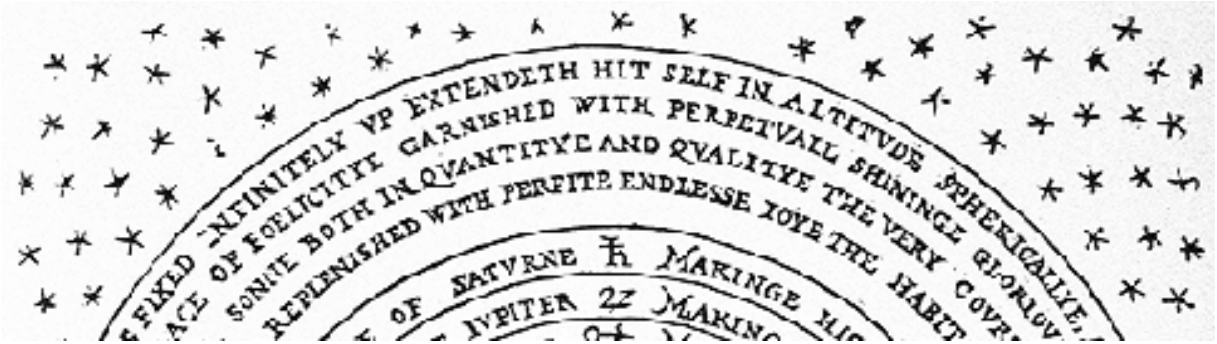


PHY1033C/HIS3931/IDH 3931 : Discovering Physics:

The Universe and Humanity's Place in It

Fall 2016

Prof. Peter Hirschfeld, Physics

Announcements

- HW 1 due today; HW 2 posted, due Sept. 13
- Lab 1 today 2nd hour
- Reading: Gregory Chs. 2,3

  Wertheim (coursepack), Lindberg (coursepack)
- HW/office hours 10:40 M,T, 11:45 W

  email/call to make appt. if these are bad

Last time

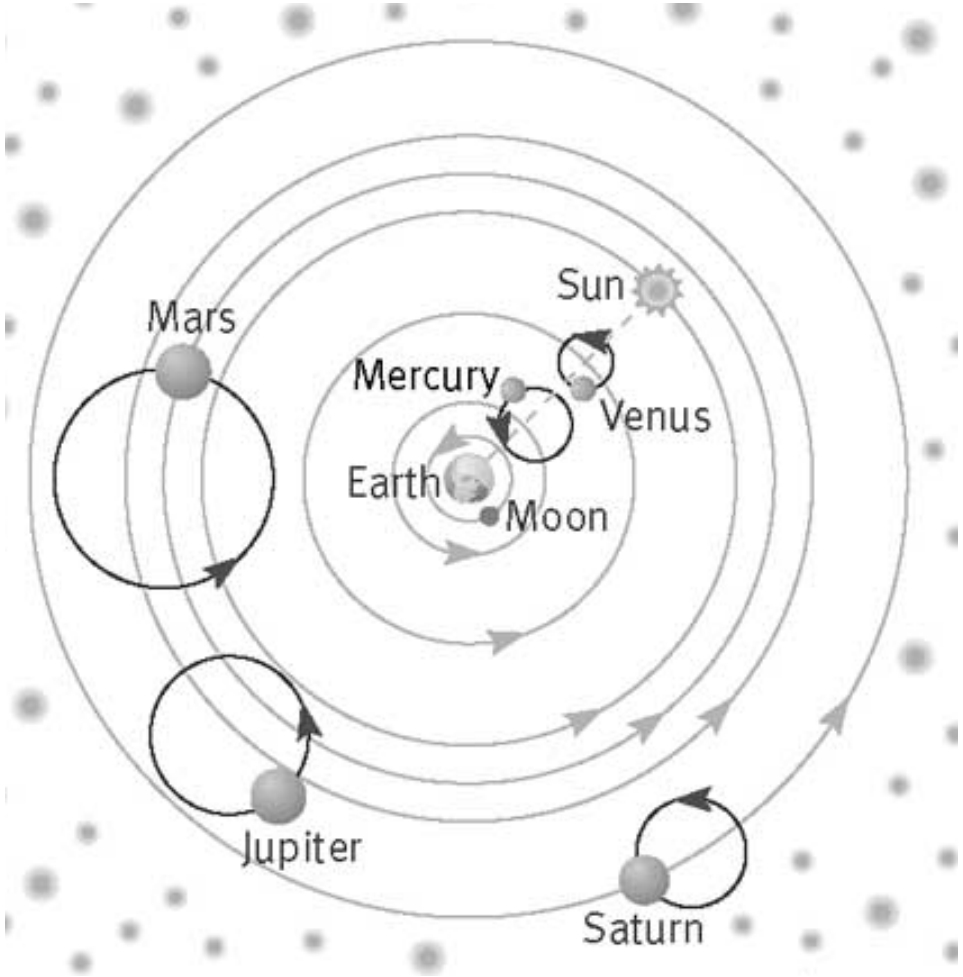
Improvements to Aristotle/Eudoxus

Appolonius of Perga (~20 -190 BCE) : proposed:

1) eccentric orbits (planet goes in circle at const. speed, but Earth was off center)
2) epicycles (planet moves on own circle [epicycle] around a point that travels in another circle [deferent] around E. His model explained
   - variation in brightness of planets
   - changes in angular speed

Ptolemy (AD 100 – c. 170): *Almagest* summarized ancient ideas about solar system. He himself proposed "equant point": eccentric point about which planet moved with *constant angular speed.* Not true uniform circular motion, but explained data better.

Ptolemaic universe (Equant point suppressed)



- Note: this picture puts planets at a distance relative to Earth corresponding to our modern knowledge, but Ptolemaic system did not predict order of planets (or care!)
- Exception: inner planets had to have orbits that kept them between Earth and Sun
- Why epicycles? Not asked.

Clicker quickies

Q1: Ptolemy's model explained *retrograde* motion of the planets. This means that

A. Some planets moved clockwise while others moved counterclockwise along their orbits
B. Some planets moved outside the plane of the ecliptic
C. Some planets were observed to stop in the sky, move apparently backwards along their path, forward again
D. Some planets were so slow they were perceived to be at rest, and mistaken for stars
E. Ptolemy wore old-fashioned clothes

Medieval scientific thought

- Ancient Greek texts rediscovered in West 10th -11th cent. Translation from Greek, Arabic $\rightarrow$ Latin
- Influence of church: growing discomfort with Aristotle's "determinism": *natural* cause$\rightarrow$effect seemed to deny possibility of miracles
- Aristotle said something could not come from nothing -- implied cosmos could not have beginning or end, conflicted with Genesis.
- New interpretations of Aristotle: Bacon (1200s), Aquinas tried to reconcile w/ teachings of church

Reminder of Aristotle's principles of motion

- **Up or down?** some things rose (away from E center; their natural place was inner surface of lunar sphere) because they consisted of light elements (fire,air) – and some fell (towards center of E) because they consisted of heavy ones (earth,water) .

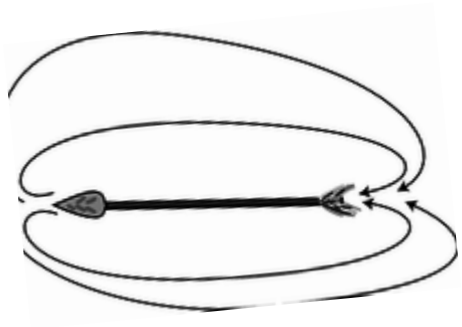
- **Motion after violent action**. Aristotle attributed motive force after arrow left bowstring to air.

- **How fast?** $v \propto F/R$ For falling body F is weight, so object with twice as much weight falls twice as fast through some medium, and if medium is more resistive, bodies fall proportionally slower.

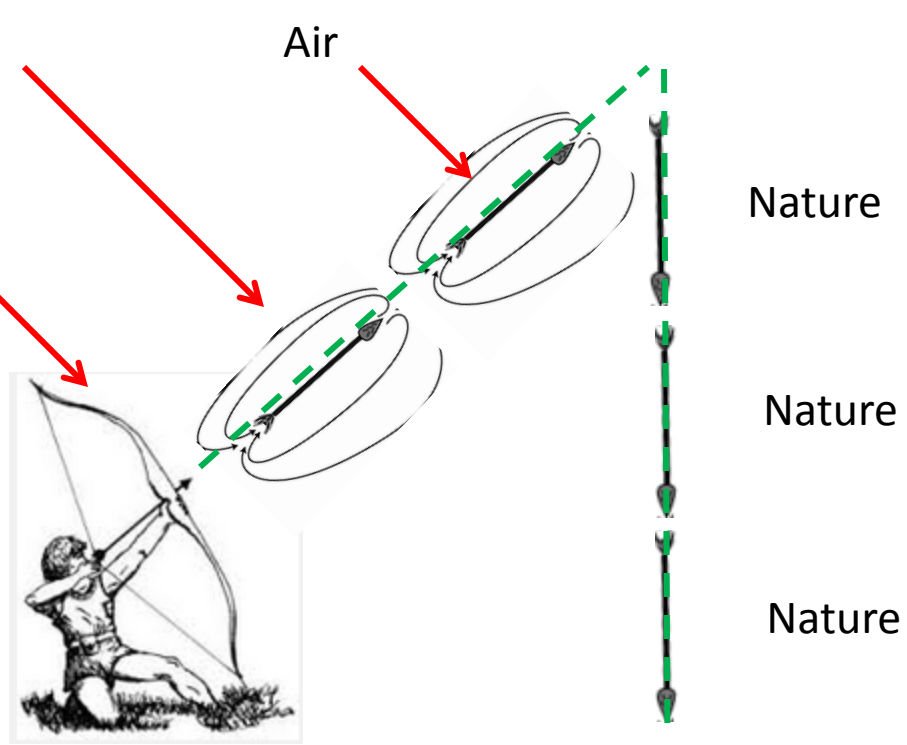
Reminder of Aristotle's principles of motion

Acceleration. Aristotle knew things fell faster each second when they fell, but didn't see to feel the need to explain this. He makes clear in some of his writings that the proportionality of velocity to weight describes some kind of average, or relative speed.

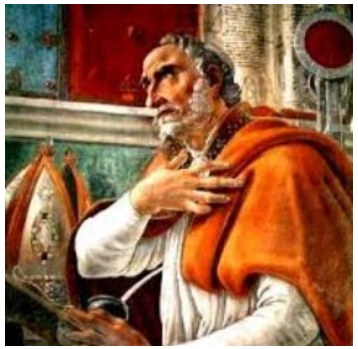
Projectile motion acc. to Aristotle



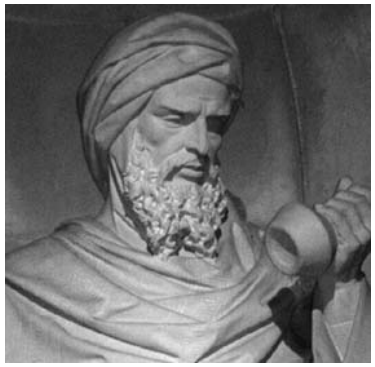
Air is the “mover”



To explain projectile motion (i.e. arrows and cannonballs) Aristotle proposed reverse air-resistance, where the air through which arrow moves passes over it and then closes in on the back of the arrow, pushing it forward, until it will finally just stop. Then the arrow’s nature is to return to earth.

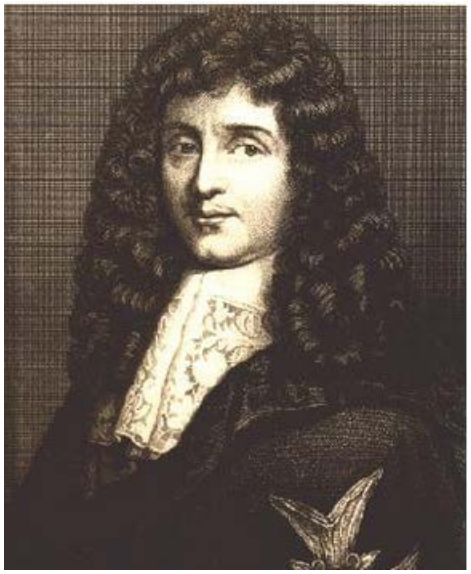


John Philoponus – 6th century Greek philosopher:
bowstring "impressed" force on arrow



Averroes (Ibn Rushd) – 12th century Spanish moor
resistive medium not necessary for motion, served only to retard it!

Avicenna (Ibn Sina) – 11th century Persian physician, philosopher,…:
body capable of receiving *impressed force* ("*mail*")
in proportion to its weight



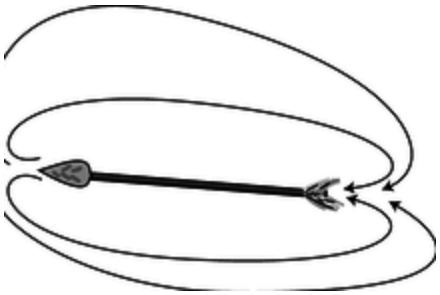
Jean Buridan (Paris, 1300s):

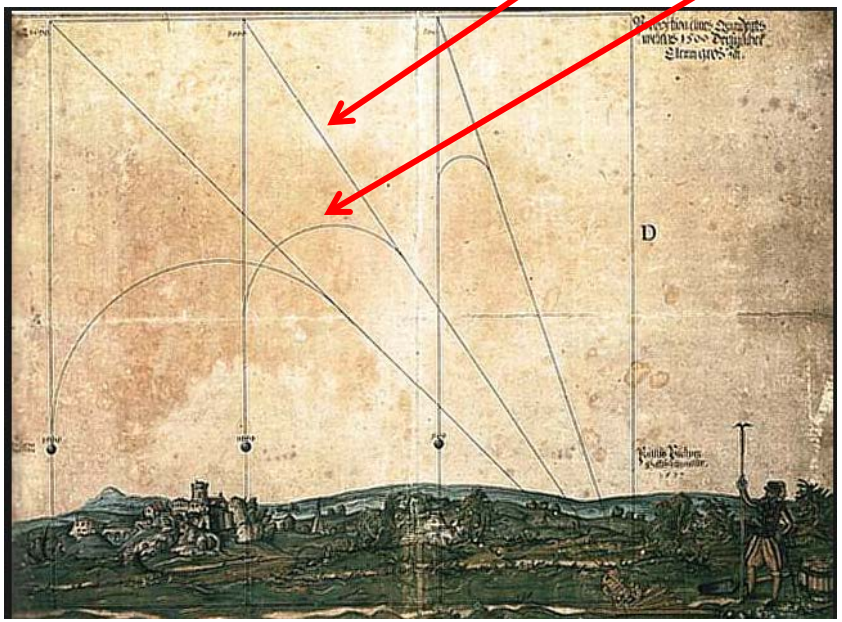
Impressed force (“impetus”) only diminishes if there is a resistance. Remove resistance, get infinite rectalinear motion – inertia!

Projectile motion

Aristotle

Buridan



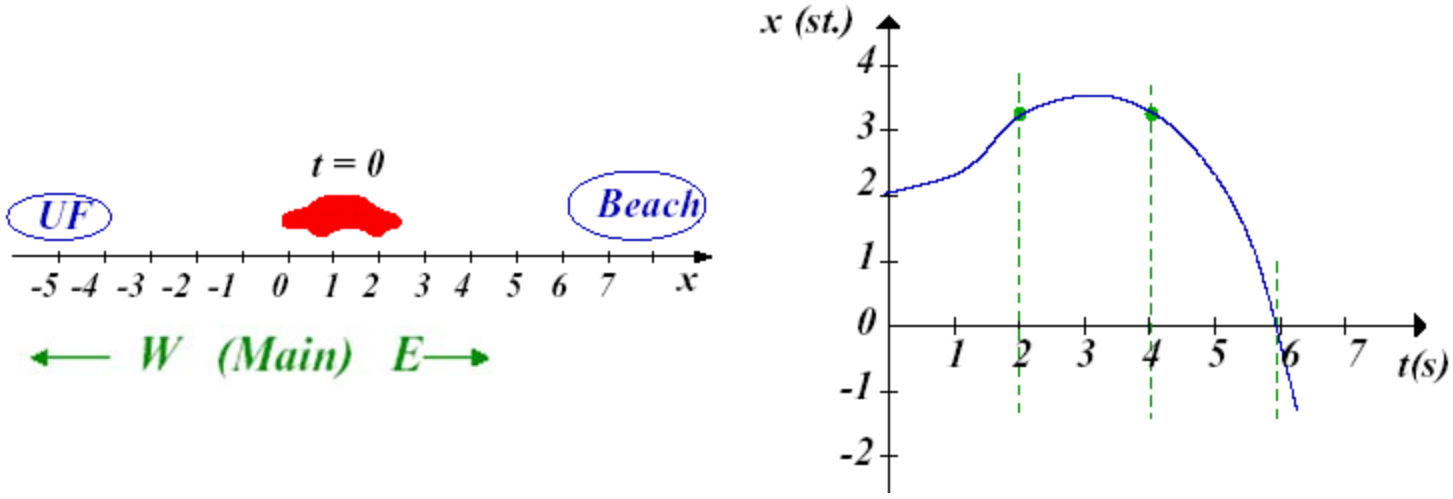


Jean Buridan (1300s) suggested that Aristotle's force ("impetus, or impressed force") diminishes with distance, so motion is slower until resistance wins, then projectile drops straight.

Buridan’s ass

Position of an object

Define the *position* of an object as where it is at some time t relative to some coordinate system.



the position of a car on University Avenue

We sometimes use the word *displacement* to mean the same thing as position.

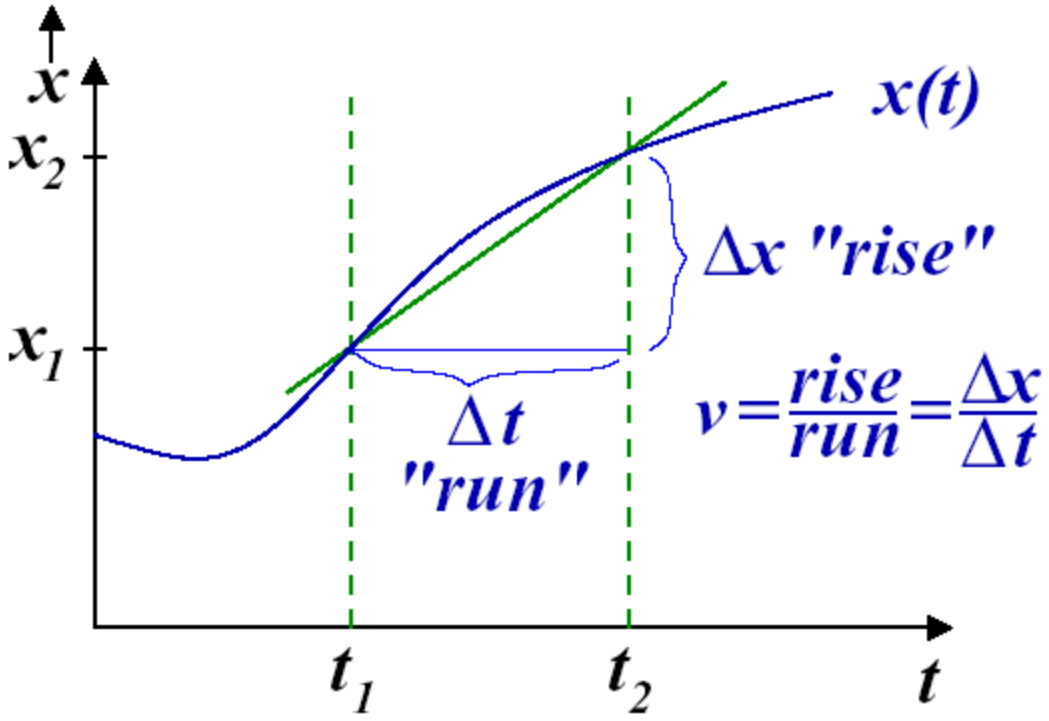
Speed & velocity

Def: Speed–rate of change of object's position. Defined always as *positive* number.

$$\text{speed} = \frac{\text{distance}}{\text{time}}$$

Def: Velocity – rate of change of position in a particular direction. Can be *+/-*.

Def: *average* velocity



$$\text{average } v = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i},$$

(*f* means final and *i* means initial)

Exercise: you drive a pickup truck down a straight road for 5.2 mi at 43 mi/hr, at which point you run out of fuel. You walk 1.2 mi farther, to the nearest gas station, in 27 min (=0.450 h). What is your average velocity?

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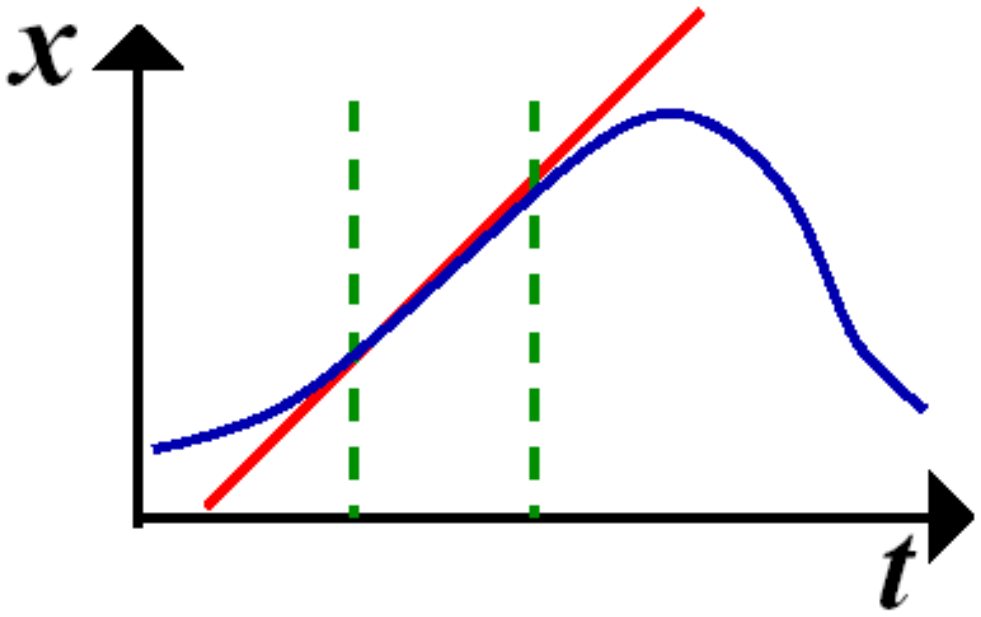
Displacement start to finish $\Delta x = 5.2\text{ mi} + 1.2\text{ mi} = 6.4\text{ mi}$

Total time $\Delta t = \Delta t_{drive} + \Delta t_{walk} = [5.2\text{mi}/(43\text{ mi/h})] + 0.450\text{h}$
$= 0.121\text{h} + 0.450\text{h} = 0.57\text{h}$

Avg. velocity = $\Delta x / \Delta t = 6.4\text{mi}/0.57\text{h} = +11\text{mi/h}$

Instantaneous v: slope of tangent line to x-t curve

If velocity is constant, *average v = instantaneous v*



Quickie

Here's a quick (trick) question to see if you're
getting some of the physicists' definitions before we go on:

Q: If you travel from Gainesville to Miami at 20 mph
and return to Gainesville at 40 mph, what is your average velocity?

A: Zero
B: 30 mph
C: Impossible to say since distances aren’t given.
D: 30 mph south

A: Zero, because

$$\text{average } v = \frac{\Delta x}{\Delta t} = \frac{x_f - x_i}{t_f - t_i},$$

and the total displacement $\Delta x = 0$

(you came back to where you started!).