SOLUTIONS

Name:
Student Number:

Science One Physics Midterm #1

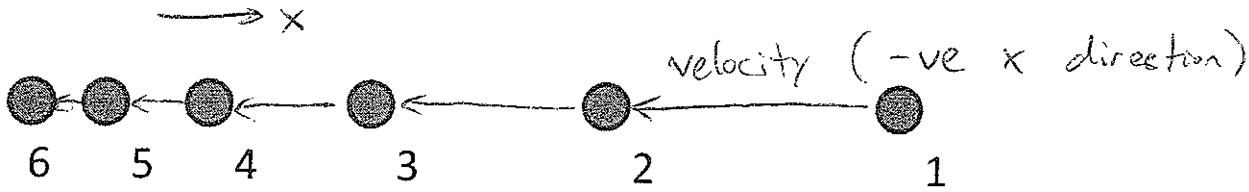
October 16, 2012

Questions 1-8: Multiple Choice: 2 points each
Questions 9-10: 3 points each
Questions 11-12: Explain your work: 20 points total

Multiple choice answers:

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

Formula sheet at the back (you can remove it)



Question 1: The figure shows the location of a ball at equal time steps. If the x axis points to the right, we can say that the ball's

A) X velocity is positive and X acceleration is positive
B) X velocity is positive and X acceleration is negative
(C) X velocity is negative and X acceleration is positive
D) X velocity is negative and X acceleration is negative
E) X velocity is negative and X acceleration is zero

speed decreasing so acceleration is opposite to velocity

$\vec{v}$ ←

→ $\vec{a}$

Question 2: A man jumps off a bridge with an elastic cable connecting him to the bridge. The cable causes him to bounce back up before he hits the ground. When the man reaches his lowest point, we can say that

A) All the forces on the man cancel out
(B) There is a net force upwards
C) There is a net force downward

JUST BEFORE: $\vec{v}$ ↓

JUST AFTER: ↑ $\vec{v}$

change : ↑ so acceleration is <u>up</u>

Question 3: For the object described by the position vs time data below, the instantaneous velocity at time 0.03s is *closest to*

A) 158m/s B) 18m/s (C) 15 m/s) D) 5m/s E) 1m/s

Time (s)	Position (m)
0.00	4.20
0.01	4.40
0.02	4.58
0.03	4.74
0.04	4.88

0.02s → 0.03s :

$V = \frac{\Delta x}{\Delta t} = \frac{4.74-4.58}{0.01}$ m/s

$= 16$ m/s

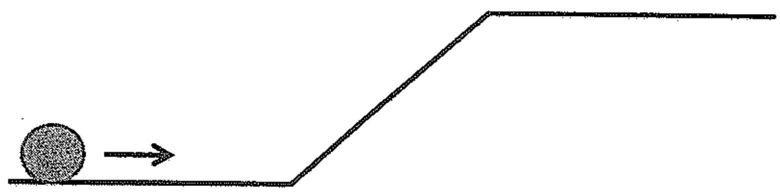
0.03 → 0.04

$V = \frac{\Delta x}{\Delta t} = \frac{4.88-4.74}{0.01}$ m/s

$= 14$ m/s

(assume the position is smoothly increasing during the times shown)

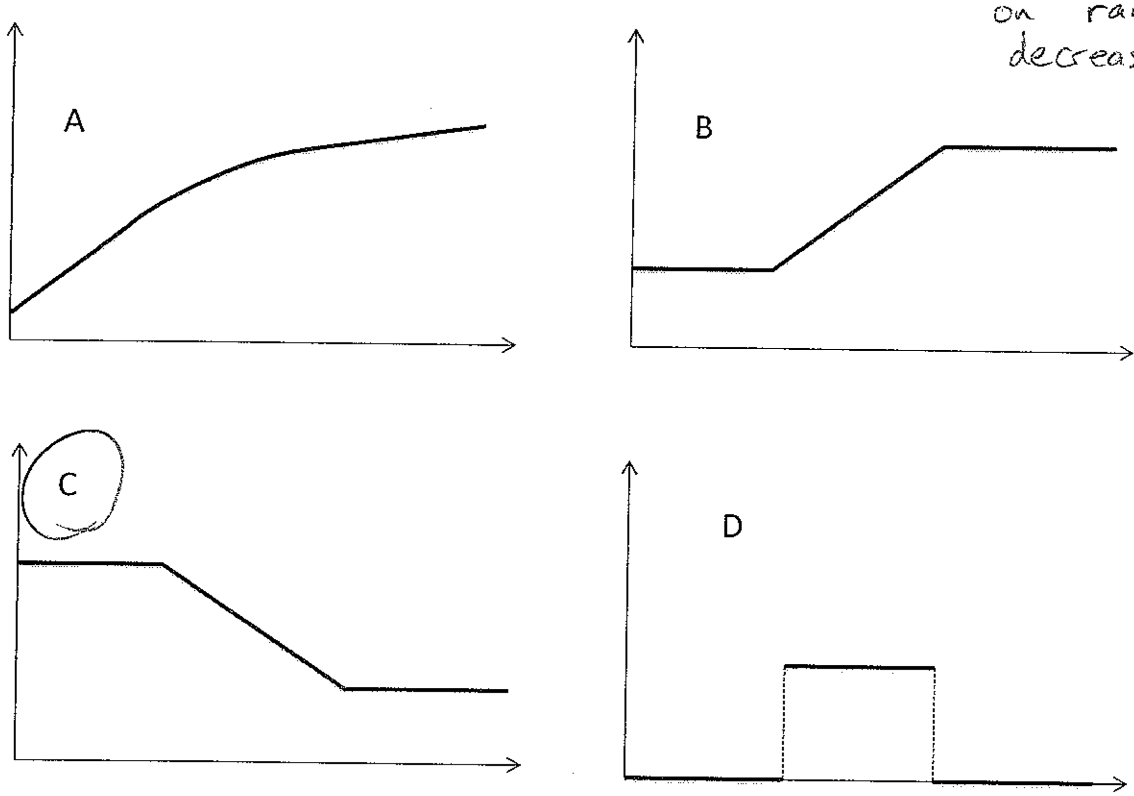
So probably around 15m/s at t=0.03s.



const. velocity on flat parts.

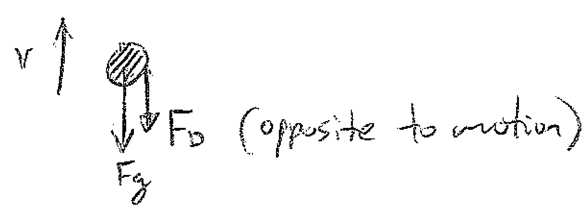
Question 4: A ball rolls up a ramp as shown. Which of the following graphs could represent the ball's horizontal velocity as a function of time?

will be slowing down on ramp (velocity decreasing)

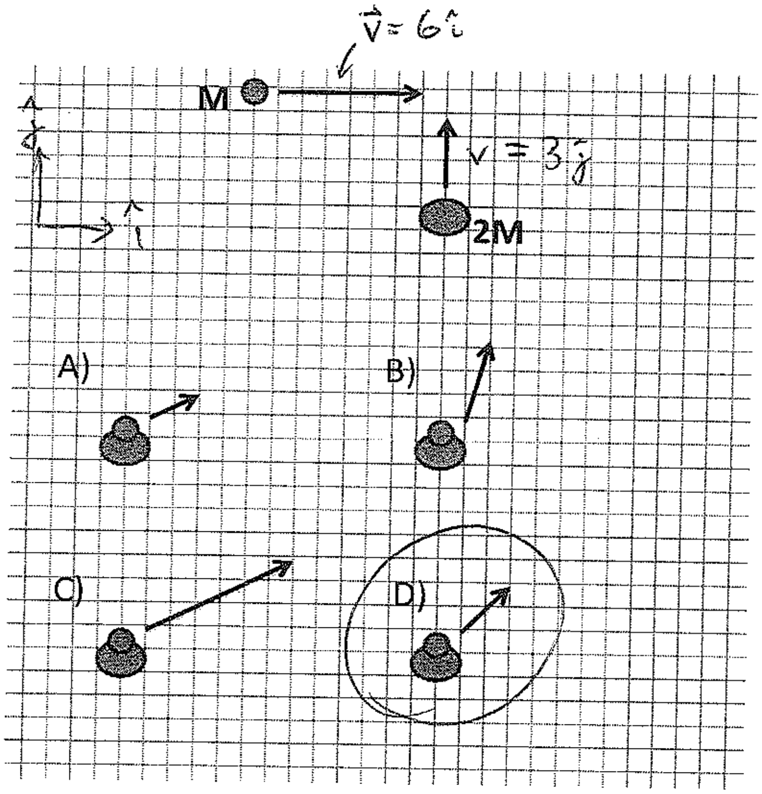


Question 5: A rock is thrown straight up into the air. Taking into account air drag, we can say that the downward acceleration *after* the throw but *before* the rock reaches its maximum height is

A) Greater than g
B) Equal to g
C) Less than g but greater than zero
D) Equal to zero



$$a_{DOWN} = \frac{F_g + F_D}{m} = g + \frac{F_D}{m} > g.$$



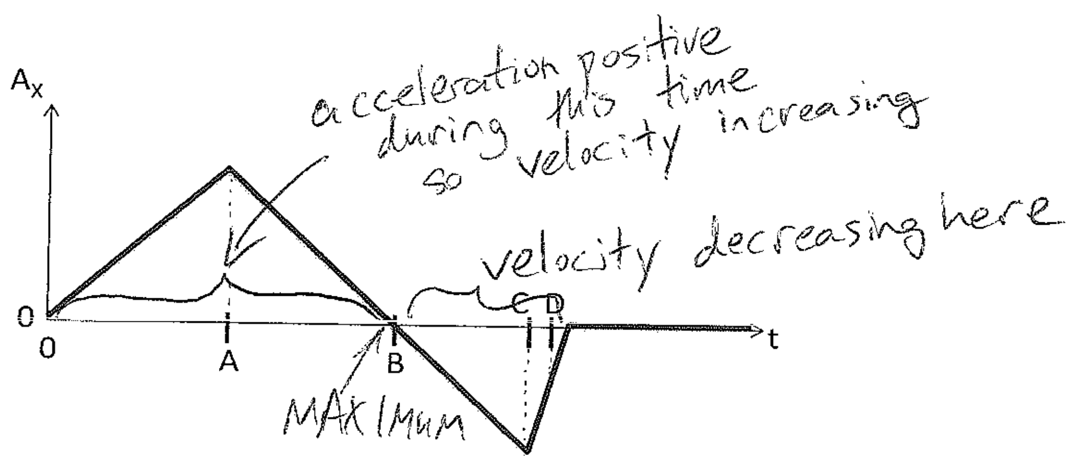
$p_x^{BEFORE} = 6M$

$p_y^{BEFORE} = 6M$

$\therefore p_x^{AFTER} = 6M \qquad v_x^{AFTER} = \frac{6M}{3M} = 2$

$p_y^{AFTER} = 6M \qquad v_y^{AFTER} = \frac{6M}{3M} = 2.$

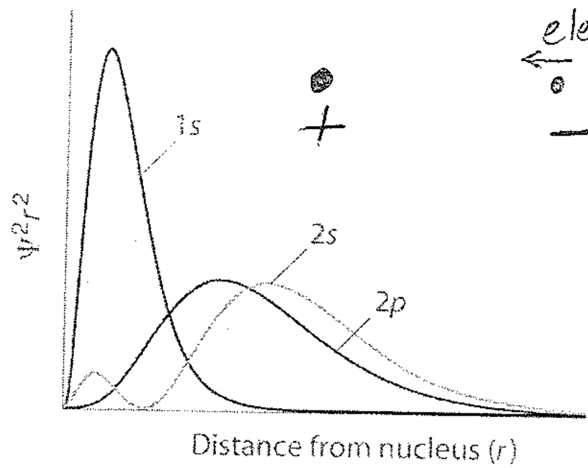
Question 6: In the top picture above, the arrows show the velocities of two balls (of mass M and 2M) that collide and stick together. Which of the other four pictures best represents the velocity after the collision?



Question 7: The graph above shows the acceleration vs time for an object that starts at rest at t=0. At which time is the speed of the object is greatest?

A) A B) B C) C D) D E) Cannot be determined

Question 8: The figure shows the radial probability distribution for electrons in different orbitals of a hydrogen atom. Suppose we measure the potential energy of the electron in various hydrogen atoms for which an electron occupies the 1s or 2p orbital before the measurement. We will find that:



electron wants to move this way so LOWER potential energy for CLOSER electron.

1s electrons closer on AVERAGE but may find one further than a 2p. electron sometimes.

A) Each of the 1s electrons has smaller potential energy than each of the 2p electrons.
B) Each of the 1s electrons has larger potential energy than each of the 2p electrons.
C) Some 1s electrons may have smaller potential energy than some 2p electrons but the average potential energy for the 1s electrons is larger than the average potential energy for the 2s electrons.
(D) Some 1s electrons may have larger potential energy than some 2p electrons but the average potential energy for the 1s electrons is smaller than the average potential energy for the 2s electrons.

Question 9: An object of mass *M* is acted on by a net force *F* for which depends on the object's position X by:

$$F/M = -(10m/s^3)\,X$$

$a = F/M = -(10\,m/s^2)\cdot(1.20\,m) = -12\,m/s^2$

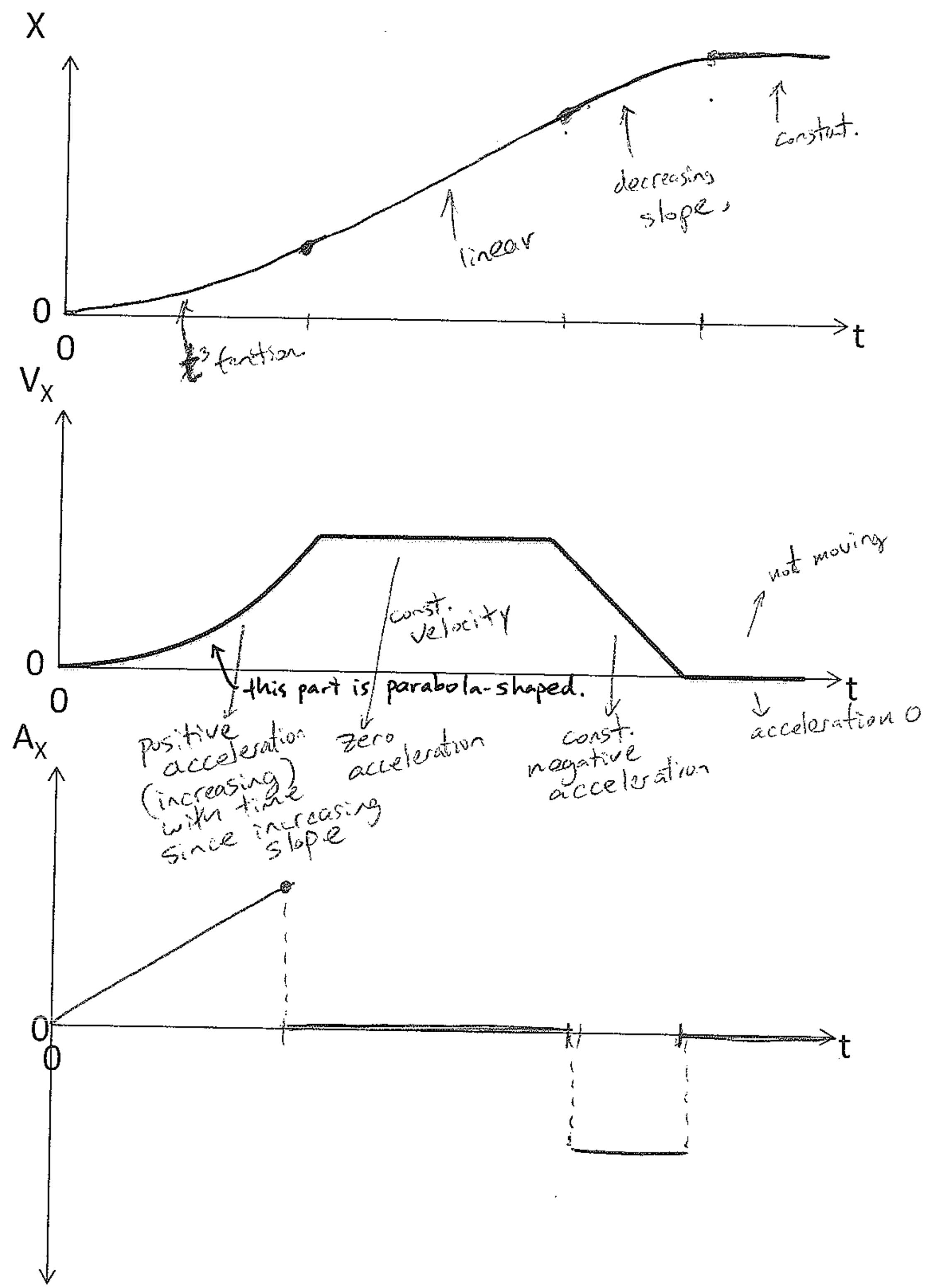
In the table below, fill in the acceleration at time 0 and the position and velocity at time t = 0.01s (estimated).

Time (s)	position (m)	velocity (m/s)	acceleration (m/s^2)
0	1.20	8.00	−12.0
0.01	1.28	7.88	

$x(0.01) \approx x(0) + v(0)\cdot\Delta t = 1.2m + 0.08m = 1.28\,m$

$v(0.01) \approx v(0) + a(0)\Delta t = 8.00\,m/s - 0.12\,m/s = 7.88\,m/s$

Question 10: The middle graph below shows velocity vs time for a moving object. Fill in the top and bottom graphs of position and acceleration vs time, assuming the position of the object is 0 at t=0.

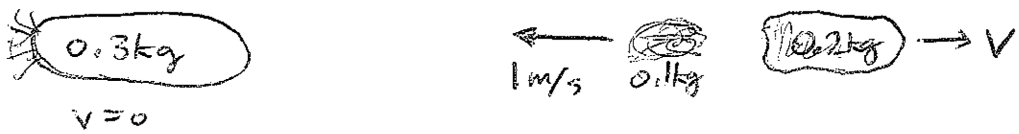


Question 11: On the final flight of the space shuttle *Atlantis*, astronauts brought along a sea cucumber as part of an astro-marine-biology experiment . When the sea cucumber was removed from its tank and allowed to float freely, it became nervous because of the zero-gravity environment and expelled its viscera (various internal organs).

If the sea cucumber (with initial mass 0.3kg) was initially stationary relative to the shuttle and if the viscera (mass 0.1kg) are observed to travel at 1m/s relative to the shuttle after being ejected, how long does it take until the sea cucumber and its insides are 2m apart? You may assume the viscera are expelled all at once.

(8 points)

BEFORE: AFTER:



Momentum is conserved.
We have:

$$P_{BEFORE} = P_{AFTER}$$

$$0 = -1 m/s \cdot 0.1 kg + 0.2 kg \cdot v$$

$$\Rightarrow v = 0.5 m/s.$$

The innards move apart from the sea cucumber at 1.5m/s, so they are 2m apart when

$$T = \frac{2m}{1.5 m/s} = 1.33 s.$$

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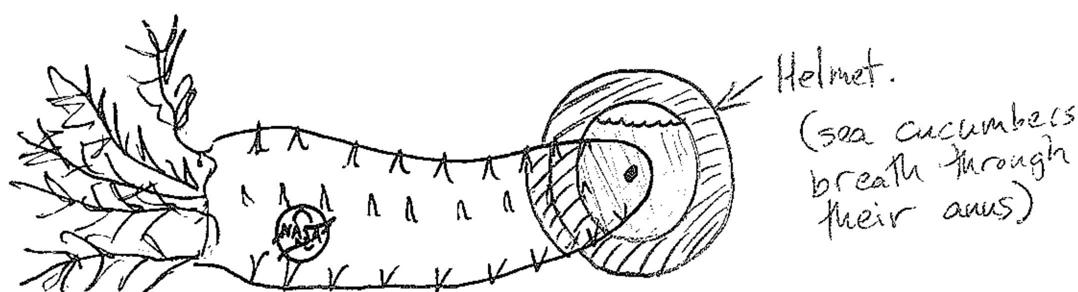
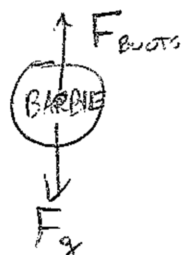


BONUS PART (for zero marks): Suppose the sea cucumber wants to go for a space walk. On which end should we put the water-filled space helmet so that the sea cucumber can breath? Draw the space helmet on the sea cucumber above.

Question 12: Barbie finds out that her owner is planning to launch her into the sky on a rocket with no parachute. So, she quickly changes into her Barbie Jet Boots (and a matching outfit). When she is falling, Barbie (mass 0.2kg) reaches a terminal velocity of 50m/s. If her jet boots produce a thrust force of (1.6N/s) t, how high above the ground should Barbie turn on her jet boots if she wants her speed to decrease to zero just as she reaches the ground? Use $g=10m/s^2$ and assume we can ignore air drag after the boots are turned on. **(9 points)**

FORCE DIAGRAM:



We have:

$$\frac{dv_z}{dt} = \frac{F_{NET}}{m} = -g + \frac{1.6\,N/s \cdot t}{0.2\,kg}$$

$$\Rightarrow \frac{dv_z}{dt} = -10\,m/s^2 + 8\,m/s^3 \cdot t$$

$$\Rightarrow V_z = -(10\,m/s^2)\,t + 4\,m/s^3 \cdot t^2 + C$$

At $t=0$ $\quad V_z = -50\,m/s$ $\quad$ so $\quad C = -50\,m/s$

$$V_z = 4\,m/s^3\, t^2 - 10\,m/s^2\, t - 50\,m/s$$

The velocity is 0 when:

$$4t^2 - 10t - 50 = 0$$

$$2(t-5)(2t+5) = 0$$

so $t = 5s$ is how long it takes Barbie to slow down to $v=0$.

(see next)

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How far does she drop in this time?

We have:

$$\frac{dz}{dt} = V_z = 4\,m/s^3 \cdot t^2 - 10\,m/s^2 \cdot t - 50\,m/s$$

So: $$Z(5s) = Z(0) + \int_0^{5s} \left(4\,m/s^3 \cdot t^2 - 10\,m/s^2 \cdot t - 50\,m/s\right) dt$$

$$\Delta Z = \left(\frac{4}{3}\,m/s^3\, t^3 - 5\,m/s^2\, t^2 - 50\,m/s \cdot t\right)\Big|_0^{5s}$$

$$\approx -208\,m.$$

Barbie should turn on her jet boots 208m above the ground.