Physics 11 Unit 2 Worksheet 4 "Newton's Universal Law of Gravitation"

Name: _____

$$F_g = \frac{GMM}{R^2} \qquad \mathbf{F_g = mg}$$

- The equation $\mathbf{F_g = mg}$ only works in locations where we know the value of "g". "g" is the gravitational field strength and is varies from location to location. On Earth the gravitational field strength is approximately 9.8 N/kg but this is only an average.
- Anytime we are an appreciable distance off the surface of the Earth we need to either recalculate g or we need to use Newton's universal formula, which works in any location.

1. The force of gravity on 1 kg on Earth _____

2. The force of gravity on 2 kg on Earth _____

3. This one you will need to find out the info on your own. Use $\mathbf{F_g = mg}$

For either your vehicle or one of your parents vehicles calculate the force of gravity. You can either google the vehicle and look for GVW (gross vehicle weight) which is often listed in pounds in the US or Kg in Canada or you can look in the owners manual or you can look just inside the drivers side door.

Vehicle name and brand _____

GVW _____kg

Force of gravity on vehicle (in Newtons) _____

4. We cannot always use the equation $\mathbf{F_g = mg}$ to calculate the force of gravity. We can only use it if we know the value of "**g**" at that location.

- For places where we do not know the value of "**g**" we can instead use the equation $F_g = GMM/R^2$
- What is the official name for the constant "G" ? (look on formula sheet)
- What is the value of "G"?
  - G = _____

5. Calculate the force of gravity between the Sun and the Earth. See data sheet for distance and masses.

- Hint: Looking up the distance is always the tricky one. Look under the Earth section for a radius around sun
- Hint: Do the math step by step the first time and check your values against another student or two. The numbers you are putting in your calculator are in scientific notation and some students struggle with how to properly do this with their calculator.

$F_g = GMM/R^2$

6. Calculate the force of gravity between the Moon and the Earth.

- Hint: you need to look under the Moon section to find the correct distance.

7. Calculate the force of gravity on a 480 kg satellite that is **700 km above the surface of the Earth**.

- Hint, calculate R carefully.
- The total distance you want is the radius of the Earth plus 700 km

R = _____ + _____ = _____

F_g = _____

8. Calculate the force of gravity on a 1980 kg satellite that is **2700 km above the surface of the Earth**.

9. Calculate the force of gravity between two people with a mass of 70 kg that are 2 m apart.

- use the equation $F_g = GMM/R^2$

This should illustrate that the force of gravity is weak, as compared to other types of forces.

10.Sometimes we want to calculate “g” at locations other than the surface of the Earth, to do this we can us the following.

$Fg = Fg$

$mg = GMM/R^2$

$\mathbf{g = GM/R^2}$

Using the above equation solve for gravitation field strength (g) on the surface of an asteroid with a mass of 4.68×10^7 kg and a radius of 500 m.

11. Find the value of “g” at the altitude that the space shuttle orbits at, 300 km above the surface of the Earth

12. The relationship between R and $\mathbf{F_g}$ is not intuitive, meaning you have never had the chance to experience how $\mathbf{F_g}$ changes at different distance from the Earth because you never get to travel off the Earth, perhaps your grand kids will get to do this field trip!

Below are some different ways to explain the relationship

- Assume we have two masses that are 2 m apart and the $\mathbf{F_g}$ between the two masses is 40 N.

- If we move the mass to a distance of 4 m (2x further away or double) the $\mathbf{F_g}$ would be less, 40 N/$(2x)^2$ or 40 N/4 or 10 N

- In "English" this means, if you double the distance the $\mathbf{F_g}$ is 4 x less.
- If you triple the distance the $\mathbf{F_g}$ is 9 x less

- The same process works if you get closer. If we move the two masses to 1 m apart or 1/2x closer then the new $\mathbf{F_g}$ would be 40 N/$(1/2)^2$ or 40 N/(1/4) or 40 N/ (.25) or 160 N.

Force of Gravity	Distance
	11 m
48 N	22 m
	44 m
	66 m

13. The force of gravity between two masses a distance d apart is Fg = 20 N.

$$F_g = GMM/R^2$$

a) What is the force of gravity if one of the masses is doubled? _____

b) What is the force of gravity if both of the masses are doubled? _____

c) What is the force of gravity if the two masses are brought closer so that they are only half as far apart? _____

14. a) Fill in the following table assuming the following

$F_g = GMM/R^2$

mass 1 = 200,000,000 kg mass 2 = 400,000,000 kg

look G up on your formula sheet

Distance	Force of gravity
10 m	
20 m	
30 m	
40 m	
50 m	
60 m	
70 m	

b) Create a graph on the supplied graph paper

- plot Force of gravity on the y axis
- plot distance on the x axis
- draw a smooth curved line through your points

c) Briefly describe the shape of your graph.