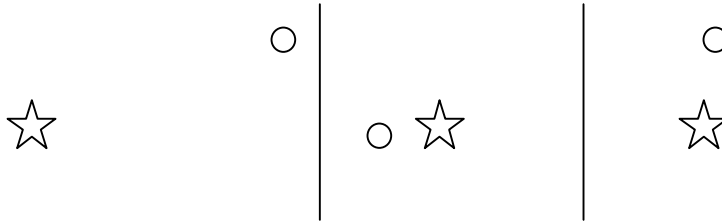


Orbits: Connecting Newton and Kepler

Part I: Gravity: The pictures below show the Sun and a comet. Each picture shows the comet in a different point relative to the Sun.

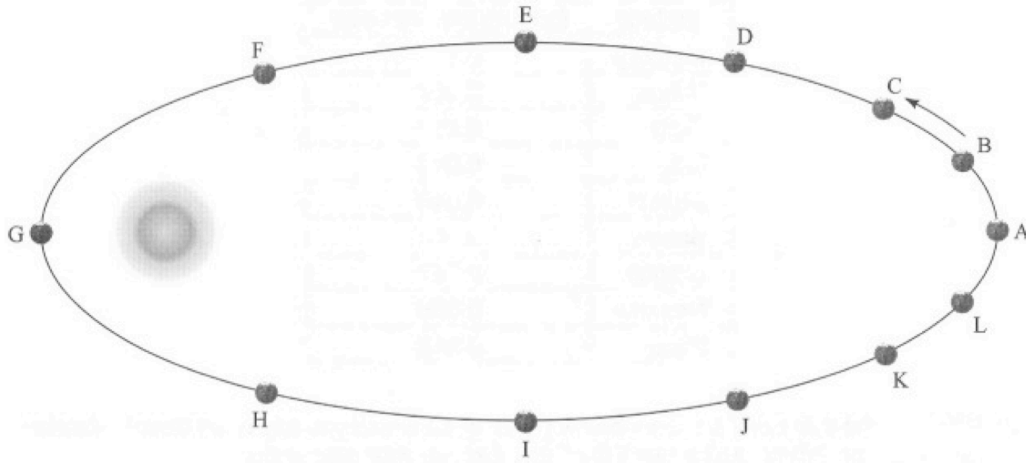


1. Newton's law of gravitation is $F = G \frac{Mm}{r^2}$ where r is the distance between the two masses. On each picture above draw an arrow that shows the gravitational force the Sun exerts on the comet. **The arrow should point in the direction the Sun's gravity is pulling on the comet and should be longer when the Sun is pulling harder.**
2. Explain why you drew the arrows the way you did.

Part II: Kepler's 2nd Law and speeds. The picture at the top of the next page shows the orbit of the comet with several points labeled.

3. At which point in its orbit does the comet move fastest? Slowest? Explain your reasoning.
4. At point E in the orbit is the comet's speeding up or slowing down? Explain your reasoning.

*The material on the front page of this sheet is an adaption of part of the tutorial "Kepler's Second Law", from **Lecture Tutorials in Astronomy**, 2nd Ed., by E. Prather, et al., Pearson Addison-Wesley (2007).*



5. At point J in the orbit is the comet's speeding up or slowing down? Explain your reasoning.

Part II: Connecting Gravity and Kepler

6. At each point on the orbit above draw an arrow showing which way the gravitational force on the comet points, and how big the force is. Use a longer arrow for bigger forces and a shorter arrow for smaller forces.
7. Look back at your answer to 5. Now explain why the speed of the comet changes using your drawing of the gravitational force to explain what is pulling or pushing on the comet to change its speed.

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