Universal Gravitation Worksheet Answers

Circular and Satellite Motion **Name:** _____

Universal Gravitation

Read from **Lesson 3** of the **Circular and Satellite Motion** chapter at **The Physics Classroom**:
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MOP Connection: Circular Motion and Gravitation: sublevels 6 and 7

1. The evidence that stimulated Newton to propose the law of universal gravitation emerged from a study of ____. Answer: **A**
a. the motion of the moon and other celestial or heavenly bodies
b. the fall of an apple to the Earth
c. the gravitational interaction of smaller objects upon the Earth
d. ...nonsense! There was no evidence; it was just proposed as a theory.

2. The *universal* of Newton's law of universal gravitation is a common source of confusion. The *universal* means that **C**.
a. the amount of gravitational forces is the same for all objects.
b. the acceleration caused by gravity is the same for all objects.
c. the force of gravity acts between all objects - not just between the Earth and an object, but also between two people. All objects with mass attract.

3. According to Newton's gravitation law, the force of gravitational attraction between a planet and an object located upon the planet's surface depends upon _____. Choose all that apply. Answers: **ABC**
a. the radius of the planet **b. the mass of the planet**
c. the mass of the object d. the volume of the object
e. ... nonsense! None of these variables affect the force of gravity.

4. The more massive that an object is, the **more** (more, less) that the object will be attracted to Earth.

5. The more massive the Earth is, the **more** (more, less) that another object will be attracted to Earth.

6. The greater that Earth's radius is, the **less** (more, less) that another object will be attracted to Earth.

7. In the mathematical form of Newton's law of universal gravitation (see equation at right), the symbol **G** stands for _____. Answer: **C**
$$F_{grav} = \frac{G \cdot m_1 \cdot m_2}{d^2}$$
a. gravity b. the acceleration of gravity **c. the gravitational constant**

8. **TRUE** or **FALSE**:
The value of **G** (in the equation above) is an enormously large number; that explains why (at least in part) the force of gravitational attraction between the Sun and the very distant Earth is such a large number.
Answer: **FALSE**. G is very small ($\sim 10^{-11}$) ... but the masses are very large.

9. **TRUE** or **FALSE**:
Two lab partners attract each other with a gravitational force. However, it is impossible to calculate such a force since it is only an unproven theory.
Answer: **FALSE**. Knowing their masses and separation distances, the force of attraction can be calculated using the equation in question #7.

10. **TRUE** or **FALSE**:
The notion that any two objects attract each other gravitationally is a theory. There is no empirical evidence for such a notion.
Answer: **FALSE**. Cavendish has tested the theory using people-sized masses (actually, smaller than people-masses).

11. Orbiting astronauts on the space shuttle do not have weight in space because _____. Answer: **E**
a. there is no gravity in space b. there is no air resistance in space
c. there are no scales in space d. the food is terrible and they work all the time
e. ... nonsense! The astronauts do have weight in space.

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Universal gravitation worksheet answers are essential for students studying physics and understanding the fundamental principles of gravity as formulated by Sir Isaac Newton. This principle is a cornerstone of classical mechanics and explains how objects with mass attract one another. In this article, we will delve into the concept of universal gravitation, provide examples of common worksheet problems, and offer detailed answers to help students deepen their comprehension of this critical topic.

Understanding Universal Gravitation

Universal gravitation is described by Newton's law of gravitation, which states that every point mass attracts every other point mass in the universe with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their

centers. The formula for this law can be expressed mathematically as:

The Law of Universal Gravitation Formula

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

Where:
- F is the gravitational force between two objects,
- G is the gravitational constant ($6.674 \times 10^{-11} \, \text{N m}^2/\text{kg}^2$),
- m_1 and m_2 are the masses of the two objects,
- r is the distance between the centers of the two objects.

Concepts Related to Universal Gravitation

To effectively solve worksheet problems related to universal gravitation, students need to understand several key concepts:

1. Gravitational Force

- The gravitational force is a vector quantity that has both magnitude and direction.
- It always acts along the line connecting the centers of the two masses.

2. Mass and Weight

- Mass is the amount of matter in an object and does not change regardless of location.
- Weight is the force exerted by gravity on an object and can change based on the gravitational field strength.

3. Gravitational Field Strength

- The gravitational field strength (g) at a distance (r) from a mass (m) can be calculated using:

$$
g = G \frac{m}{r^2}
$$

4. The Gravitational Constant

- The gravitational constant G is a fundamental physical constant that quantifies the strength of gravity.

Common Worksheet Problems and Solutions

To illustrate the application of universal gravitation, we will present some common problems that might appear on worksheets, along with detailed solutions.

Problem 1: Calculating Gravitational Force

Problem Statement:
Calculate the gravitational force between two 5 kg masses that are 2 meters apart.

Solution:
Using the formula:

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

Substituting the values:

- $m_1 = 5 \, \text{kg}$
- $m_2 = 5 \, \text{kg}$
- $r = 2 \, \text{m}$

$$
F = 6.674 \times 10^{-11} \frac{{5 \times 5}}{{2^2}} = 6.674 \times 10^{-11} \frac{25}{4}
$$

$$
F = 6.674 \times 10^{-11} \times 6.25 = 4.17 \times 10^{-10} \, \text{N}
$$

Thus, the gravitational force is approximately $4.17 \times 10^{-10} \, \text{N}$.

Problem 2: Weight of an Object on Earth

Problem Statement:
What is the weight of a 10 kg object on the surface of the Earth? (Use $g \approx 9.81 \, \text{m/s}^2$)

Solution:
Weight can be calculated using the formula:

$$
W = m \cdot g
$$

Substituting the values:

- $m = 10 \, \text{kg}$
- $g = 9.81 \, \text{m/s}^2$

$$
W = 10 \cdot 9.81 = 98.1 \, \text{N}
$$

So, the weight of the object is $98.1 \, \text{N}$.

Problem 3: Gravitational Field Strength

Problem Statement:
Calculate the gravitational field strength at a distance of 6,371 km from the center of the Earth (mass of Earth $m = 5.97 \times 10^{24} \, \text{kg}$).

Solution:
Using the formula for gravitational field strength:

$$
g = G \frac{m}{r^2}
$$

Where:
- $G = 6.674 \times 10^{-11} \, \text{N m}^2/\text{kg}^2$
- $m = 5.97 \times 10^{24} \, \text{kg}$
- $r = 6,371,000 \, \text{m}$

Substituting the values:

$$
g = 6.674 \times 10^{-11} \frac{5.97 \times 10^{24}}{(6,371,000)^2}
$$

Calculating $(6,371,000)^2 = 4.058 \times 10^{13}$:

$$
g = 6.674 \times 10^{-11} \frac{5.97 \times 10^{24}}{4.058 \times 10^{13}} = 9.81 \, \text{m/s}^2
$$

Thus, the gravitational field strength is approximately $9.81 \, \text{m/s}^2$.

Common Mistakes in Universal Gravitation Problems

Understanding the common pitfalls can help students avoid errors:

- Neglecting Units: Always ensure that mass is in kilograms and distance is in meters.
- Misapplying the Formula: Ensure the correct formula is used for the specific problem.
- Forgetting the Direction: Remember that gravitational force is attractive, and direction should be considered in vector problems.
- Rounding Errors: Be cautious with rounding intermediate calculations, which may lead to significant errors in the final answer.

Conclusion

Universal gravitation is a fundamental principle that governs the interactions between masses in the universe. By understanding the law of universal gravitation, students can solve various physics problems related to gravitational force, weight, and gravitational field strength. The worksheet problems outlined in this article are typical of those encountered in educational settings, and the detailed solutions provided can serve as a valuable resource for students seeking to enhance their understanding. Mastering these concepts is essential for any student pursuing further studies in physics or related fields.

Frequently Asked Questions

What is universal gravitation?

Universal gravitation is a physical law that describes the gravitational attraction between two masses, stating that every point mass attracts every other point mass in the universe with a force that is directly proportional to the product of their masses and inversely proportional to the square of the distance between their centers.

How do you calculate the gravitational force between two objects?

The gravitational force can be calculated using Newton's law of universal gravitation, represented by the formula F = G (m1 m2) / r^2, where F is the gravitational force, G is the gravitational constant (6.674 × 10^-11 N(m/kg)^2), m1 and m2 are the masses of the objects, and r is the distance between the centers of their masses.

What is the gravitational constant (G)?

The gravitational constant (G) is a fundamental physical constant that quantifies the strength of the gravitational force between two masses. Its approximate value is 6.674 × 10^-11 N(m/kg)^2.

What are some common applications of universal gravitation worksheets?

Universal gravitation worksheets are commonly used in educational settings to help students understand concepts such as gravitational force, mass, distance, and the effects of gravity on objects in motion, including satellites and planets.

How can I check my answers on a universal gravitation worksheet?

To check your answers on a universal gravitation worksheet, you can use online calculators or reference solutions provided by educators or textbooks, ensuring you understand the application of the universal gravitation formula.

What are some common mistakes made when solving universal gravitation problems?

Common mistakes include incorrect unit conversions, miscalculating the distance between centers, failing to square the distance in the formula, and confusing the values of mass and force.

Where can I find universal gravitation worksheet answers?

Universal gravitation worksheet answers can be found in educational resources such as textbooks, online educational platforms, teacher resource websites, or by collaborating with classmates or educators for guidance.

Universal Gravitation Worksheet Answers

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How to use the IF function (combined with the AND, OR, and NOT functions) in Excel to make logical comparisons between given values.

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