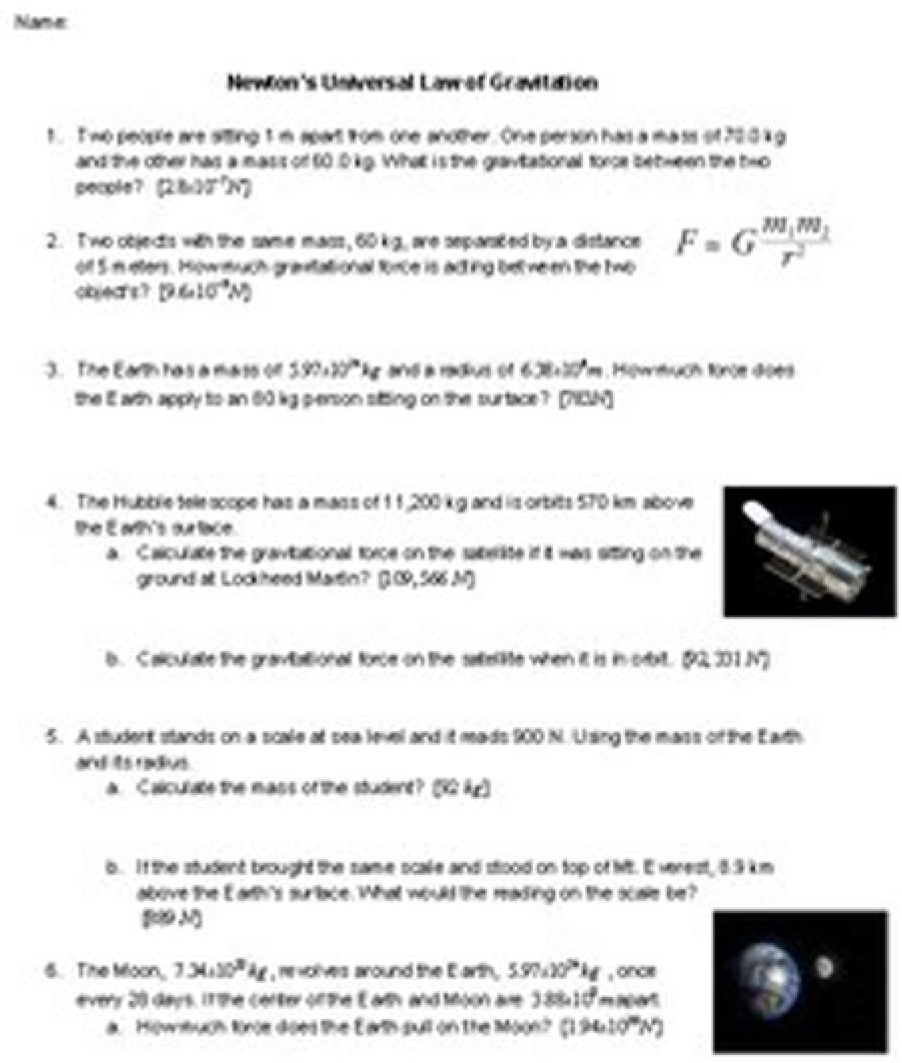
Newtons Law Of Universal Gravitation Practice Problems



Name:

Newton's Universal Law of Gravitation

1. Two people are sitting 1 m apart from one another. One person has a mass of 70.0 kg and the other has a mass of 60.0 kg. What is the gravitational force between the two people? [$2.8 \times 10^{-7} N$]
2. Two objects with the same mass, 60 kg, are separated by a distance of 5 meters. How much gravitational force is acting between the two objects? [$9.6 \times 10^{-9} N$]

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

3. The Earth has a mass of $5.97 \times 10^{24} kg$ and a radius of $6.38 \times 10^{6} m$. How much force does the Earth apply to an 80 kg person sitting on the surface? [783N]
4. The Hubble telescope has a mass of 11,200 kg and is orbits 570 km above the Earth's surface.
   a. Calculate the gravitational force on the satellite if it was sitting on the ground at Lockheed Martin? [109,566 N]
   b. Calculate the gravitational force on the satellite when it is in orbit. [92,201 N]
5. A student stands on a scale at sea level and it reads 900 N. Using the mass of the Earth and its radius.
   a. Calculate the mass of the student? [92 kg]
   b. If the student brought the same scale and stood on top of Mt. Everest, 8.9 km above the Earth's surface. What would the reading on the scale be? [899 N]
6. The Moon, $7.34 \times 10^{22} kg$, revolves around the Earth, $5.97 \times 10^{24} kg$, once every 28 days. If the center of the Earth and Moon are $3.88 \times 10^{8} m$ apart.
   a. How much force does the Earth pull on the Moon? [$1.94 \times 10^{20} N$]

Newton's law of universal gravitation practice problems are essential for anyone studying physics, particularly mechanics. This law fundamentally describes the gravitational attraction between two bodies and is a cornerstone of classical physics. Understanding how to apply this law through practice problems can deepen comprehension and improve problem-solving skills. This article will explore the law itself, provide practice problems with solutions, and discuss common pitfalls and tips for effectively solving these problems.

Understanding Newton's Law of Universal Gravitation

Newton's law of universal gravitation states that every point mass attracts every other point mass 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 can be expressed as:

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

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

Key Concepts to Remember

Before diving into practice problems, it's essential to grasp several key concepts:

- **Mass:** The quantity of matter in an object, which affects the strength of the gravitational force.
- **Distance:** The separation between the centers of two masses significantly impacts the gravitational pull.
- **Gravitational constant (G):** This constant plays a critical role in quantifying the gravitational force.
- **Inverse square law:** As distance increases, the gravitational force decreases exponentially.

Practice Problems

Now that the foundational knowledge is set, let's work through some practice problems involving Newton's law of universal gravitation.

Problem 1: Calculating Gravitational Force

Problem Statement:
Calculate the gravitational force between two objects: object A with a mass of $5 \, \text{kg}$ and object B with a mass of $10 \, \text{kg}$, separated by a distance of $2 \, \text{m}$.

Solution:
Using the formula:

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

Substituting the known values:

$$
F = (6.674 \times 10^{-11}) \frac{(5)(10)}{(2)^2}
$$

Calculating further:

$$
F = (6.674 \times 10^{-11}) \frac{50}{4}
$$

$$
F = (6.674 \times 10^{-11}) \times 12.5
$$

$$
F = 8.3425 \times 10^{-10} \, \text{N}
$$

Thus, the gravitational force between the two objects is approximately $8.34 \times 10^{-10} \, \text{N}$.

Problem 2: Finding Distance Between Two Masses

Problem Statement:
Given two masses, $m_1 = 60 \, \text{kg}$ and $m_2 = 80 \, \text{kg}$, which exert a gravitational force of $0.25 \, \text{N}$ on each other, find the distance between the centers of the two masses.

Solution:
Rearranging the formula to solve for r:

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

Substituting the known values:

$$
r^2 = (6.674 \times 10^{-11}) \frac{(60)(80)}{0.25}
$$

Calculating:

$$
r^2 = (6.674 \times 10^{-11}) \frac{4800}{0.25}
$$

$$
r^2 = (6.674 \times 10^{-11}) \times 19200
$$

$$
r^2 = 1.280128 \times 10^{-6}
$$

Taking the square root:

$$
r \approx 1.13 \times 10^{-3} \, \text{m} \text{ or } 1.13 \, \text{mm}
$$

Thus, the distance between the two masses is approximately $1.13 \, \text{mm}$.

Problem 3: Mass of One Object

Problem Statement:
If the gravitational force between two masses is $3.6 \times 10^{-11} \, \text{N}$, and one mass is $10 \, \text{kg}$ while the distance between their centers is $0.5 \, \text{m}$, find the mass of the second object.

Solution:
Using the formula:

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

Rearranging to solve for m_2:

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

Substituting the known values:

$$
m_2 = \frac{(3.6 \times 10^{-11})(0.5)^2}{(6.674 \times 10^{-11})(10)}
$$

Calculating:

$$
m_2 = \frac{(3.6 \times 10^{-11})(0.25)}{6.674 \times 10^{-10}}
$$

$$
m_2 = \frac{9.0 \times 10^{-12}}{6.674 \times 10^{-10}}
$$

$$
m_2 \approx 0.0135 \, \text{kg} \text{ or } 13.5 \, \text{g}
$$

Hence, the mass of the second object is approximately $13.5 \, \text{g}$.

Common Pitfalls

When working through problems involving Newton's law of universal gravitation, students often encounter several common pitfalls:

1. **Misunderstanding the formula:** Ensure you are using the correct formula and rearranging it properly.

2. **Units:** Always double-check that all units are consistent, particularly mass in kilograms and distance in meters.

3. **Neglecting significant figures:** Be mindful of significant figures in your final answers based on the precision of given values.

4. **Ignoring the inverse square relationship:** Remember that as distance increases, gravitational force decreases dramatically.

Tips for Solving Problems

To effectively tackle practice problems on Newton's law of universal gravitation, consider the following tips:

- Write down the known values and what you need to find before starting calculations.

- Familiarize yourself with the gravitational constant and its significance.

- Practice a variety of problems to enhance your understanding and adaptability.

- Review the concept of gravitational force in different contexts, such as in planetary motion and satellite dynamics.

Conclusion

Newton's law of universal gravitation is a critical principle in physics, and practice problems are an effective way to understand and apply this concept. By working through the examples provided and avoiding common pitfalls, students can enhance their understanding of gravitational forces and strengthen their problem-solving skills. Regular practice and application of foundational concepts will ultimately lead to greater confidence and proficiency in physics.

Frequently Asked Questions

What is the formula for Newton's law of universal gravitation?

The formula is $F = G (m1\ m2) / r^2$, where F is the gravitational force, G is the gravitational constant, m1 and m2 are the masses of the two objects, and r is the distance between the centers of the two objects.

How can I calculate the gravitational force between two objects with masses of 5 kg and 10 kg that are 2 meters apart?

Using the formula $F = G (m1\ m2) / r^2$, with G approximately equal to $6.674 \times 10^{-11}\ N(m/kg)^2$, you would substitute m1 = 5, m2 = 10, and r = 2 to calculate F.

What is the significance of the gravitational constant (G) in solving practice problems?

The gravitational constant (G) is a proportionality factor that allows the calculation of gravitational force between two masses. Its value is essential for accurately determining the force in practice problems involving Newton's law of universal gravitation.

If the distance between two masses is doubled, how does the gravitational force change?

If the distance is doubled, the gravitational force becomes one-fourth of its original value, as the force is inversely proportional to the square of the distance ($F \propto 1/r^2$).

How do you approach a problem involving three bodies interacting gravitationally?

You can calculate the gravitational force between each pair of bodies using Newton's law and then use vector addition to find the net force acting on each body.

What is the gravitational force acting on a 1000 kg satellite located 700 km above the Earth's surface?

First, calculate the distance from the center of the Earth (approximately 6371 km + 700 km). Then use F = G (m1 m2) / r^2, where m1 is the Earth's mass and m2 is the satellite's mass.

How can I use Newton's law of universal gravitation to predict the orbital period of a satellite?

You can derive the orbital period using Kepler's third law, which relates the period to the radius of the orbit and the mass of the central body. The formula is T = 2π sqrt(r^3 / (G M)), where T is the period, r is the distance from the center of the mass, and M is the mass of the central body.

What are common mistakes to avoid when solving problems with Newton's law of universal gravitation?

Common mistakes include forgetting to convert units, not using the correct value for G, misapplying the formula, and neglecting the vector nature of gravitational forces in multi-body problems.

Newtons Law Of Universal Gravitation Practice Problems

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3. Plug in values and multiply – Use the equation F = m*a to calculate the force exerted on that object in Newtons. Example Let’s consider a 10 kg object being pushed with an acceleration of …

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