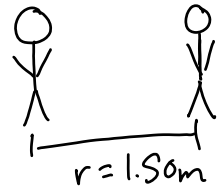
Worksheet 5.1 - Newton's Law of Universal Gravitation

1) Two students are sitting 1.50 m apart. One student has a mass of 70.0 kg and the other has a mass of 52.0 kg. What is the gravitational force between them?



$$F_g = \frac{GMm}{r^2} = \frac{(6.67\times10^{-11})(70.0)(52.0)}{(1.50)^2}$$

$$= 1.08\times10^{-7}\ N$$

2) What gravitational force does the moon produce on the Earth is their centers are 3.88×10^{8} m apart and the moon has a mass of 7.34×10^{22} kg?

$$F_g = \frac{GMm}{r^2} = \frac{(6.67\times10^{-11})(5.98\times10^{24})(7.34\times10^{22})}{(3.88\times10^{8})^2}$$

$$= 1.94\times10^{20}\ N$$

3) If the gravitational force between objects of equal mass is 2.30×10^{-8} N when the objects are 10.0 m apart, what is the mass of each object?

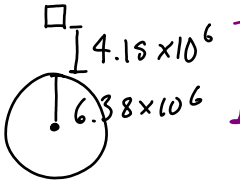
$$F_g = \frac{GMm}{r^2} \qquad M = m$$

$$\therefore F_g = \frac{Gm^2}{r^2}$$

$$m = \sqrt{\frac{F_g r^2}{G}} = \sqrt{\frac{(2.30\times10^{-8})(10.0)^2}{6.67\times10^{-11}}}$$

$$= 186\ kg$$

4) Calculate the gravitational force on a 6.50×10^{2} kg that is 4.15×10^{6} m above the surface of the Earth?



$$F_g = \frac{GMm}{r^2} = \frac{(6.67\times10^{-11})(5.98\times10^{24})(650)}{(1.053\times10^{7})^2}$$

$$= 2340\ N$$

5) The gravitational force between two objects that are 2.1×10^{-1} m apart is 3.2×10^{-6} N. If the mass of one object is 55 kg what is the mass of the other object?

$$F_g = \frac{GMm}{r^2}$$

$$M = \frac{F_g r^2}{Gm} = \frac{(3.2\times10^{-6})(2.1\times10^{-1})^2}{(6.67\times10^{-11})(55)}$$

$$= 38\ kg$$

6) If two objects, each with a mass of 2.0×10^{2} kg, produce a gravitational force between them of 3.7×10^{-6} N. What is the distance between them?

$$F_g = \frac{GMm}{r^2}$$

$$r = \sqrt{\frac{GMm}{F_g}} = \sqrt{\frac{(6.67\times10^{-11})(2.0\times10^{2})(2.0\times10^{2})}{3.7\times10^{-6}}}$$

$$= 0.85\ m$$

7) What is the gravitational force acting on a 70.0 kg object standing on the Earth's surface?

$F_g = mg$

$= (70.0)(9.80)$

$= \underline{686\ N}$

8) What is the gravitational force on a 35.0 kg object standing on the Earth's surface?
(You can use your answer from #7 to reduce your calculations)

since $F_g \propto m$

and $m_2 = \frac{1}{2} m_1$

$F_g = 343\ N$

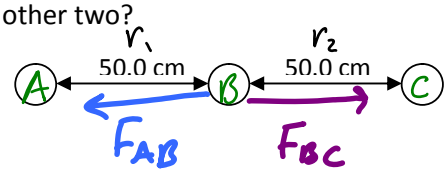
9) What is the gravitational force on a 70.0 kg that is 6.38×10^6 m **above** the Earth's surface?
(You can use your answer from #7 to reduce your calculations)

$F_{g1} = \frac{GMm}{r^2} = 686\ N$

$F_{g2} = \frac{GMm}{(2r)^2} = \frac{GMm}{4r^2}$

$= \frac{686}{4} = \boxed{172\ N}$

10) Three objects each with a mass of 10.0 kg are placed in a straight line 50.0 cm apart. What is the net gravitational force on the center object due to the other two?



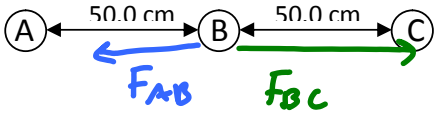
since $m_A = m_C$

and $r_1 = r_2$

then $F_{AB} = F_{BC}$

$\therefore F_{net} = 0$

11) Three objects A, B, C are placed 50.0 cm apart along a straight line. A and B have a mass of 10.0 kg, while C has a mass of 15.0 kg. What is the net force on B due to A and C?



$F_{BC} = \frac{G m_B m_C}{r_2^2} = 4.00 \times 10^{-8}\ N$

$F_{AB} = \frac{G m_A m_B}{r_1^2} = 2.67 \times 10^{-8}\ N$

$F_{net} = F_{BC} - F_{AB}$

$= \boxed{1.33 \times 10^{-8}\ N}$

1) 1.08×10^{-7} N 2) 1.94×10^{20} N 3) 186 kg 4) 2340 N 5) 38 kg 6) 0.85 m 7) 686 N 8) 343 N 9) 172 N 10) 0 N 11) 1.33×10^{-8} N