Chapter 12

Kepler's Laws

1. elliptical orbits
2. equal areas in equal times => faster when closer to sun
3. $K = \frac{r^3}{T^2}$ ← unique for each central body

Newton's Law of Universal Gravitation:

$$F_g = \frac{Gm_1 m_2}{r^2} \rightarrow g$$

where m_1 is the central mass

Fc is really Fnet

orbiting mass

Newton's Hypothesis: $F_g = F_c \rightarrow F_{net} = ma$

$$a = \frac{v^2}{r} = \frac{4\pi^2 r}{T^2} = 4\pi^2 r f^2$$

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14.

$m_{galaxy} = ?$

$v_{star} = 2.0 \times 10^2$ km/s 2.0×10^5 m/s

$r_{star\ orbit} = 5 \times 10^9$ AU

1 AU $= 1.49 \times 10^8$ km 1.49×10^{11} m

$$F_g = F_c$$

$$\frac{Gm_{galaxy}\cancel{m_{star}}}{(\cancel{r_{star\ orbit}})^2} = \frac{\cancel{m_{star}} v_{star}^2}{\cancel{r_{star\ orbit}}}$$

$$\frac{Gm_{galaxy}}{r_{star\ orbit}} = v_{star}^2$$

$$m_{galaxy} = \frac{v_{star}^2 r_{star\ orbit}}{G}$$

$$m_{galaxy} = \frac{(2.0 \times 10^5 \text{ m/s})^2 (5 \times 10^9 \text{ AU})\left(\frac{1.49 \times 10^{11} \text{ m}}{1 \text{ AU}}\right)}{6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}}$$

Geosynchronous or Geostationary Satellite

The satellite will always be directly above a specified location on the Earth.

$T_{\text{earth's rotation (in its axis)}} = T_{sat} = 24h = 86400\,s$

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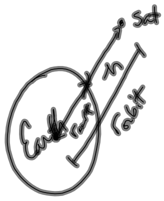


$T = 86400s$

$r_{earth} = 6.38 \times 10^6 m$

$r_{sat\ orbit} = ?$ $(r_{earth} + h)$

$h = ?$

$v = ?$

$m_{earth} = 5.98 \times 10^{24} kg$

$$F_g = F_c$$

$$\frac{G m_{earth} \cancel{m_{sat}}}{r_{sat\ orbit}^2} = \frac{\cancel{m_{sat}} 4\pi^2 r_{sat\ orbit}}{T^2}$$

$$G m_{earth} T^2 = 4\pi^2 r^3$$

$$r^3 = \frac{G m_{earth}}{4\pi^2} T^2$$

K_{earth}

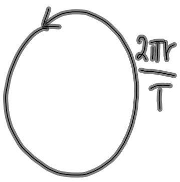
$$r^3 = \frac{\left(6.67 \times 10^{-11} \frac{N \cdot m^2}{kg^2}\right)\left(5.98 \times 10^{24} kg\right)\left(86400 s\right)^2}{\left(4\pi^2\right)}$$

radius of the satellites orbit $\rightarrow r = 4.23 \times 10^7 m$

$0.638 \times 10^7 m$

altitude: $h = 4.23 \times 10^7 m - 6.38 \times 10^6 m$

$h = 3.59 \times 10^7 m$



$$v = \frac{2\pi r_{sat\ orbit}}{T}$$

$$v = \frac{2\pi(4.23 \times 10^7 m)}{86400 s}$$

$$v = 3.07 \times 10^3 \frac{m}{s}$$

TO DO

- Newton's Cannon animation
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