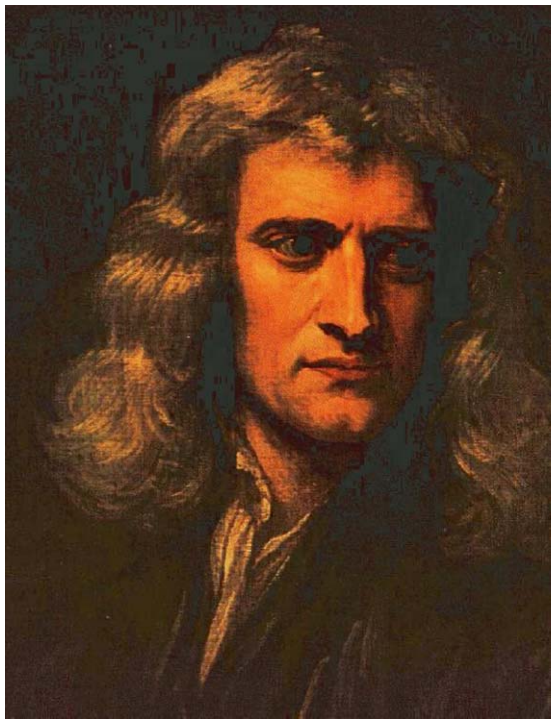
Physics 113 - August 30, 2012

Note Title 1/14/2009



1980's rock star
or
Awesome superstar
of physics ?

What is Science ?

What is science?

A way of looking at and trying to comprehend the world around us.

Same for religion ...
Same for some art ---

What sets science Apart?

Also Scientific Method

Science bows to observation
Science is testable and refutable
Science attempts to minimize Ambiguity

Religion is irrefutable. It is a matter of faith and opinion

What is truth?

Religious truth is whatever the chosen book or prophet says.

Scientific truth does not exist.

We have scientific laws and principles that have withstood many experiments and are generally accepted.

But a single experiment can overthrow or show need for modifying the theory.

The scientific method says nothing about Truth!

How does the mission of science lead to the nature of science?

What is

The Human Experience

in terms of time
Distance
Mass
?

Roughly

- Time 10^{-3} s - 100s of yrs
- Distance 10^{-9} m - 25000 m.
- Mass 10^{-6} g - 100 tons

How does the scales of the human experience compare to what we can see in our universe?

Length:

Distance	Length (m)
Radius of visible universe	1×10^{26}
To Andromeda Galaxy	2×10^{22}
To nearest star	4×10^{16}
Earth to Sun	1.5×10^{11}
Radius of Earth	6.4×10^{6}
Sears Tower	4.5×10^{2}
Football field	1.0×10^{2}
Tall person	2×10^{0}
Thickness of paper	1×10^{-4}
Wavelength of blue light	4×10^{-7}
Diameter of hydrogen atom	1×10^{-10}
Diameter of proton	1×10^{-15}

Time:

Interval	Time (s)
Age of universe	5×10^{17}
Age of Grand Canyon	3×10^{14}
32 years	1×10^{9}
One year	3.2×10^{7}
One hour	3.6×10^{3}
Light travel from Earth to Moon	1.3×10^{0}
One cycle of guitar A string	2×10^{-3}
One cycle of FM radio wave	6×10^{-8}
Lifetime of neutral pi meson	1×10^{-16}
Lifetime of top quark	4×10^{-25}

Mass:

Object	Mass (kg)
Milky Way Galaxy	4×10^{41}
Sun	2×10^{30}
Earth	6×10^{24}
Boeing 747	4×10^{5}
Car	1×10^{3}
Student	7×10^{1}
Dust particle	1×10^{-9}
Top quark	3×10^{-25}
Proton	2×10^{-27}
Electron	9×10^{-31}
Neutrino	1×10^{-38}

The human experience encompasses only a tiny fraction of the

Time/Length/Mass Scales in the Universe

We have likely evolved with biases (physical and mental) that work well for the scales we experience

Eye resolution (y) vs. body height (x)

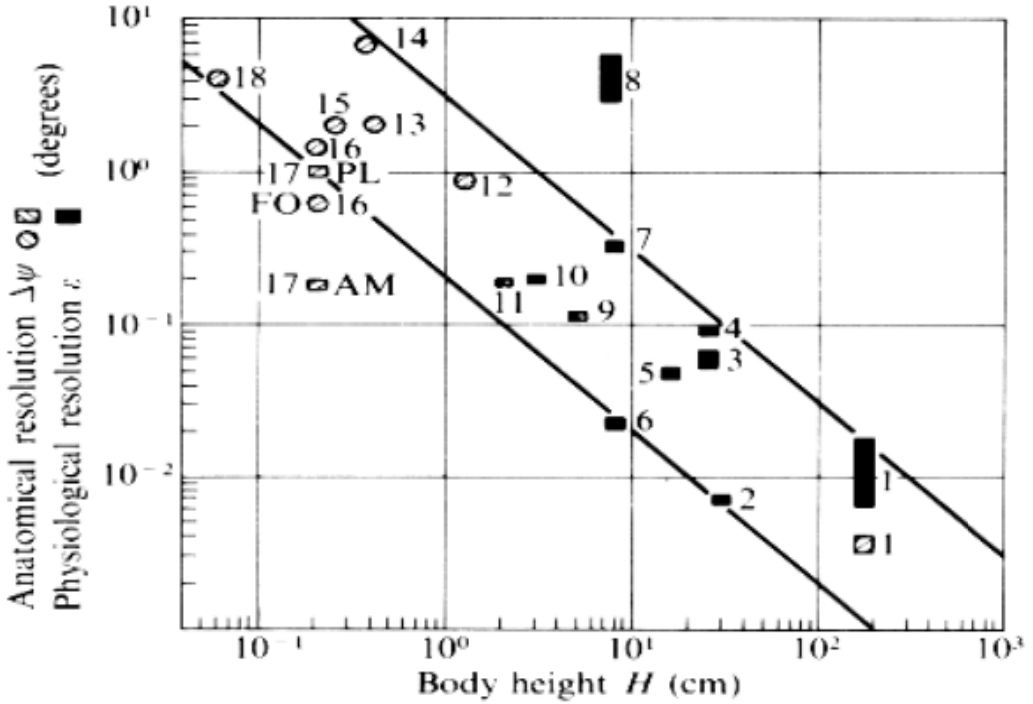


Fig. 2.9. Resolution of the eyes of various animals measured physiologically and deduced from anatomical criteria compared to body height: (1) man; (2) peregrine falcon; (3) hen; (4) cat; (5) pigeon; (6) chaffinch; (7) rat; (8) bat (*Myotis*); (9) frog; (10) lizard; (11) minnow; (12) dragonfly (*Aeschna*); (13) bee (Apis); (14) *Chlorophanus*; (15) housefly (*Musca*); (16) hover fly (*Syrrita*), frontal region FO; (17) jumping spider (*Methaphidippus*), anteromedian eye AM, postero-lateral eye PL; (18) fruit fly, *Drosophila*. (From Kirschfeld 1976.)

Example of place where evolution supplies a bias that fits the scale of the species need/experience

Beware of the "human bias"

You have faulty intuition

You have built in bias that may lead you to expect something that is not, after all, how nature operates

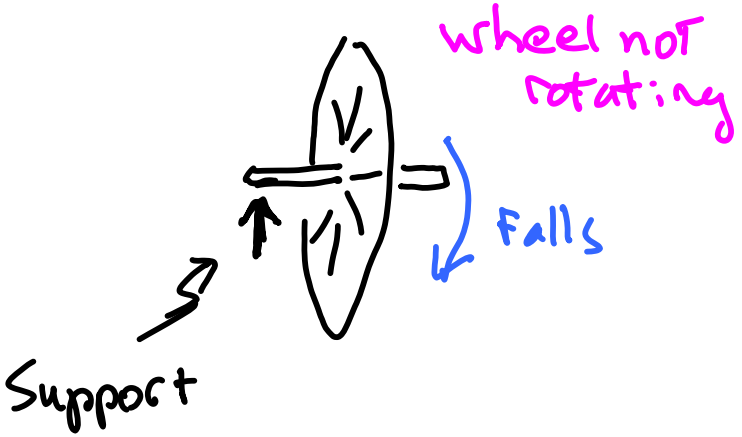
Physics has much of this:

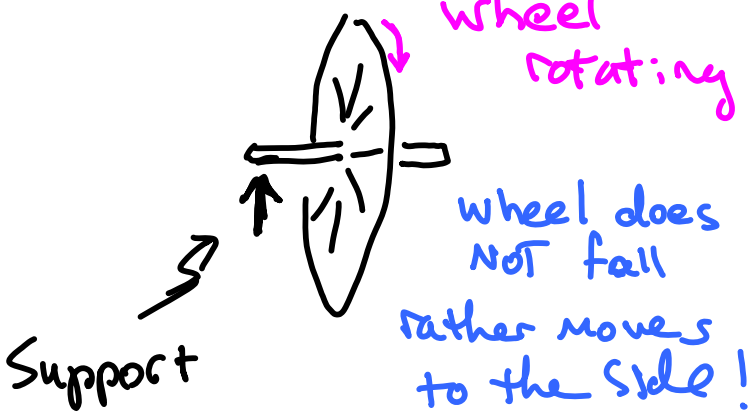
- light is both a wave and a particle
- At large velocities the nature of space and time are not at all what we think intuitively

⋮

If you do careful observations ... even at "human" scales nature has some surprises

bicycle wheel demo





Even at everyday scales physical effects can surprise you.

Physics uses mathematical formalism to avoid such pitfalls. It may see tedious at times ... but is necessary

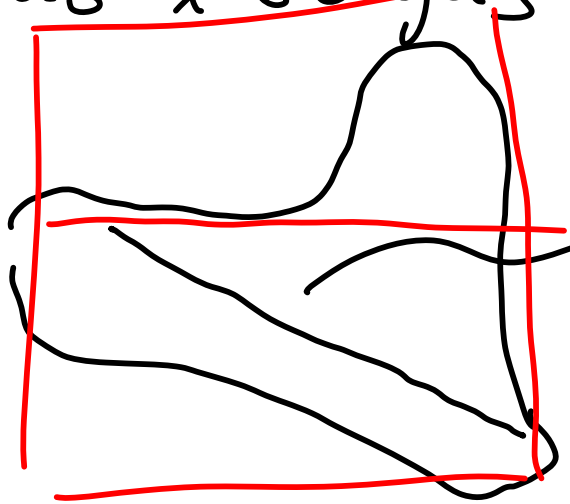
Surprise!

At the same time you must learn to use your common sense to see if what you find is sensible

How many birds are in NY STATE?

10 birds per football field

100 yds x 50 yds



6 hrs at 60 mph → 360 mi

"order of magnitude estimate"

$\left(\frac{1}{2}\right) 360^2 \text{ mi}^2 = 64\,800 \text{ mi}^2$

True → 49,576 mi^2

yard → Mile

$$1 \text{ yard} \times \frac{3 \text{ ft}}{1 \text{ yard}} \times \frac{1 \text{ Mi}}{5280 \text{ feet}} = .0006 \text{ Mi}$$

Football field 100 yd x 50 yd

↳ $.0016 \text{ Mi}^2$

$$\frac{10 \text{ birds}}{.0016 \text{ M}^2} = \frac{X \text{ birds}}{64800 \text{ Mi}^2}$$

405 Million birds