Physics 121 – August 24, 2017

Assignments:

This week:

- Read the syllabus carefully
- Get iclicker (or app), register clicker online
- Register for Expert TA (ETA) online
- Read Chapter 1 of textbook
- Complete ETA Intro assignment and Set #1 (1.1.7, 1.3.1, 1.4.1, 1.4.3, 1.4.16)
- End-of-chapter problems 16, 26, 33, 41, and 88
- Start reading Chapter 2

Note: no 121 labs or recitation meetings this week.
Be ready to hit the ground running next week!

Class demographics:

Choose the appropriate response for your class level

A. Freshman

B. Sophomore

C. Junior

D. Senior

E. Other

Class demographics:

Choose the appropriate response for your math level

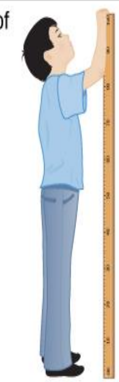
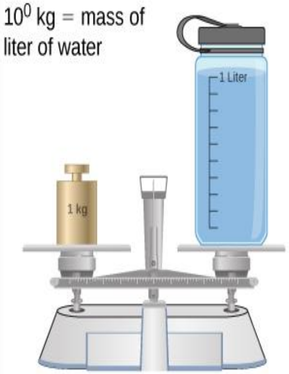
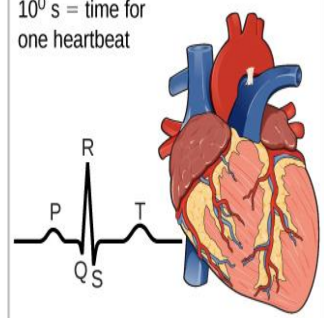
A. Taking Calculus I now

B. Finished with Calc 1

C. Finished with Calc 2

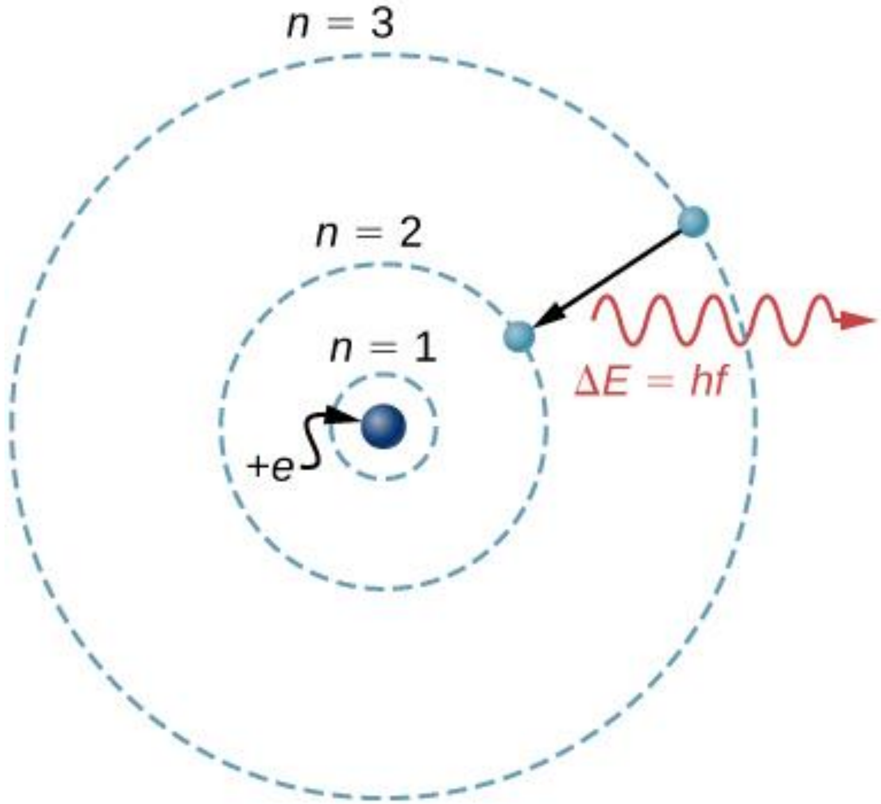
D. Finished with Calc 3

E. Finished with higher than Calc 3

Length in Meters (m)	Masses in Kilograms (kg)	Time in Seconds (s)
10^{-15} m = diameter of proton	10^{-30} kg = mass of electron	10^{-22} s = mean lifetime of very unstable nucleus
10^{-14} m = diameter of large nucleus	10^{-27} kg = mass of proton	10^{-17} s = time for single floating-point operation in a supercomputer
10^{-10} m = diameter of hydrogen atom	10^{-15} kg = mass of bacterium	10^{-15} s = time for one oscillation of visible light
10^{-7} m = diameter of typical virus	10^{-5} kg = mass of mosquito	10^{-13} s = time for one vibration of an atom in a solid
10^{-2} m = pinky fingernail width	10^{-2} kg = mass of hummingbird	10^{-3} s = duration of a nerve impulse
10^{0} m = height of 4 year old child 	10^{0} kg = mass of liter of water 	10^{0} s = time for one heartbeat 
10^{2} m = length of football field	10^{2} kg = mass of person	10^{5} s = one day
10^{7} m = diameter of Earth	10^{19} kg = mass of atmosphere	10^{7} s = one year
10^{13} m = diameter of solar system	10^{22} kg = mass of Moon	10^{9} s = human lifetime
10^{16} m = distance light travels in a year (one light-year)	10^{25} kg = mass of Earth	10^{11} s = recorded human history
10^{21} m = Milky Way diameter	10^{30} kg = mass of Sun	10^{17} s = age of Earth
10^{26} m = distance to edge of observable universe	10^{53} kg = upper limit on mass of known universe	10^{18} s = age of the universe

We might need this for later….

FIGURE 1.6



What is a model? The Bohr model of a single-electron atom shows the electron orbiting the nucleus in one of several possible circular orbits. Like all models, it captures some, but not all, aspects of the physical system.

The book has a pretty interesting discussion of theories and laws

A **theory** is a testable explanation for patterns in nature, supported by scientific evidence and verified multiple times by various groups of researchers.

A **law** uses concise language (or a mathematical equation) to describe a generalized pattern in nature, supported by scientific evidence and repeated experiments. Similar to a theory, but a law is more specific to a single process, whereas a theory explains a broader class of related phenomena.

IMPORTANT: Laws can never be known with absolute certainty because it is impossible to perform every imaginable experiment to confirm a law for every possible scenario. Physicists operate under the assumption that all scientific laws and theories are valid until a counterexample is observed. If a good-quality, verifiable experiment contradicts a well-established law or theory, then the law or theory must be modified or overthrown completely.

Base units, derived units, metric prefixes, and unit conversions

1. **Base units**

ISQ Base Quantity	SI Base Unit
Length	meter (m)
Mass	kilogram (kg)
Time	second (s)
Electrical current	ampere (A)
Thermodynamic temperature	kelvin (K)
Amount of substance	mole (mol)
Luminous intensity	candela (cd)

Table 1.1 ISQ Base Quantities and Their SI Units

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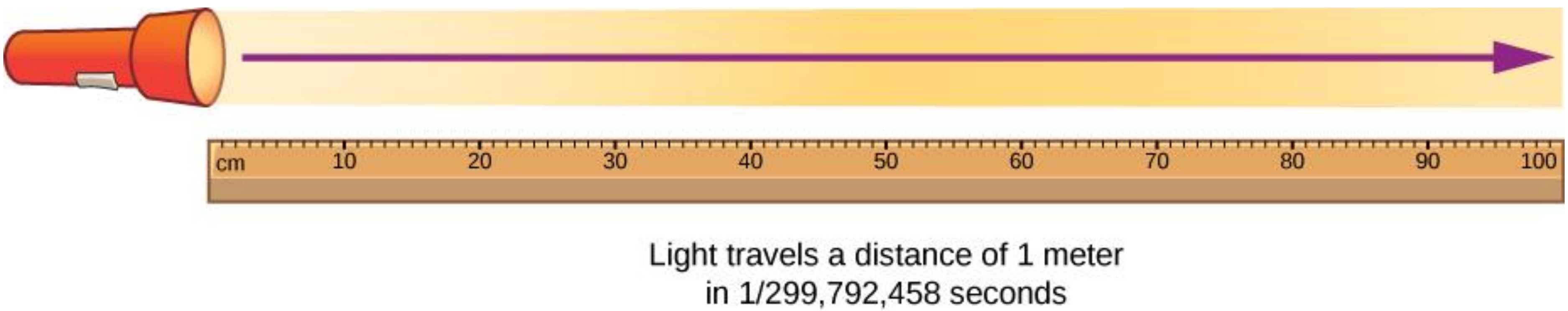
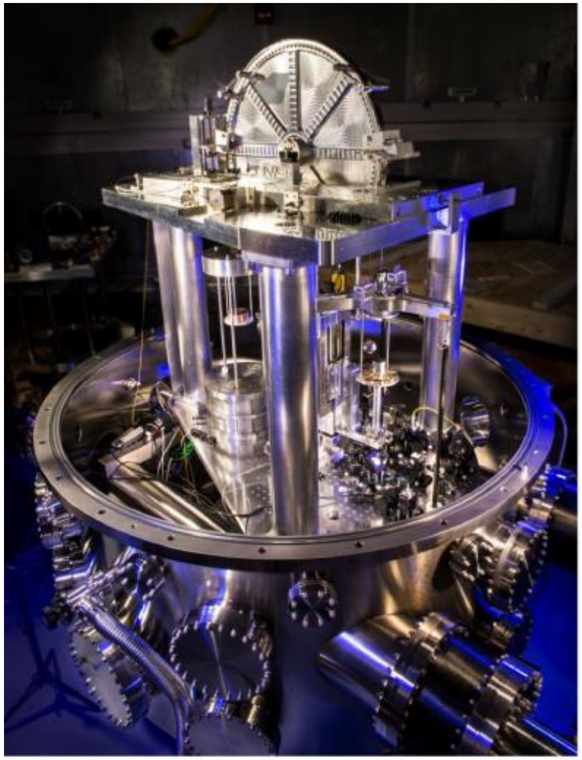
FIGURE 1.9



The meter is defined to be the distance light travels in 1/299,792,458 of a second in a vacuum. Distance traveled is speed multiplied by time.

FIGURE 1.10



(a)

(b)

Redefining the SI unit of mass. Complementary methods are being investigated for use in an upcoming redefinition of the SI unit of mass.

(a) The U.S. National Institute of Standards and Technology’s watt balance is a machine that balances the weight of a test mass against the current and voltage (the “watt”) produced by a strong system of magnets.

(b) The International Avogadro Project is working to redefine the kilogram based on the dimensions, mass, and other known properties of a silicon sphere. (credit a and credit b: National Institute of Standards and Technology)

FIGURE 1.8

An atomic clock such as this one uses the vibrations of cesium atoms to keep time to a precision of better than a microsecond per year. The fundamental unit of time, the second, is based on such clocks. This image looks down from the top of an atomic fountain nearly 30 feet tall. (credit: Steve Jurvetson)

Base units, derived units, metric prefixes, and unit conversions

2. Derived units

Derived units are generally some combination of products and quotients involving powers of the base units.

e.g. unit for force is a Newton (N) where 1 N = 1 kg m s^{-2}

Also can have combinations of other derived units

e.g. unit for pressure is a Pascal (Pa) where 1 Pa = 1 N m^{-2}
(but note we can ultimately express this in terms of base units)

Base units, derived units, metric prefixes, and unit conversions

3. Metric prefixes

Metric Prefixes

SI units are part of the **metric system**, which is convenient for scientific and engineering calculations because the units are categorized by factors of 10. Table 1.2 lists the metric prefixes and symbols used to denote various factors of 10 in SI units. For example, a centimeter is one-hundredth of a meter (in symbols, 1 cm = 10^{-2} m) and a kilometer is a thousand meters (1 km = 10^{3} m). Similarly, a megagram is a million grams (1 Mg = 10^{6} g), a nanosecond is a billionth of a second (1 ns = 10^{-9} s), and a terameter is a trillion meters (1 Tm = 10^{12} m).

Prefix	Symbol	Meaning	Prefix	Symbol	Meaning
yotta-	Y	10^{24}	yocto-	y	10^{-24}
zetta-	Z	10^{21}	zepto-	z	10^{-21}
exa-	E	10^{18}	atto-	a	10^{-18}
peta-	P	10^{15}	femto-	f	10^{-15}
tera-	T	10^{12}	pico-	p	10^{-12}
giga-	G	10^{9}	nano-	n	10^{-9}
mega-	M	10^{6}	micro-	μ	10^{-6}
kilo-	k	10^{3}	milli-	m	10^{-3}
hecto-	h	10^{2}	centi-	c	10^{-2}
deka-	da	10^{1}	deci-	d	10^{-1}

Table 1.2 Metric Prefixes for Powers of 10 and Their Symbols

The only rule when using metric prefixes is that you cannot "double them up." For example, if you have measurements in petameters (1 Pm = 10^{15} m), it is not proper to talk about megagigameters, although $10^{6} \times 10^{9} = 10^{15}$. In practice, the

Base units, derived units, metric prefixes, and unit conversions

4. Unit conversions

Multiply by one

To convert from “English” to SI, you will need to know:

1 m = 3.28 feet
1 km = 0.621 miles
1 kg is “equivalent” to 2.2 pounds

Also it’s good to remember 60 s = 1 minute, 3,600 s = 1 hour, etc.

Scale analysis is an important skill

Base Quantity	Symbol for Dimension
Length	L
Mass	M
Time	T
Current	I
Thermodynamic temperature	Θ
Amount of substance	N
Luminous intensity	J

Table 1.3 Base Quantities and Their Dimensions

Physicists often use square brackets around the symbol for a physical quantity to represent the dimensions of that quantity. For example, if r is the radius of a cylinder and h is its height, then we write $[r] = \mathrm{L}$ and $[h] = \mathrm{L}$ to indicate the dimensions of the radius and height are both those of length, or L. Similarly, if we use the symbol A for the surface area of