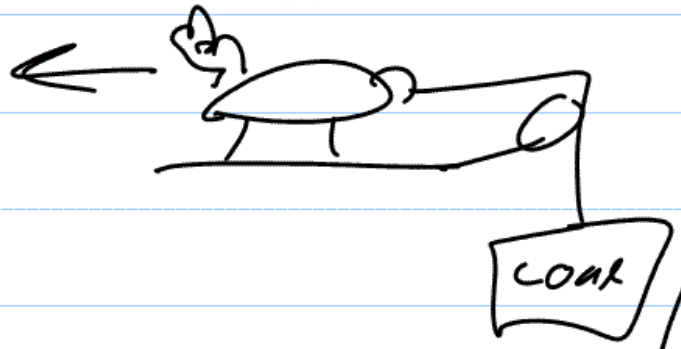
Class 12 - October 24/05

§ 11.9 Power

James Watt ~1775



strong horse lift 150 lbs of coal a distance of 220 feet in 1 min

horsepower ≡

$$\frac{150 \text{ lbs} \times 220 \text{ feet}}{1 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ sec}}$$

$$1 \text{ hp} = 550 \frac{\text{ft-lbs}}{\text{sec}}$$

$$\times \frac{4.45\ N}{1\ lb} \times \frac{.305\ m}{1\ ft} = \boxed{746\ W}$$

Metabolism

burning energy

radiates energy!

$$\frac{dE}{dt} \sim \text{(1) } T_{surface} - T_{air}$$

(2) Surface area

Equilibrium $bmr = \frac{dE}{dt}$

$$\rightarrow \frac{dE}{dt} \propto A \propto L^2$$

$$m = \rho V \propto L^3$$

$$L = m^{1/3}$$

$$bmr \propto \frac{dE}{dt} \propto m^{2/3}$$ "allometry"

Kleiber (1932): $b_{MR} \propto m^{3/4}$

true 27 orders of magnitude

CHAPT 13 - ROTATION OF RIGID BODIES

Here often models are not particles

§13.1 - Kinematics

Done for particles:

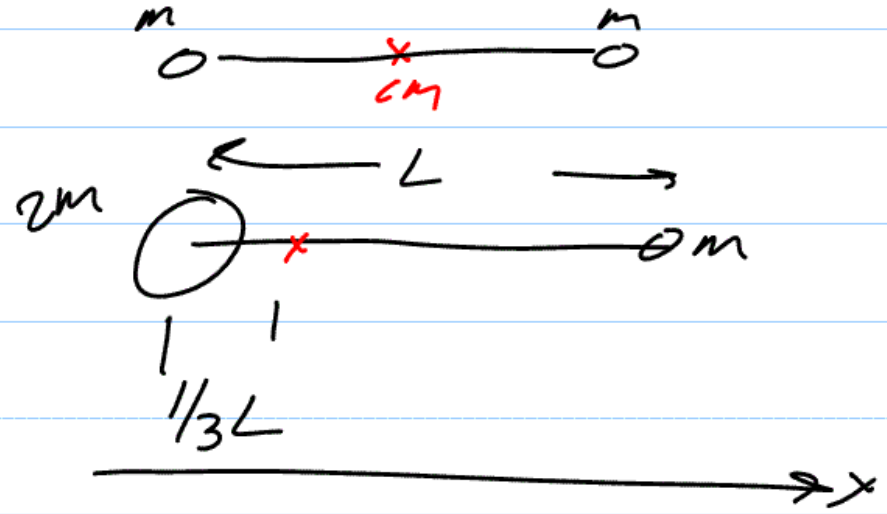
ω Class 7 -

α Class 8

Rigid body

ω, α } same for all points

§13.2 - Centre of Mass



$$x_{cm} \equiv \frac{\sum_i m_i x_i}{\sum m_i} = \frac{1}{M} \sum m_i x_i$$

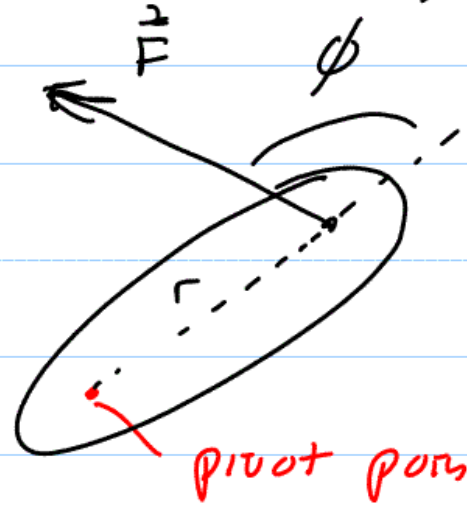
$$= \frac{1}{M} \int x \, dm$$

Isolated Object rotates about its cm

§13.3 – Torque

$$a = \frac{F}{m}$$

more carefully @ cause of α



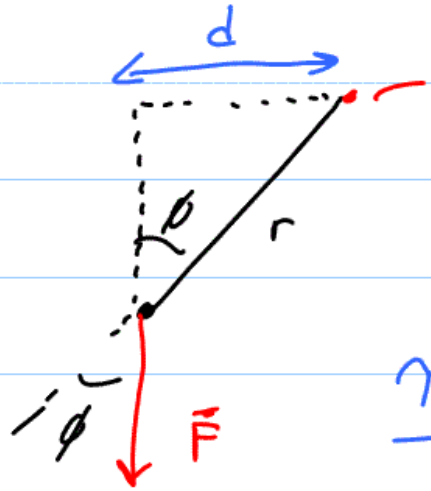
$$F_t = F \sin\phi$$

Torque

$$\tau = F_t r$$

$$= F r \sin\phi$$

Forces on pivot point! $\tau = 0$

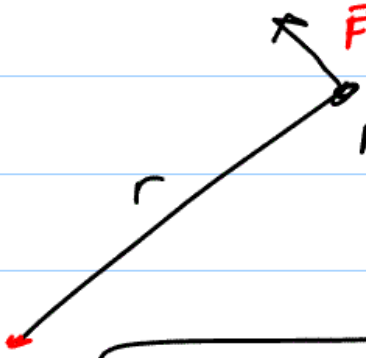


$d = r \sin\phi$

"moment arm"

$$\tau = F d = F_t r = F r \sin\phi$$

§ 13.4 - Dynamics



$F = mg$

$F_t = m a_t$

$F_t = m r \alpha$

$r F_t = m r^2 \alpha$

$\tau = m r^2 \alpha$

Rigid Body

collection of i particles

$\tau_i = m_i r_i^2 \alpha$

$$\tau_{tot} = \sum_i \tau_i = \left(\sum_i m_i r_i^2 \right) \alpha$$

$$\tau_{j \text{ on } k} = -\tau_{k \text{ on } j} \quad (3^{rd} \text{ Law})$$

$$\sum \tau_i = \tau_{tot} = \sum_i \tau_{ext} = \left(\sum_i m_i r_i^2\right)\alpha$$

$$\sum \tau_{ext} = \left(\sum_i m_i r_i^2\right)\alpha$$

moment of inertia I

$$\rightarrow \quad a = \frac{F_{net}}{m}$$

$$\boxed{\alpha = \frac{\tau_{net}}{I}}$$

$$I = \sum_i m_i r_i^2 = \int r^2 \, dm$$

$I = cMR^2$ c - const for a given object and axis of rotation

$c = 0$: point particle

$c = 1$: all mass is distance R away from axis

arbitrary rigid body: $0 < c < 1$