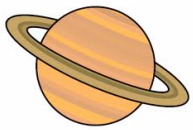
"PHLYZICS"

Newton's Universal Law of Gravitation



- All objects are attracted to each other. In other words, all objects exert attractive forces on each other.
- The larger an object's mass, the larger the attractive force it exerts.
- As you move away from an object, the force decreases, BUT NOT LINEARLY. The force variation is inversely proportional to the square of the distance from the center.

- Newton's Universal Law, in equation form, says that the force between two objects is

- G has a VERY small value, approximately _____, with units of _____.
- Newton's "ULOG" is a **vector** law!!!
- Since the force due to gravity on an objects is known as the object's weight, and since weight equals _____, then

What happens to the force between two objects if you …..

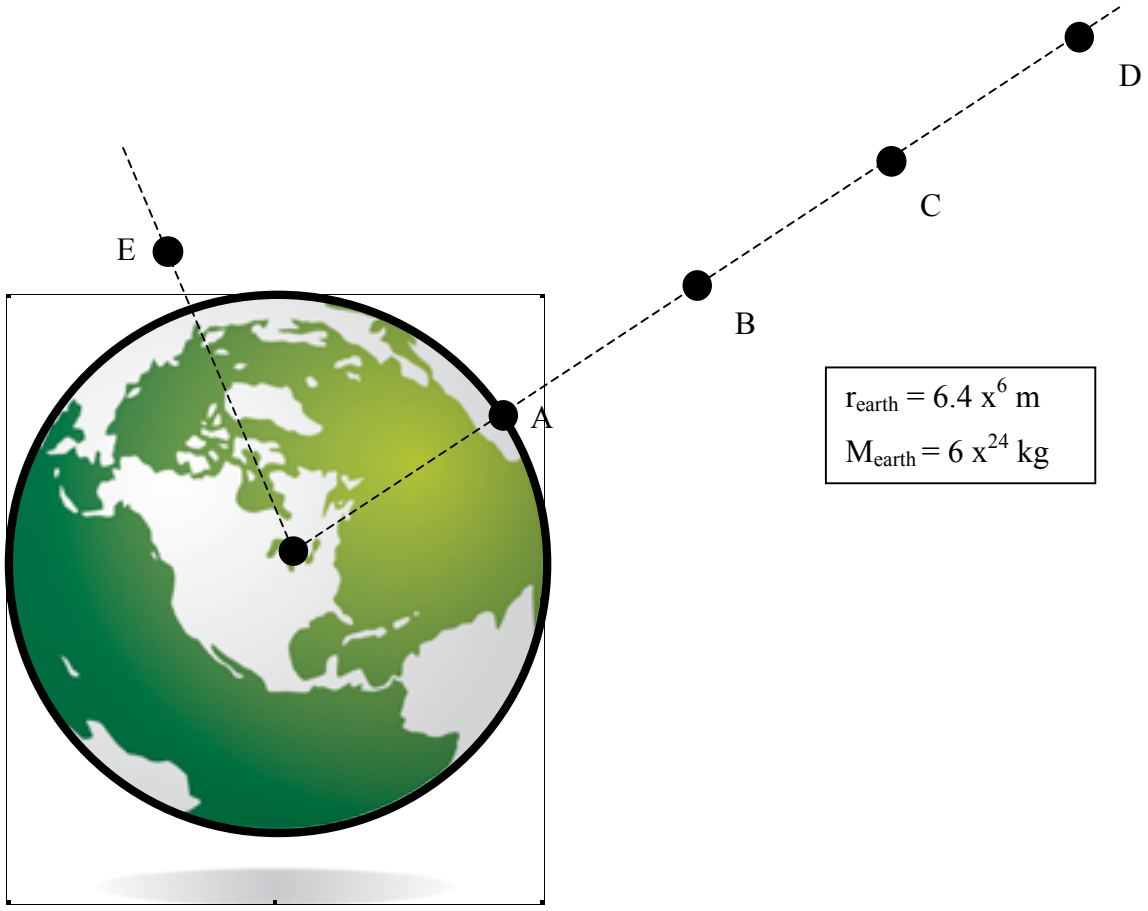
a) triple R _____ b/c _____

b) halve R _____ b/c _____

c) double m _____ b/c _____

d) quadruple both m and M _____ b/c _____

e) fourth R, halve m, and triple M _____



At each labeled point above, find the weight of an 80 kg person, the acceleration due to gravity felt by the person, and the force of attraction between tbe person and the earth. Each point is exactly 1 "earth's radius" away from the previous point, except for point E, which is 10,000 m above the earth's surface.

Point	Weight of person	Accel. due to Gravity	Force of attraction to the earth
A			
B			
C			
D			
E			

Lyzinski, CRHS-South

Newton's Universal Law of Gravitation (ULOG)

$G = 6.67 \times 10^{-11}$ $M_{earth} = 6.0 \times 10^{24}$ kg $R_{earth} = 6.4 \times 10^{6}$ m

1. A 5.0 kg and a 10 kg sphere are 0.3 m apart (center-to-center distance). Find the force of attraction between them.

2. An object weighs 100 N on the surface of the earth. Find its weight if it was 6.38×10^{6} m above the surface?

3. Calculate the acceleration due to gravity at a point 1000 km above the surface of the earth.

4. The force of gravity on a 60 kg woman is 588 N. The woman also exerts a gravitational force on the Earth. How large a force is this?

5. The force of attraction between m_1 and m_2 is 26 N. What will this force become if m_2 is tripled and the distance between it and m_1 is halved?

6. The force of gravity between two masses was 14 N when they were 10 m apart. The distance between them was changed and the force became 56 N. How far apart were they then?

7. The force of gravity between A and B is 100 N. When the mass of B is doubled and the distance between it and A is quadrupled, what is the new force?

8. If the moon's mass were suddenly to double, what effect would this change have on the moon's orbit, and how would such a change affect the Earth? (Assume that the velocity of the moon remains unchanged.)

9. What are the units of G in the MKS (m-kg-sec) system?

10. Calculate the gravitational attraction between a proton of mass 1.67×10^{-27} kg and an electron of mass 9.11×10^{-31} kg if they are 5×10^{-11} m apart (as they are in a normal hydrogen atom).

11. Find the acceleration of a falling object on Mars, given that the radius of Mars is one-half that of Earth and the mass of Mars is one-eighth that of Earth.

12. The planet Saturn has mass of 5.67×10^{26} kg and radius of 6.3×10^{7} m. Find the acceleration due to gravity on Saturn. How much will the gravitational force be on a 60 kg man there?

13. A woman standing on the surface of the Earth, 6.38×10^{6} m from its center, has a mass of 50.0 kg. If the mass of the Earth is 5.98×10^{24} kg, what is the force of gravity on the woman?

14. The force of gravitational attraction between two masses is 36 N. What will be the force if one mass is doubled and the distance between them is tripled?

15. The planet Jupiter has a mass of 1.9×10^{27} kg and a radius of 7.2×10^{7} m. Calculate the acceleration due to gravity on Jupiter.

16. <u>Tough/Deep (no pun intended) Question. But try to think about it.</u>
It is known that g varies as we go down into a hole towards the center of the earth. The variation is not inversely proportional to the square of the distance from the center. Why?

17. A person proceeds away from the earth. How do you expect his weight to vary and why?

18. A mass, of "M" kg, has a force of 50 N when "R" meters from another mass of "m" kg. What is the force on the mass "M" when the distance is changed to (a) R/2; (b) R/3; (c) R/10?

19. (a) What is the weight of a 1.0 kg mass one earth radius from the surface of the earth?
    (b) At what distance from the surface is a man's weight reduced to one-half its original value?

20. How many earth radii away from the surface of the earth must one be to have one's weight reduced to 1 percent of its value at the surface?

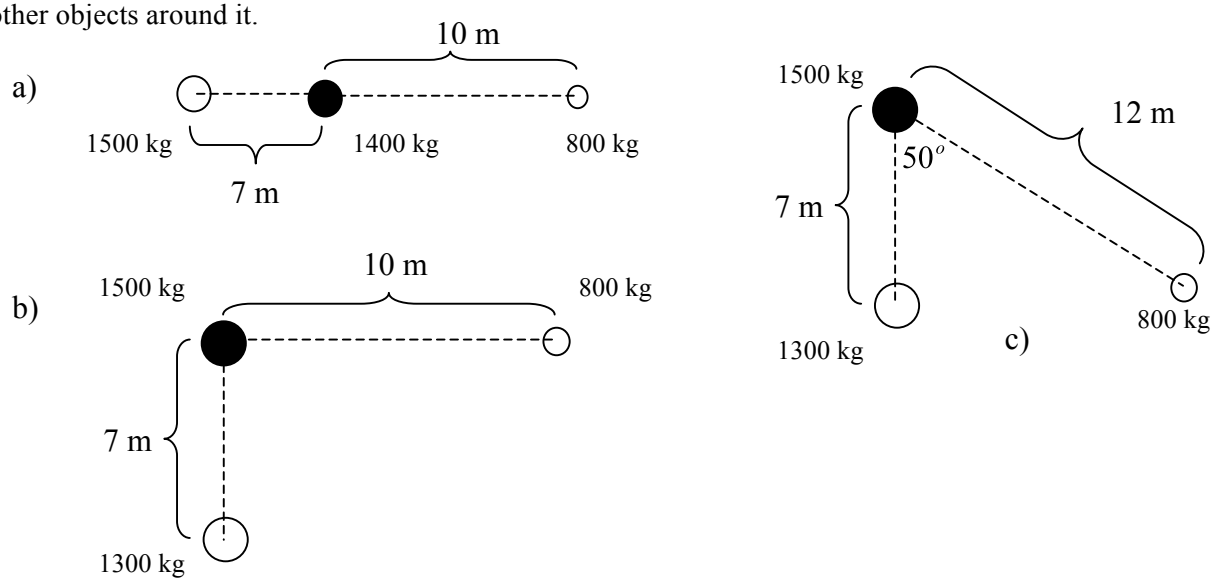
21. Calculate the gravitational force on the earth due to the sun. It is this force which holds the earth in its orbit.

$\text{Mass}_{\text{Sun}} = 1.99 \times 10^{30}$ kg $\text{Mass}_{\text{Earth}} = 6. \times 10^{24}$ kg $R = 1.5 \times 10^{11}$ m

22. Sally (55 kg) and Jimmy (70 kg) have been giving each other googily-eyes in class for weeks. Some say they are "in love", but others say that they are simply "attracted" to one another. What is the force of attraction between these two, assuming that they sit 10 m apart (from center of gravity to center of gravity) in class.

23. In deep, deep, deep, space, nothing exists. Suddenly, two masses appear, separated by a short distance. One mass is twice the size of the other mass. Find the acceleration of the large mass relative to the acceleration of the smaller mass.

24. Find the gravitational force (magnitude & direction) exerted on each black object below by the other objects around it.



Answers

1) 3.71×10^{-8} N 2) 25 N 3) 7.3 m/s^2 4) 588N 5) 312N 6) 5m 7) 12.5 N

8) discuss in class 9) m^3/kg-s^2 10) 4.0×10^{-47} N 11) 4.9 m/s^2 12) 9.5 m/s^2, 5.7×10^2 N 13) 490N

14) 8.0 N 15) 24 m/s^2 16 & 17) discuss in class 18) 200 N; 450 N; 5000 N 19) 2.45 N; .414 r_E

20) 9 (not 10) 21) 3.54×10^{22} N 22) 2.56×10^{-9} N 23) $a_{small} = 2\, a_{big}$

24) 2.1E-6 N (left); 2.8E-6 N (right 73° down); 3E-6N (right 82° down)