PHYS 2211 M - Test 3 - Summer 2022

Please clearly print your name & GTID in the lines below

Name: ____ GTID: ____

Instructions

- This exam is closed internet/books/notes, except for the Formula Sheet which is included with the exam.
- You must work individually and receive no assistance from any person or resource.
- You are not allowed to post screenshots, files, or any other details of the test anywhere online, not even after the test is over.
- Work through all the problems first, then scan/upload your solutions after time is called.
  - Your uploaded files **must** be in either PNG, JPG, or PDF format.
  - Your uploaded files must be readable in order to be graded. Unreadable files will earn a zero.
  - You can upload a single file containing work for multiple problems as long as you upload the file for each problem individually.
  - Clearly label your work for each sub-part and box the final answers.
- To earn partial credit, your work must be legible and the organization must be clear.
  - Your solution should be worked out algebraically.
  - Numerical solutions should only be evaluated at the last step. Incorrect solutions that are not solved algebraically will receive an 80 percent deduction.
  - You must show all work, including correct vector notation.
  - **Correct answers without adequate explanation will be counted wrong.**
  - Incorrect work or explanations mixed in with correct work will be counted wrong. Cross out anything you do not want us to grade
  - Make explanations correct but brief. You do not need to write a lot of prose.
  - Include diagrams!
  - **Show what goes into a calculation, not just the final number, e.g.:** $\frac{a \cdot b}{c \cdot d} = \frac{(8\times10^{-3})(5\times10^{6})}{(2\times10^{-5})(4\times10^{4})} = 5 \times 10^4$
  - Give standard SI units with your numeric results. Your symbolic answers should not have units.

Unless specifically asked to derive a result, you may start from the formulas given on the formula sheet, including equations corresponding to the fundamental concepts. If a formula you need is not given, you must derive it.

If you cannot do some portion of a problem, invent a symbol for the quantity you can not calculate (explain that you are doing this), and use it to do the rest of the problem.

**"In accordance with the Georgia Tech Honor Code,
I have not given or received unauthorized aid on this test."**

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Sign your name on the line above

Springs - Q3 on Gradescope [35 pts]

A package of mass m needs to be delivered to the Moon (mass M, radius R) from Earth (mass $81.3M$, radius $3.7R$). To do this, you use a horizontal spring-loaded mechanism on the surface of the Earth that will launch the package at the necessary speed for it to reach the surface of the Moon. Over on the Moon, the package is received with another horizontal spring-loaded mechanism.

1. [20 pts] The spring on the Moon has stiffness k, relaxed length L_0, and at its maximum compression it has length $L_0/4$. What should be the launch speed v_i on Earth such that when the package is caught by the spring on the Moon, the package comes to rest when the spring is maximally compressed? Your answer should be expressed in terms of the variables known in the problem (m, M, R, k, L_0) and fundamental physical constants such as G. **You do not need to simplify your final answer**.

2. [15 pts] The spring on Earth has stiffness $2k$ and relaxed length L_0. When the package is at rest and ready to launch, the spring is maximally compressed. What does this compression have to be in order for the package to reach the launching speed you found in the previous part? **Use the variable v to represent the speed found in part 1**.

Thermal Energy - Q2 on Gradescope [35 pts]

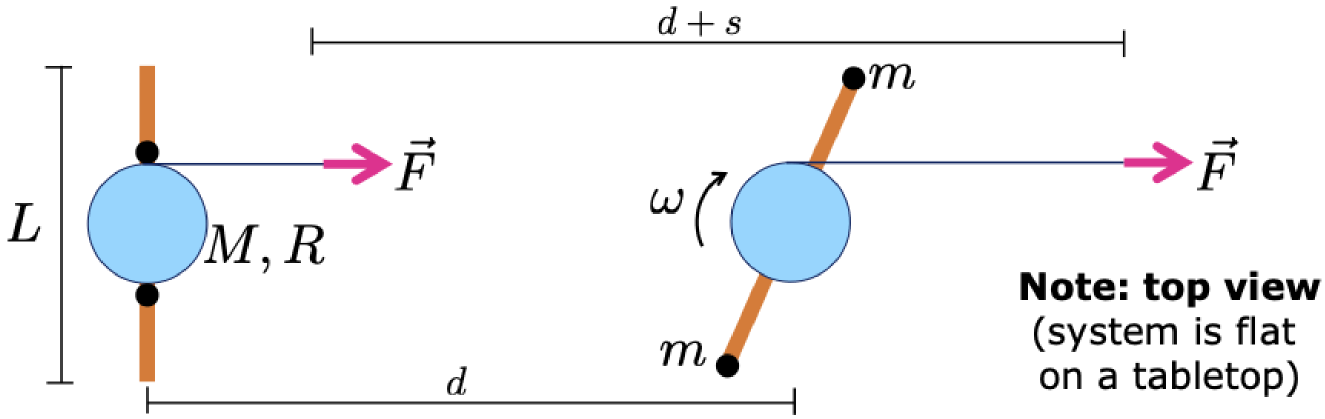
1. [20 pts] A car with mass $M = 1400$ kg travels at a speed of $v = 80$ km/hr, then it brakes to a stop. In the process of braking, the brakes' steel disks get hotter. If we need the disks' temperature to not increase by more than 120°C, how much mass m should the disks have? The heat capacity of steel is $C = 0.47$ J/(g°C). You can assume that the temperature of the rest of the car does not change.

2. [15 pts] You have a block of $m = 100$ g of an unknown substance at room temperature ($T_i = 25°\text{C}$), and you want to determine what material it is by finding its heat capacity. To do this, you bring out a copper pot ($m_c = 25$ g, $C_c = 0.385$ J/(g°C), $T_c = 15°\text{C}$) that sits inside an insulating container. Then you put the block in the pot and add $m_w = 300$ g of water ($C_w = 4.2$ J/(g°C)) at $T_w = 80°\text{C}$. After some time, the entire system reached an equilibrium temperature of $T_f = 54°\text{C}$. What is the heat capacity C of the unknown material?

Rotations - Q4 on Gradescope [30 pts]

A system consists of a uniform solid disk of mass M and radius R attached to the middle of a massless rod of length L. Two small point masses m rest on the rod next to the disk. The entire apparatus sits at rest on top of a table. (see the left side of the figure).

A string is wound up around the disk, and you start pulling on the string with a constant force of magnitude F. The apparatus slides to the right along the frictionless tabletop. When the center of the disk has moved a distance d, a length of string s has come off the disk, the disk is spinning, and the two point masses slid along the rod and got stuck at the ends of the rod (see the right side of the figure).



1. [10 pts] Use the point-particle system to find what is the speed v of the disk in the final state (right side of the figure).

2. [20 pts] Use the extended system to find what is the angular speed ω of the disk in the final state (right side of the figure).

This page is left blank if needed for extra work