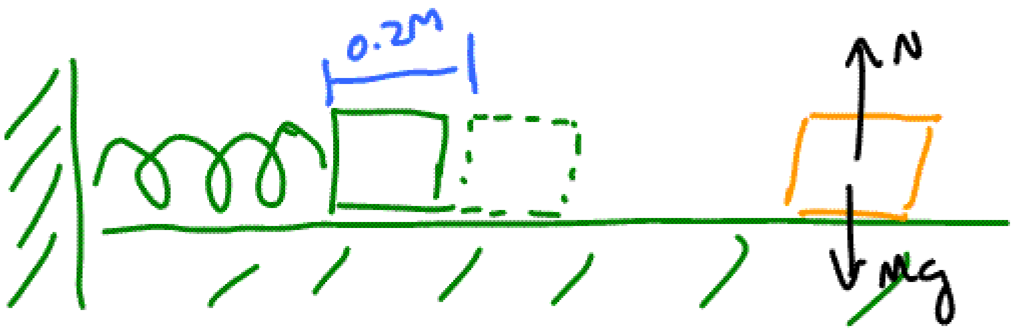
Physics 113 - October 19, 2006

- dropped "d" at end of Example



correct your notes

$$\mu_k = \frac{kx^2}{2Mgd}$$

- Exam in 1 week — Thurs. Oct 26 0800 Hubbell

  will be in touch → material covered
  review (Q+A) session
  formula sheet

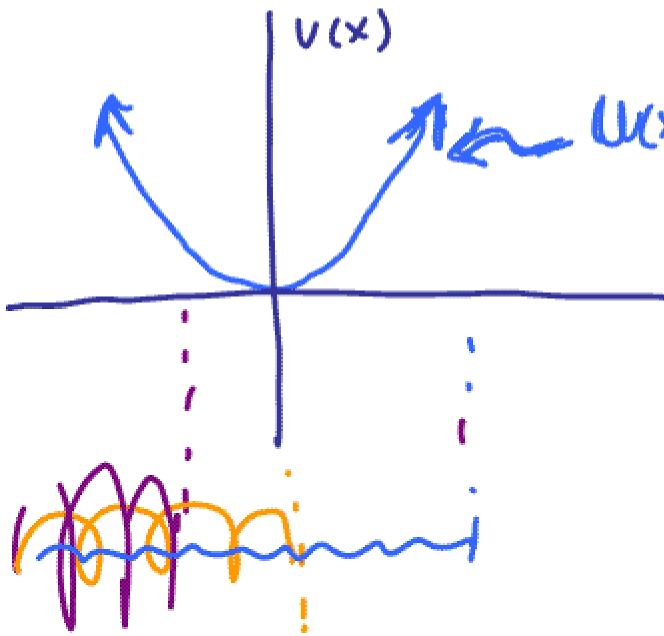
Last Time:

$$\text{Power} \equiv \frac{\Delta w}{\Delta t}$$

$$P = \frac{dw}{dt} \quad \frac{\text{Joules}}{\text{sec}} \equiv \text{Watt}$$

Important

PE function



$U(x) = \frac{1}{2} k x^2$

$$\frac{du}{dx} = kx = F_x$$

$$\boxed{F_s = -\frac{dU(s)}{ds}}$$

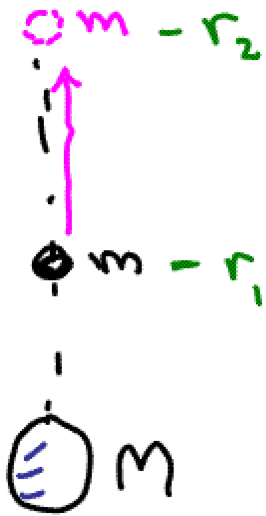
sign oversimplification

Important

Gravitation

$$\vec{F} = -\frac{G M_1 M_2}{r^2}\,\hat{r}$$

Cavendish



How much work done to move m from $r_1 \to r_2$?

$$d\vec{s} = d\vec{r}$$

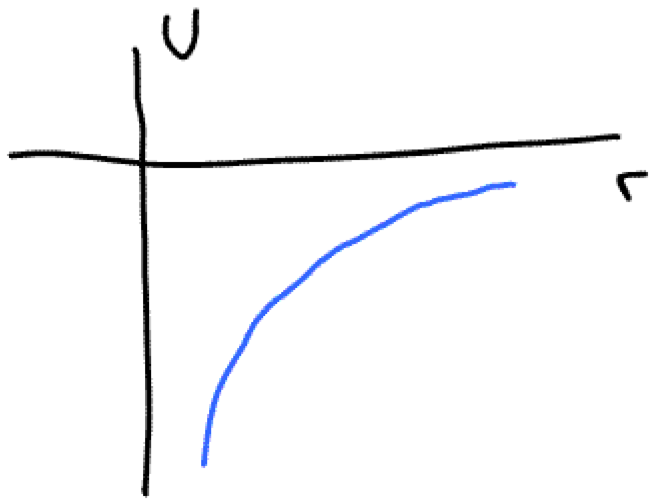
$$d\vec{s} \uparrow \; \uparrow F$$

$$W = \int_{r_1}^{r_2} \vec{F} \cdot d\vec{s} = \int_{r_1}^{r_2} F\,dr = \int_{r_1}^{r_2} \frac{G m_1 m_2}{r^2}\,dr$$

$$W = G m_1 m_2 \int_{r_1}^{r_2} \frac{1}{r^2}\,dr = -G m_1 m_2 \frac{1}{r}\Bigg|_{r_1}^{r_2}$$

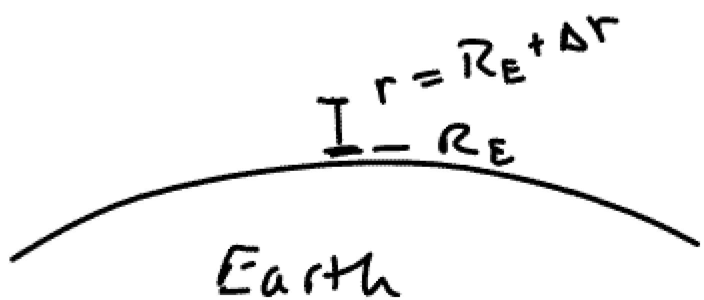
$$W = -\frac{G m_1 m_2}{r_2} + \frac{G m_1 m_2}{r_1} \qquad +$$

gravitational $PE \equiv -\dfrac{G m_1 m_2}{r}$



$$-\frac{dU}{dr} = -\frac{G M_1 m_2}{r^2} = F(r)$$

$$PE_{grav} \sim mgh$$



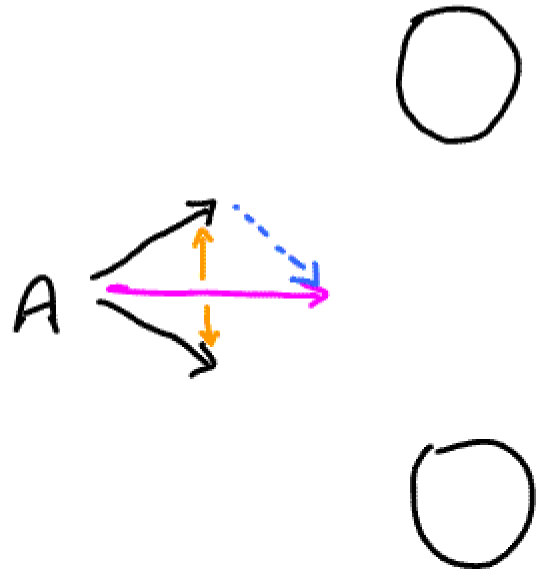
$$\Delta PE = PE_{end} - PE_{start}$$

$$= -\frac{GM_E m}{r} + \frac{GM_E m}{R_E} \qquad r = R_E + \Delta r$$

$$= \frac{GM_E m r - GM_E m R_E}{r R_E}$$

$$= \frac{GM_e m (r - R_E)}{r R_E} = \frac{GM_e m (R_E + \Delta r - R_E)}{(R_E + \Delta r) R_E}$$

$$= \underbrace{\frac{GM_E m}{R_E^2}}_{g} \overbrace{\Delta r}^{h} = mgh$$



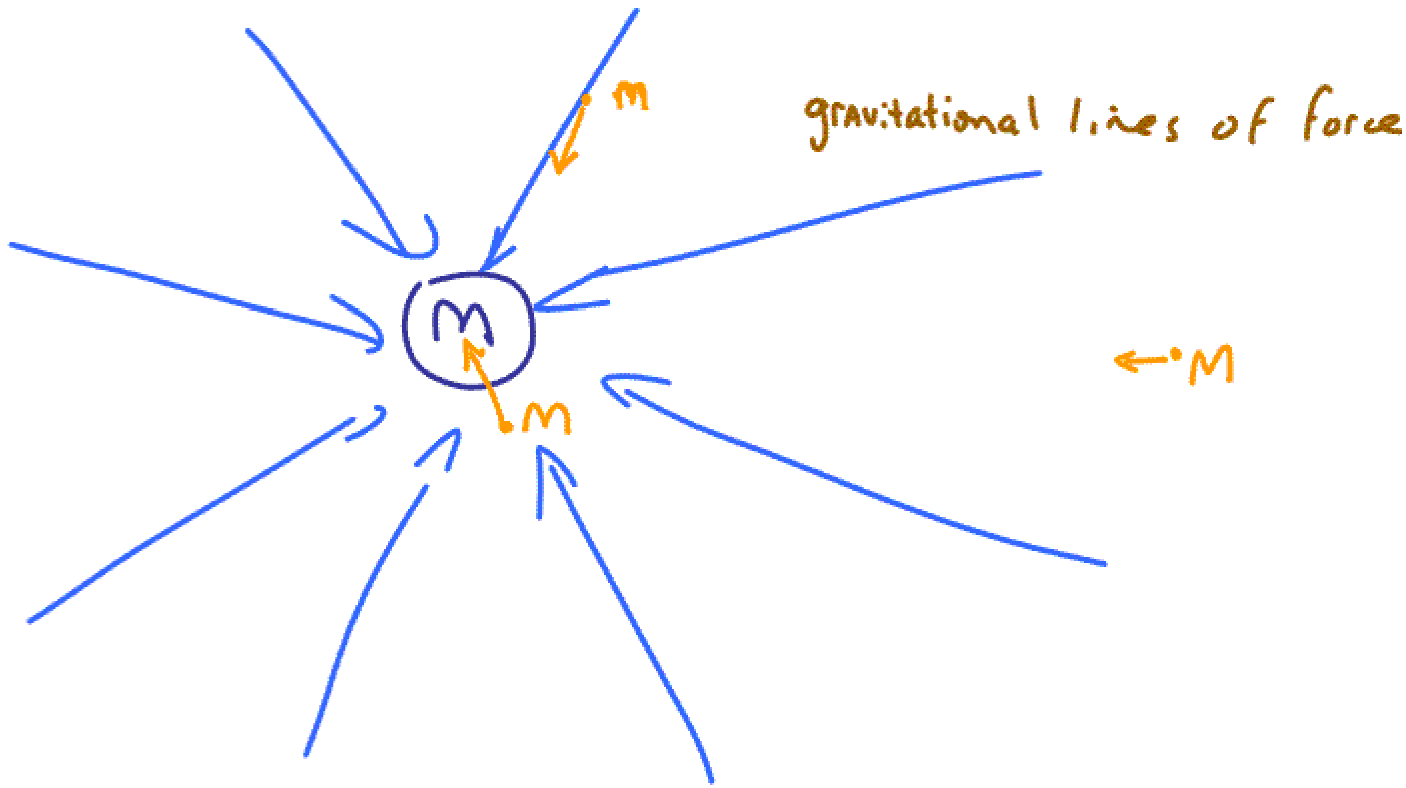
$$\vec{F} = \frac{-GMm}{r^2}\hat{r}$$

Test mass

m

$$\vec{g}(\vec{r}) = \frac{\vec{F}}{m} = -\frac{GM}{r^2}\hat{r}$$

grav. field


m
gravitational lines of force
M
m
M


F=ma

NOT For EXAM — just for fun

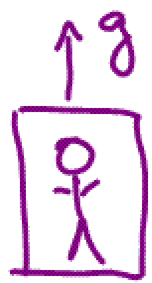
Newton

grav. field

Action at a distance

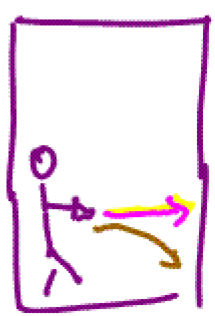
Einstein

General Relativity



Earth

Force due to curved space



gravitation — No quantum theory yet but expect one someday

Electromagnetism

Strong Nuclear force

Weak Nuclear force

$\Big\}$ Standard Model

quantum field theory

$$\Delta x \, \Delta p \sim h$$

v

$$\Delta E \, \Delta t \sim h$$

Force viewed

Exchange of "virtual" quanta

that only exist because of Heisenberg Uncertainty Principle