Physics 211 Exam 2

Problem 1	Problem 2	Problem 3	Problem 4	Total
/25	/25	/30	/25	/100

Name: ______________________________

Recitation section number: __________

(see back page)

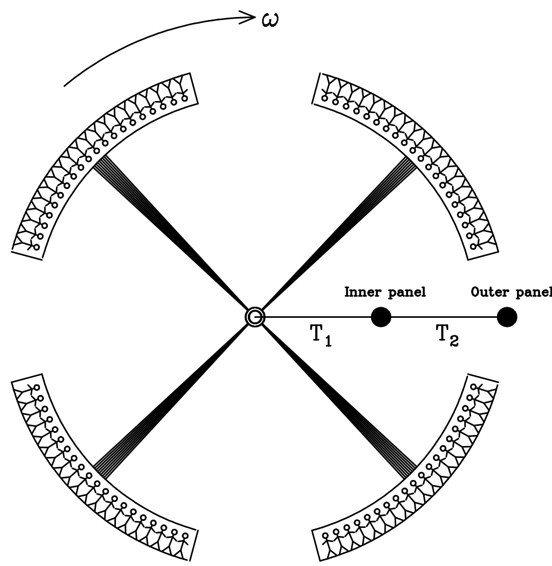
- There are four questions worth a total of 105 points, including five points extra credit.
- **You must show your reasoning to receive credit**. An answer with no logic shown will be treated as no answer.
- You are highly encouraged to use both pictures and words to show your reasoning, not just algebra.
- If you run out of room, continue your work on the scratch paper on the back, and indicate that on the main page of the exam.
- Remember, show your reasoning as thoroughly as possible for partial credit.
- You may use $g = 10\,\mathrm{m/s^2}$ throughout, except where indicated, to minimize arithmetic.

Recitation Schedule

M005	10:35-11:30A	Physics B129E	Bradley Cole
M013	10:35-11:30A	Physics 106	Emily Syracuse
M021	10:35-11:30A	Heroy 013	Xuan Zheng
M006	11:40A-12:35P	Physics B129E	Bradley Cole
M014	11:40A-12:35P	Physics 106	Kesavan Manivannan
M022	11:40A-12:35P	Heroy 013	Alexander Hartwell
M007	12:45-1:40P	Physics B129E	Merrill Asp
M015	12:45-1:40P	Physics 106	Emily Syracuse
M008	2:15-3:10P	Physics B129E	Bradley Cole
M016	2:15-3:10P	Physics 106	Kesavan Manivannan
M009	3:45-4:40P	Physics B129E	Ohana B. Rodrigues
M017	3:45-4:40P	Physics 104N	Kesavan Manivannan
M010	5:15-6:10P	Physics B129E	Julia Giannini
M018	5:15-6:10P	Physics 106	Emily Syracuse
M003	8:25-9:20A	Physics B129E	Merrill Asp
M011	8:25-9:20A	Physics 106	Julia Giannini
M004	9:30-10:25A	Physics B129E	Merrill Asp
M012	9:30-10:25A	Physics 106	Julia Giannini
M020	9:30-10:25A	Heroy 013	Xuan Zheng
M024	9:30-10:25A	Hall/Lang 205	Alexander Hartwell

Question 1

Futurists and science-fiction authors have often imagined circular spacecraft with “artificial gravity”, in which humans (or other things accustomed to gravity) occupy a ring-shaped habitat. The ring rotates around a central hub, creating the impression of gravity for its inhabitants. They feel heavy, objects that they drop fall to the floor, and they otherwise experience all of the same things that people on a planet do.



Imagine that such a ship has a radius of R and is in deep space, where there is almost no (actual) gravity. Suppose that the crew of the ship wants the passengers to experience “artificial gravity” similar to that on Earth. (In an actual station R would be much larger than the height of people; this drawing is not to scale.)

a) Explain how this works. Why does a rotating, ring-shaped spacecraft simulate gravity for its inhabitants? Specifically, what force presses them against the floor? If there is no such force, then explain why a person on such a spacecraft standing on a scale could see the same reading as they would on Earth, and why an object that they drop falls to the floor. (8 points)

(This question continues on the next page.)

b) At what rate must the spacecraft rotate so that the people aboard experience artificial gravity that feels equal to Earth's? Give your answer in terms of g and R.

This station is powered by solar panels of mass m connected by cables to the central hub. A cable of length $\frac{1}{2}R$ runs from the hub to the inner panel; a second cable runs from the inner panel to the outer panel. These solar panels also rotate along with the rest of the station at the same angular velocity.

c) Draw a force diagram for the inner solar panel and the outer solar panel. (Note that the tension in the two cables is different.) (5 points)

d) In terms of m, R, and ω, calculate the tension T_1 in the cable between the hub and the inner solar panel, and the tension T_2 in the cable between the inner solar panel and the outer solar panel. (7 points)

Question 2

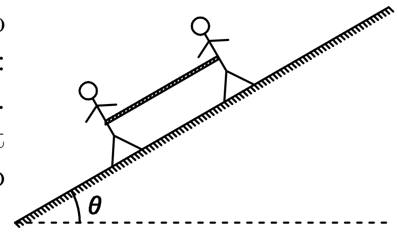
Two Physics 211 students of equal mass m are good friends and go hiking together in an icy forest. Otto is wearing shoes without much traction; Eustace has on boots with better tread. The coefficients of friction between their shoes/boots and the ice are as follows:

	μ_s	μ_k
Otto	0.3	0.2
Eustace	0.5	0.4

a) What is the steepest slope that Otto can walk up without help? (Otto wants to walk at constant speed.) (10 points)

(This question continues on the next page.)

They now encounter a steeper slope that is too steep for Otto to climb, since he keeps slipping on the ice. Eustace has an idea: they tie a rope between them, so Eustace can help Otto climb. Eustace is in front, and Otto is behind him. As before, they want to travel at constant velocity: they're just trying to make it up the hill.

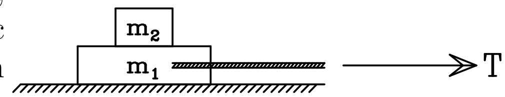


b) Draw force diagrams for Otto and for Eustace. (5 points)

c) Find the steepest slope they can climb by cooperating like this, and the tension in the rope connecting them while they are climbing such a slope. (10 points)

Question 3

Two boxes sit on a table. The bottom box has mass m_1, and the top box has mass m_2. The coefficient of kinetic friction between the table and the bottom box, and between the bottom box and the top box, is μ_k.



A rope is tied to the bottom box, and a large tension T is applied horizontally. This is large enough to pull the bottom box out from under the top box.

a) Draw a force diagram for the top box and for the bottom box. (10 points total)

b) Newton's third law says that $\vec{F}_{AB} = -\vec{F}_{BA}$. Are there any pairs of forces in your diagram which form Newton's-third-law pairs? If so, list those pairs. You should ensure that your force diagrams are consistent with Newton's third law. (5 points)

(This question continues on the next page.)

d) Calculate the acceleration a_2 of the top box. (5 points)

e) Calculate the acceleration a_1 of the bottom box. (10 points, including the possibility of five points extra credit)

Question 4: Short Answer

a) Give a one- or two-sentence statement of Newton's third law of motion in words: you should be precise, but avoid using mathematical symbols. You may not use the words "action" or "reaction". (5 points)

b) The value of g on the surface of the Moon is about 1/6 of its value on the surface of the Earth. The mass of the Earth is about 96 times as large as the mass of the Moon. How does the radius of the Earth compare to the radius of the Moon? (Tell whether it is larger or smaller, and by what factor.) (5 points)

c) Consider the following story:

> During the Second World War, United States aircraft often flew on missions where they were hit by enemy fire. Many damaged aircraft could return to base despite their damage; others were damaged badly enough that they could not fly and crashed.
>
> The US military wanted to understand where aircraft were most commonly being hit, so they could add additional armor protection to those locations.
>
> Suppose that 1000 aircraft took part on a certain mission. 100 of those aircraft were shot down; 900 of them returned, most of them with damage where they had been hit. The military decided to make a map of the damage to the aircraft. They took the 900 aircraft that returned from the mission and mapped out the location of the holes, and concluded that the aircraft were most frequently being hit in the tail, on the wings, and in the fuselage, but *not* on the engines. Thus, they wanted to add armor to those areas, since that is where they found the damage to the 900 aircraft in their sample.
>
> Abraham Wald, a Hungarian statistician, disagreed. He claimed that the military's conclusion about the data was faulty, and that they should instead add armor to the engines.

What was Wald's objection to the US military's conclusions? How is this an example of "cherry-picking" data, and how could it produce an incorrect conclusion? Your answer may be brief (just a few sentences) if it identifies the crucial factor in Wald's objections. (15 points)

(This is the end of the exam.)

Scratch Paper

Scratch Paper