Physics 113 – October 11, 2012

- Exam 1 graded – Will return papers + Discuss at end of class
- Workshop cycle for now runs Wed → Tuesday
- Midterm Survey For TA's

Last Time

Energy is Conserved ... NOT always useful for you

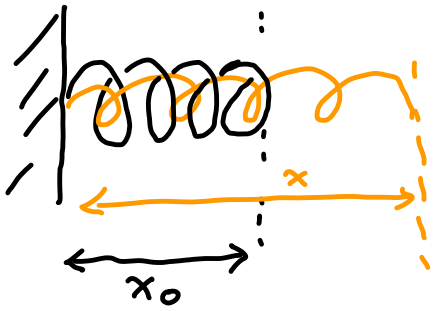
$$W_{NC} = \Delta KE + \Delta PE$$

W_{NC}: nonconservative work

↳ friction ... hand of God whatever

Think your way through the energy flow

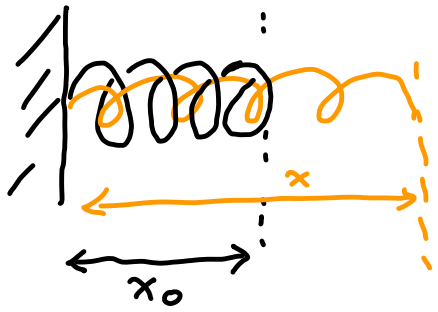
Two conservative systems considered so far: gravity, springs



$$\vec{F} = -k(\vec{x} - \vec{x}_0)$$

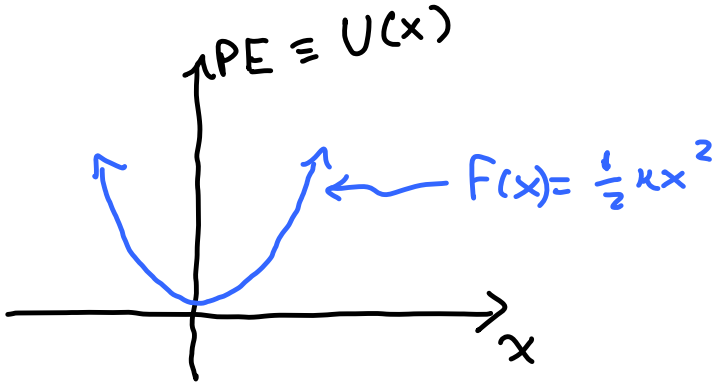
We looked at $dW = \vec{F} \cdot d\vec{s}$ to stretch spring

$$PE_{spring} = \frac{1}{2}k(x - x_0)^2 = \frac{1}{2}kx^2$$ if $x_0 = 0$



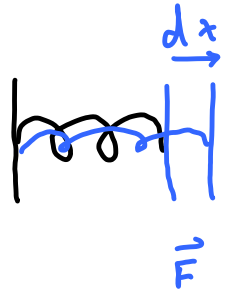
As we change x → PE in system changes

$$PE = \frac{1}{2}kx^2 \qquad (\text{let } x_0 \equiv 0)$$



I stretch spring $dW \sim F\,dx$

$dU \sim \Delta PE$



$$\frac{dU}{dx} = F_x$$

Better to ask what is force of spring on something + how that is related to U flips sign on work

$$-\frac{dU}{dx} = F_x$$

In general $F_s = -\frac{dU}{ds}$ along coordinate s

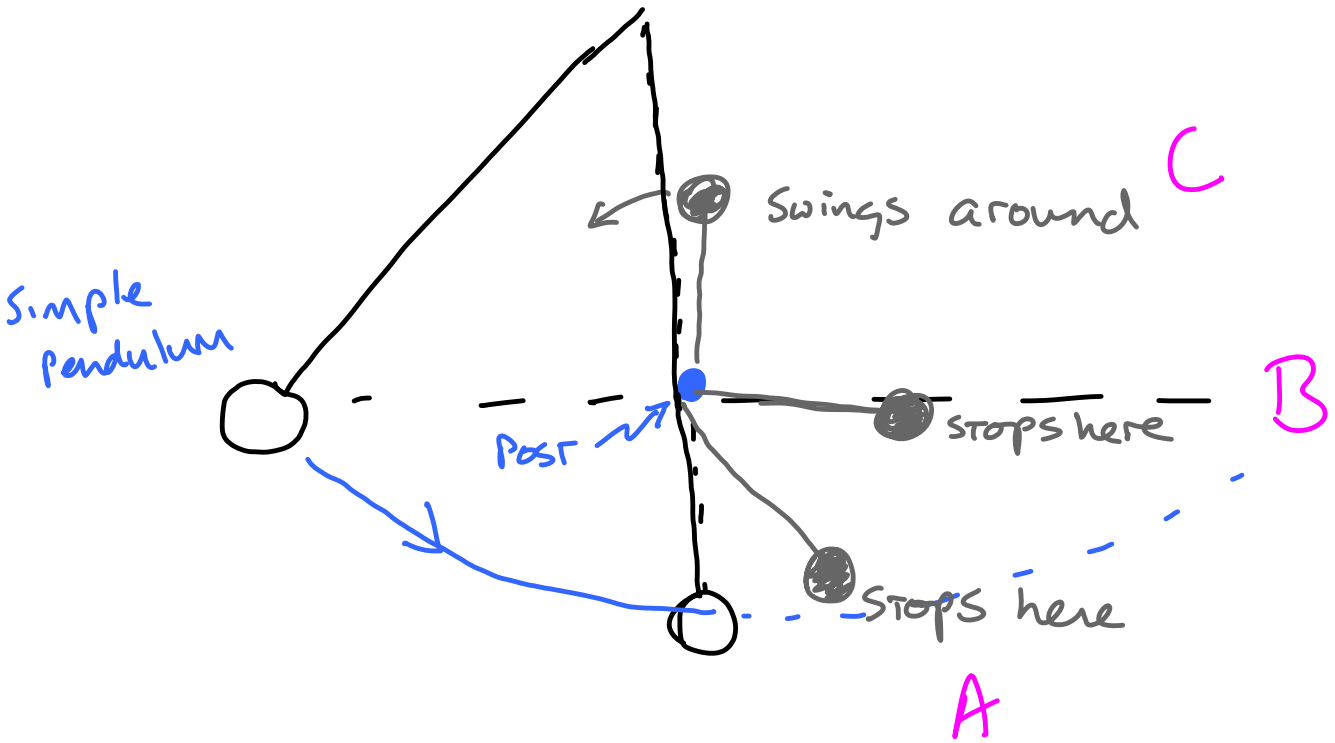
Example

$PE_{spring} = \frac{1}{2}kx^2$ $\quad F_{spring} = -\frac{d(PE)}{dx} = -kx$

Let's look at gravitation + come back to this ...

yeah, yeah ... $F = mg$ $\quad \Delta PE = mgh$ Boring!!

What's the big deal ...

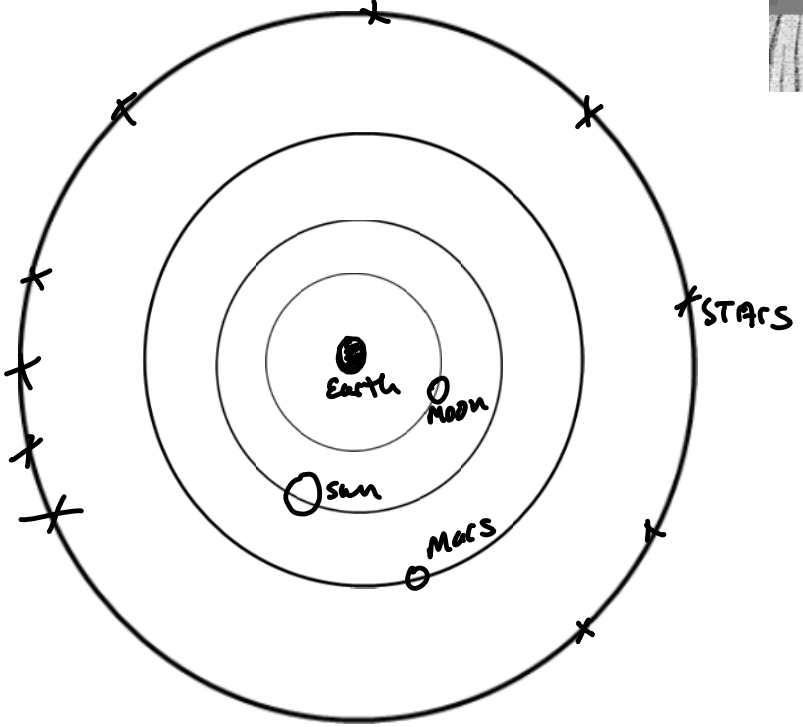


Demo and clicker exercise

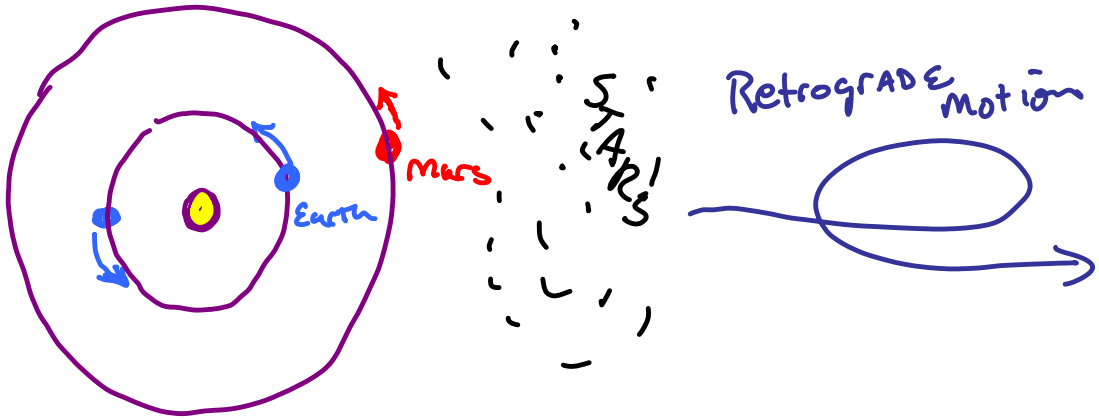
Newton's
Law of universal
gravitation
+ Why it was
a BFD

Pythagorian theory

Early Greek view of the universe

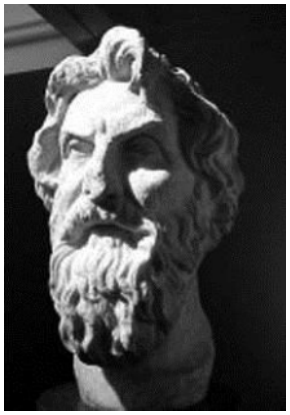


Pythagoras
of
Samos
~500BC



Fix the theory

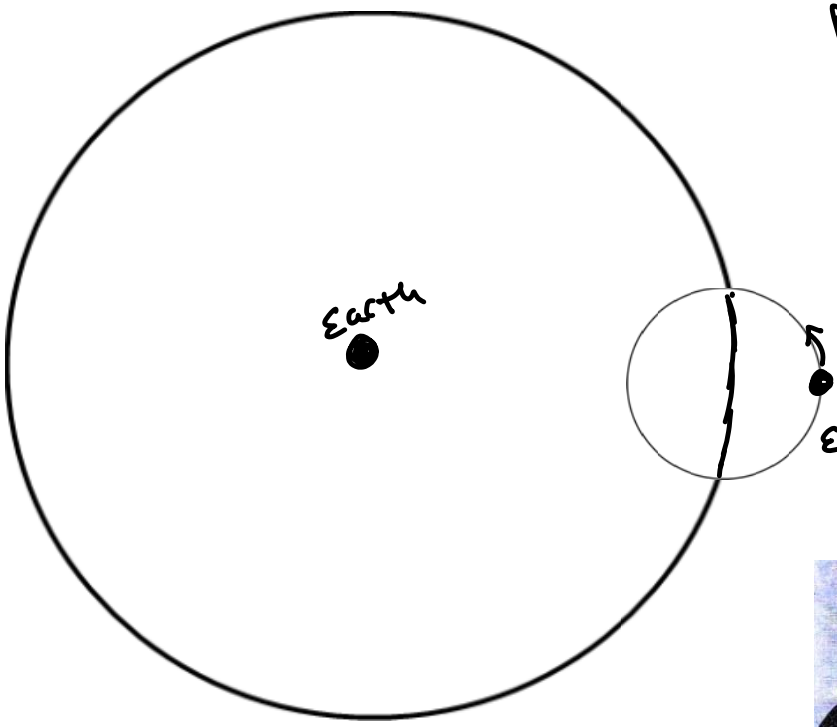
Plato ~400 BC ~ Multiple spheres



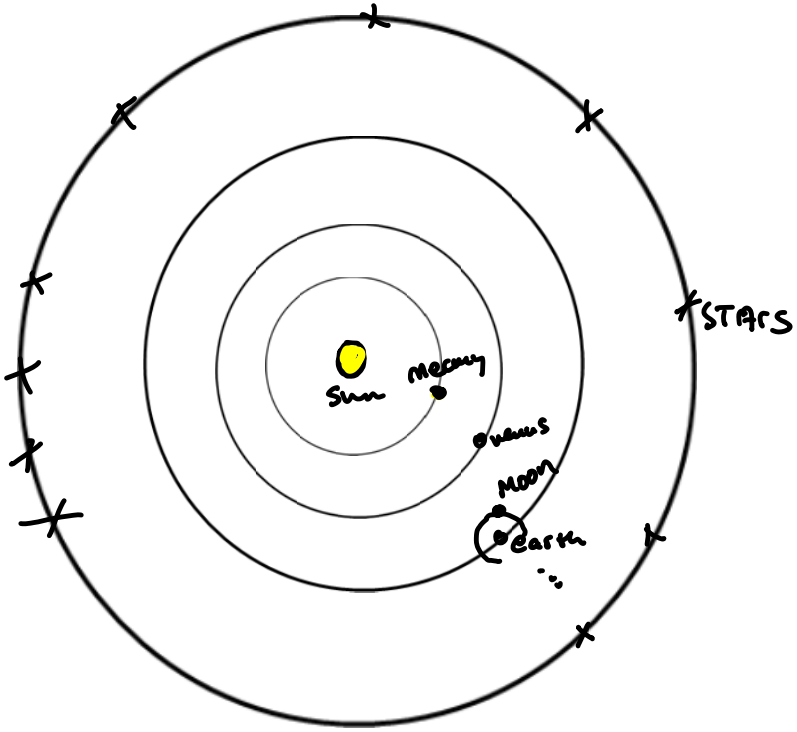
Aristarchus ~310 - 230 BC
(Greek)

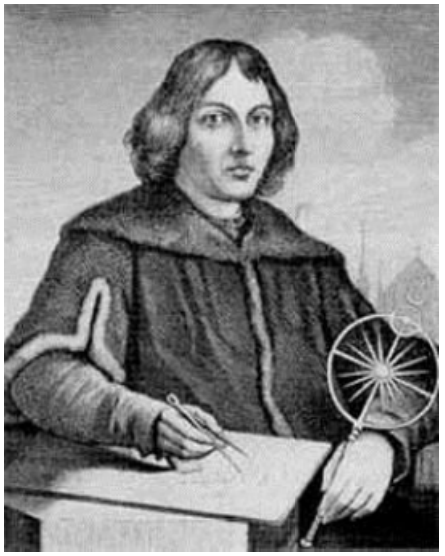
Proposed sun-centered universe
→ rejected

Ptolemy
~100 AD



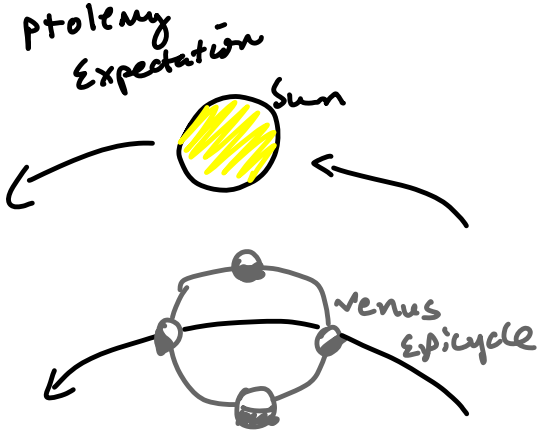
The Heliocentric universe



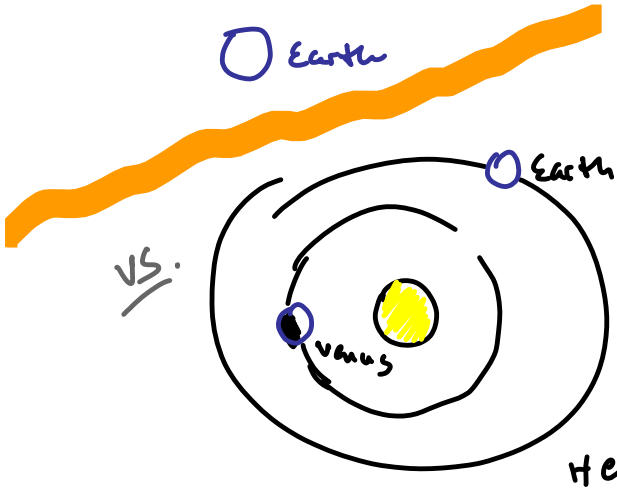


Nicolaus Copernicus
1473-1543
(Poland)

On the Revolutions of the Heavenly Spheres



Galileo Galilei:
(1564 - 1642)



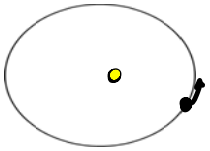
Observed phases of venus

Heliocentric expectation

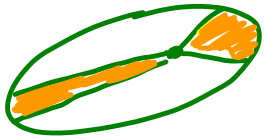
Tycho Brahe
1546 - 1601
(Dane)
careful observations
of positions
of sun, moon, planets

Brahe's data did NOT fit perfectly
with Copernicus' theory

Johannes Kepler
1571 - 1630
(German)



⇒ Elliptical orbits
fits the data !



Determined 3 laws
that mathematically
describe orbits seen —
relate periods, areas, axes ....

Sir Isaac Newton
1643 - 1727
(England)

universal law of gravitation

$$F = G\frac{M_1 M_2}{r^2}$$

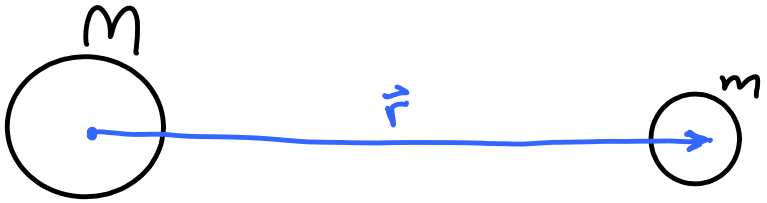
+

Laws of Motion

$\Rightarrow$ derived Kepler's
3 laws of planetary motion

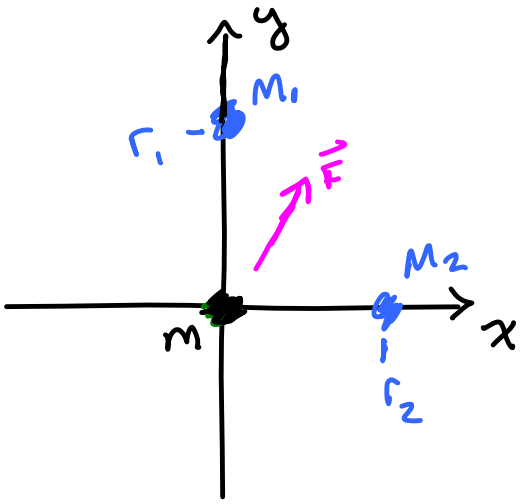
In your text
Sect 6.5
Not stressed here

same law that governs Motion on Earth



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

For spherically symmetric bodies, "r" measured from center



$$\vec{F} = \frac{GM_1m}{r_1^2}\hat{y} + \frac{GM_2m}{r_2^2}\hat{x}$$

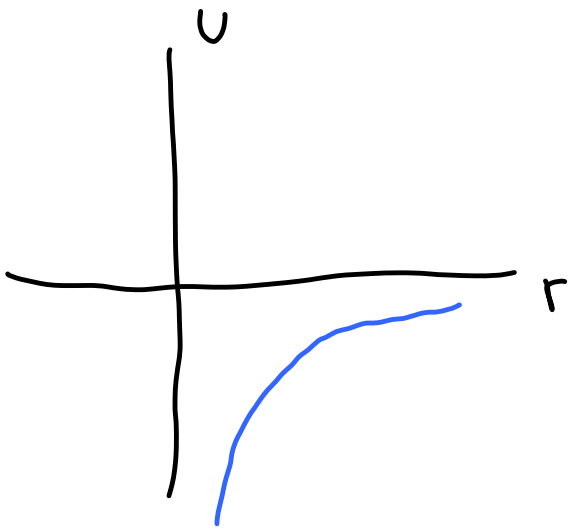
How much work done to move m from $r_1 \rightarrow r_2$
(along radial line)

$$dW = \vec{F} \cdot \vec{dS} = \vec{F} \cdot \vec{dr} = F\,dr$$

$$W = \int_{r_1}^{r_2} F\,dr = \int_{r_1}^{r_2} \frac{GMm}{r^2}\,dr = -GMm\frac{1}{r}\Big|_{r_1}^{r_2}$$

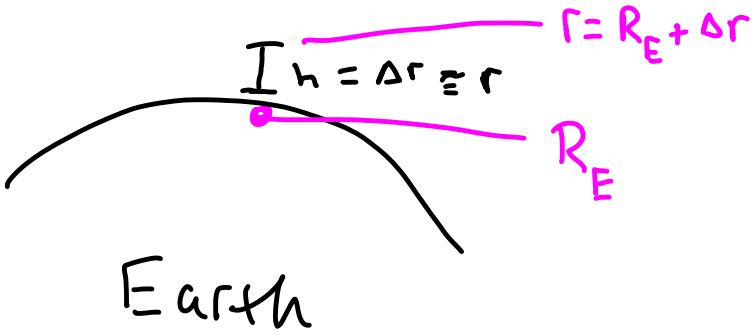
$$W = -GMm\left(\frac{1}{r_2} - \frac{1}{r_1}\right) = -\frac{GMm}{r_2} + \frac{GMm}{r_1}$$

define grav. $PE = -\frac{GMm}{r}$



grav. PE ~ mgh

WTF?



ΔPE go from $R_E \rightarrow R_E + \Delta r \equiv r$

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

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

$$= \frac{G M_E m (R_E + \Delta r - R_E)}{R_E (R_E + \Delta r)} \approx \frac{G M_E m h}{R_E^2} \equiv g$$

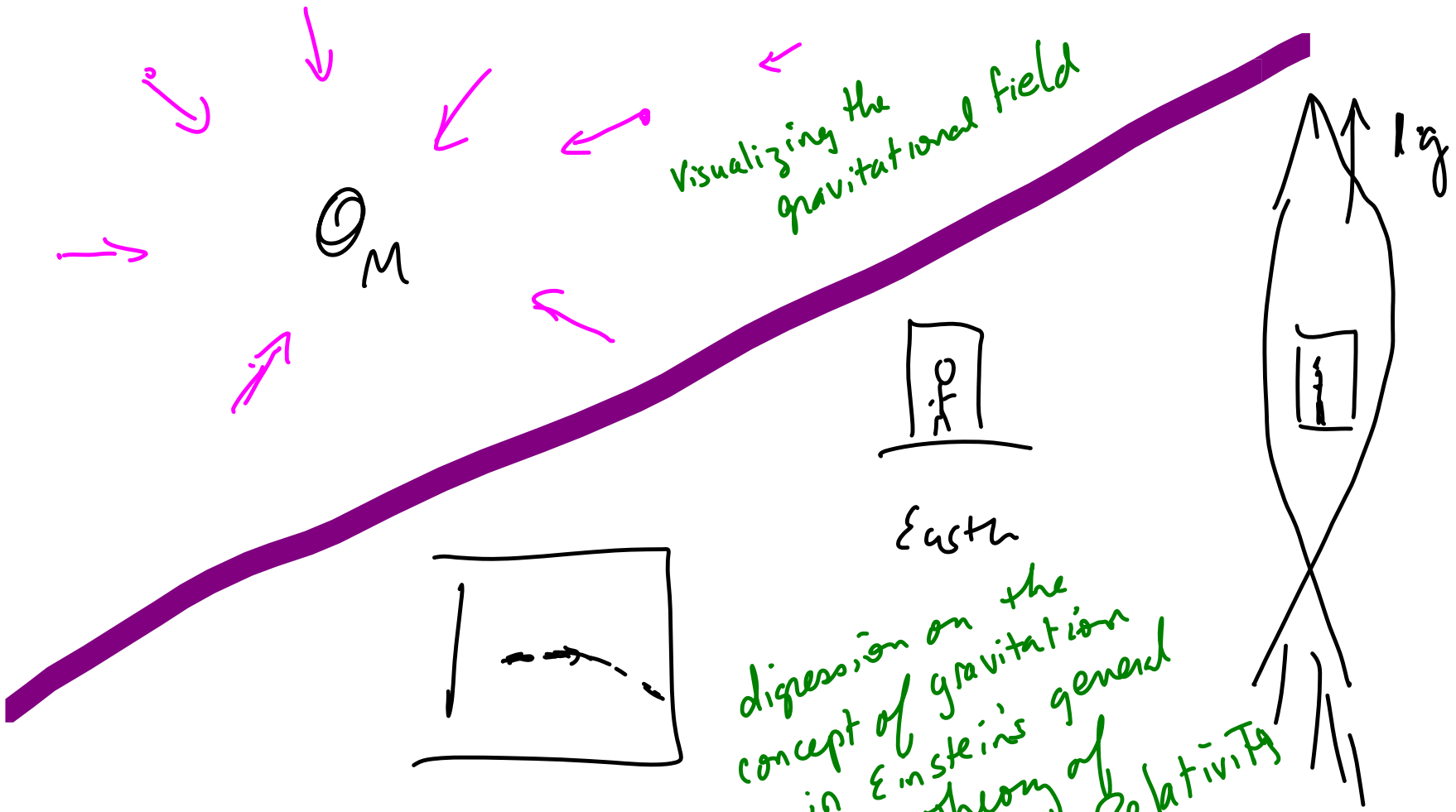
$\Delta r \sim 0$

SAME as mgh

$\vec{g} \equiv$ gravitational field

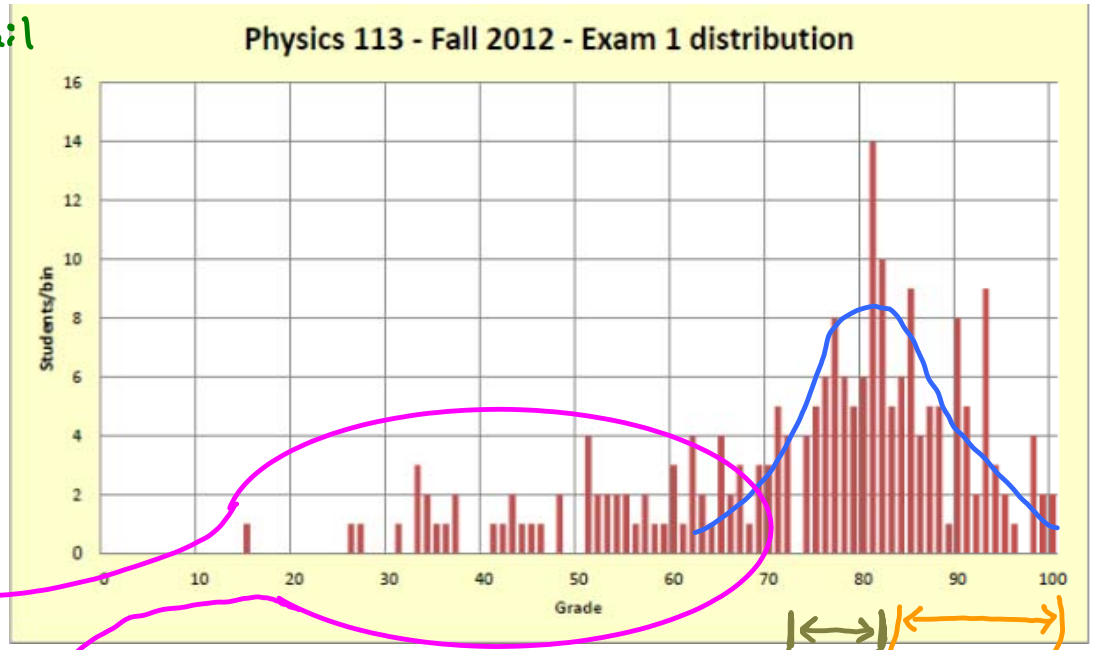
$\equiv \vec{F}_g / m$ at each point

$= -\frac{GM}{r^2} \hat{r}$


$\mathcal{O}_M$
Visualizing the gravitational field
1g
Earth
digression on the concept of gravitation in Einstein's general theory of Relativity

- Mean ~ 74 ... Note long low tail
- median ~ 79

- Don't ask me to translate this into letter grades.
- Study Solutions
- regrade policy
- Troubleshooting guide



Syllabus allows for a drop ☺

Something is broken w/ respect to you + this course/exam ☹

Now is the time to figure it out and make changes

Doing okay

Room for improvement

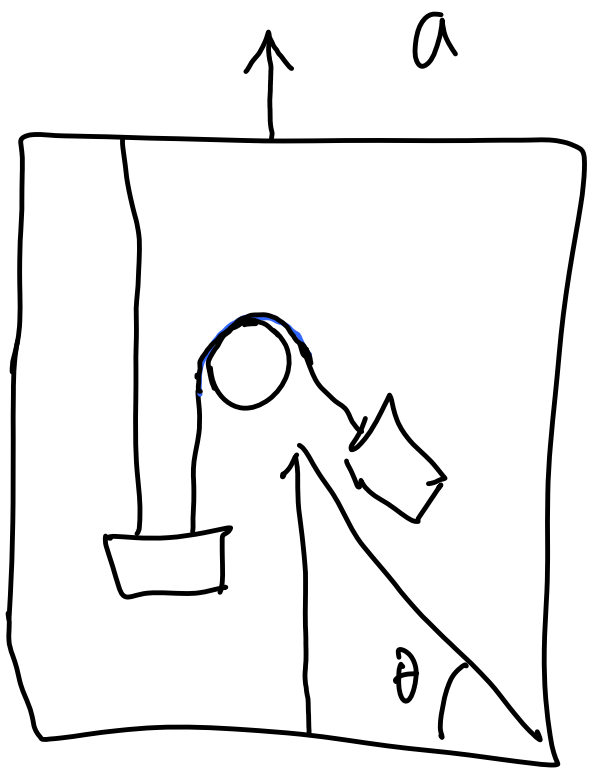
Examine solns ...

See if you can identify issues to tighten up

Things going well.

Keep it up.

Don't get cocky.



Problem 6 on Exam:

unfortunately a cancels out in final equation for θ. Still it is explicitly incorrect to set $a=0$ in solution to problem.