Physics 211 Quiz 5

Instructions for this quiz:

This quiz has three full-length questions worth 30 points and a short-answer question worth 10 points. This means that this quiz is graded out of 100 points. There is the potential for 10 points extra credit in one of the questions.

The quiz period begins at 11:00 and runs until the end of class. We anticipate that it will take you no more than an hour to complete; you will likely have substantially more time than you need. 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 1:00 and submit by 1:10; if you receive double time, you should complete it by 1:40 and submit by 1:50. 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 mad-science professor, after seeing the Physics 211 rocket-powered car, makes some "modifications" to it. They enhance the rocket to provide a greater thrust force of $F_T = 2$ kN, and head out to a large field to test it. The rocket car and professor together have a mass of $m = 200$ kg. (Assume that the mass of the expelled propellant is small compared to m, so that m does not change.)

Since the field is somewhat rough, the coefficient of rolling friction between the car's wheels and the ground is $\mu_r = 0.2$.

They fire the rocket and travel forward along the field. After traveling a distance $d = 100$ m, they confirm that this will suffice for their mad-scientific purposes[1], and shuts down the engine; they coast a further distance b before coming to a stop.

a) Find the distance b. In finding this, you should draw diagrams of relevant moments in the motion and label them clearly, and reference them in doing your calculation. (10 points)

[1] World domination, obviously

b) Suppose now that the rocket exhaust is directed at an angle $\theta = 40^\circ$ below the horizontal[2]*. Write an expression for the work done by friction during the entire motion in this case. (10 points)*

c) Find the distance b in this case. (10 points)

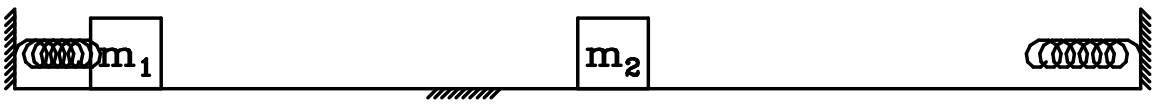
[2]Their mad-science graduate student assistant messed up a conversion between radians and degrees and pointed it in the wrong direction.

Question 2

A spring of spring constant k is compressed by a distance d by a mass m_1 and released. This propels the mass down a flat track. Another spring, also of spring constant k, is on the other side.

Another object of mass m_2 is sitting in the middle of the track. The first mass strikes it and sticks to it.

The entire track is frictionless, except for a small region of the track to the left of m_2, of width b, with a coefficient of kinetic friction μ. (This is indicated by diagonal lines on the track in the diagram.)



The space below is for you to draw diagrams of important stages in the motion and indicate the techniques that you will use to relate them to one another. Any insight you show here will be considered by the graders.

Question 2, continued

a) How fast is the first mass moving right before it collides with the second block? (10 points)

b) How fast are the two masses moving right after the collision? (10 points)

c) When the two blocks reach the spring on the other side, they will bounce off of it, compressing it in the process. What is the maximum distance that this spring is compressed? (10 points)

Question 2, continued

Suppose that the numeric quantities in this problem are as follows:

- $m_1 = 2$ kg; $m_2 = 1$ kg
- $k = 1000$ N/m
- $d = 0.1$ m
- $b = 0.1$ m
- $\mu = 0.2$

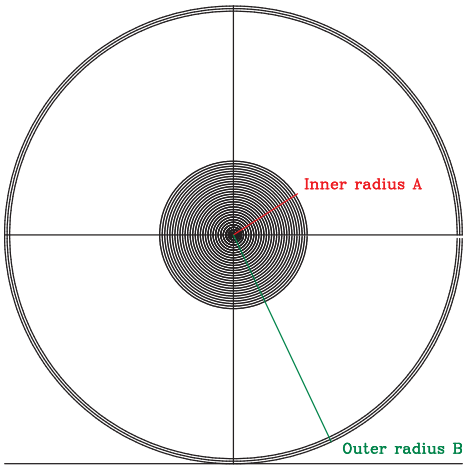
d) How many times will the blocks cross the track before they come to rest? (10 points extra credit) Hint: There is an easy way and a hard way to do this!

Question 3

Imagine a device that consists of a dense, solid inner cylinder of radius A and mass m, surrounded by an outer, hollow cylinder of radius B and negligible mass. The inner cylinder is attached rigidly to the outer one, so they rotate together. *(All of the mass is in the inner cylinder.)*

The moment of inertia of a solid cylinder is $I = \frac{1}{2}mr^2$.

Suppose that this object first rolls forward without slipping on a level surface at speed v, then rolls up an incline until it comes to rest and rolls back down. There is no rolling friction.



a) Determine the maximum height h that it makes it up the incline before it comes back down in terms of m, A, B, and g. (Your result may not depend on all of these.) (10 points)

Question 3, continued

b) Suppose that the inner radius A is increased, while keeping everything else the same. Will h increase, decrease, or stay the same? Why? (You may reference your mathematical answer to (a) or give an explanation solely in words.) (8 points)

c) Suppose that the outer radius B is increased, while keeping everything else the same. Will h increase, decrease, or stay the same? Why? (You may reference your mathematical answer to (a) or give an explanation solely in words.) (8 points)

d) Suppose that the mass m is increased, while keeping everything else the same. Will h increase, decrease, or stay the same? Why? (You may reference your mathematical answer to (a) or give an explanation solely in words.) (4 points)

Question 4

If an object moves from point A to point B and the work done by a force *does not depend* on the path that it takes from A to B, that force is called a *conservative force*.

Is kinetic friction a conservative force? *(10 points)*

If it is, argue why the work that it does will not depend on the path taken.

If it is not, give a counterexample: describe a situation where the work done by kinetic friction depends on the path an object takes as it moves from one point to another.

You may mix diagrams, words, and (if needed) mathematics in your explanation below.