Physics 211 Quiz 4

Instructions for this quiz:

This quiz has two full-length questions and one shorter one. The full-length questions are worth 40 points each; the shorter one is worth 20.

The quiz period begins at 11:20 and runs until the end of class. We anticipate that it will take you no more than an hour to complete. You may have an extra ten minute grace period to scan and submit your work; if for any reason you are not able to submit your work by 12:30, please contact Walter or Mario.

Questions during the quiz: You may reach teaching staff to ask questions during the quiz by:

- Joining the course Zoom and asking by chat or voice
- Asking a question in `#quiz-questions` on Discord
- (Only if both of these methods are not available to you) Email to `wafreema@syr.edu`

Exception: Students who receive an extra-time accommodation through the Center for Disability Resources may take that extra time. If you receive 1.5x time for the quiz, you should complete by 12:50 and submit by 1:00; if you receive double time, you should complete it by 1:20 and submit by 1:30. If this timetable does not work for you or you require additional accommodations, please contact Walter or Mario immediately.

- **You must show your reasoning to receive credit**. Where appropriate you should make use of words and diagrams, alongside equations and numbers, to show your reasoning.
- You may use $g = 10\,\mathrm{m/s^2}$ throughout to minimize arithmetic.

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

If you submit scans or photographs, please ensure that you are submitting JPEG or PDF files. Do not submit "Live Photos" (from newer iOS devices) or .HEIC files. The best format to submit is a single PDF.

You may:

- Consult any materials on the course website, video library, any of your notes, or the OpenStax textbook for reference
- Contact teaching staff over Zoom, Discord, or email to ask for clarification on any portion of the exam.
- Use a graphing calculator to do arithmetic or graph functions
- Make use of Google Calculator, Desmos, or similar tools to do arithmetic or graph functions
- Use a translation tool or dictionary to translate anything to your native language

You may not:

- Provide assistance to anyone else in our class on this quiz while they are taking it
- Seek assistance from anyone other than teaching staff on this quiz while you are taking it
- Use a computer program or calculator to do algebra for you
- Consult online references outside the class other than the OpenStax textbook (for example, Chegg and Coursehero) regarding the material on the quiz after the quiz period begins

Regardless of format, please copy the following text below, or write it 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 quiz."*

Question 1

A person of mass 50 kg is ice-skating on a frozen lake with his dog Kibeth, who has a mass of 15 kg. He is skating due north at 3 m/s.

Kibeth realizes that he's carrying snacks in his pocket, and would like one for herself. (Or maybe she is just being friendly!) She runs after him and tackles him from behind and the side, knocking him down. The two of them collapse on the ice and begin to slide, as Kibeth tries to get the treats out of his pocket; they are moving at an angle 20 degrees west of north at 4 m/s.

What was Kibeth's velocity before she tackled him? *(Remember velocity is a vector.) (40 points)*

Question 2

The dread pirate captain Piarrrr Squared has a peg leg, a parrot, and a ship whose horizontal deck is a height h above the water. The captain has just found a new cannon and has hauled it to the edge of the deck. The coefficient of kinetic friction between the cannon and the deck is μ_k.

The cannon is very massive; it has a mass a hundred times greater than the cannonballs that it fires.

Piarrrr test-fires the cannon, which launches a cannonball horizontally; it flies out to sea, and the cannon slides back a distance D before coming to rest.

In this question, you will determine the range R[†] that the cannonball travels out to sea before splashing into the water. (The below space is for you to draw diagrams, if you choose.)

a) What technique can you use to relate the forward velocity of the cannonball after it is fired to the backward velocity of the cannon? Determine this relationship. *(10 points)*

b) What technique can you use to relate the backward velocity of the cannon right after it is fired to the distance that it slides before coming to rest? Determine this relationship. *(10 points)*

[†]Pronounced "arrrrrrr", of course.

Question 2, continued

c) What technique can you use to relate the forward velocity of the cannon after it is fired to the range that the cannonball flies out to sea? Determine this relationship. *(10 points)*

d) Putting together the above information, if the cannon slides a distance D backwards, determine the range R that the cannonball flies out to sea, in terms of D, g, μ_k, and h. *(10 points)*

Question 3

When very large stars reach the end of their lives, their cores are made of solid iron. A supernova is triggered when the iron core can no longer support the weight of its own gravity; it collapses into a much smaller object (of essentially the same mass) called a neutron star.

Suppose that before the core collapses, it has a radius of 6000 km. During the core collapse, it shrinks to a neutron star with a radius of 50 km. In both cases, you can model it as a uniform sphere with a moment of inertia of $I = \frac{2}{5}mR^2$.

a) Even if the core is rotating only very slowly before it collapses, it will be rotating quickly once it does. Explain briefly why. *(10 points)*

b) Suppose that the neutron star rotates once every second. How quickly did the iron core rotate before it collapsed? *(You can either describe its angular velocity in rotations per second, or tell me how many seconds it took to rotate before it collapsed.) (10 points)*