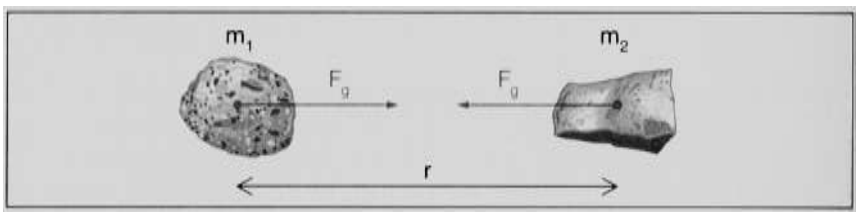
Newton's Law of Universal Gravitation

For an object to have weight, it must interact with another object. In other words, weight is dependent upon the surroundings. Any two masses will exert a mutual, attractive force, upon each other, called the gravitational attractive force. When Newton studied these attractive forces, he discovered, he discovered that larger masses had greater attractive forces. As well, he observed that the force decreased as the distance between the masses increased. From these observations, Newton formulated his law of universal gravitation.

$$F_g = Gm_1m_2 / r^2$$

In the formula, m_1 and m_2 are the magnitudes of the masses and r is the distance between their centers as shown below.



G is a number called the "Gravitational Constant", which relates the gravitational force in newtons to the masses in kilograms and the distance in meters. Its value is 6.67×10^{-11} Nm^2/kg^2. This value is extremely small, so the gravitational attractive force between two objects, like your body and a baseball, is so small that it goes unnoticed. The only object you encounter regularly that is massive enough to exert a noticeable force on you is the earth. This force is your weight.

Example: A melon is taken to the moon as a food item by astronauts. Its mass is 0.65kg. The mass of the moon is 7.36×10^{22}kg and the radius of the moon is 1.74×10^6m. What is the weight of the melon on the moon?

Solution: Weight = F_g

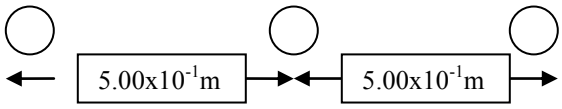
$F_g = Gm_1m_2 / r^2 = 6.67 \times 10^{-11} N\cancel{m^2} \times 0.65\cancel{kg} \times 7.36 \times 10^{22}\cancel{kg} / \cancel{kg^2} (1.74 \times 10^6 \cancel{m})^2$

F_g = 1.1N

Name: «First» «Last»

Universal Gravitation Worksheet

1. Two students are sitting 1.50m apart. One student has a mass of 70.0kg and the other has a mass of 52.0kg. What is the gravitational force between them? **($1.08x10^{-7}$N)**
2. What gravitational force does the moon produce on the earth if the centers of the moon and earth are $3.88x10^{8}$m apart and the moon has a mass of $7.34x10^{22}$kg? **($1.94x10^{20}$N)**
3. If the gravitational force between two objects of equal mass is $2.30x10^{-8}$N when the objects are 10.0m apart, what is the mass of each object? **($1.86x10^{2}$kg)**
4. Calculate the gravitational force on a $6.50x10^{2}$kg spacecraft that is $4.15x10^{6}$m above the surface of the earth. **($2.34x10^{3}$N)**
5. The gravitational force between two objects that are $2.1x10^{-1}$m apart is $3.2x10^{-6}$N. If the mass of one object is $5.5x10^{1}$kg, what is the mass of the other object. **(38kg)**
6. If two objects each with a mass of $2.0x10^{2}$kg, produce a gravitational force between them of $3.7x10^{-6}$N, what is the distance between them? **($8.5x10^{-1}$m)**
7. What is the gravitational force on a 70.0kg object sitting on the earth's surface? **($6.88x10^{2}$N)**
8. What is the gravitational force on a 35.0kg object standing on the earth's surface? **($3.44x10^{2}$N)**
9. What is the gravitational force on a 70.0kg object that is $6.37x10^{6}$m above the surface of the earth? **($1.72x10^{2}$N)**
10. What is the gravitational force on a 70.0kg object that is $3.18x10^{6}$mabove the earth's surface? **($3.06x10^{2}$N)**
11. Three objects A (m=10.0kg), B (m=10.0kg) and C (m= 15.0kg) are placed $5.00x10^{-1}$m apart in a straight line as shown below. What is the net gravitational force on object B due to A and C? **($1.33x10^{-8}$N)**



12. The gravitational force between two small masses A and B when placed a short distance apart is $3.24x10^{-7}$N. What is the gravitational force between these objects if the masses of both A and B are doubled and the distance is tripled? **($1.44x10^{-7}$N)**