Physics 211 Group Practice Quiz 2, Complete

Your Name: _____

Group Member 1: _____ Group Member 2: _____

Instructions: You should complete these questions alongside your group. You may ask questions of TA's and coaches, but may not communicate with anyone else.

You may either:

- Write on this document electronically, using a stylus and tablet
- Submit a physical copy, if you attend recitation in person
- 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.

Each member of your group should independently submit a complete quiz. We will choose one to grade; everyone in your group will get the same grade.

You may:

- Speak freely to the other students in your recitation group
- 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 Blackboard Collaborate and Discord during this time for your questions. Proctors will also be monitoring Blackboard Collaborate for questions.)
- 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, other than the members of your group
- 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
- Share the contents of this quiz with anyone until 5PM Friday (when I will post copies)

Question 1

A "merry-go-round" is a large, horizontal platform free to rotate around its axis. Children can stand on top of the platform while it spins; you know the coefficients of static and kinetic friction between their shoes and the ground. Suppose that a merry-go-round with a radius $R = 3$ m is spinning, and that it rotates around its axis in a time $\tau = 3$ s.

Suppose that the coefficient of kinetic friction μ_k between the children's feet and the platform is 0.6, while the coefficient of static friction μ_s between their feet and the platform is 0.75.

a) Draw a force diagram for a child standing on the platform. Indicate your choice of coordinate system. (10 points)

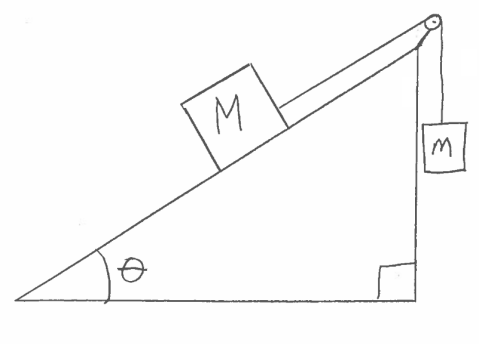
b) How close to the edge can a child stand to the edge without slipping? (30 points)

Question 1, continued

c) Suppose now that the children spinning the platform want to slow it down enough that their friends on top can safely walk to the edge and jump off. What is the maximum angular velocity ω that would allow a child to stand on the edge of the platform without slipping? (10 points)

Question 2

A book of mass M sits on an inclined plane angled at an angle θ above the horizontal;
it is connected by a string to another book of mass m hanging over the top. (See picture.) You know the coefficients of friction between the book and the surface.



a) In terms of M and m, what must the angle θ be such that the two books do not move? Assume for this part that there is no friction. (10 points)

Now, assume that M is large enough that it slides down the ramp. There is kinetic friction between that book and the ramp; the coefficient of kinetic friction is μ_k.

b) Draw force diagrams for both books. Indicate your choice of coordinate system for both of them (they do not have to be the same, and in fact shouldn't be!) (6 points)

Question 2, continued

c) Give a mathematical statement of Newton's second law for both books, substituting in quantities specific to this problem. (In other words, don't just write $\vec{F} = m\vec{a}$; write something useful that will help you solve the remaining parts.) (10 points)

d) What is the relationship between the acceleration of the two books? (4 points)

e) Calculate the acceleration of both books in terms of M, m, g, θ, and μ_k. (20 points)

Question 3

A person is standing in a subway car, looking forward. She is not holding onto anything, trusting the friction between her shoes and the ground to keep her balance.

Draw force diagrams for the person for the following situations. Make sure you indicate which direction is which (i.e. tell me whether I am looking at the person from above, from the side, etc., and which direction is toward the front of the subway car.) Indicate the relative sizes of the forces by the lengths of the arrows in your force diagram. Forces that have the same magnitude should have the same size arrows; if you think it's not clear, you can write a little text telling me which forces are larger, smaller, or equal.

a) The subway car is moving forward at a constant velocity $\vec{v}$. (5 points)

b) The subway car is going over the top of a hill, and is accelerating straight downward at 3 $\mathrm{m/s^2}$*. (10 points)*

Question 3, continued

c) The subway car is moving at a constant speed v; it is turning left, gently enough that the passengers do not slip and fall. (10 points)

d) The subway car is accelerating forward at $3\,\mathrm{m/s^2}$. *(10 points)*

Question 3, continued

e) Anyone who has ridden a subway car feels themselves "thrown backwards" when it accelerates forward. What force is pushing them backwards? (If there is no such force, then explain why they feel themselves thrown backwards when the car accelerates.) (15 points)

Question 4

The coefficient of kinetic friction between a table of mass $m = 120$ kg and the ground is $\mu_k = 0.5$. You would like to move this table by pushing on it. (You are not trying to make the table accelerate, only to make it continue to move at a constant speed.)

Calculate the minimum force required to make the table move under the following conditions. If *no* force, no matter how large, will move the table, then say so. Note that you will want to draw force diagrams as part of your solutions to each part.

a) You push on the table horizontally, parallel to the ground. (10 points)

b) You push on the table at an angle directed 20 degrees above the horizontal (that is, you are pushing sideways and upward.) (10 points)

Question 4, continued

c) You push on the table at an angle directed 20 degrees below the horizontal (that is, you are pushing sideways and downward.) (10 points)

d) You push on the table at an angle directed 60 degrees below the horizontal (that is, you are pushing a bit sideways, and mostly downward.) (10 points)

e) Explain in words why your answers to parts (b) and (c) are different. Specifically, could you predict which would be larger without doing any mathematics? (10 points)

Question 5

Suppose that a planet of mass m is traveling around a star of mass M in a circular orbit with radius r. In this problem, you will determine the angular velocity ω of the planet around the star.

a) Draw a force diagram for the planet. (5 points)

b) Planets follow Newton's second law $\sum \vec{F} = m\vec{a}$ just like anything else. Write down an expression of Newton's second law for the planet, substituting in what you know about its acceleration and the forces acting on it. (15 points)

Question 5, continued

c) Calculate the angular velocity ω of the planet in terms of G, M, m, and r. (Your answer may not depend on all of these.) (20 points)

d) Both Earth and Saturn travel around the Sun in nearly circular orbits. However, the radius of Saturn's orbit is about 10 times as large as Earth's. How many times does Earth orbit the Sun during the time that it takes Saturn to orbit the Sun once, and how do you know? (You do not need to, and are not permitted to, look up anything about Saturn for this problem.) (10 points)

Question 6

A ball of mass m is connected by two strings to a pole and made to rotate around it at angular velocity ω. One string is at an angle θ above the horizontal; the other string is at an angle θ below the horizontal. The radius of the ball's motion is r. The tensions in the two strings are T_1 and T_2. You are interested in the relationships between these quantities.

a) Draw a cartoon of the system (showing the ball's path as it rotates) and a force diagram for the ball. Indicate the coordinate system you will use for this problem next to your force diagram. (10 points)

b) Based solely on the character of its motion (i.e. without doing any mathematics), describe its acceleration vector. (10 points)

Question 6, continued

c) Relate this acceleration to the forces on the object using Newton's second law. (This will entail writing one or more equations.) (10 points)

d) Calculate T_1 and T_2 in terms of θ, r, m, and g. (10 points)

Question 7

A book with a mass of 2 kg rests on a table; the coefficient of kinetic friction μ_k between them is 0.4. A string connects that book to another book hanging vertically off the side of the table with mass 3 kg; this hanging book is 140 cm above the ground. When the hanging book is released, it accelerates toward the ground, dragging the other book on the table with it.

a) Draw a force diagram for both books. Indicate your choice of signs for the $x-$ and $y-$axes on both diagrams; that is, which directions do you consider positive, and which do you consider negative? (10 points)

b) Are the accelerations of the two books related? If so, write a mathematical relationship between them. (10 points)

c) Calculate the accelerations of the books and the tension in the string. (20 points)

d) With what velocity will the hanging book strike the floor? (10 points)

Question 8

A ramp with a small coefficient of kinetic friction μ_k is elevated at an angle of θ. An object is pushed toward the ramp. It reaches the bottom of the ramp with speed v_0; it slides up the ramp and then back down.

a) Draw a force diagram for the object on the way up. (5 points)

b) Calculate the acceleration of the object on the way up. (15 points)

Question 8, continued

c) Draw a force diagram for the object on the way back down. (5 points)

d) Calculate the acceleration of the object on the way back down. (15 points)

e) Does the object have the same acceleration on the way up as it does on the way down? Explain why you expect these to be the same, or why they will not be the same, without doing any mathematics. (10 points)