**Objectives:**

* Students will be able to identify and explain how gravity and other forces cause daily oceanic tides.
* Students will be able to use the patterns and positions of the Earth, Sun, and Moon to make predictions of tides.

**Prior Knowledge**

1. What are tides?
2. Based on what you know at this time what causes the drastic changes in the Bay of Fundy.

**Part I: Gravity: How does the force of gravity change?**

**Click on the following link to open the interactive. Use the gravity force simulator to explain changes in the gravitational force between two objects.** <https://phet.colorado.edu/sims/html/gravity-force-lab/latest/gravity-force-lab_en.html>

1. Identify two variables in this simulation you can change that may change the magnitude (strength) of the force of gravity.
2. Predict what will happen if you change each variable. Give a specific prediction for each variable you identified above. *(For example: If variable A increase, then the gravitational force will decrease.)*

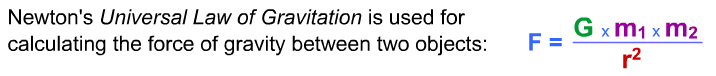
***When performing an experiment it is important to keep all variables constant and only change 1 at a time. Make sure you change only one variable at a time in the next several steps.***

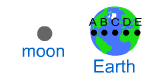
1. Put the spheres 5m apart. Then change the mass of the spheres. Try several different changes of each sphere. How does changing the mass of the balls change the force of gravity? Explain your claim using specific numerical reasoning.
2. Set the mass of each sphere to 25kg. Place the spheres 10m apart to start. Change the distance between the spheres by moving the red sphere towards/away from the blue. Try the same thing with both spheres at the same higher/lower mass. How does changing the distance between the balls change the force of gravity? Explain your claim using specific numerical reasoning.
3. Based on the simulation: Explain what is gravity? How can you calculate the force of gravity between two objects?
4. Imagine that the Earth was the blue ball and the Moon the Red ball. What effect would the Moon have on the Earth?

7. **Extension**: Gravity is a force of attraction between objects based on their mass and their distance apart. If the earth is pulling on you are you pulling on the Earth? Explain.

Why don’t other objects, like your pencil, appear to be pulled towards you? Explain your reasoning.

**Part II: Gravity’s Effects on Earth**



*The Part I Simulation is a concrete way of showing Newton’s Universal Law of Gravitation. The equation listed above is used to calculate the Force of Gravity between any objects.* ***F*** *stands for the force (gravitational).* ***G*** *is a constant used in the mathematical equation.* ***M1*** *and* ***M2*** *stand for the masses of the objects and* ***r*** *is the distance between the two objects.*

1. Imagine there were 5 points on Earth. According to what you learned so far predict which location(s) would have the greatest gravitational force from the Earth/Moon relationship. Provide evidence for your prediction.



1. Imagine there were 5 points on Earth. According to what you learned so far predict which location(s) would have the greatest gravitational force from the Earth/Sun relationship. Provide evidence for your prediction.
2. Would the Moon or the Sun have a greater gravitational force and influence on the Earth? Explain your answer using the simulation or the equation.
3. Summarize what you have learned about gravitational force today. How is this information useful in describing changes in the Bay of Fundy?

**Part III: What causes the Tides?**

**Open the following link:** <http://www.pbs.org/wgbh/nova/venice/tides.html> **Click on “What Causes Tides?” Then the “Launch Interactive” button.**

1. How many high tides and low tides are there everyday in most places on the Earth?
2. What causes the tides to change over the course of a day?
3. What two forces create the tidal bulges?
4. Does the moon actually revolve around the Earth?  Explain.
5. Where is the center of gravity located between the Earth and moon?
6. Name and Describe the force that causes tides on the far side of the Earth from the moon? (Hint: page 4/5)
7. How does the moon’s gravity affect the water on the far side of the Earth? (Hint: Look at the arrows on page 6/7)
8. Why is the pull of gravity weaker on the far side of the Earth?
9. Name and Describe the force that causes tides on the near side of the Earth from the moon?
10. How is the inertial force different on the near side of the Earth?
11. Draw a picture show how Earth/Moon are positioned. Label where high tides and low tides would occur in that instance.

**Part IV: Spring/Neap Tides**

***The Sun will also play a role in the tides on Earth. Even though the Sun has more mass than the moon it is farther away so its influences are different.***

1. Predict: Based on what you know right now when in the moon phase cycle do you think Earth experiences the largest tidal bulges? (Hint: Think about the influence of gravity on the blue/red spheres in Part II).

**Open the link:** [**http://aspire.cosmic-ray.org/Labs/Tides/tides\_simulator.html**](http://aspire.cosmic-ray.org/Labs/Tides/tides_simulator.html) **Click the box that says Spring/Neap tides in the lower right hand corner. Watch the motion of the Sun, Moon, Earth, and points surrounding the Earth. The points surrounding the Earth represent the tidal bulges, while they appear to be moving they would not in reality. Stop the simulator whenever you see the words Spring Tide or Neap Tide appear on the screen. Draw connections between the positions of these objects and the size of the bulges.**

1. When do Neap Tides occur? Draw a diagram showing the relative positions of the Earth, Moon, and Sun and tidal bulges.
2. When do Spring Tides occur? Draw a diagram showing the relative positions of the Earth, Moon, and Sun and tidal bulges.
3. How are Neap and Spring Tides different?
4. When and how often would Neap and Spring Tides occur?