Gravity and Kepler Test Name: Key

1. Isaac Newton is credited with the law of universal gravitation. One of the major elements of Newton's discovery (that had not yet been recognized) was the recognition that the force that causes the apple to fall to the Earth is ______.
   a. the same force that causes rain to fall to the Earth
   b. gravity
   c. the same force that causes any two objects in the universe to attract each other ← All correct but best is
   d. the same force that causes any object on Earth to fall to the Earth

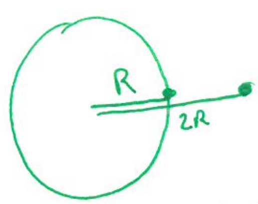
2. According to Newton's law of universal gravitation, which of the following pairs of objects would not experience a mutual force of gravitation?
   a. The Earth and the moon
   b. An apple and the Earth
   c. You and your lab partner
   d. Nonsense! All of the above since all objects experience a mutual force of gravitational pull.

3. The force of gravitation between two objects is ____.
   a. always an attractive force
   b. usually (but not always) an attractive force
   c. a force which is attractive for one object and repulsive for the other
   d. an attractive force on Earth but neither attractive nor repulsive in space
   e. an attractive force which is always balanced by a repulsive force to keep the objects from moving towards each other

4. The force of gravitational attraction between any two objects is ____ to the product of the masses.
   a. directly proportional
   b. inversely proportional
   c. not related

5. The force of gravitational attraction between any two objects is ____ to the square of the separation of the masses.
   a. directly proportional
   b. inversely proportional
   c. not related

6. Suppose that an object weighs 20 Newton on the surface of the earth (a distance of R from its center). If the same object is located a distance of R above the Earth's surface (a distance of 2R from its center, i.e. twice as far away), then the force of gravity upon it would be ____ Newton.
   a. 2.22
   b. 5.00
   c. 10.0
   d. 20.0
   e. 40.0



2X as far so 1/4 force

$20N \times 1/4 = 5\ N$

$F = \frac{G m_1 m_2}{d^2}$

7. Suppose that an object weighs 90 Newton on the surface of the earth (a distance of R from its center). If the same object is located a distance of 2R above the Earth's surface (a distance of 3R from its center, i.e. 3 times farther away), then the force of gravity upon it would be ____ Newton.
   a. 10.0
   b. 22.5
   c. 30.0
   d. 45.0
   e. 270
   f. 810

3X farther so $(1/3)^2 = 1/9$ force

$F = \frac{G m_1 m_2}{d^2}$

$90N \times 1/9 = 10N$

8. Physicists use *g* to mean _____.
   a. gravitation
   b. force of gravity acting upon an object
   c. acceleration due to gravity
   d. the universal gravitational constant

9. Physicists use *G* to mean _____.
   a. gravitation
   b. force of gravity acting upon an object
   c. acceleration due to gravity
   d. the universal gravitational constant

10. Physicists use F_g to mean _____.
   a. gravitation
   b. force of gravity acting upon an object
   c. acceleration due to gravity
   d. the universal gravitational constant

11. The acceleration of gravity on the surface of the Earth is 9.8 m/s/s. As one moves increasingly further from the surface of the Earth, the acceleration of gravity value _____.
   a. increases
   b. decreases
   c. remains the same
   d. ... impossible to tell without knowledge of the mass of the object.

$g = \frac{GM}{r^2}$

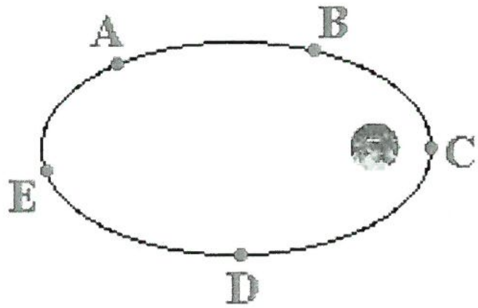
12. The acceleration of gravity at Mars' surface is 3.75 m/s/s. At a height above Mars' surface that is equal to Mars' radius (that is twice as far away from Mars' center) the acceleration of gravity is closest to _____ m/s/s.
   a. 3.75
   b. 1.88
   c. 1.25
   d. 0.94
   e. 0.42
   f. 7.50

2X farther so $(1/2)^2 = 1/4\ g$

$g = \frac{GM}{r^2}$

$3.75 m/s^2 \times 1/4 = .94 m/s^2$

13. The elliptical path of an orbiting satellite is shown below. Several locations along the path are labeled with letters.



Rank these locations in *increasing order of speed*, beginning with the location of lowest speed.
a. EADBC
b. CBDAE
c. EABCD
d. CDEAB

14. Which one of the following statements would NOT be consistent with Kepler's three laws of planetary motion?
a. The orbit of planets about the Sun are elliptical.
b. During its orbit about the Sun, a planet will travel fastest when it is nearest the Sun.
c. Planets that are furthest from the Sun have longer periods than those that are closer.
d. ... nonsense! All of these statements are consistent with Kepler's laws.

15. Kepler's second law of planetary motion is the law of equal areas. Which one of the following statements would be an extension of this law?
a. A planet would move at the same speed at all times during its orbit about the Sun.
b. The length of an imaginary line drawn from a planet to the Sun multiplied by the period is equal to the planet's area.
c. The longer the imaginary line from a planet to the Sun, the greater the speed of the planet.
d. Any given planet will travel fastest along its orbital path when it is closest to the Sun.

16. Two masses are gravitationally attracting each other. If one mass is doubled and the other mass is tripled while their separation remains the same, what happens the gravitational force?
a. increase 5 times
b. increase 3/2 times
c. increase 2/3 times
d. increase 6 times
e. decrease 36 times

17. If the acceleration due to gravity on the Moon's surface is 1.6 m/s^2, how much does a 10.0 kg mass weigh there?
a. 98 N
b. 16 N
c. 6.25 N
d. 8.4 N

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Puzzles (Please Show Your Work = PSYW)

18. Two students stand 3.0 meters apart on the dance floor. One student has a mass of 52.0 kg and the other a mass of 61.0 kg. Compute the gravitational force the exert on each other. Would they notice this force?

$$F = \frac{G m_1 m_2}{d^2}$$

$$F = \frac{(6.67E^{-11})(52)(61)}{(3)^2}$$

$$= \frac{0.000\ 000\ 211\ 572}{9}$$

$$= 0.000\ 000\ 023\ 508\ N$$

$$2.3 \times 10^{-8} N$$

F = 2.3×10^{-8} N

Notice? No (too small to notice)

19. Calculate the mass of the International Space Station (ISS) if its orbital radius (distance from Earth's center) is 6.8 x 10^6 m, the mass of the Earth is 5.98 x 10^{24} kg and the force of attraction between the Earth and the ISS is 3.623 x 10^6 N.

$$F = \frac{G m_1 m_2}{d^2}$$

$$3.623E6 = \frac{(6.67E^{-11})(5.98E24)\, m_{ISS}}{(6.8E6)^2}$$

$$3.623E6 = \frac{3.98866E14\,(m_{ISS})}{4.624E13}$$

$$(4.624E13)(3.623E6) = \frac{(3.98866E14)\,m}{4.624E13}\left(\frac{4.62E13}{1}\right)$$

$$\frac{1.6752752E20}{3.98866E14} = \frac{3.98866E14\,m}{3.98866E14}$$

$$420{,}005.5 = m$$

$$4.20 \times 10^5\ kg$$

Mass = 4.20×10^5 kg

20. Compute the acceleration due to gravity on the surface of Mercury if the mass of Mercury is 3.3 x 10^{23} kg and its radius is 2.44 x 10^6 m.

$$g = \frac{GM}{r^2}$$

$$g = \frac{(6.67E^{-11})(3.3E23\,kg)}{(2.44E6)^2}$$

$$g = \frac{2.2011 \times 10^{13}}{5.9536E12}$$

$$g = 3.6971\ m/s^2$$

(less than Earth... makes sense.)

g = $3.7\ m/s^2$

21. Europa, a moon of Jupiter, likely has a liquid water ocean under its icy surface (Some have hope that this ocean harbors life!). It takes Europa 306,000 s (85 hours) to orbit Jupiter once at a distance of 607,900 km (607,900,000 m) from Jupiter's center. Calculate the mass of Jupiter.

$$\left(\frac{M}{1}\right)T^2 = \frac{4\pi^2 R^3}{GM}\left(\frac{M}{1}\right)$$

$$\left(\frac{1}{T^2}\right) M T^2 = \frac{4\pi^2 R^3}{G}\left(\frac{1}{T^2}\right)$$

$$M = \frac{4\pi^2 R^3}{G T^2}$$

$$M = \frac{4(\pi)(\pi)(607{,}900{,}000)^3}{(6.67E^{-11})(306{,}000)^2}$$

$$= \frac{8.8686\ldots E27}{6.2455212}$$

$$= 1.41999E27\ kg$$

(large, larger than Earth's mass, makes sense for planet Jupiter.)

Mass = 1.42×10^{27} kg