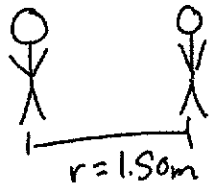
Worksheet 7.1 - Newton's Law of Universal Gravitation

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?

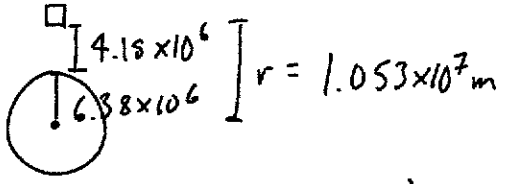
$$F_g = \frac{GMm}{r^2} \qquad M = m$$

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

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

$$= 186\,kg$$

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?



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

$$= 2540\,N$$

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

$F_g = 343\ N$

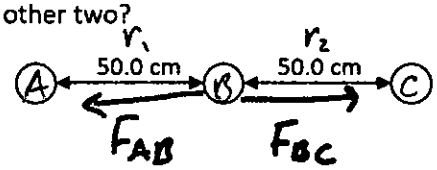
9) What is the gravitational force on a 70.0 kg that is 6.38×10^6 m **above** the Earth's surface?
(You can use your answer from #7 to reduce your calculations)

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

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

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

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?



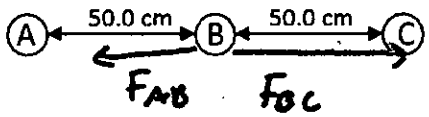
since $m_A = m_C$

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

Worksheet 2 - Gravitational Field Strength

1) What is the weight of a 25.0 kg object near the surface of the earth?

$F_g = mg$

$= (25.0\text{ kg})(9.80\text{ m/s}^2)$

$= \boxed{245\text{ N}}$

2) What is the mass of an object if it has a weight of 80.0 N near the earth's surface?

$F_g = mg$

$m = \frac{F_g}{g} = \frac{80.0\text{ N}}{9.80\text{ m/s}^2}$

$= \boxed{8.16\text{ kg}}$

3) What is the acceleration due to gravity near the surface of the moon if an object that has a mass of 22.0 kg has a weight of 36.0 N near the moon's surface?

$F_g = mg \quad g = \frac{F_g}{m} = \frac{36.0\text{ N}}{22.0\text{ kg}}$

$= \boxed{1.64\text{ m/s}^2}$

4) What is the weight of a 72.0 kg object near the surface of the Moon?

$F_g = mg = (72.0\text{ kg})(1.64\text{ m/s}^2)$

$= \boxed{118\text{ N}}$

5) What is the mass of an object if it has a weight of 127 N near the earth's surface?

$F_g = mg$

$m = \frac{F_g}{g} = \frac{127\text{ N}}{9.80\text{ N/kg}} = \boxed{13.0\text{ kg}}$

6) What is the gravitational field strength at a point 6.38×10^6 m above earth's surface?

$6.38\times10^6\text{ m}$
$6.38\times10^6\text{ m}$ $\Big]\ r = 1.276\times10^7\text{ m}$

$g = \frac{GM}{r^2} = \frac{(6.67\times10^{-11})(5.98\times10^{24})}{(1.276\times10^7)^2}$

$= 2.45\text{ m/s}^2$

7) What is the acceleration due to gravity on the surface of the sun?

$r_{sun} = 6.96\times10^8$ m
$m_{sun} = 1.99\times10^{30}$ kg

$g = \frac{GM}{r^2} = \frac{(6.67\times10^{-11})(1.99\times10^{30})}{(6.96\times10^8)^2}$

$= \boxed{274\text{ m/s}^2}$

8) The Earth orbits the Sun at a distance of 1.46×10^{10} m from center to center. What is the strength of the Sun's gravitational field at this distance?

$g = \frac{GM}{r^2} = \frac{(6.67\times10^{-11})(1.99\times10^{30})}{(1.46\times10^{10})^2}$

$= \boxed{0.622\text{ m/s}^2}$

1) 245 N 2) 8.16 kg 3) 1.64 m/s^2 4) 118 N 5) 13.0 kg 6) 2.45 m/s^2 7) 274 m/s^2 8) 0.622 m/s^2