PHYSICS 211 GROUP EXAM 2, FORM 3

Problem 5	Problem 6	Total
/25	/25	/50

Name: ____________________

Partner #1: ____________________

Partner #2: ____________________

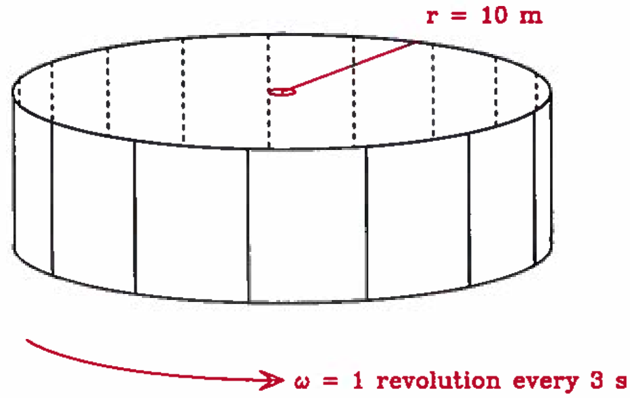
Recitation section number: ________

- There are two questions, each worth twenty-five points.
- **You must show your reasoning to receive credit.** A numerical 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, ask for an extra sheet of paper, or get one from your notebook.
- how 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.

Question 5

A carnival ride consists of a large cylindrical room of radius $r = 10$ m. People stand with their backs to the walls; the room rotates around its center once every three seconds.

These people feel themselves pressed against the walls. After the room is rotating, the floor falls away; instead of falling, the people stay "stuck" to the walls.

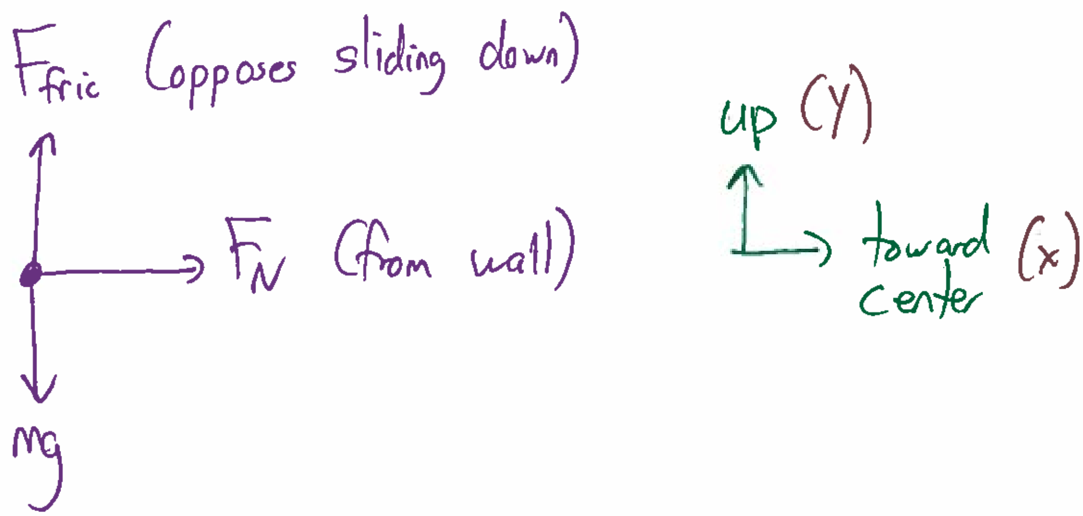


a) What is the angular velocity of the spinning room, in radians per second? (3 points)

$$\frac{1\text{ rev}}{3\text{s}} \cdot \frac{2\pi\text{ rad}}{\text{rev}} = \frac{2\pi}{3}\ \frac{\text{rad}}{\text{s}}.$$

b) Draw a free-body diagram for the person stuck to the wall. (5 points)

Side view:



c) Determine the minimum coefficient of static friction between a person's clothing and the walls so that they will not fall. (10 points)

When they are just about to fall, $F_{fric} = \max = \mu_s F_N$.

Note $\vec{a} = \omega^2 r$ toward center. $(a_y = 0.)$

$$\Sigma F_x = ma_x : F_N = ma_x = m\omega^2 r$$

$$\Sigma F_y = ma_y : F_{fric} - mg = ma_y \Rightarrow \mu_s F_N - mg = 0.$$

$$\text{So: } \mu_s m\omega^2 r - mg = 0 \Rightarrow \mu_s = \frac{g}{\omega^2 r} = 0.228.$$

d) While the room is spinning, a person then takes a piece of popcorn and holds it horizontally front of their nose, then releases it. The piece of popcorn flies into their open mouth. What force propelled the popcorn horizontally toward them into their open mouth? If there is no such force, explain why the piece of popcorn went into their mouth, rather than falling down. (7 points)

The popcorn doesn't accelerate toward their mouth.

But they are accelerating forward – toward the center of the room – at $\omega^2 r$.

So their mouth accelerates "into" the popcorn!

Question 6

You are trying to drag a heavy object across the floor with a rope. This rope makes an angle θ with the horizontal.

You apply a tension T to the rope. The coefficient of friction between the object and the ground is μ_k.

I would like to find the acceleration of the object.

On the next page, you'll find my solution, but my solution contains an error. On the following page, I will ask you a few questions about my work, and ask you to fix my mistake.

a) What mistake did I make? You can describe it briefly here, or indicate it clearly on the previous page. (10 points)

The normal force is <u>not</u> mg. (There are other forces in y!)

b) What should the answer be instead? Correct my work on the previous page or below, and tell me what the acceleration should be instead. (15 points)

Instead we need to use $\Sigma F_y = ma_y$ to find F_N:

$$F_N + T\sin\theta - mg = 0 \rightarrow F_N = mg \underbrace{- T\sin\theta}_{\text{the bit I left out}}$$

So then in X:

$$\Sigma F_x = ma_x : -\mu_k(mg - T\sin\theta) + T\cos\theta = ma_x$$

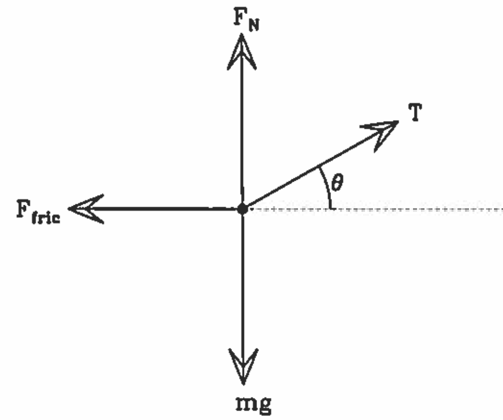
$$a = \frac{T\cos\theta - \mu_k mg + \mu_k T\sin\theta}{m}$$

that is new

QUESTION 6, CONTINUED

Since this problem asks us to connect the forces on objects to their acceleration, I will use Newton's second law $\vec{F} = m\vec{a}$ and solve for $\vec{a}$.

First I draw a force diagram for the object. Imagine that the rope is pulling up and to the right. Then friction points to the left. The normal force points upward to stop the object from falling through the ground, and gravity points downward.



Since the object moves only in the x-direction, I only need to worry about it. The x–component of the tension in the rope is $T\cos\theta$.

Reading Newton's second law off of the force diagram, we have

$$\sum F_x = ma_x$$
$$T\cos\theta - F_{\text{fric}} = ma_x$$

not valid!

We know that the frictional force is $\mu_k F_N$; since the object is resting on a flat surface, $F_N = mg$. Putting this in:

$$T\cos\theta - \mu_k mg = ma_x$$

which gives us an acceleration of

$$a = \frac{T\cos\theta - \mu_k mg}{m}$$