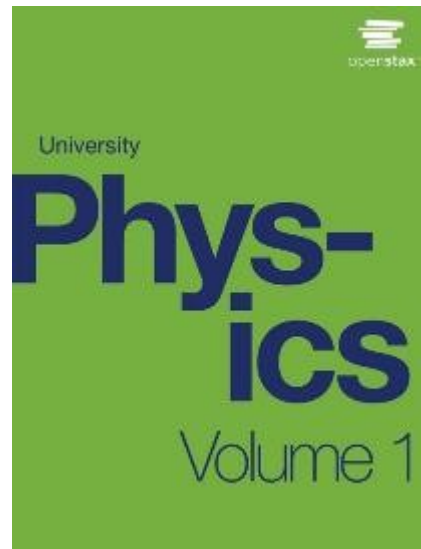


# UNIVERSITY PHYSICS

## Chapter 1 UNITS AND MEASUREMENT

PowerPoint Image Slideshow



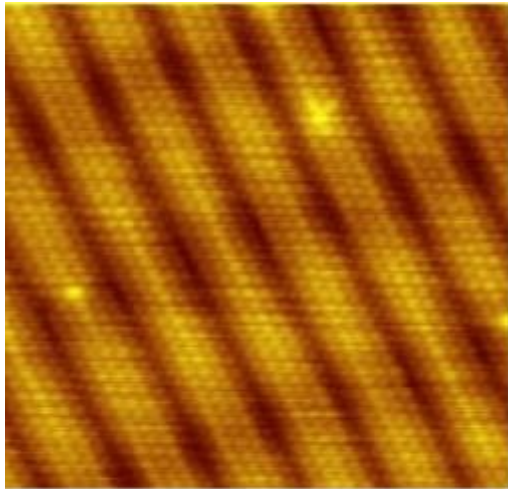
# Scales

## FIGURE 1.1

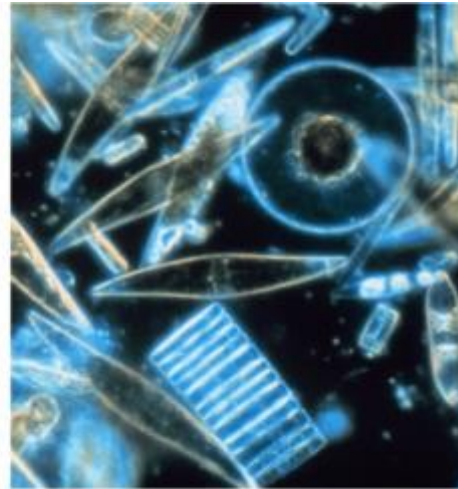


This image might be showing any number of things. It might be a whirlpool in a tank of water or perhaps a collage of paint and shiny beads done for art class. Without knowing the size of the object in units we all recognize, such as meters or inches, it is difficult to know what we're looking at. In fact, this image shows the Whirlpool Galaxy (and its companion galaxy), which is about 60,000 light-years in diameter (about  $6 \times 10^{17}$  km across). (credit: S. Beckwith (STScI) Hubble Heritage Team, (STScI/AURA), ESA, NASA)

# FIGURE 1.3



(a)





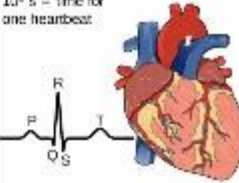
(b)



(c)

- a) Using a scanning tunneling microscope, scientists can see the individual atoms (diameters around  $10^{-10}$  m) that compose this sheet of gold.
- b) Tiny phytoplankton swim among crystals of ice in the Antarctic Sea. They range from a few micrometers ( $1 \mu\text{m}$  is  $10^{-6}$  m) to as much as 2 mm ( $1 \text{mm}$  is  $10^{-2}$  m) in length.
- c) These two colliding galaxies, known as NGC 4676A (right) and NGC 4676B (left), are nicknamed “The Mice” because of the tail of gas emanating from each one. They are located 300 million light-years from Earth in the constellation Coma Berenices. Eventually, these two galaxies will merge into one. (credit a: modification of work by Erwinrossen; credit b: modification of work by Prof. Gordon T. Taylor, Stony Brook University; NOAA Corps Collections; credit c: modification of work by NASA, H. Ford (JHU), G. Illingworth (UCSC/LO), M. Clampin (STScI), G. Hartig (STScI), the ACS Science Team, and ESA)

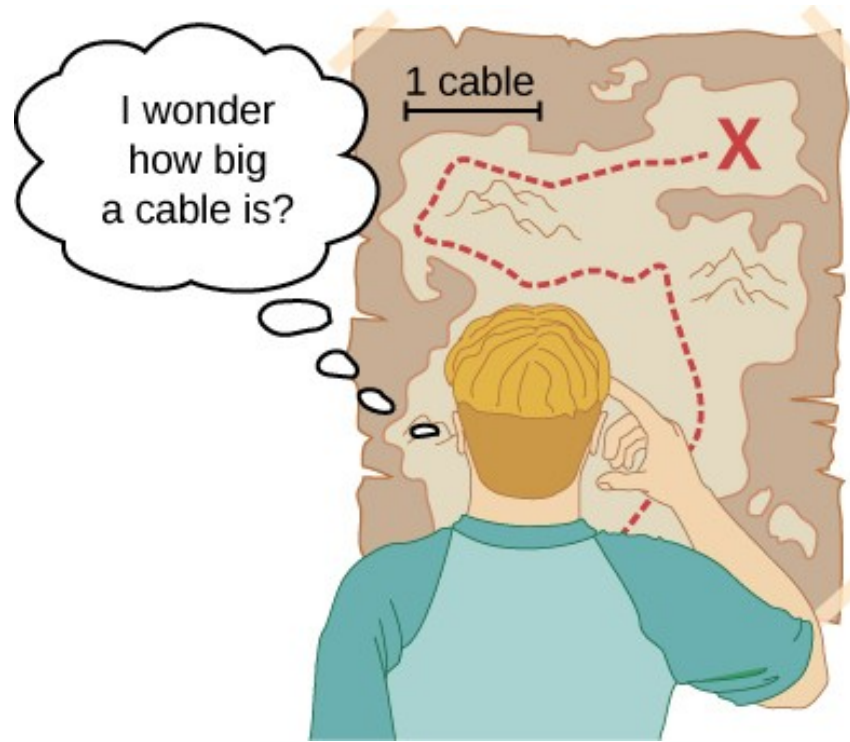
# FIGURE 1.4

Length in Meters (m)	Masses in Kilograms (kg)	Time in Seconds (s)
$10^{-16}$ 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	$10^{-22}$ 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	$10^{-12}$ s – time for one vibration of an atom in a solid
$10^{-2}$ m – pinky fingernail width	$10^{-2}$ kg – mass of hummingbird	$10^{-2}$ 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	$10^{12}$ kg – mass of atmosphere	$10^7$ s – one year
$10^{13}$ m – diameter of solar system	$10^{22}$ kg – mass of Moon	$10^8$ 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

This table shows the orders of magnitude of length, mass, and time.

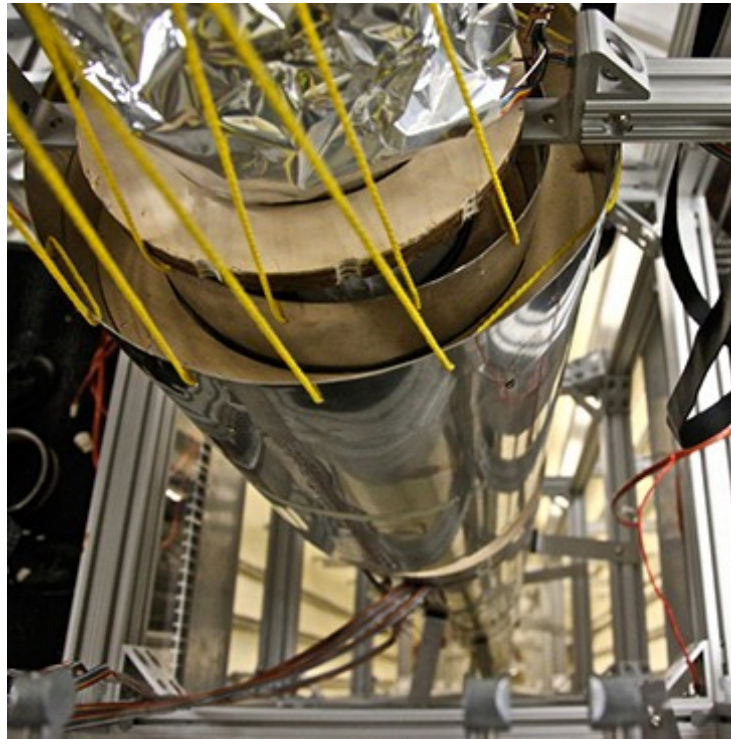
# Units

## FIGURE 1.7



Distances given in unknown units are maddeningly useless.

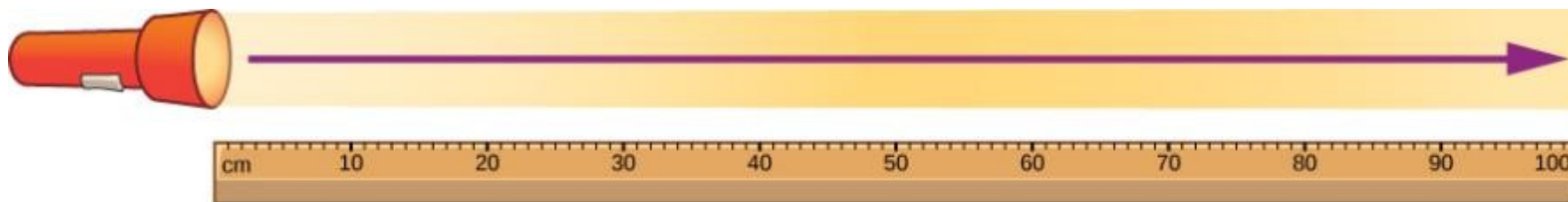
## FIGURE 1.8



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)



## FIGURE 1.9



Light travels a distance of 1 meter  
in  $1/299,792,458$  of a second

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)



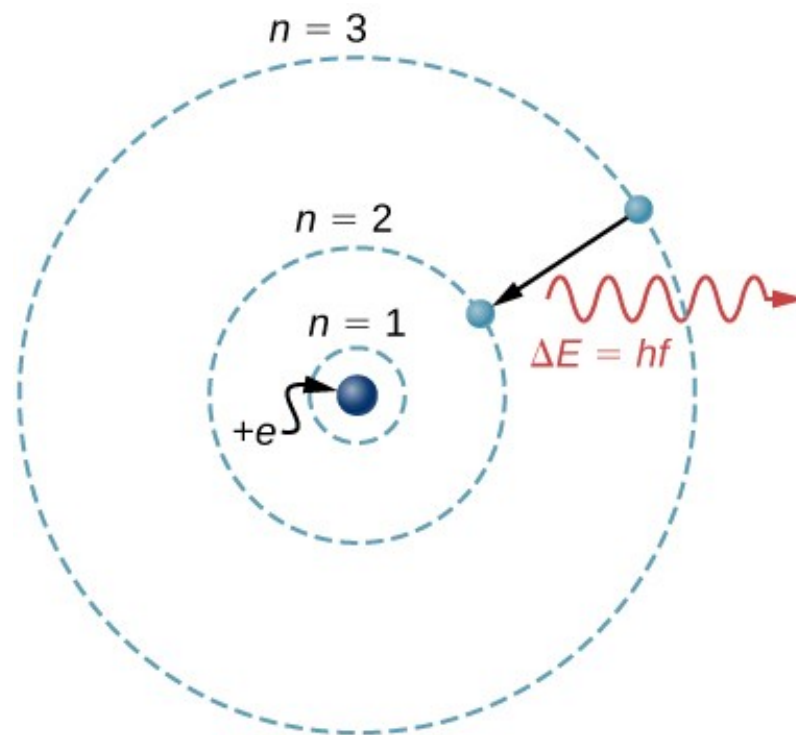
(b)

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)

# Models

## 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.

# **Accuracy vs precision**

## FIGURE 1.12



(a) High accuracy, low precision



(b) Low accuracy, high precision

A GPS attempts to locate a restaurant at the center of the bull's-eye. The black dots represent each attempt to pinpoint the location of the restaurant.

- a) The dots are spread out quite far apart from one another, indicating low precision, but they are each rather close to the actual location of the restaurant, indicating high accuracy.
- b) The dots are concentrated rather closely to one another, indicating high precision, but they are rather far away from the actual location of the restaurant, indicating low accuracy. (credit a and credit b: modification of works by Dark Evil)



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