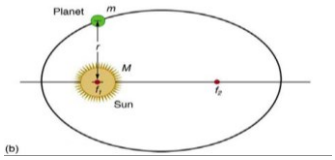
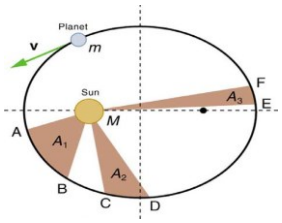
Physics 05-01 Kepler's Laws of Planetary Motion *Name:* _____

- 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 _____

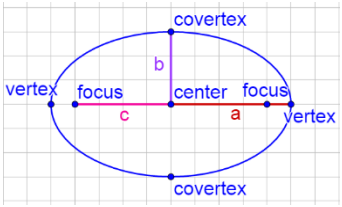


Kepler's Laws

1. The _____ of each planet about the Sun is an _____ with the sun at one _____.
   a. Closest point to the sun _____
   b. Farthest point to the sun _____
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.



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



- Parts of an ellipse
  - *a* = _____axis (distance from _____to _____) $a = \frac{r_a + r_p}{2}$
  - *b* = _____axis (distance from _____to _____) $b = \sqrt{r_a r_b}$
  - *c* = _____length (distance from _____to _____)$c = r_a - a$
  - Area of ellipse: $A = \pi ab$

Eccentricity

- Measure of how _____an ellipse is $e = \frac{c}{a}$
- *e* = 0 _____; *e* = 1 _____

The perihelion of the moon from earth is 358000 km. Its aphelion is 399000 km. What is the moon's orbit's semimajor axis, seminor axis, focal length, and eccentricity?

If it takes 27.3 days for the moon to orbit the earth, how much area does a line from the earth to the moon sweep out every day?

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The moon's average radius of orbit is 384,399 km and takes 27.322 days to orbit the earth. The International Space Station's average radius of orbit is 417.5 km above the earth. What is the period of the ISS's orbit?

Practice Work

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. Comets have very elongated elliptical orbits with the sun at one focus. Using Kepler's Law, explain why a comet travels much faster near the sun than it does at the other end of the orbit. (HSP 7.2)
4. Explain how the masses of a satellite and its parent body must compare in order to apply Kepler's laws of planetary motion. (HSP 7.27)
5. The orbit of Halley's Comet has an eccentricity of 0.967 and stretches to the edge of the solar system.
   (a) Describe the shape of the comet's orbit.
   (b) Compare the distance traveled per day when it is near the sun to the distance traveled per day when it is at the edge of the solar system.
   (c) Describe variations in the comet's speed as it completes an orbit. Explain the variations in terms of Kepler's second law of planetary motion. (HSP 7.35)
6. A moon orbits a planet in an elliptical orbit. The foci of the ellipse are 50,000 km apart. The closest approach of the moon to the planet is 400,000 km. What is the length of the major axis of the orbit? (HSP 7.12) **850,000 km**
7. The focal point of the elliptical orbit of a moon is 50000 km from the center of the orbit. If the eccentricity of the orbit is 0.25, what is the length of the semi-major axis? (HSP 7.21) **200,000 km**
8. An artificial satellite orbits the Earth at a distance of 1.45×10^4 km from Earth's center. The moon orbits the Earth at a distance of 3.84×10^5 km once every 27.3 days. How long does it take the satellite to orbit the Earth? (HSP 7.22) **0.200 days**
9. Earth is 1.496×10^8 km from the sun, and Venus is 1.08×10^8 km from the sun. One day on Venus is 243 Earth days long. What best represents the number of Venusian days in a Venusian year? (HSP 7.23) **0.92 days**
10. Mars has two moons, Deimos and Phobos. The orbit of Deimos has a period of 1.26 days and an average radius of 2.35×10^3 km. The average radius of the orbit of Phobos is 9.374×10^3 km. According to Kepler's third law of planetary motion, what is the period of Phobos? (HSP 7.30) **10.0 days**