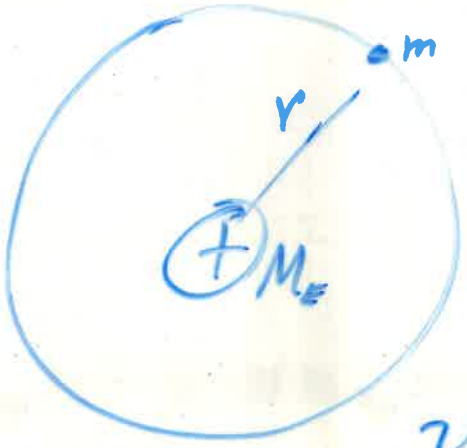
Find the radius of orbit for a geosynchronous satellite.

$$T = 1\ \text{day}\left(\frac{24\text{h}}{1\text{d}}\right)\left(\frac{3600\text{s}}{1\text{h}}\right)$$

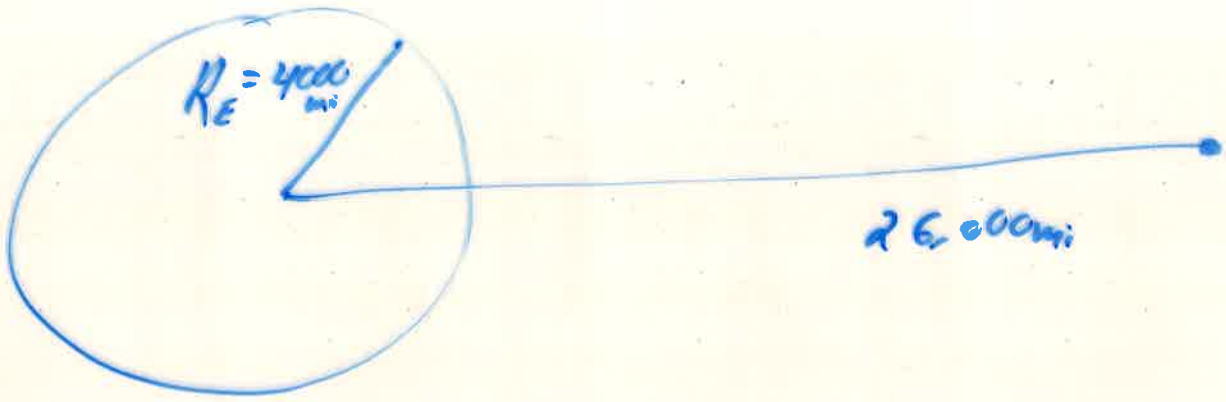


$$F = \frac{GM_E m}{r^2} = \frac{mv^2}{r}$$

$$v = \frac{\text{total dist}}{\text{total time}} = \frac{2\pi r}{T}$$

$$\frac{GM_E \cancel{m}}{r^2} = \frac{\cancel{m}}{r}\left(\frac{2\pi r}{T}\right)^2$$

$$r = \left(\frac{GM_E T^2}{4\pi^2}\right)^{1/3} = 4.2\times10^7\ \text{m} = 42000\text{km} = 26{,}000\text{mi}$$



Convention: gravitational potential energy is zero at infinite separation.

Maoz Ch 3

↓

$$E_{gravity} = U = \int dU$$

Assume ρ = constant density

$$\rho = \frac{\text{Mass}}{\text{Volume}} = \frac{M(r)}{\frac{4}{3}\pi r^3}$$

$$dU = -\frac{G M(r)\, dM}{r}$$

$$M(r) = \rho \frac{4}{3}\pi r^3$$

$$dM = \rho \frac{4}{3}\pi 3 r^2 dr = \rho 4\pi r^2 dr$$

$$U = \int dU = \int_{r=0}^{R_*} -\frac{G\left(\rho \frac{4}{3}\pi r^3\right)\left(\rho 4\pi r^2 dr\right)}{r}$$

$$= -\frac{G\rho^2 16\pi^2}{3}\int_{r=0}^{R_*} r^4 dr = -\frac{G\rho^2 16\pi^2}{3}\frac{R_*^5}{5}$$

$$= -\frac{G 16\pi^2}{15} R_*^5 \left(\frac{M_*}{\frac{4}{3}\pi R_*^3}\right)^2 = \boxed{-\frac{3}{5}\frac{G M_*^2}{R_*}}$$

Ideal Gas Law: low density, high Temp.

Interactions between gas molecules are rare.

$$PV = N k_B T = \nu R T$$

- P: pressure (Pa)
- V: volume (m^3)
- N: # of molecules
- k_B: Boltzmann's constant
- T: absolute temperature (K)
- ν: # moles
- R: universal gas constant

$$\nu = \frac{N}{N_A}$$

N_A ← Avogadro's #

6.02×10^{23}

Equipartition:

$\frac{1}{2}(k_B T)$ per quadratic degree of freedom

① Monatomic ideal gas (e.g. He) → •

In 3 dimensions $\frac{1}{2} m v_x^2$ or $\frac{1}{2} m v_y^2$ or $\frac{1}{2} m v_z^2$

3 degrees of freedom (d.f.) per atom

$$E_{Th} = K = \frac{1}{2} k_B T \, 3N = \frac{3}{2} N k_B T = \frac{3}{2} PV$$

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② Diatomic ideal gas (e.g. N_2) •—•

How many d.f. $3 + 2 + 2$ ← vibration $= 7$

translation ↑ rotation