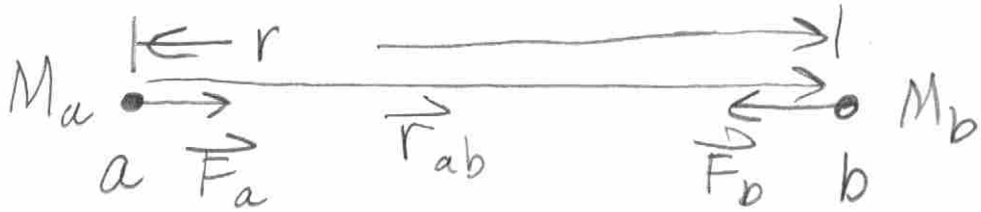
Gravitation:

pp. 343–352 RHK4
pp. 80–86 KK.

Two point masses



- Each feels an attraction
- along a line joining
- equal in magnitude, opposite in direction
- $\propto M_a, M_b, 1/r^2$

NOTE: M_b could be $\ll M_a$
(fly) (earth ?)

still.. $|\vec{F}_a| = |\vec{F}_b|$

$$|\vec{F}_a| = |\vec{F}_b| = G \frac{M_a M_b}{r^2}$$

G → gets units correct

$$\cong \frac{2}{3} \cdot 10^{-10} \frac{N \cdot m^2}{kg^2}$$

think 1 kg sep by $1 m^2$

$\vec{r}_{ab}$: vector from a to b
($\vec{r}_{ba}$ other way around)

$$\hat{r}_{ab} \equiv \frac{|\vec{r}_{ab}|}{r}$$ magnitude is 1
direction

$$\vec{F}_b = -\frac{G M_a M_b}{r^2} \hat{r}_{ab}$$ ← $-$ means attraction.

only gravity

$$\vec{a}_b = \frac{\vec{F}_b}{M_b} = -\frac{G M_a}{r^2} \hat{r}_{ab}$$

$$\left(\vec{a}_a = -\frac{G M_b}{r^2} \hat{r}_{ba}\right)$$

note: $|\vec{a}_a|$ may be $\neq |\vec{a}_b|$

WHY?

comment

$M_b \vec{a}$ ← "inertial mass"

$-\frac{G M_a M_b}{r^2} \vec{r}_{ab}$ ← "Gravitational Mass"

SAME (?)

KK 225

- suppose $M_a = M_b$
- circular orbit

$$M_b \frac{v^2}{r} = G \frac{M_a M_b}{r^2} \qquad M_a = M_b = M$$

$$v^2 = \frac{GM}{r}$$

period: $vT = 2\pi r$

$$T = \frac{2\pi r}{v}$$

$$= \frac{2\pi r}{\frac{G^{1/2} M^{1/2}}{r^{1/2}}}$$

$$T = \frac{2\pi r^{3/2}}{G^{1/2} M^{1/2}}$$

$$T \propto r^{3/2}$$

or $T^2 \propto r^3$

Kepler's Third Law

shortest ... r smallest ... pack it in!

Force of a uniform spherical shell

<u>inside</u> $\vec{F}_{Net} = 0$

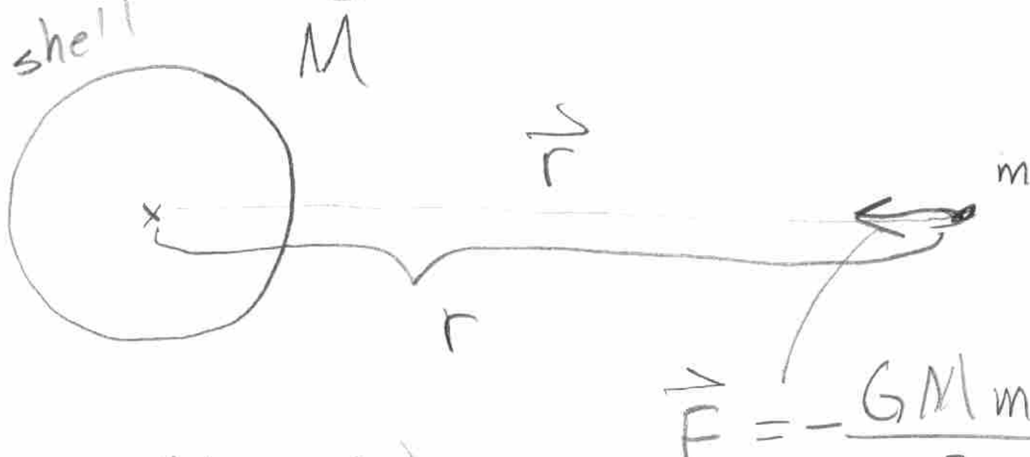
see congruent shapes?

→ <u>size</u> of caps $\propto$ distance

→ <u>area</u> of caps $\propto$ (size)^2 $\propto$ <u>distance^2</u>

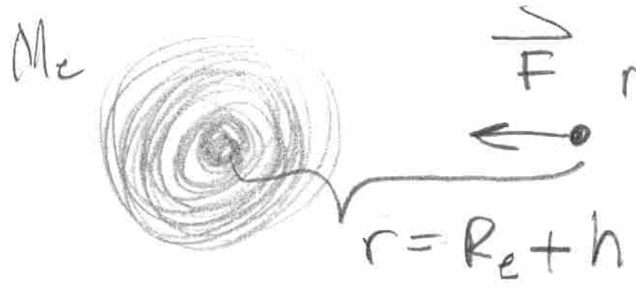
→ ∴ <u>Forces</u> <u>cancel</u>

Outside: like mass concentrated at origin



$$\vec{F} = -\frac{GMm}{r^2}\hat{r}$$

ball (like earth)



$$\vec{F} = -\frac{GM_e m}{(R_e + h)^2}\hat{r}$$