NAME ___________________     Gravity and Orbits Lab Activity

Fill in the blanks to complete Newton’s Laws:

Law of Inertia: An object at ______ stays at ______ and an object in ______ stays in _______ with the same speed and in the same direction unless acted upon by ____________.

Law of Force: Force = ________________ X ________________.

Law of Action/Reaction: For every action, there is an _______ and _______ reaction.

GRAVITY: Gravity attracts all objects towards each other. Gravity has been around since the very beginning of the universe, and it works the same way everywhere in the universe, on all kinds of different objects, of all different sizes (larger than atoms - those are held together by atomic forces instead). The bigger an object is, and the closer you are to it, the stronger its gravitational pull is.

In the very beginning of the universe, after the Big Bang, gravity pulled atoms together to make stars and planets. Once the stars and planets had formed, gravity kept the planets in orbit around the stars, and moons orbiting around the planets. And on each planet that is large enough, gravity keeps an atmosphere around the planet.

On Earth, gravity keeps the air around us (and everything else) from drifting off into space. Gravity also causes things to fall to the ground, and causes the ocean's tides, and causes hot air to rise while colder air falls (which in turn causes wind).

Nobody fully understands how gravity works, or even why gravity exists. One way of looking at gravity is to think of it not as a force like magnetism, but instead as a natural result of the way mass bends space. Any object with mass (like a star) pushes on space and bends it, so that other objects (like planets) that are moving in a straight line are also going around the star. It looks to us like the star is pulling on the planet, but really the star is bending space.

\[ F = \frac{G m_1 m_2}{r^2} \]

\( F = \text{gravitational force between two objects} \)
\( m_1 = \text{mass of first object in kilograms} \)
\( m_2 = \text{mass of second object in kilograms} \)
\( r = \text{distance between objects} \)
\( G = \text{Gravitational constant} \)
INERTIA: A law of physics states that "an object at rest tends to remain at rest, and an object in motion tends to remain in motion." Newton called these tendencies inertia. Inertia is a way of measuring how hard it is to change the momentum of an object, whether that's getting it to speed up or getting it to slow down. That depends on how much mass the object has. Big heavy things (things with a lot of mass) have more inertia than light things. You have to push a bus harder than a scooter to get it to move. If something has a lot of mass, it's also hard to get it to stop moving. If the bus was moving fast, you'd need good brakes to get it to stop. Because the bus has more mass than the scooter, it would be a lot harder to stop the bus. That's also inertia - inertia's a way of measuring how hard it is to get something to stop moving, too. According to Newton, the planets are constantly traveling in straight lines away from the Sun. However while they are traveling away from the Sun, the Sun is constantly pulling them back inward. This causes them to appear to circle or “orbit” the Sun. If the Sun suddenly disappeared or lost all of its gravity one day, the planets would go flying outward into space in straight lines.

1. Read the above paragraphs and explain why the Earth orbits the Sun (you must include both of the terms gravity and inertia. (please be thorough in your explanation!)

2. If the Earth slowed down suddenly and its inertia dropped (so it stopped trying to fly away as fast) what would happen?

REVOLUTION AND ROTATION: When one object circles another object it is said to “revolve” around it. The Earth revolves around the Sun. The moon revolves around Earth. You revolve around the center of a Ferris wheel. On the other hand, when an object turns itself around (spinning) it is said to “rotate” on its axis. The Earth spinning on its axis is considered to be “rotating.” The Earth both rotates and revolves around the Sun at the same time.

1. Read the paragraph above. How long does it take the Earth to “revolve”?

2. How long does it take for the Earth to “rotate”?

3. Does the Earth’s rotation cause the Seasons or does it cause Day/Night?
LAB 1:

Materials: 1 hoop, 1 marble, 1 sheet of paper (if you are at home, you can use a hula hoop or an upside down bowl and a small pebble or anything round and heavy like a marble)

Procedure:
- Take the hoop and use it to trace a circle on your paper. Number all 4 sides of the circle with a “1,” a “2,” a “3,” and a “4.”
- Rest the hoop on your traced circle. Put a marble inside of the hoop. Slowly rotate the hoop to make the marble spin inside along the edges. Don’t spin the marble too fast or it will go flying.
- Once the marble is rolling around at a steady pace, tilt the hoop up at point one keeping the other side of the hoop flat on the paper. Watch what happens to the marble (watch which way it goes). Draw a line on your paper next to your circle to show which way your marble went.
- Repeat for sides 2, 3, and 4. For each one, draw an arrow showing which way your marble went flying.

Questions:
8. How would you describe the path that the marble took when it exited the hoop? (draw or describe)
9. Is the path the marble took, the same for all 4 exit points?
10. As the marble traveled within the hoop, what direction does the hoop “push” the marble? (Hint: how does it stop the marble from flying outward?)
11. If we compare this model to an orbiting planet, what force does the hoop represent?
12. How would you compare the marble within the hoop to the forces that are on a satellite (moon/spaceship) orbiting the Earth?

NOW PUT YOUR MARBLE AND HOOP AWAY!!!! (DON’T loose the MARBLE OR YOU WILL HAVE TO STAY UNTIL YOU FIND IT)
LAB 2:

Materials: gravitational model “rope thing” (if you are at home, you can make one by tying something heavy on both ends of a string and using your hand as the center point)

Procedure:
- Find a place where you are not near other students in the classroom
- Identify someone to keep time and someone to swing the rope
- Measure about 20 cm of rope. Place your fingers at that point.
- Hold the rope thing so that one end dangled downward and the other end is ready to be spun around (like the picture above)—if you are using one of the “pre-assembled ones, be sure to swing the rubber stopper end, not the metal washers end—it is more dangerous)
- Swing the top part of the string around (just fast enough to keep it rotating around but not too fast)
- Have your partner time how long it takes for the stopper to make 10 revolutions (count how long it takes to go around 10 times)
- Divide this number by 10 to find out how long 1 “period of revolution” is (the time it takes to revolve once). PUT THIS NUMBER IN THE TABLE BELOW.
- Do this trial 2 more times and record the number all three times.
- Now pull the rope so that about 40 cm of rope is on top ready to swing (double the length of before)
- Repeat the previous steps with 40 cm of rope rotating around (swing it around 10 times, time it, find the period of 1 revolution, write the numbers in the table below, and do it 3 times at 40 cm.)
- Pull the rope out again to triple the original length (about 60 cm) and repeat the steps for 60 cm. Record all of the trials in the table below.
- Find the averages of all of the trial runs and record it in the table below (to find the average, add them all up, and then divide by how many items you added)

<table>
<thead>
<tr>
<th>Distance (cm)</th>
<th>Period of Revolution (the time it takes to go around 1 time)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Trial 1</td>
</tr>
<tr>
<td>20</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td></td>
</tr>
<tr>
<td>60</td>
<td></td>
</tr>
</tbody>
</table>
Questions:

13. What kept the object that was flying around from flying away?

14. Why didn’t the object come flying inward toward your hand when you were swinging it?

15. Why did it go in a circle and not in a straight line as you swung it around?

16. What happened to the length of time when you lengthened the distance of the string that was swinging? ________ Why do you think that was?

17. Imagine that the model you just used was an actual solar system. In space there is not a string holding the planets orbiting the sun. What force acts like the string in the solar system keeping the planets held in? (what did the string represent)

18. What part of your model represented the Sun? __________ Which one represented the planet? __________ (the other weight was just to hold it in place)

19. When the swinging object was really close (when the string length was short), was the force of “gravity” strong or weak? __________ How was it different when the string was lengthened?

20. Using the knowledge of how speeds change when distances increase, which planets do you think take less time to revolve around the Sun? (the closer ones or the farther ones)

21. Imagine if the Earth suddenly sped up. What do you think would happen to its orbit?

22. What would happen to the orbit of the planets if the Sun suddenly disappeared from space?