AP Physics 1- Universal Gravitation PhET Lab

Introduction:

Every object around you is attracted to you. In fact, every object in the galaxy is attracted to every other object in the galaxy. Newton postulated and Cavendish confirmed that all objects with mass are attracted to all other objects with mass by a force that is proportional to their masses and inversely proportional to the square of the distance between the objects' centers. This relationship became *Newton's Law of Universal Gravitation*. In this simulation, you will look at two massive objects and their gravitational force between them to observe *G*, the constant of universal gravity that Cavendish investigated.

Important Formulas: $F = G\dfrac{m_1 m_2}{d^2}$ $\quad F_c = ma_c \quad$ $a_c = \dfrac{v^2}{r}$

Procedure: *PhET Simulations → Play with the Sims → Physics → Gravity Force Lab*

Run Now! *Simulation also available under Unit 5 at www.pedersenscience.com*

1. Take some time and familiarize yourself with the simulation. Notice how forces change as mass changes and as distance changes.
2. Fill out the chart below for various objects at various distances.
3. Solve for the universal gravitation constant, G and compare it to published values.

Remember significant digits!

Mass Object 1, kg	Mass Object 2, kg	Distance, m	Force, N	Gravitation Constant, G
55.3 kg	52.2 kg	3.5 m		

Average value of G: _____   **Units of G:** _____

Published value of G: _____   Source: _____

How did your value of G compare to the published value you found? _____

Conclusion Questions and Calculations:

1. Gravitational force is always *attractive / repulsive. (circle)*

2. Newton's 3rd Law tells us that if a gravitational force exists between two objects, one very massive and one less massive, then the force on the less massive object will be *greater than / equal to / less than* the force on the more massive object.

3. The distance between masses is measured from *their edges between them / from their centers / from the edge of one to the center of the other.*

4. As the distance between masses decreases, force *increases / decreases.*

5. Doubling the mass of **both** masses would result in a change of force between the masses *of 8x / 6x / 4x / 2x / no change / ½x / ¼x / 1/6x / 1/8x.*

6. Reducing the distance between two masses to half while doubling the mass of **one** of the masses would result in a change of force between the masses of *8x / 6x / 4x / 2x / no change / ½x / ¼x / 1/6x / 1/8x.*

7. What is the gravitational force between two students, Dylan and Sarah, if Dylan has a mass of 75 kg, Sarah has a mass of 54 kg, and their centers are separated by a distance of .45 m?   _____ N

8. What is the gravitational force between two students, John and Mike, if John has a mass of 81 kg, Mike has a mass of 93 kg, and their centers are separated by a distance of .62 m?   _____ N

9. Imagine a 4820 kg satellite in a geosynchronous orbit. If an 85 kg piece of space junk floats by at a distance of 3.5 m, what force will the space junk feel?   _____ N

10. With what acceleration will the space junk move toward the satellite?   _____ m/s^2

11. With what acceleration will the satellite move (if any)?   _____ m/s^2

12. *(harder)* Using the above information and what you know about kinematics, how far will the satellite have moved when it encounters the space junk, assuming they meet, each moving with the accelerations you solved for in #10, 11? (don't worry about them getting closer, just use #10,11)   _____ m

The moon has a mass of 7.35×10^{22} kg and is a lot farther away than is shown in textbooks. The mass of the earth is 5.97×10^{24} kg. The moon's mean orbit distance (center-to-center) is around the earth is 3.84×10^8 m. With all this information determine:

13. The gravitational force on the moon by the earth.   _____ N

14. The gravitational force on the earth by the moon.   _____ N

15. The centripetal acceleration of the moon around the earth, realizing that the gravitational force is also centripetal force.   _____ m/s^2

16. The speed of travel of the moon around the earth, using the formula for the speed of a moving object in a circular path.   _____ m/s