# Physics 211 Exam 1, Form A

| Dog | Geese | Soccer | Football | 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

| Section | Day / Time | Room | TA |
|---|---|---|---|
| M025 | TTh 5:00-5:55 | Bowne Hall 105 | Chad |
| M009 | TTh 5:00-5:55 | Physics B129E | Kelly |
| M017 | TTh 5:00-5:55 | Physics 106 | Byron |
| M018 | TTh 6:30-7:25 | Physics 106 | Byron |
| M010 | TTh 6:30-7:25 | Physics B129E | Mingwei |
| M003 | WF 8:25-9:20 | Physics B129E | Chad |
| M011 | WF 8:25-9:20 | Physics 106 | Mingwei |
| M012 | WF 9:30-10:25 | Physics 106 | Trent |
| M004 | WF 9:30-10:25 | Physics B129E | Chandler |
| M020 | WF 9:30-10:25 | Life Sciences 156 | Byron |
| M005 | WF 10:35-11:30 | Physics B129E | Aklima |
| M013 | WF 10:35-11:30 | Physics 106 | Chad |
| M006 | WF 11:40-12:35 | Physics B129E | Aklima |
| M014 | WF 11:40-12:35 | Physics 106 | Manabputra |
| M022 | WF 11:40-12:35 | 765 Irving 221 | Trent |
| M007 | WF 12:45-1:40 | Physics B129E | Chandler |
| M015 | WF 12:45-1:40 | Physics 106 | Manabputra |
| M023 | WF 12:45-1:40 | Newhouse 2 | Kelly |
| M016 | WF 3:45-4:40 | Physics 106 | Aklima |
| M008 | WF 3:45-4:40 | Physics B129E | Kelly |
| M024 | WF 3:45-4:40 | Crouse-Hinds 017 | Trent |

# Question 1

Cecco, Massimo's dog, loves to chase rabbits. He is resting under a tree when he sees a rabbit come out of its burrow a distance 30 meters away.

Suppose Cecco can accelerate at a rate of 4 m/s$^2$, up to a top speed of 12 m/s. *(This means that once he reaches 12 m/s, he cannot accelerate any more.)*

*Cecco the rabbit-chasing dog who lives in Madrid.*

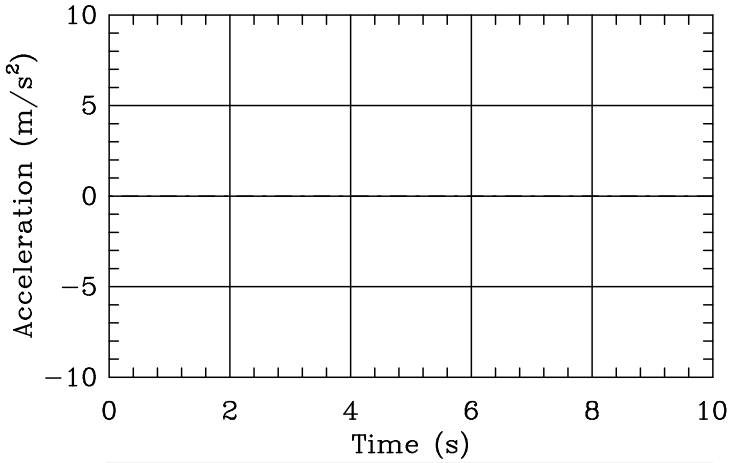
a) How much time does the rabbit have to duck back into its hole before Cecco reaches it and catches it? *(5 points)*

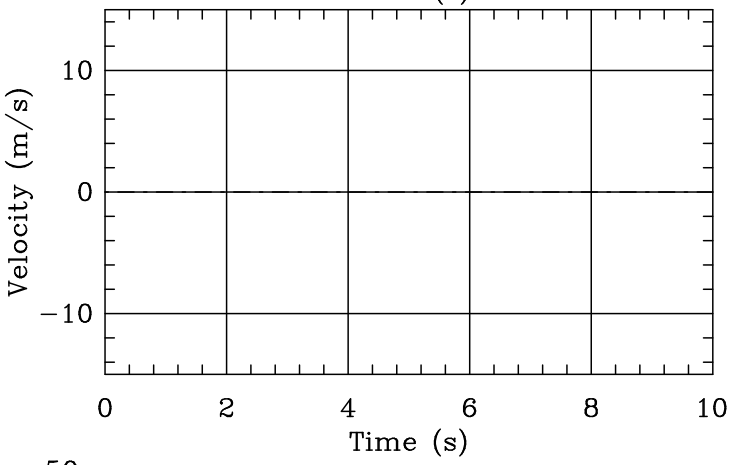
The rabbit ducks back into its hole. Cecco isn't going to give up, so he tries to stop and turn around to go back to the hole to start digging it up. Suppose that he then accelerates back to the rabbit hole at 4 m/s$^2$, first slowing to a stop and then running back to the rabbit hole. (His acceleration is 4 m/s$^2$ whether he is slowing down or speeding up.)

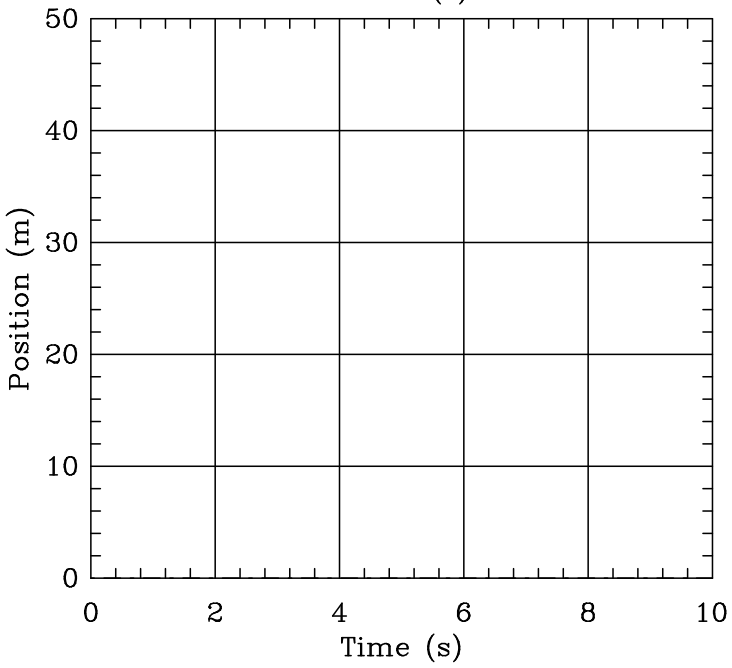
b) How far does Cecco run past the rabbit hole before turning around? *(5 points)*

# Question 1, continued

c) Draw graphs of Cecco's position, velocity, and acceleration on the graphs below. (You may need to calculate a few more things, like the amount of time it takes Cecco to come back to the hole.)



# Question 1, continued

d) You can divide the velocity vs. time graph into several geometric shapes. What is the physical interpretation of their areas? Briefly describe as many of them as you can, and relate them to things you may have calculated earlier. *(5 points)*

# Question 2

Canada geese can fly around $v_{\text{fly}}$=60 km/hr in still air.

When geese are flying, there are three velocity vectors we might want to think about:

- $\vec{v}_{\text{fly}}$, which can have a magnitude of 60 km/hr in any direction the goose wants; this is the velocity of the goose relative to the air that it is in.
- $\vec{v}_{\text{wind}}$, the velocity of the air relative to the ground
- $\vec{v}_{\text{ground}}$, the velocity of the goose relative to the ground (the direction the goose actually travels)

a) Write a vector equation (e.g. $\vec{A} = \vec{B} + \vec{C}$) relating $\vec{v}_{\text{fly}}$, $\vec{v}_{\text{wind}}$, and $\vec{v}_{\text{ground}}$. *(5 points)*

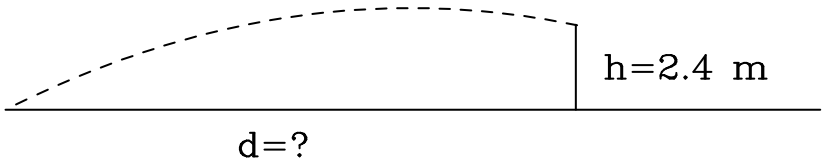
During the fall migration, suppose a flock of geese wants to travel from one pond to another pond that is 300 km due south on a certain day. On that day, the wind is blowing at 30 km/hr eastward.

b) Represent the vector equation you wrote in part (a) graphically below. *(10 points)*

c) How much time will it take the geese to reach the second pond? *(10 points)*

# Question 3

A football (soccer) player takes a shot on goal. He kicks the ball at an angle $\theta = 30°$ above the horizontal at a speed of $v_0 = 15$ m/s. The ball bounces off of the crossbar, located a height $h = 2.4\,\text{m}$ above the ground. Ignore air resistance.




a) Write expressions for $x(t)$ and $y(t)$. *(5 points)*

b) How much time after the ball is kicked does it take for it to strike the crossbar? You may give your answer as a numerical value or an algebraic expression. (10 points)

# Question 3, continued

c) In part (b), you likely used the quadratic formula. One of the two roots you obtained is the one you used to answer part (b). What is the physical meaning, if any, of the other one? (If you did not use the quadratic formula for part (b) but got it right, you will get full credit for this part.) *(5 points)*

d) What is the distance $d$ between the kicker and the goal line? *(5 points)*

# Question 4

One of the placekickers on the Syracuse American football team is in our PHY211 class. American football is played on a flat field, and you can neglect air resistance for this problem.

Suppose that after he kicks the ball, you see the ball sail through the air for a time $\tau$ before it lands a distance $d$ away on the other side of the field.

a) Write expressions for the components of the ball's position and velocity as a function of time. *(5 points. It will be easiest if you leave the unknown initial velocity in terms of its components.)*

b) What was the magnitude of the ball's velocity right after he kicked it? Give your answer in terms of $d$, $g$, and $\tau$. *(10 points)*

# Question 4, continued

c) What direction was the ball traveling in right after he kicked it? Give your answer in terms of $d$, $g$, and $\tau$. *(5 points)*

d) What is the maximum height above the field that the ball reached? Give your answer in terms of $d$, $g$, and $\tau$. *(5 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

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

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Definitions of trig functions:

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

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Quadratic formula: if

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

then

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

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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