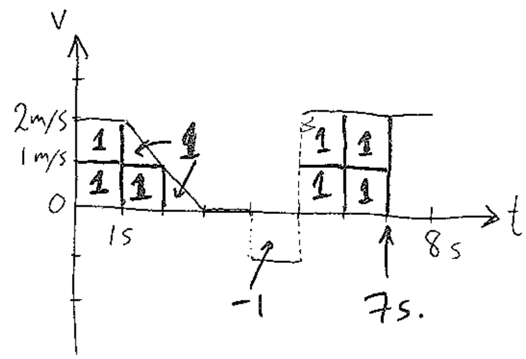
Choose A, B, C, D, E, or: F) none of the above

$\vec{a} = 0$ so $\vec{F}_{NET} = 0$.

Question 4: Confused Carl has lost his i-Phone. Helpless without it, he wanders around aimlessly trying to find it. If the picture above shows t=0 and if Carl's x-velocity versus time is shown in the graph below, when does Carl find his phone?

A) 3s
B) 4s
C) 5s
D) 6s
E) 7s
F) > 7s

Δx is area under graph of velocity from $t=0$ to the final time



Question 5: An object's acceleration vs time data is provided in the table below. If the object's velocity at time t=0.02s is v=3m/s, the velocity at t=0.03s is closest to

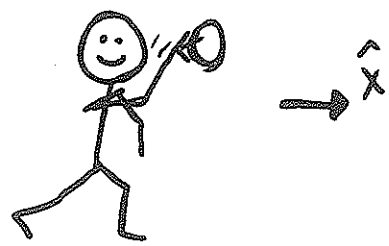
A) 3.01m/s B) 3.1m/s C) 3.2 m/s D) 3.3m/s E) 43m/s

Time (s)	Acceleration (m/s^2)
0.00	10.0
0.01	9.9
0.02	9.7
0.03	9.3
0.04	9.6

$$V(0.03s) \approx V(0.02s) + a(0.02s)\cdot\overbrace{(0.03s - 0.02s)}^{\Delta t} = 3m/s + 9.7m/s^2 \cdot 0.01s$$

(assume the acceleration is changing smoothly during the times shown)

$$\approx 3.1m/s$$



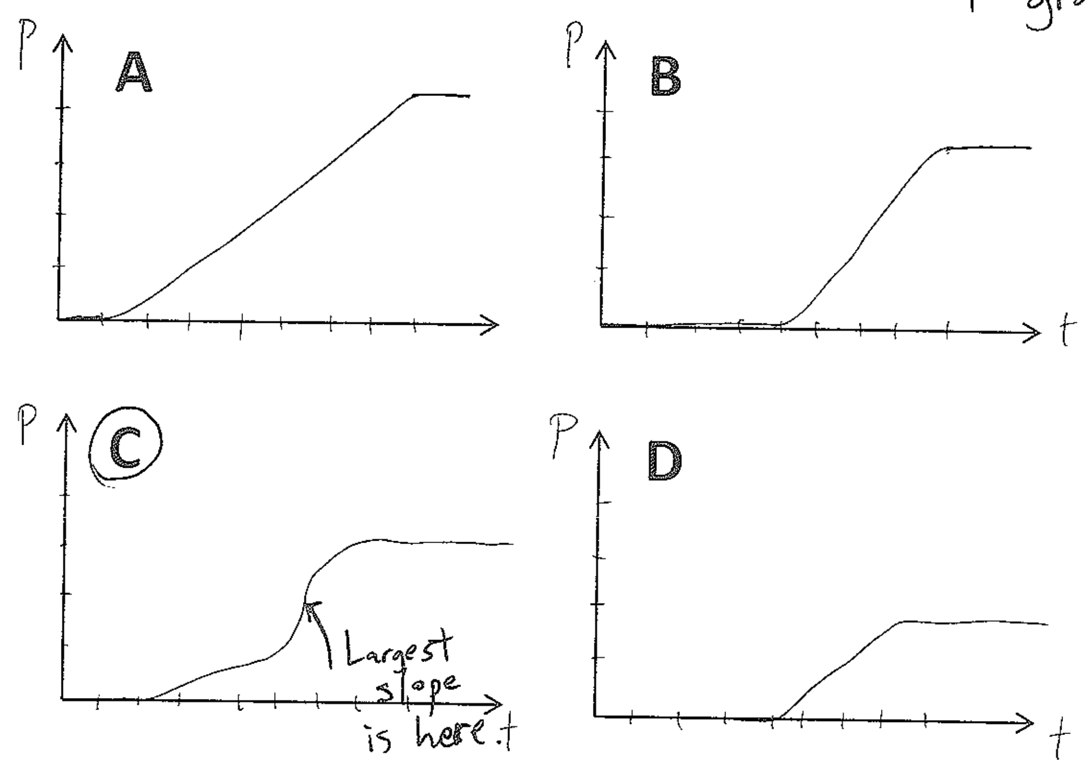
Question 6: James throws a ball. During the throw, we can say that

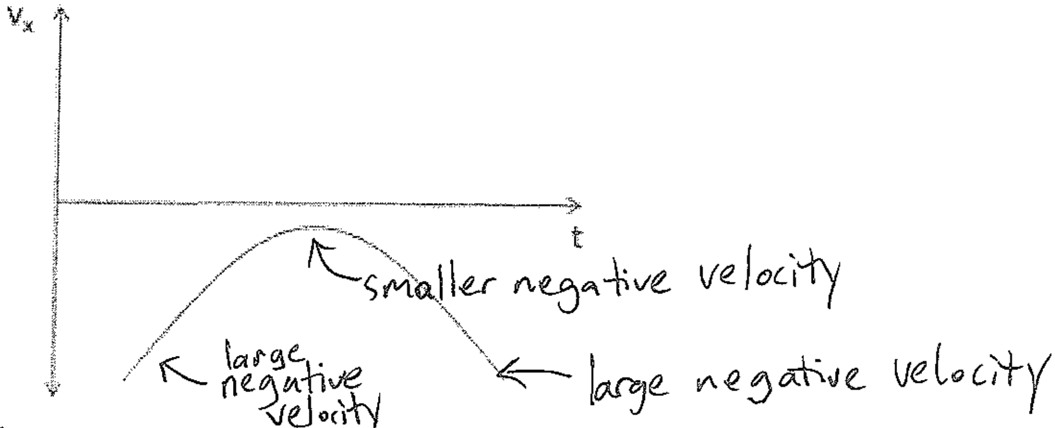
A) There is a force on James from the ball. Its magnitude is greater than the magnitude of the force that James exerts on the ball.
B) There is a force on James from the ball. Its magnitude is less than the magnitude of the force that James exerts on the ball.
C) There is a force on James from the ball. Its magnitude is the same as the magnitude of the force that James exerts on the ball.
D) There is no force on James from the ball.

Newton's 3rd Law guarantees this.

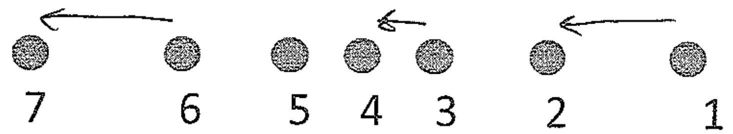
Question 7: The momentum of the ball vs time is graphed for four different throws below. During which throw did James achieve his maximum force exerted on the ball? The scales on each graph are the same.

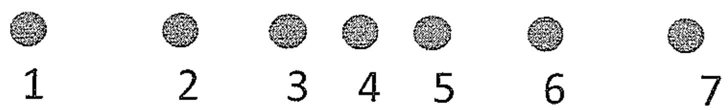
$F = \frac{dp}{dt}$ = slope at p vs t graph.

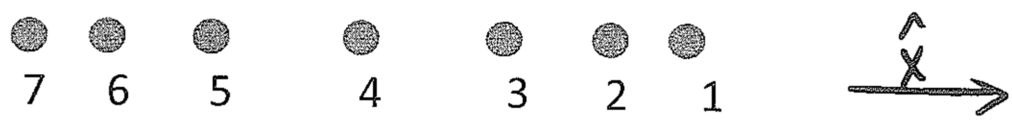


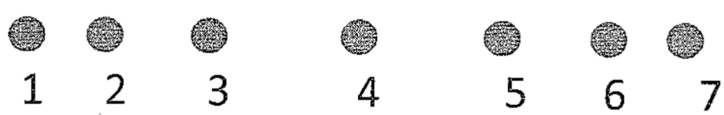


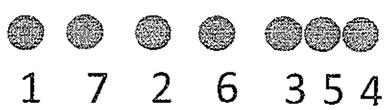
Question 8: The graph above shows the velocity vs time for an object. Which of the following motion diagrams could this graph be referring to?

A)


B)


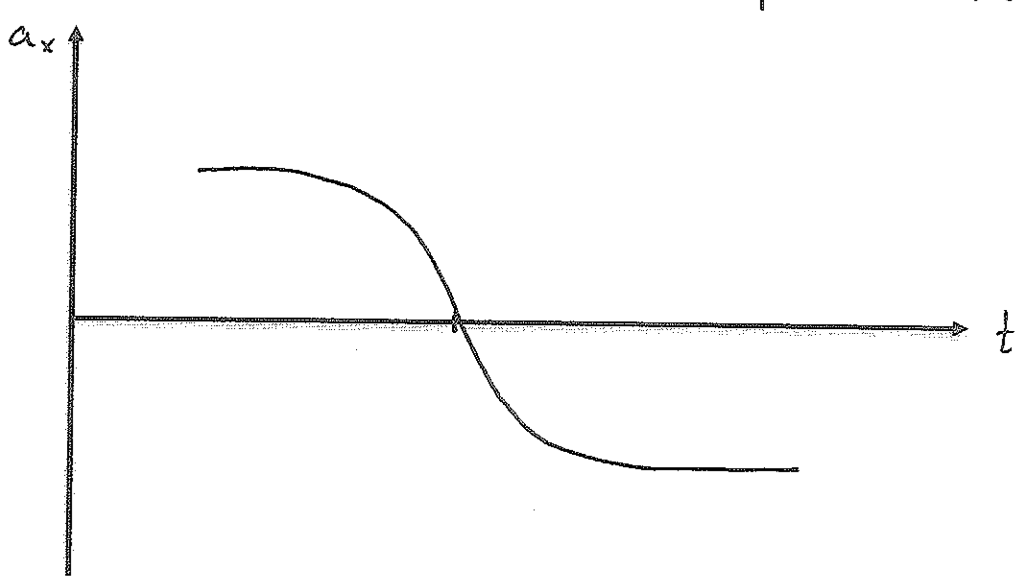
C)


D)


E)


Question 9: On the axes below, sketch the acceleration vs time for this object.
(2 points)

acceleration: slope of v vs t



Question 10: In a standard pea shooter, a 1 gram pea accelerates through a tube, propelled by a puff of air. The tube is 10cm long and the force of the air increases as

$$F(t)=(0.1\,N/s)\,t$$

until the pea leaves the tube. At what speed does the pea leave the tube?
(6 points)

We have : $\frac{dv}{dt} = \frac{1}{m} F$, by Newton's 2nd Law.

$$\Rightarrow \frac{dv}{dt} = \frac{(0.1\,N/s)\cdot t}{0.001\,kg} = 100\,\frac{m}{s^3}\cdot t$$

$$\Rightarrow v(t) = 50\,\frac{m}{s^3}\cdot t^2 + C$$

Since $v(t=0)=0$, we have $C=0$. Thus :

$$V = \frac{dx}{dt} = 50\,\frac{m}{s^3}\cdot t^2$$

$$\Rightarrow x(t) = \frac{50}{3}\,\frac{m}{s^3}\cdot t^3 + C$$

Again $C=0$ since $x(t=0)=0$. The pea reaches the end of the tube when $x=0.1\,m$. This happens at time t such that

$$0.1\,m = \frac{50}{3}\,\frac{m}{s^3}\cdot t^3$$

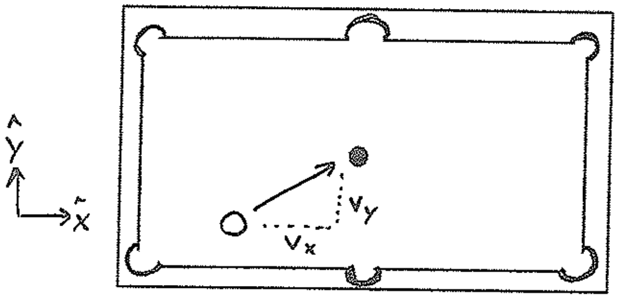
$$\Rightarrow t^3 = 0.006\,s$$

$$\Rightarrow t = 0.182\,s$$

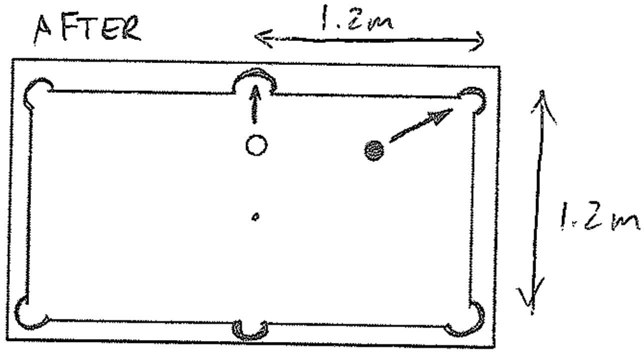
At this time, the velocity is

$$V = 50\,m/s^3\cdot(0.182\,s)^2 = \underline{\underline{1.65\,m/s}}.$$

BEFORE:



AFTER



Question 11: A black ball sits in the middle of a standard 1.2m by 2.4m pool table. To impress your friends, you casually wander up to the table, place a white ball somewhere along the edge, and then hit it towards the black ball just right so that after the balls collide, the black ball goes in the corner pocket and the white ball goes in the side pocket, as shown in the picture to the right. If the two balls each have a mass of 100g and each reach the pockets at exactly the same time, 0.6s after the collision, what was the velocity of the white ball before the collision?
(You may ignore the size of the balls, and assume that the balls roll perfectly without losing speed. However, the collision is an inelastic collision where energy is NOT conserved.) **(6 points)**

Momentum is conserved during the collision. Thus, we have:

① $P_x^{BEFORE} = P_x^{AFTER}$ ② $P_y^{BEFORE} = P_y^{AFTER}$.

To find the final momenta, we use

BLACK: $(V_F^{black})_x = \dfrac{\Delta x}{\Delta t} = \dfrac{1.2m}{0.6s} = 2\,m/s \Rightarrow (p_F^{black})_x = M\cdot(2m/s)$

$(V_F^{black})_y = \dfrac{\Delta y}{\Delta t} = \dfrac{0.6m}{0.6s} = 1\,m/s \Rightarrow (p_F^{black})_y = M\cdot(1m/s)$

WHITE: $(V_F^{white})_x = 0 \Rightarrow (p_F^{white})_x = 0$

$(V_F^{white})_y = \dfrac{0.6m}{0.6s} = 1\,m/s \Rightarrow (p_F^{white})_y = M\cdot(1m/s)$

Before the collision, the black ball has no momentum. So using the momentum conservation equations:

① $\Rightarrow (P_{before}^{white})_x = (p_F^{white})_x + (p_F^{black})_x = M\cdot(2m/s)$

$\Rightarrow M(V_{before}^{white})_x = M\cdot(2m/s) \Rightarrow (V_{before}^{white})_x = 2m/s$

Also: ② $\Rightarrow \left(p^{white}_{before}\right)_y = \left(p^{white}_{F}\right)_y + \left(p^{black}_{F}\right)_y = M \cdot (2m/s)$

$$\Rightarrow M\left(v^{white}_{before}\right)_y = M \cdot (2m/s) \Longrightarrow \left(v^{white}_{before}\right)_x = 2m/s$$

Thus, the initial velocity of the white ball was

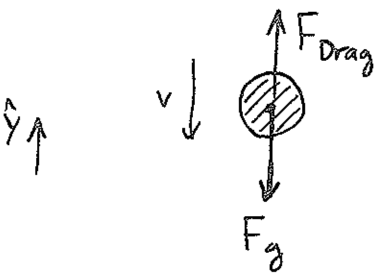
$$\underline{\underline{(v_x, v_y) = (2m/s, 2m/s)}}$$

Question 12:

The y-velocity of a piece of space junk falling vertically downward through the air towards the Earth is given for several times by the following chart (negative velocity means downward motion):

Time (seconds)	y-velocity (m/s)
0.000	-50.000
0.001	-49.760
0.002	-49.522
0.003	-49.287

Eventually, the space junk reaches terminal velocity (i.e. its downward velocity becomes constant). Using the information provided, estimate this terminal velocity. (**4 points**)



We have

$$\vec{F}_{NET} = \vec{F}_{gravity} + \vec{F}_{drag}$$
$$= -mg + Cv^2 \text{ (up)}.$$

Thus, $\frac{dv_y}{dt} = \frac{1}{m} F_y = -g + \left[\frac{C}{m}\right] v^2$

Don't know this yet.

Now, using the Euler method we should have

$$v(0.001s) \approx v(0.000s) + a(0.000s) \cdot 0.001s$$

Plugging in

$$v(0.001s) = -49.760 \text{ m/s}$$
$$v(0.000s) = -50.000 \text{ m/s}$$
$$a(0.00s) = \left[-9.8 \text{ m/s}^2 + \left[\frac{C}{m}\right] \cdot (-50 \text{ m/s})^2\right]$$

we get:

$$-49.760 \text{ m/s} = -50 \text{ m/s} + \left[-9.8 \text{ m/s}^2 + \left[\frac{C}{m}\right] \cdot (2500 \text{ m}^2/\text{s}^2)\right] \cdot 0.001 s$$

$$\Rightarrow 240 \text{ m/s}^2 = -9.8 \text{ m/s}^2 + \left[\frac{C}{m}\right] \cdot 2500 \text{ m}^2/\text{s}^2$$

$$\Rightarrow 249.8 \text{ m/s}^2 = \frac{C}{m} \cdot 2500 \text{ m}^2/\text{s}^2$$

$$\Rightarrow \frac{C}{m} \approx 0.1 \text{ m}^{-1}$$

Now, at terminal velocity, $\vec{a} = 0$ so $\vec{F}_{DRAG} + \vec{F}_{grav} = 0$.

Thus:

$$mg = C \cdot V_T^2$$

$$\Rightarrow \quad V_T^2 = \frac{mg}{C}$$

$$\Rightarrow \quad V_T^2 = 9.8\,m/s^2 \cdot \frac{1}{0.1\,m^{-1}} \quad \leftarrow \frac{c}{m}$$

$$= 98\,m^2/s^2$$

$$\Rightarrow \quad \underline{\underline{V_T \approx 9.9\,m/s}}$$