Physics 211 Exam 3, Question 1

Instructions for this exam:

This exam is in *five separate parts*. **This is not the whole exam; this is part 1 of 5.** It contains the instructions, an academic integrity affirmation, and some short answer questions.

You will download each part separately and submit it separately. All parts must be submitted to Blackboard in the same way that you submit your homework before 1 PM on Wednesday, April 8 (Syracuse time: Eastern Daylight Time, UTC -4:00).

You may either:

- Write on this document electronically, using a stylus and tablet
- Print this document out and write on it, and submit scans or photographs of it
- Write the answers on your own paper, and submit scans or photographs of it

This is *not* a "Blackboard exam" – you do not need to maintain a connection to Blackboard while working on it.

If there is anything interfering with your ability to submit your responses on time, please notify us as soon as possible.

You may:

- Consult any materials on the course website, video library, any of your notes, or the OpenStax textbook for reference
- Contact teaching staff to ask for clarification on any portion of the exam. (We will try to provide quick responses to emails and monitor the Virtual Physics Clinic, WeChat, and Discord.)
- Make use of Google Calculator or similar tools to do arithmetic

You may not:

- Provide assistance to anyone else in our class on this exam
- Consult online references other than the OpenStax textbook (for example, Chegg and Coursehero) regarding the material on the exam after the exam period begins

Regardless of format, please copy the following text in your submission and sign your name to it:

"I affirm that my answers represent my own work and understanding,
and that I have not given or received unauthorized help on this exam."

We discussed "measurement bias" as an example of the failure of the process of science in class. This happens when measurements are made on a limited and thus biased set of data, and thus result in drawing erroneous conclusions.

The United States was unprepared in many ways for the COVID-19 pandemic; one of those ways is the *shortage of test kits* to determine if people had contracted the SARS-CoV-2 virus that causes this disease. We thus can only test a limited set of people for the SARS-CoV-2 virus.

Among people who contract the SARS-CoV-2 virus that causes COVID-19:

- Some will have no symptoms; some will have only minor symptoms that do not require treatment in a hospital
- Some people will have serious symptoms that lead them to seek treatment in a hospital
- Of those, some small fraction will die

Suppose that a given city in the USA has only very limited access to SARS-CoV-2 testing. Since they have only a limited number of tests available, they only test people who come to a hospital complaining of serious symptoms. Suppose that SARS-CoV-2 testing and treatment in this city has the following outcomes:

- The city's hospitals have given 2000 tests to people with serious symptoms who have come to the hospital
- 500 of these tests have come back "positive", meaning that the patient has the virus
- 10 out of these 500 people have died

Someone writes the following about these statistics: *"In our city, there are 500 people with SARS-CoV-2. Out of these cases, 10 people have died. This means that this virus has a 2% mortality rate."*

This person has made two claims:

(i) that 500 people in the county have SARS-CoV-2, *(ii)* that the virus kills 2% of the people who contract it

a) Are each of these claims accurate? If not, explain in a few sentences how measurement bias has affected their accuracy, and explain whether the true figure (for the number of cases and for the mortality rate) is likely to be higher or lower. (*8 points***)**

(This question continues on the next page.)

Epidemiologists are scientists who study the spread of infectious disease, trying to understand how diseases spread and how many people have them, in an effort to design better ways to stop their spread and focus resources in the right places.

Even though the USA has only a very limited number of SARS-CoV-2 tests, some epidemiologists have suggested that instead of primarily giving tests to people who are sick in hospitals, we should use some fraction of our tests to *test people chosen at random*, even those who do not appear sick.

b) What advantages would this have, and what might we learn from it? If we have only a limited number of tests to give, why would epidemiologists want to "waste" some of them by testing people who are not seriously sick? Explain in a few sentences. *(7 points)*

c) Describe briefly how the conservation of momentum is a consequence of Newton's laws of motion. You may do this either in mathematics, in words, or in a combination of the two. *(10 points)*

PHY 211 Exam 3: Problem 2

April 7, 2020

This is only one of the exam problems. You must read the full instructions on problem 1 before starting the exam.

Instructions: Solve this problem and submit it to Blackboard before 1 PM Syracuse time (Eastern Daylight Time) on Wednesday, April 8. You will submit all four problems as separate submissions to help us grade more efficiently.

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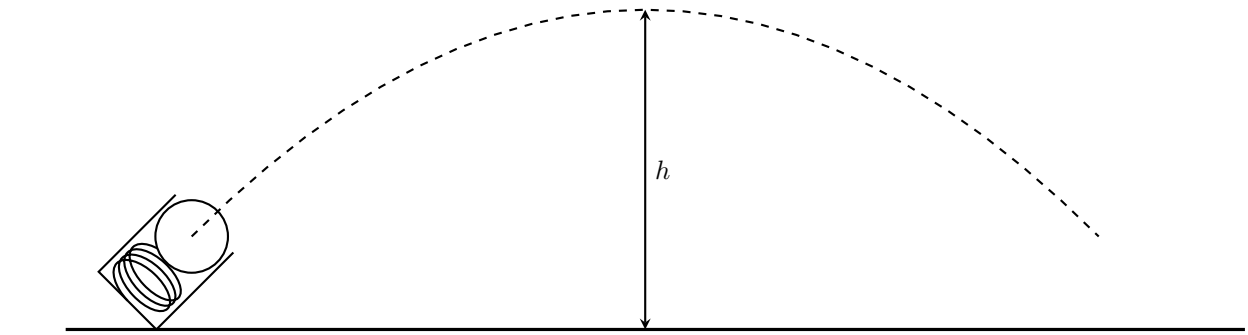
A spring launcher fires a ball with a mass of 2.7 g at an angle $\theta = 45°$ above the horizontal. The energy comes from a spring with spring constant $k = 80\,\mathrm{N/m}$ that is compressed by 5 cm. You can ignore the height difference between the ground and where the ball is fired.



launcher not to scale

(a) (10 points)**.** What will the velocity of the ball (magnitude and direction) be just as it leaves the launcher?

(b) (15 points)**.** What is the maximum height above the ground that the ball will reach?

PHY 211 Exam 3: Problem 3

April 7, 2020

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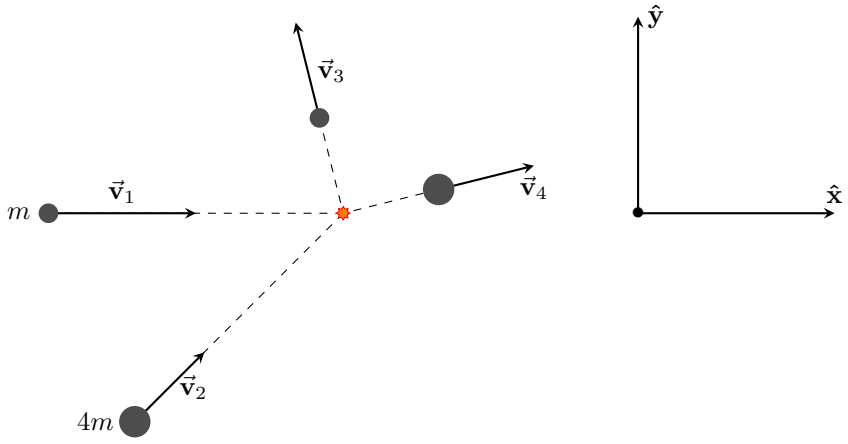
Instructions: Solve this problem and submit it to Blackboard before 1 PM Syracuse time (Eastern Daylight Time) on Wednesday, April 8. You will submit all four problems as separate submissions to help us grade more efficiently.

Problem 3

A large marble with a mass of $4m$ (four times a regular marble) is rolling across the floor in front of you, but you aren't sure with exactly what velocity. Carefully timing your throw, you shoot a smaller marble of mass m with a speed $v_1 = 7\,\mathrm{m/s}$ at it; define the x-direction as the direction of your throw. The two marbles then collide. Afterwards you measure the velocities of the two marbles: the smaller one has a velocity $\vec{\mathbf{v}}_3 = -1\,\hat{\mathbf{i}} + 4\,\hat{\mathbf{j}}\,\mathrm{m/s}$, and the larger one $\vec{\mathbf{v}}_4 = 4\,\hat{\mathbf{i}} + 1\,\hat{\mathbf{j}}\,\mathrm{m/s}$. You can ignore any effects of rolling in this problem, including friction.



(a) (20 points)**.** What was the velocity of the larger marble before the collision?

(b) (5 points)**.** Was energy conserved in the collision? Be sure to answer fully (not just yes or no).

Physics 211 Exam 3, Question 4: Obligatory Dog Question

This is not the full exam; this is part 4 of 5. The full instructions are in part 1; read them before you begin.

Finn is a water-loving and very strong dog who has gotten good at jumping off of a boat to catch a Frisbee floating in the water. He's got a mass of $m = 25$ kg. When he jumps, his muscles are able to produce 450 J of energy. For simplicity, let's think about Finn jumping horizontally from the side of a boat, just so we don't have to do any trigonometry. You may approximate Finn as a single point, even though that's not quite realistic.

a) Suppose that Finn jumps horizontally from a very massive boat (so massive that it will not move) as fast as he can from a height of $h = 1$ meter. What velocity v_0 will Finn have once he jumps? *(5 points)*

b) If this boat is floating 2.5 m away from a Frisbee in the water, will Finn be able to jump on top of it? *(5 points)*

(This problem continues on the next page.)

c) Now, suppose that Finn jumps horizontally from a much lighter canoe with the same mass as Finn (25 kg), also from a height of $h = 1$ meter. (The canoe is floating in the water, and is free to move.) Recall that Finn's muscles can only produce $E = 450$ J of energy in a jump, which must be shared between the canoe and Finn.

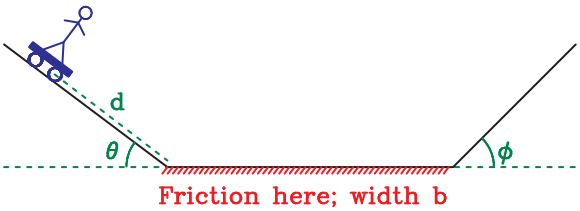
Determine the velocities of Finn and the canoe after he jumps. *(10 points)*

d) If this canoe is floating 2.5 m away from the same Frisbee, and Finn is again jumping from a height of $h = 1$ m, will Finn be able to jump on top of the Frisbee? *(5 points)*

Physics 211 Exam 3, Question 5

This is not the full exam; this is part 5 of 5. The full instructions are in part 1; read them before you begin.

A skateboarder of mass m is standing on the edge of a drainage channel, as shown. The left side, where the skateboarder starts, is elevated at an angle θ; the right side is elevated at an angle ϕ. The slopes on either side are smooth, and the skateboard moves over them with essentially no friction, but the flat bottom of width b is covered with a little sand, and the skateboard experiences a small amount of rolling friction there, with μ_k known.



The skateboarder starts a distance d up the left-hand side. They roll down the left side, across the sand-filled bottom, and up the right side.

(*Give your answers to the first two parts in terms of the variables above, along with g.*)

a) Determine the maximum distance d_2 that the skateboarder makes it up the right side. (This is the diagonal distance, not the height.) *(10 points)*

(This problem continues on the next page.)

b) After rolling up and back down the right side, the skateboarder will come back to the left side. How far will they travel back up the left side? *(5 points)*

c) Suppose that you know numeric values as follows:

- $m = 75$ kg
- $\theta = 30°$
- $\phi = 40°$
- $\mu_r = 0.05$
- $d = 4$ m
- $b = 7$ m

How many times will the skateboarder travel across the sandy bottom of the channel before coming to rest? Explain the approach behind your solution fully. *(10 points)*