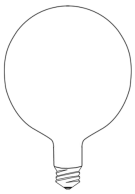
ASTR 311 Tutorial 1

Part 1: Which is brighter?

This is Fry. He's looking at light bulbs. Some are big and bright, others are smaller and dimmer. Sometimes he's close to the bulb, sometimes he's far. Sometimes he looks at the light bulbs with his eyes wide open and sometimes he squints to let only some light in. In each Example below, circle the case (A or B) that **hurts Fry's eyes more**. If there is no way to tell for sure, circle "can't tell".

1.






A

B

can't tell

2.



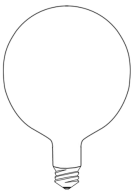
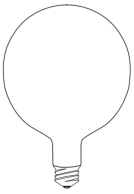

A

B

can't tell

3.



A

B

can't tell

4.

A

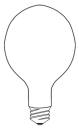
B

can't tell

5.

A

B



can't tell

Two students are discussing their choices in Example 5:

Student 1: In the top case in Example 5, Fry's eyes are wide open and the bulb is very bright. It hurts Fry's eyes more even though the light bulb is farther way.

Student 2: I disagree. If the bottom bulb is close enough, even squinting wouldn't stop it from hurting more.

Do you agree or disagree with either or both of the students? Explain your reasoning.

Part 2: Measure the Pain

Fry is tired of hurting his eyes. He wants a way to predict how much pain he'll feel so he can decide whether or not to look at the light bulb.

An **index** is a number that helps people compare things.

> *Litres per 100 kilometres* is an index of how well a car uses gas.
> *Batting average* is an index of how well a baseball player hits.
> *Grades* are an index of how well you are doing in school.
> *Star rating* is an index of how good a movie is.

We want you to invent a procedure for computing Fry's Pain Index, a number that will measure how much pain he will feel if he looks at the light bulbs. The rules for the index are:

- you have to use the exact same procedure for each case to find its Pain Index
- the higher the Pain Index value, the more pain Fry feels

Use the whiteboard and be prepared to share your procedure with the rest of the class. Test your procedure on the cases in Examples using these values:

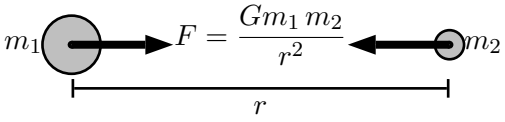
Quantity	Values
light bulbs	small: 25 watts
	medium: 100 watts
	large: 200 watts
distances	close: 1 metre
	far: 2 metres
area of eye opening	squinting: 8 mm^2
	eyes wide open: 25 mm^2

Does your pain index agree with the choices you made for which case hurts more? What does it say about Example 5?

Part 3: Gravity

The amount of pain Fry feels when he looks at a light bulb depends on the size of the light bulb, the size of his eye opening and the distance to the light bulb. The bigger the bulb or his eye opening, the bigger the pain; the bigger the distance, the smaller the pain.

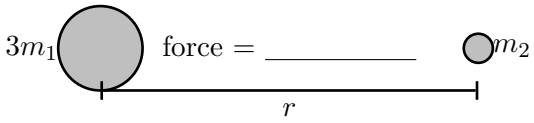
The force of gravity pulling two objects together follows the same pattern. Suppose two objects with masses m_1 and m_2 are separated by a distance r.



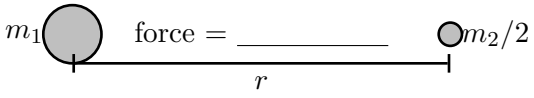
- The force F between them is directly proportional to the masses: for example, if m_1 doubles, then F doubles.
- The force F between them is inversely proportional to the **square** of the distance: for example, if r increases by a factor of 3, F decreases by a factor of $3^2 = 9$.
- G is the constant of proportionality. In this activity, you can use $G = 1$.

The examples below have different masses and distances. For each one, **first** decide if the force of gravity between the masses is bigger or smaller than the original case shown above. Or, if there is no way to tell for sure, circle "can't tell". **Second**, find the new force and write it in terms of the original force, F.

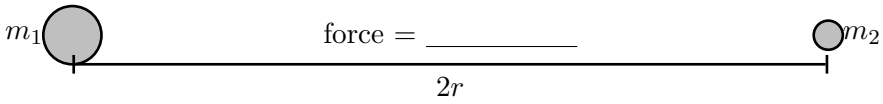
bigger
smaller
can't tell



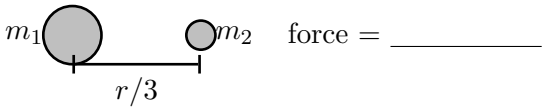
bigger
smaller
can't tell



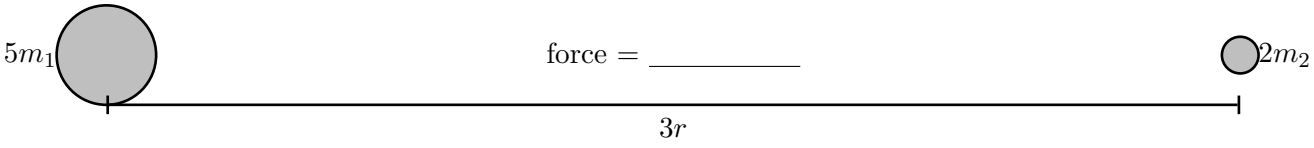
bigger
smaller
can't tell



bigger
smaller
can't tell



bigger
smaller
can't tell



Right now, you are sitting thousands of kilometres from the center of the Earth. (In astronomy, we measure distances from the center of objects, not from their surfaces.) The force you feel holding you down on your chair is the force of gravity between the Earth (m_1) and you (m_2) separated by $r = 6400$ km. Let's call this force F_{Earth}.

1. Suppose you become an astronaut and take a trip to the Moon. The Moon's mass is 100 times less than the mass of the Earth and the radius of the Moon is 4 times smaller than the radius of the Earth. When you're standing on the Moon, how does the force of gravity feel compared to the force here on Earth?

   mass is __100 times__ bigger/smaller (circle one) so force is _____times_ bigger/smaller

   distance is ___4 times___ bigger/smaller so force is _____times_ bigger/smaller

   compared to the force of gravity on Earth, force on Moon is $F_{\text{Moon}} =$ _____ F_{Earth}

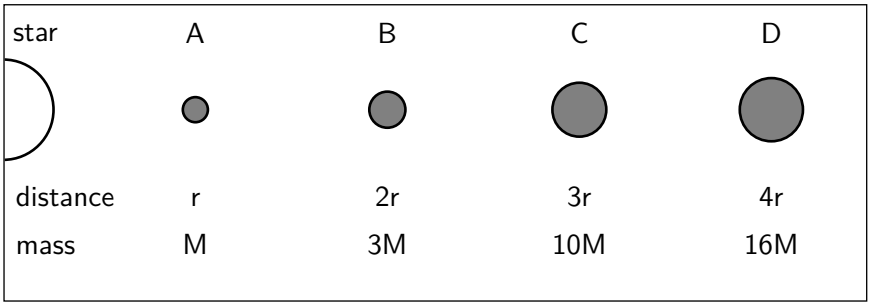
2. Someday, astronauts will travel to the asteroids. Suppose you're standing on the tiny asteroid called Ida. Its mass is 200 million times smaller than the mass of the Earth and its radius is 200 times smaller. How does the force of gravity on Ida compare the force here on Earth?

3. Suppose you're standing on the surface of a neutron star, the strange object left behind after a massive star explodes in a supernova. A neutron star's mass is 500 000 times bigger than the Earth but its radius is 500 times smaller than the radius of the Earth. How does the force of gravity on the neutron star compare the force here on Earth?

Name _____ ID No. _____ Tutorial Day/Time _____

Part 4: Questions Please hand in this worksheet to your TA when you are done.

1. In a certain solar system, 4 planets orbit the star in circular orbits. The planets' distances from the star and their masses are shown in the diagram. For which planet A–D is the gravitational force between the planet and the star the largest?



2. An astronaut standing on the surface of Planet A feels the force of gravity F_A. Suppose the astronaut visits the surface of Planet B which has radius 10 times bigger and mass 10 times bigger than Planet A. The force of gravity F_B the astronaut feels on Planet B is

   A) 10 times bigger than F_A
   B) the same as F_A
   C) 10 times smaller than F_A
   D) 100 times smaller than F_A

3. Copy your results from Part 3 into the Table and then rank the force of gravity you'd feel.

Object	Earth	Moon	Ida	Neutron star
Force of gravity (from Part 3)	F_{Earth}			
Rank (1=biggest, 4=smallest)				

   If you're standing on a scale, your weight is how much the force of gravity pulls you down. A certain ASTR 311 student weighs 150 lbs here on Earth. How much does he weigh on the other bodies?

Weight of student	150 lbs			

   Optional: How much would *you* weigh on these bodies?

Your weight				

4. Sometimes you hear people say, "there's no gravity in space." Where in space do you have to go so there is no gravity?