THE GRAVITATIONAL FORCE WORKSHEET

Course: "Defy"ning Gravity

Materials: Access to **PhET's "Gravity Force Lab (Basics)" Simulation**, a pencil, your imagination 🚀

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During this lesson, **you will be asked to do the following:**

- Run the simulation
- Complete activities
- Summarize findings
- Answer questions

LEARNING GOALS:

- **Gain** an introduction to **Newton's Laws of Motion** and his **Law of Universal Gravitation**
- **Explore** how **gravity** works between **two objects**
- **Observe** how **mass and distance influence gravity**

QUICK VOCAB:

Distance – How **far apart** two objects are.

Gravity - A force that **pulls objects** with mass toward each other.

Force- something that can either **push objects or pull objects**

Mass - How much **"stuff"** is in an object.

Newton (N) – A **unit** of force.

Inverse Relationship – When **one thing increases**, the **other decreases**

Variable – Something that **can be changed**. Think of a container--**you can choose** what goes inside and how much)

Independent Variable – A variable that **can be changed,** though it **isn't affected by other changes** made in an experiment. These are **the variables that get manipulated.**

Dependent Variable - A variable that **changes because of changes made to independent variables.** These are **the variables that offer change, that we can observe and measure.**

Before you begin, remember to **HAVE FUN!** After all, **you're learning about one of the craziest, coolest topics in all the Universe!**

A QUICK STORY

The gravitational force was discovered by **Sir Issac Newton** after he witnessed **an apple fall down to Earth from a tree**. From this, he thought about **the planets and our Sun above**, and how **they too have mass** like the apple, though a lot more **(since planets are much larger than apples).** From this he obtained his **three laws of motion:**

- **#1** An object **at rest will stay at rest**, until **acted on by an external force**, and an object **in motion will stay in motion** until (also) **acted on by an external force**
- **#2** The force an object has is a **product of its mass and acceleration**
  - **(F = ma)**
- **#3** Every action has an **equal and opposite reaction**

Though, only the 3rd law is of importance for this lesson. I simply state these laws because **the earlier you learn them the better.**

So now, what is GRAVITY? Well, **gravity is one of the four fundamental forces in the Universe**, with the others being the electromagnetic force, the strong force, and the weak force. We won't necessarily address these other forces in this course, though, **just like Newton's Laws**, it's good to get an understanding of the four fundamental forces early on. **Gravity is a "pull-force"**, that is, **an attractive force. It brings objects with mass together rather than pushes them apart.**

To word it like Newton: The Gravitational force between two objects is **proportional** (a multiplication term) **to the product of the masses of the objects, and inversely proportional** (a term for division) **to the distance between them, squared**.

A VERY FANCY WAY OF SAYING: The **greater an object's mass**, the **greater the gravitational pull**. This force also becomes **stronger as the distance** between two objects **decreases.**

You should now have the tools needed to **begin the simulation** and start your investigation! **Best of luck to you!**

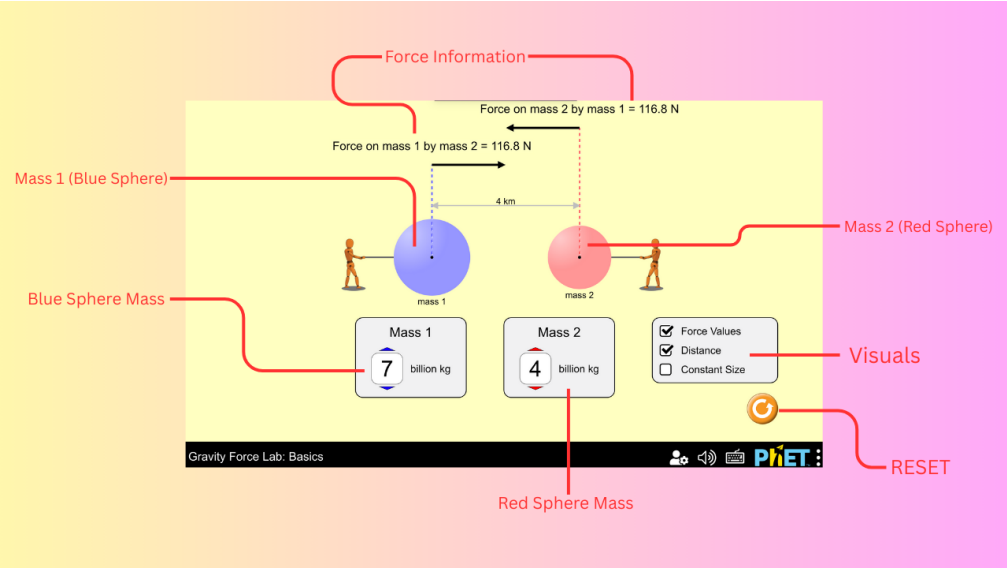
MODULE 1: OPENING THE SIMULATION

To **access/open** the **PhET simulation Gravity Force Lab (Basics)**, click **HERE!**

- You should see a blue and a red sphere – each of them look like they're being pulled by human-like figures.
  - You should also see a few gray boxes with information inside each of them.
- Now that you have the simulation open, continue to the next module to learn the layout and controls!

MODULE 2: LEARNING THE LAYOUT

We will now go over the different components of the simulation!



1. **The Center Display**
   a. A blue sphere (left) and a red sphere (right)
      i. Both have lines that go up to black arrows, pointing at each other
      ii. **CLICK AND HOLD** each sphere to change its distance!
2. **Mass1 and Mass2 Boxes**
   a. Use the up and down arrows in the boxes to change the mass of the spheres – **BE SURE** you're changing the right sphere!
3. **Visuals Box**
   a. Distance can be turned on/off ⟶ **CHECK THE BO**X, so it's on.
   b. Force Values can also be turned on/off ⟶ **CHECK THE BOX**, so this too is turned on.
   c. **DO NOT** check the 'Constant Size' box
4. **Above Information**
   a. These are known as ***force arrows.***
   b. The numbers shown represent the values for the amount of gravity each sphere has on each other. **Force is measured in Newton's (N)** – after Sir Issac Newton of course!

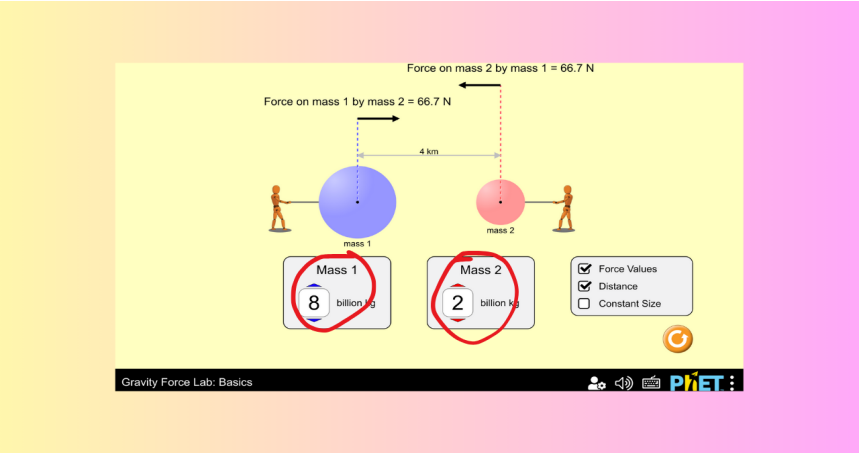
Now, take a minute to mess around with the simulation. **Note a few observed changes below (or in your notebook):**

MODULE 3: THE EXPERIMENT

Before you begin, remember to have *Distance* **and** *Force Values* **CHECKED!**

- Before you make any changes, record the following values:
  - Write down the **starting mass of the blue sphere.**
  - Write down the **starting mass of the red sphere.**
  - Write down the **distance between the spheres.**
  - Write down the **amount of force each sphere has on each other** (HINT: they should be the same – Newton's 3rd Law!)

- Next, using the up/down arrows in the Mass 1 Box, **set the mass of the blue sphere (left) to 8 billion kg.**
  - Then **set the mass of the red sphere (right) to 2 billion kg**, using the Mass 2 Box. **See below.**

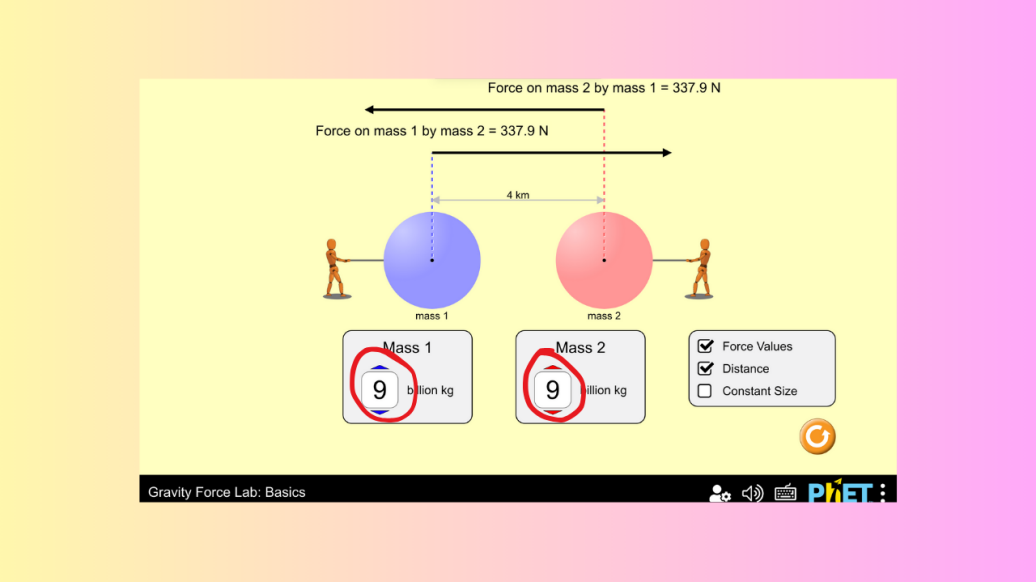


- Record any changes you see **below:**

- Now, **CLICK AND HOLD** to **drag** the blue sphere to the left **until the distance reaches 6km.**
  - What changes occurred?
  - **Record your results below:**

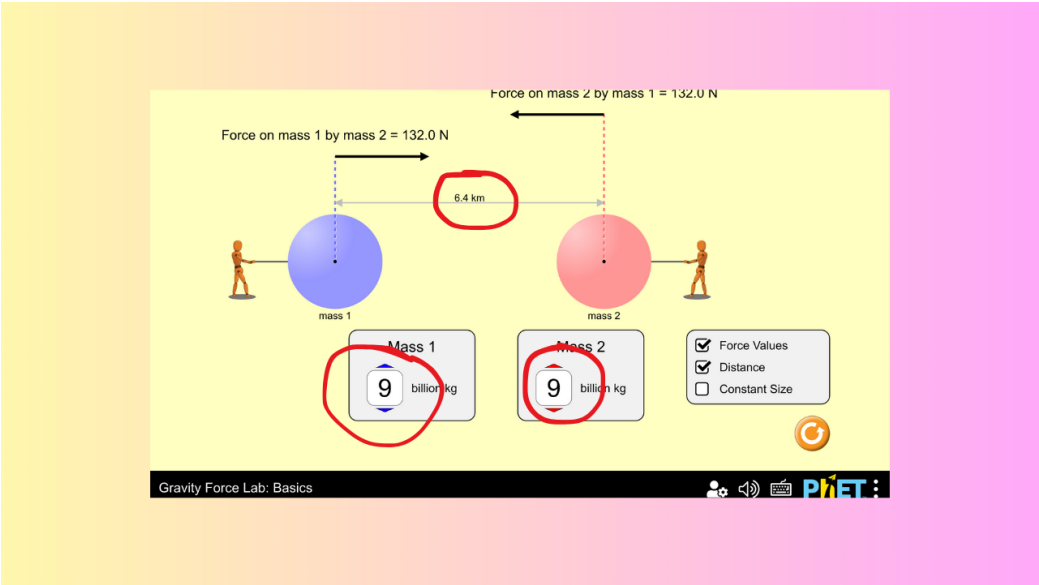
- Now, pull the red sphere to the right **until the distance reaches 7.2 km.**
  - What changes occurred?
  - **Record your results below:**

- **RESET** the simulation!
- **Set the mass for both spheres to 9 billion kg.**



- What changed?
  - **Record your results below:**

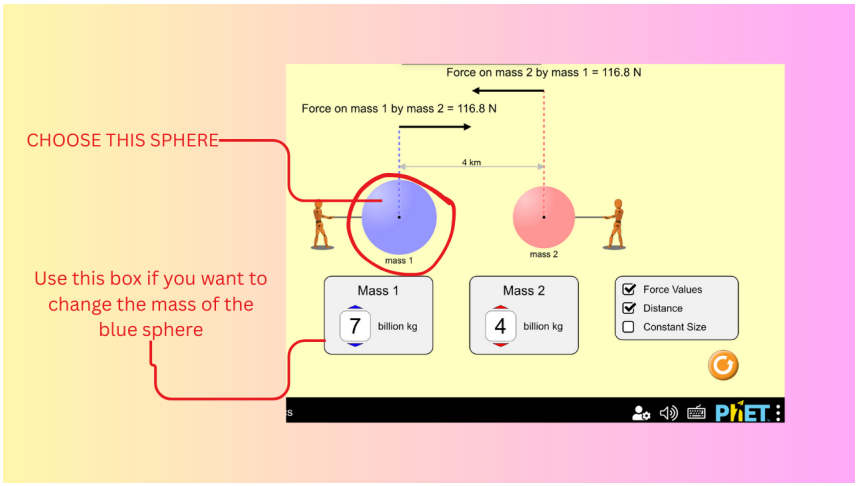
- Keeping the mass of the spheres at 9 billion kg, **click and drag the blue sphere until the distance reaches 6.4km.**



- **Record any changes that you observe below:**

MODEL 4: ACTIVITY A (BLUE SPHERE)

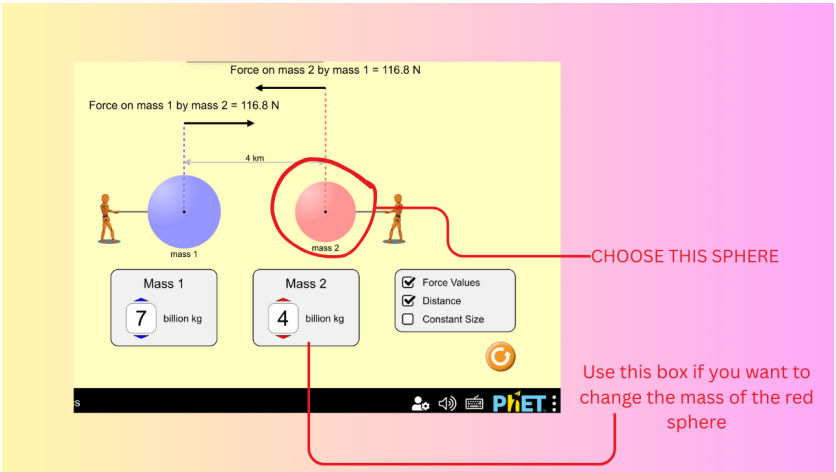
Before you begin, remember to have *Distance* and *Force Values* **CHECKED!**



- Now, begin by **manipulating the blue sphere (left)** – this is Mass 1.
  - Label this on your page as **Trial #1 Blue Sphere**
- Note what changes you made to the sphere.
  - Did you **change the mass of sphere?**
  - Did you **change the distance?**
    - If you did change the distance, **did you pull it further away or closer to the other sphere?**
  - **Were there any other changes** that you noticed, because of manipulating the blue sphere?

MODEL 5: ACTIVITY B (RED SPHERE)

Before you begin, remember to have *Distance* and *Force Values* CHECKED!



- Now you will **manipulate the red sphere (right)** – this is Mass 2.
- Label this on your page as **Trial #2 Red Sphere**
- Like before, note what you did to change the sphere.
    - Start by **performing the same things to this sphere** that you did to the other one.
    - You can also **change something that you didn't change last time**
        - This is **HIGHLY ENCOURAGED!**
- Take a few minutes and compare the results (the notes you took) of **Trial #1** and **Trial #2.**
    - What was the same? **What was different?**
    - What happens if you **RESET** the simulation and **CHECK** the 'Constant Size' box?

MODEL 6: ANSWER QUESTIONS (T/F)

Please answer the following **True/False questions:**

1. Gravity is a "push-force".
2. Gravity is something that we observe as **an effect of two objects with mass interacting.**
3. A small object has **more gravity** than a large object.
4. Changing the distance between two objects **won't change the amount of gravity** they feel.
5. Every action has an equal and opposite reaction.

MODEL 7: SHORT ANSWER QUESTIONS

Please answer the following **short answer questions:**

1. In the experiment, **is gravity a dependent or an independent variable?**
    a. **Why** do you think this?
2. Gravity is affected by what variables in the experiment? **Please list all that apply.**
3. If both spheres **have the same mass**, and they're roughly **5km** apart, but then **get pulled back** until they are roughly **8km** apart, does the **gravitational force** between them **strengthen or weaken? Please explain.**

UP NEXT: LESSON 2 - GRAVITY & ORBITS!