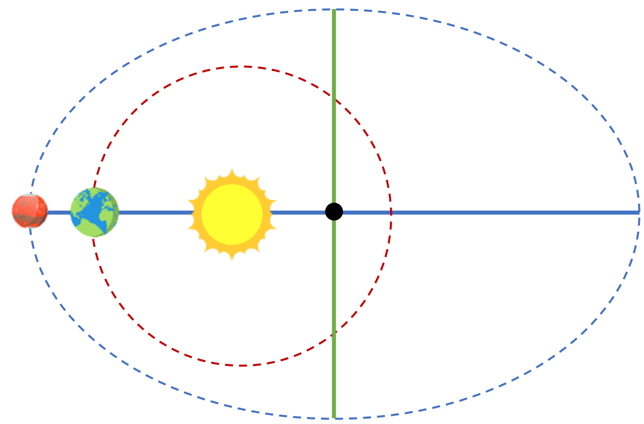
<u>**CONCEPT: Kepler's Third Law for Elliptical Orbits**</u>

● Kepler's 3rd Law also works for elliptical orbits! Instead of orbital distance **r**, we replace it with semi-major axis **a.**

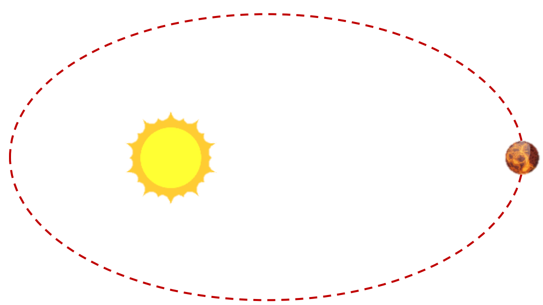
Circular Orbits
$T^2 = \frac{4\pi^2}{GM} r^3$

- For circular orbits, __________.



Elliptical Orbits
$T^2 = \frac{4\pi^2}{GM} \quad ^3$

<u>EXAMPLE</u>**:** A planet orbits a star of mass 4×10^{30} kg in an elliptical orbit, and scientists have calculated its eccentricity to be 0.4**.** Its aphelion distance is 1.5×10^{11} m**.** What is the orbital period?



ELLIPTICAL ORBITS	**CONSTANTS**
$a = \frac{R_a + R_p}{2}$ $R_a = a(1+e)$ $R_p = a(1-e)$ $T^2 = \frac{4\pi^2 a^3}{GM}$	G = 6.67×10^{-11}

PRACTICE: Comet Halley has a highly elliptical orbit around the Sun, circling once every 75.6 years with its closest point to the Sun being only 0.57AU ("Astronomical Unit", where 1AU = 1.5×10^{11}m and represents the average Earth-Sun distance). How far will Comet Halley get from the Sun?

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EXAMPLE: A distant star is believed to be orbiting an extremely massive black hole. Careful measurements show this star moves in a highly elliptical orbit (e = 0.9) with a period of 14 years. Recently, this star reached its periapsis of 1.8×10^{13} m. What is the mass of the alleged black hole this star orbits?

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$R_p = a(1-e)$	$R_E = 6.37\times10^{6}$ m
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