Physics 02-08 Satellites **Names: _____**

- Any object _____ another object only under the influence of _____
- Gravity provides the _____ force

There is only _____ speed that a satellite can have if the satellite is to remain in an orbit with a _____ radius.

$$v = \sqrt{\frac{GM}{r}}$$

- r is measured from _____ of the Earth
- As r _____, v_____
- _____ of the satellite is not in equation

Calculate the speed of a satellite 500 km above the earth's surface.

Find the mass of a black hole where the matter orbiting it at r = 2.0×10^{20} m move at speed of 7,520,000 m/s.

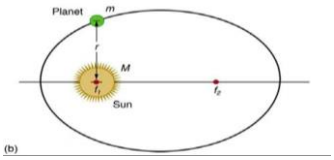
Since satellites are moving only under the influence of _____, and the acceleration points towards _____, satellites are in _____.

Kepler's Laws of Planetary Motion

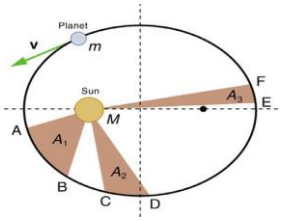
After studying motion of planets, _____ came up with his laws of planetary motion _____ then proved them all using his Universal Law of Gravitation

Assumptions:

- A _____ mass, *m*, orbits much _____ mass, *M*, so we can use *M* as an approximate inertia reference frame
- The system is _____



1. The _____ of each planet about the Sun is an _____ with the sun at one _____.
2. Each _____ moves so that an _____ line drawn from the _____ to the _____ sweeps out equal _____ in equal _____.
3. The _____ of the _____ of the _____ of any two planets about the sun is equal to their _____ of the _____ of their average _____ from the sun.



$$\frac{T_1^2}{T_2^2} = \frac{r_1^3}{r_2^3}$$

For circular orbits

$$\frac{T^2}{r^3} = \frac{4\pi^2}{GM}$$

Physics 02-08 Satellites ***Names:*** _____

Use the data of Mars to find the mass of the sun assuming a circular orbit. ($r = 2.279 \times 10^8$ km, $T = 1.881$ yr)

Homework

1. Draw a free body diagram for a satellite in an elliptical orbit showing why its speed increases as it approaches its parent body and decreases as it moves away.
2. Are Kepler's laws purely descriptive, or do they contain causal information?
3. A satellite is in a circular orbit around an unknown planet. The satellite has a speed of 1.70×10^4 m/s, and the radius of the orbit is 5.25×10^6 m. A second satellite also has a circular orbit around this same planet. The orbit of this second satellite has a radius of 8.60×10^6 m. What is the speed of the second satellite? (Cutnell 5.27) $\mathbf{1.33 \times 10^4\ m/s}$
4. A satellite is placed in orbit 6.00×10^5 m above the surface of Jupiter. Jupiter has a mass of 1.90×10^{27} kg and a radius of 7.14×10^7 m. Find the orbital speed of the satellite. (Cutnell 5.29) $\mathbf{4.20 \times 10^4\ m/s}$
5. The moon orbits the earth at a distance of 3.85×10^8 m. Assume that this distance is between the centers of the earth and the moon and that the mass of the earth is 5.98×10^{24} kg. Find the period for the moon's motion around the earth. Express the answer in days and compare it to the length of a month. (Cutnell 5.30) **27.5 days**
6. A geosynchronous Earth satellite is one that has an orbital period of precisely 1 day. Such orbits are useful for communication and weather observation because the satellite remains above the same point on Earth (provided it orbits in the equatorial plane in the same direction as Earth's rotation). Calculate the radius of such an orbit based on the data for the moon in Table 6.2. (OpenStax 6.43) $\mathbf{4.23 \times 10^4\ km}$
7. Calculate the mass of the Sun based on data for Earth's orbit and compare the value obtained with the Sun's actual mass. (OpenStax 6.44) $\mathbf{1.98 \times 10^{30}\ kg}$
8. Find the mass of Jupiter based on data for the orbit of one of its moons, and compare your result with its actual mass. (OpenStax 6.45) $\mathbf{1.89 \times 10^{27}\ kg}$
9. Astronomical observations of our Milky Way galaxy indicate that it has a mass of about 8.0×10^{11} solar masses. A star orbiting on the galaxy's periphery is about 6.0×10^4 light years from its center. (a) What should the orbital period of that star be? (b) If its period is 6.0×10^7 years instead, what is the mass of the galaxy? Such calculations are used to imply the existence of "dark matter" in the universe and have indicated, for example, the existence of very massive black holes at the centers of some galaxies. (OpenStax 6.47) $\mathbf{3 \times 10^8}$ **years,** $\mathbf{2 \times 10^{13}}$ **solar masses**