

welcome to

# ASTR 160b

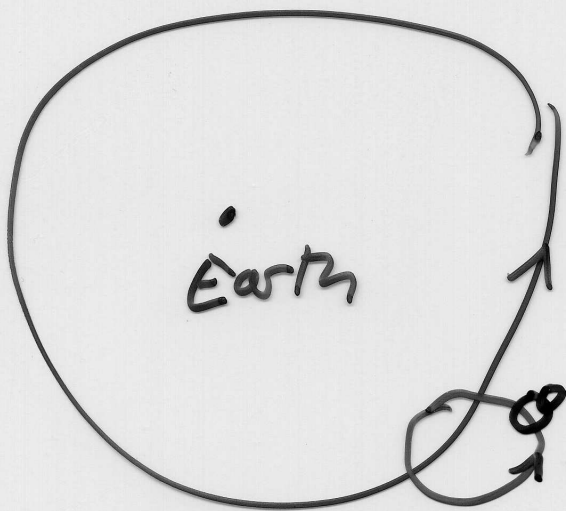
- For NON-SCIENCE MAJORS  
(scientists: check out ASTR 210)
- NOT a survey course - 3 topics  
in-depth
  - extra-solar planets
  - black holes
  - Dark Energy
- math level: high-school algebra/geometry  
(ASTR 120 has similar level, but  
better for math/science phobic)
- preference for fresh/soph
- grading:
  - 10% sections
  - 30% problem sets
  - 30% 2 midterms
  - 30% final
  - (15% optional paper)
- see classes V2 for more details!

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# PLANETARY ORBITS

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circles around Earth

geocentric  
Ptolemy

doesn't fit observation  
add "epicycles"

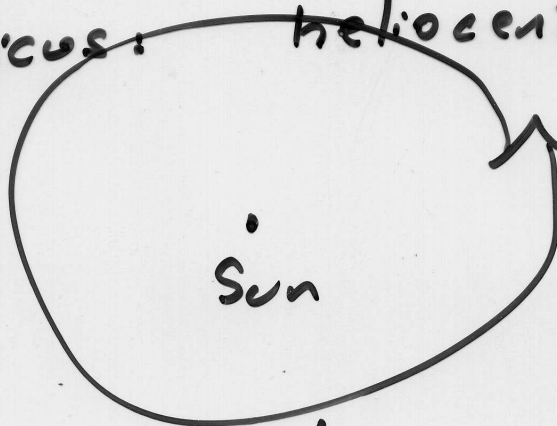
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FABLE: Ptolemaic Epicycles

MORAL: simple theories are better

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Copernicus: heliocentric



circles

still needed epicycle

Kepler :

3 Laws of Planetary Motion  
ellipses around Sun

excellent descriptive power  
NOT an explanation

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Newton : 3 Laws of Motion

$F = ma$   
↑      ↑      ↖ acceleration  
force   mass

Law of gravity:  $F_{grav}$   
derives Kepler's Law

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START OF SCIENCE:

- universe is governed by universal Laws
- these are mathematical

end of 19<sup>th</sup> century  
problems w/ Newtonian Physics

early 20<sup>th</sup> :



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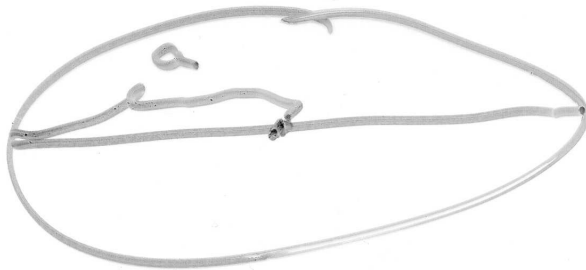
# Newtonian modification of ~~Kepler's~~ Kepler's 3rd Law

$$a^3 = \frac{GM P^2}{4\pi^2}$$

constant of nature  
orbital period

total mass of orbiting bodies

$a$  is semi-major axis of elliptical orbit



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Earth around Sun

semi-major of Earth's orbit  
"astronomical unit" AU

mass of Sun:  $M_{\odot}$

period of Earth: 1 yr

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$$(1 \text{ A.U.})^3 = \frac{G M_{\odot} (1 \text{ yr})^2}{4 \pi^2}$$

take general eq<sup>n</sup> divide by  
specific eq

$$a^3 = \cancel{P^2} \cancel{M} / \cancel{4 \pi^2}$$

$$(1 \text{ AU})^3 = (1 \text{ yr})^2 \cancel{G} \cancel{M_{\odot}} / \cancel{4 \pi^2}$$

$$\left(\frac{a}{1 \text{ AU}}\right)^3 = \left(\frac{P}{1 \text{ yr}}\right)^2 \left(\frac{M}{M_{\odot}}\right)$$

$$a^3 = P^2 M$$

← unit of AU  
 → units: 1 yr  
 → units: mass of Sun

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# orbit of Jupiter

$$a_{\text{jupiter}} \approx 5 \cdot a_{\text{earth}} = 5 \text{ AU}$$

$$5^3 = P^2$$

1 solar mass

$$125 = P^2$$

$$P = \sqrt{125}$$

11

$$121 = P^2$$

$$P = 11 \text{ years}$$