Physics 211 Exam 1, Form A

Problem 1	Problem 2	Problem 3	Problem 4	Total
/25	/25	/25	/25	/100

Name: _____

Recitation section number: _____

(see back page)

- There are four questions worth a total of 100 points.
- **You must show your reasoning to receive credit**. A numerical answer with no logic shown will be treated as no answer.
- You are encouraged to use both pictures and words to show your reasoning, not just algebra. Show your reasoning as thoroughly as possible for partial credit.
- If you run out of room, leave a note saying "see back page", and continue your work on the blank page at the end.
- Do not attempt to communicate with anyone other than teaching staff during the exam.
- You may use an ordinary scientific or graphing calculator, but not one that will do algebra for you. If you do not have a calculator, leave your answers in symbolic form.
- Other electronic devices (laptops, smartphones, smartwatches) are not allowed during the exam.
- You may use $g = 10\,\mathrm{m/s^2}$ throughout, except where indicated, to minimize arithmetic.
- Reference material and an extra sheet of paper is on the last page.

Recitation Schedule

M003	8:25-9:20	106	Chad
M016	8:25-9:20	208	Nada
M004	9:30-10:25	B129E	Chad
M013	9:30-10:25	106	JT
M017	9:30-10:25	208	Nada
M005	10:35-11:30	B129E	Patrick
M014	10:35-11:30	106	JT
M018	10:35-11:30	208	Adil
M006	11:40-12:35	B129E	Sierra
M015	11:40-12:35	106	Gentian
M019	11:40-12:35	208	Adil
M007	12:45-1:40	B129E	Sierra
M020	12:45-1:40	208	Manabputra
M021	12:45-1:40	Whitman 306	Gentian
M008	2:15-3:10	B129E	Gabriel
M022	2:15-3:10	Maxwell 110	Manabputra
M009	3:45-4:40	B129E	Gabriel
M010	5:15-6:10	B129E	Gentian
M011	5:15-6:10	104N	Patrick

Question 1

In class, you saw a demo consisting of the following. A cart could be pushed along a horizontal rail at a constant velocity $v_{0,x}$. On top of the cart was a machine that shot a ball upward with a vertical velocity $v_{0,y}$. If this machine was triggered while the cart was moving, the ball flew through the air and landed back in the machine.

a) Explain, without doing any complicated algebra, why the ball landed back in the machine. (5 points)

b) Suppose that the cart is moving at horizontal velocity $v_{0,x}$ when the machine is triggered. How far will the cart move before the ball lands back in it? Give your answer in terms of $v_{0,x}$, $v_{0,y}$, and g. (10 points)

Question 1, continued

c) What is the maximum height achieved by the ball? (5 points)

d) Sketch a graph (on your own axes) of the y-component of the ball's velocity vs. time, indicating on your graph the location where it achieves its maximum height. (5 points)

Question 2

Chloe throws a ball for her greyhound Nessie, who zooms off to go fetch it.

She runs a total distance of 40 m. She starts from rest and accelerates herself at $5\,\mathrm{m/s^2}$ until she is going at 10 m/s, travels at that speed for an unknown time, then slows down at $5\,\mathrm{m/s^2}$ until she comes to a stop, exactly 40 m away from where she started.

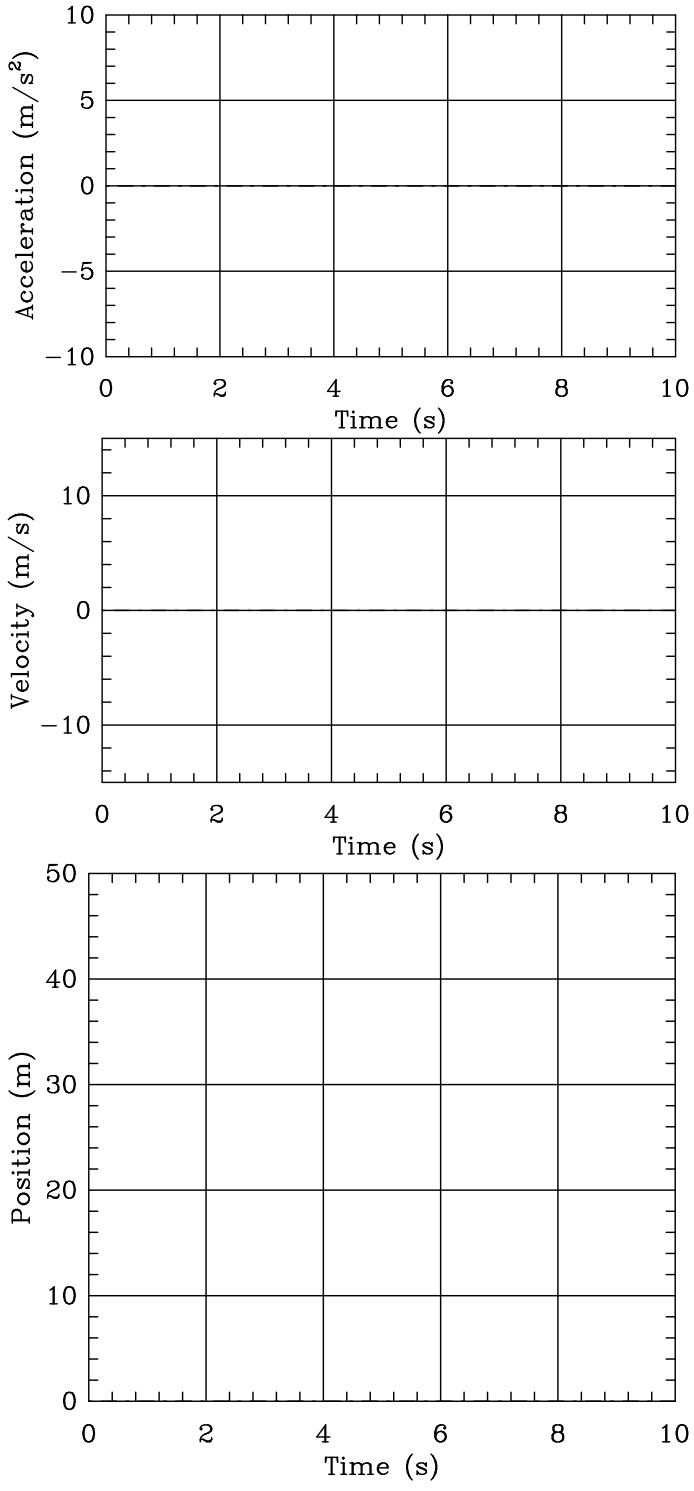
Nessie the greyhound, who Chloe says is a food thief and drama queen.

a) How long does it take her to accelerate from rest to 10 m/s? (5 points)

b) What distance does she travel at 10 m/s before starting to slow down? (10 points)

Question 2, continued

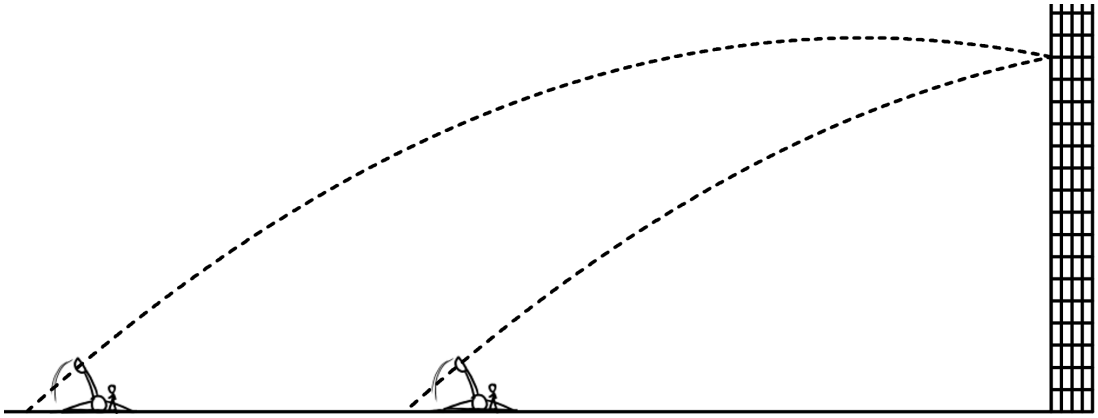
c) Graph her acceleration vs. time, velocity vs. time, and position vs. time on the axes provided. (10 points)



Question 3

A student has built a small catapult and wants to use it to throw snowballs from the Quad through the center of Walter's open window in the Physics Building. Suppose that the catapult fires snowballs at an angle $\theta = 40°$ above the horizontal at a speed of $v_0 = 20$ m/s, and the center of the window is a height $h = 7$ m above the ground.[1]

There are two places on the Quad where they could put their catapult. From one position the snowballs will go through Walter's window on the way up; from the other position, they will hit his window on the way down. In this problem, you will figure out where those two locations are.



a) Indicate your choice of coordinate system on the diagram above, and label any other distances/points you want to assign variables to. (3 points)

b) Discuss in words your approach to figuring out where to place the catapult. In particular, what mathematical condition means "the snowball goes in the window"? What variable are you going to solve for?

You may answer this part by simply writing questions in terms of your algebraic variables, as we have practiced. (5 points)

[1] Catapult image from Randall Munroe/xkcd, used under CC-BY-NC. See, we cite our sources too!

Question 3, continued

c) Determine the two points on the Quad where the snowballs will go into the window. Which one is which? (10 points)

d) If you repeat this problem with $v_0 = 15$ m/s, you will find that you get a negative under the square root sign in the quadratic formula. What is the physical interpretation of this?[2] *(7 points)*

[2] If you did not use the quadratic formula for part (c), then describe instead what will happen with $v_0 = 15$ m/s, and how you would know based on your method.

Question 4

A hiker walks, in sequence:

- 4 km east
- 5 km at an angle 20 degrees north of west
- 7 km at an angle 30 degrees east of south

a) Sketch the hiker's path. (5 points)

Question 4, continued

b) How far from their starting point have they traveled? (10 points)

c) What direction would they look to see their starting point? (Be precise – give a numerical result, e.g. "x degrees west of north" or similar). *(10 points)*

Reference Material

If an object moves with constant acceleration:

$$\vec{s}(t) = \frac{1}{2}\vec{a}t^2 + \vec{v}_0 t + \vec{s}_0$$
$$\vec{v}(t) = \vec{a}t + \vec{v}_0$$

Substituting one of these equations into the other and eliminating time gives

$$v_f^2 - v_0^2 = 2a(x_f - x_0)$$

Definitions of trig functions:

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$$
$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}}$$
$$\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$$

Quadratic formula: if

$$0 = At^2 + Bt + C,$$

then

$$t = \frac{B \pm \sqrt{B^2 - 4AC}}{2A}$$

Use the back side of this page if you need more room for any part of any problem; leave a note if you want the grader to consider what you have written there.

Scratch Paper