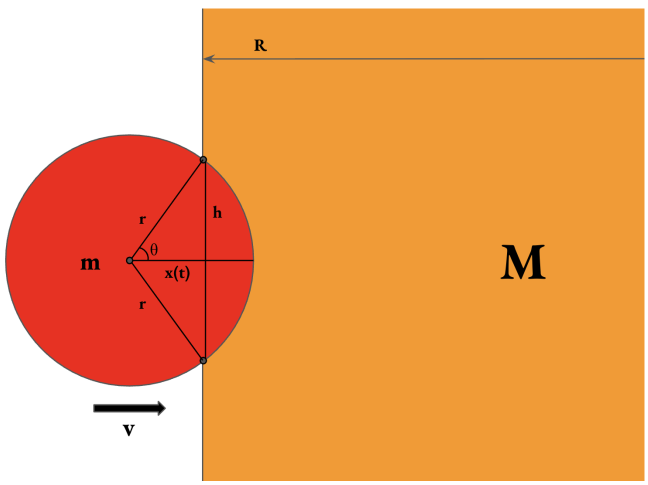
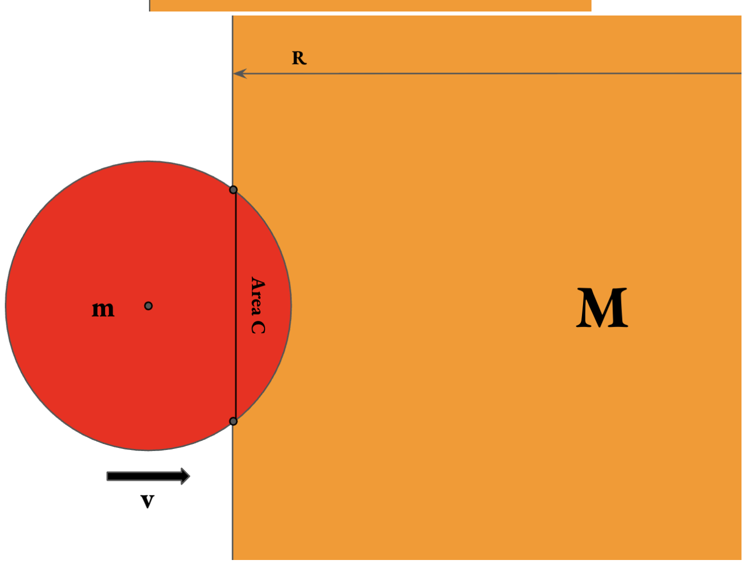
Major Assumptions:

- Uniform Luminosity Distribution (No limb darkening, luminosity/projected area = const)
- Circular Orbit (e = 0)
- Orbital Inclination is 90 deg
- Transit Velocity v (or tangential velocity) is constant
- $R \gg r$, where the edge of star of radius R is a straight line
- Distance to System >> Orbital Radii
- Mass m has no luminosity
- Celestial body m is perfectly spherical





Consider two spherical celestial bodies:

-	Star 1	Star 2
Mass	M	m
Radius	R	r
Luminosity	L_1	L_2

Orbiting on a circular orbit at a relative velocity of

$$v = \sqrt{\frac{G(m_1 + m_2)}{a}}$$

$$\text{Area of Circular Arc} = \frac{1}{2}\theta r^2$$

$$A_C = \frac{1}{2}(2\theta)r^2 - 2\left(\frac{1}{2}xh\right)$$

$$= \theta r^2 - xh = \theta r^2 - x\sqrt{r^2 - x^2}$$

For eclipse beginning at t = 0, $x(t) = r - vt,$ $x(0) = r$

$$A_C = \theta r^2 - (r - vt)\sqrt{r^2 - (r - vt)^2}$$

$$A_C = \theta r^2 - (r - vt)\sqrt{2rvt - v^2t^2}$$

$$cos(\theta) = \frac{x(t)}{r}, \qquad \theta = arccos\left(\frac{x(t)}{r}\right) = arccos\left(\frac{r - vt}{r}\right) = arccos\left(1 - \frac{vt}{r}\right)$$

For $R \gg r$:

$$A_C(t) = r^2 arccos\left(1 - \frac{vt}{r}\right) - (r - vt)\sqrt{2rvt - v^2t^2}$$

where eclipse begins at t = 0

$$L_1(t) = \left(1 - \frac{A_C(t)}{\pi R^2}\right)L_1 + L_2, \qquad 0 \le t \le \frac{2r}{v}$$

$$L_2(t) = \left(1 - \frac{r^2}{R^2}\right)L_1 + L_2, \qquad \frac{2r}{v} \le t \le \frac{2R}{v}$$

$$L_3(t) = \left(1 - \left(\frac{r}{R}\right)^2 + \frac{A_C\left(t - \frac{2R}{v}\right)}{\pi R^2}\right)L_1 + L_2, \qquad \frac{R}{v} \le t \le \frac{2R + 2r}{v}$$

For Planets: $L_2 \approx 0$

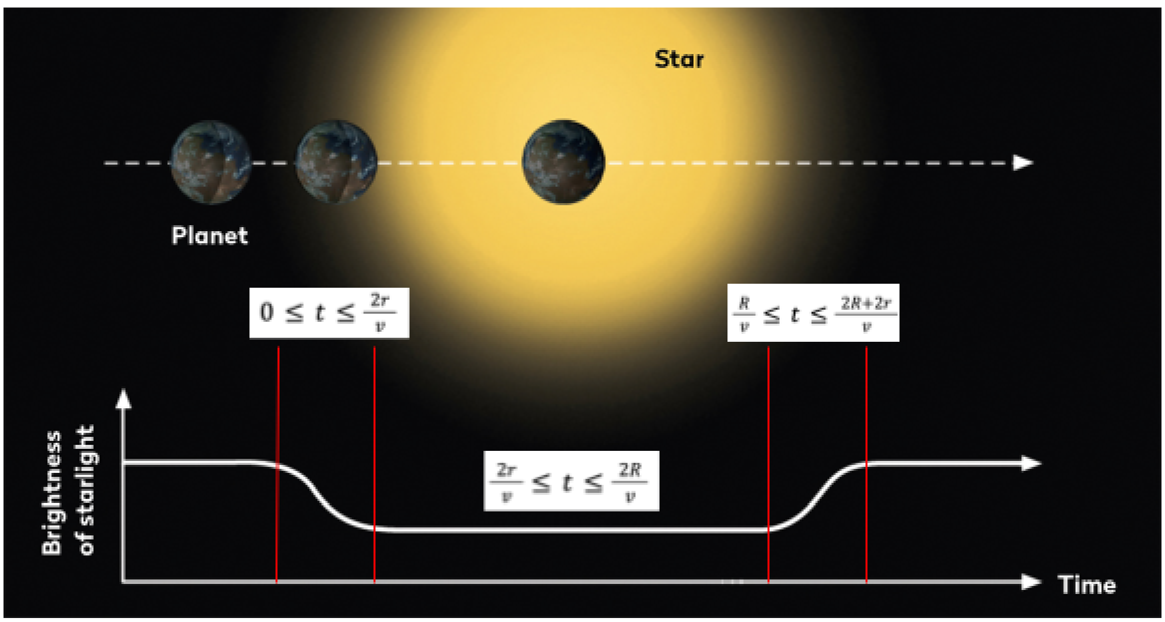
$$A_C(t) = r^2 \arccos\left(1 - \frac{vt}{r}\right) - (r - vt)\sqrt{2rvt - v^2t^2}$$

where beginning of eclipse at $t = 0$

For $R \gg r$:

$$L(t) = \begin{cases} \left(1 - \frac{A_C(t)}{\pi R^2}\right)L_1 + L_2, & 0 \le t \le \frac{2r}{v} \\ \left(1 - \frac{r^2}{R^2}\right)L_1 + L_2, & \frac{2r}{v} \le t \le \frac{2R}{v} \\ \left(1 - \left(\frac{r}{R}\right)^2 + \frac{A_C\left(t - \frac{2R}{v}\right)}{\pi R^2}\right)L_1 + L_2, & \frac{R}{v} \le t \le \frac{2R+2r}{v} \end{cases}$$

For Planets: $L_2 \approx 0$



Desmos Simulator Link (Asummes L2 = 0 and M >> m)

Variable	Units
r	**Earth Radii**
R	**Solar Radii**
P	**Days**
M	**Solar Masses**

Limitations:

- $R \gg r$ approximation
- Invalid for $R = \frac{r}{2}$