Section 2: Tools of Physics

The following maps the videos in this section to the Texas Essential Knowledge and Skills for Physics TAC §112.39(c).

2.01 Laboratory Safety

- Physics (1)(A)
- Physics (1)(B)
- Physics (2)(F)
- Physics (2)(G)

2.02 Measurement and Error

- Physics (2)(H)
- Physics (2)(I)

2.03 The International System of Units

- Physics (2)(H)

2.04 Graphing Techniques for Graphing and Reporting Data

- Physics (2)(J)
- Physics (2)(K)
- Physics (2)(L)

2.05 Vectors and Trigonometry

- Physics (3)(F)

Note: Unless stated otherwise, any sample data is fictitious and used solely for the purpose of instruction.

2.01
Laboratory Safety

General Guidelines

- Report all accidents, injuries, and broken glass or equipment to your teacher immediately.
- Keep pathways clear. If you have a book bag, place it under your table or on a shelf away from the lab area.
- If you have long hair, tie it back to avoid any accidents.
- Wear closed-toe shoes.
- Secure any loose clothing.
- Read experiment documents completely *before* beginning an experiment.
- Wear safety goggles when necessary.
- Never point a heated test tube at another student. Never look into a test tube while it is being heated.
- Do not perform unauthorized experiments.
- Leave your workstation clean and organized.
- Do not sit on the laboratory tables.
- Know the location of the fire extinguisher, eye wash station, first aid kit, and safety shower.
- Do not eat or drink in the lab at any time.
- Dispose of any waste from experiments in the areas designated by your teacher.

2.02
Measurement and Error

Accuracy and Precision

- ***Accuracy*** – The _____ of a measured value to a standard or known value, representing how true a measurement is
- ***Precision*** – The closeness of _____ measurements to one another, representing how good an experiment is at replicating the same measurement

1. Suppose the Mars candy company collects the following data to check whether the weights of individual Snickers bars fit the company's manufacturing specifications. If the accepted value of a Snickers bar is 60 g, state whether the manufacturing process is accurate, precise, or neither.

Candy Bar Sample	Weight (g)
1	59.5
2	61.0
3	60.2
4	59.8
5	60.2
6	59.9

2. Suppose Mars decides to perform the assessment from the previous question again on a different day and collects the following data. State whether the manufacturing process is accurate, precise, or neither.

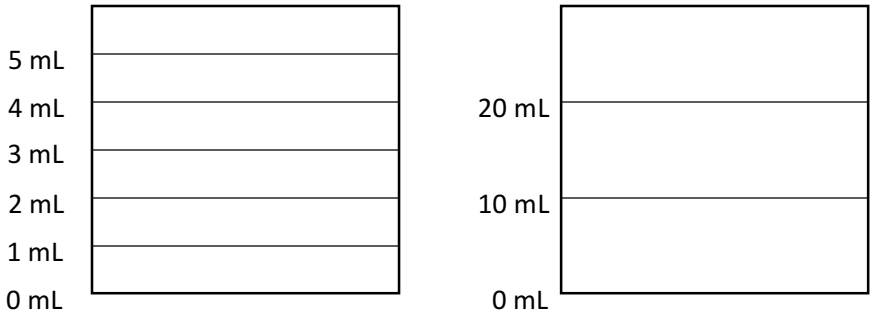
Candy Bar Sample	Weight (g)
1	57.2
2	57.3
3	56.8
4	56.9
5	57.1
6	57.0

Significant Digits

- To indicate the precision of a certain measurement, we refer to the number of ***significant digits*** of that measurement.
- The smallest unit on a measuring tool determines the number of significant digits a measurement will have.

Example:

- Suppose we wish to measure the volume of a liquid using the two measuring devices below.



- The container on the right reads only to the tens place, whereas the device on the left reads to the ones place.
- One can estimate only to the nearest _____ for the container on the right and to the nearest _____ for the container on the left.
- The following are rules for determining the significance of a digit:
  1. All nonzero digits are significant.
  2. Final zeros after a decimal point are significant.
  3. Zeros between two significant digits are significant.
  4. Zeros used *only* as placeholders are not significant.

1. For each of the measurements below, state how many significant digits there are.
   i. 7.0 L
   ii. 12.80 kg
   iii. 0.000450 g
   iv. 120 s
   v. 144.30 m

2.03
The International System of Units

- The ***International System of Units*** (SI) is the most widely accepted system of measurement in science.
- SI is based on seven ***base units***, which are used to derive all other units of measurement.
- SI is sometimes referred to as the ***MKS system***, which stands for meters, kilograms, and seconds.
- The table below lists the seven base units and their symbols:

SI Unit Name	SI Unit Symbol	Quantity Name
meter	m	length
kilogram	kg	mass
second	s	time
ampere	A	electric current
kelvin	K	temperature
mole	mol	amount of substance
candela	cd	luminous intensity

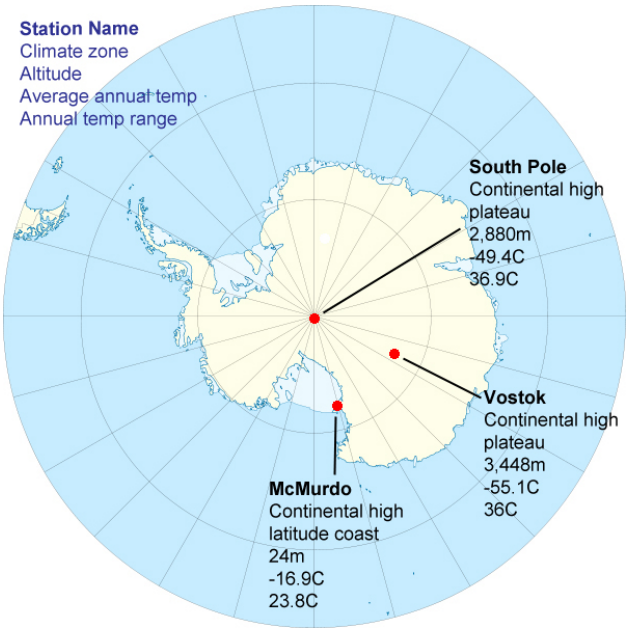
- SI also includes twenty prefixes for each unit that are helpful in describing large multiples or small fractions of a given unit:

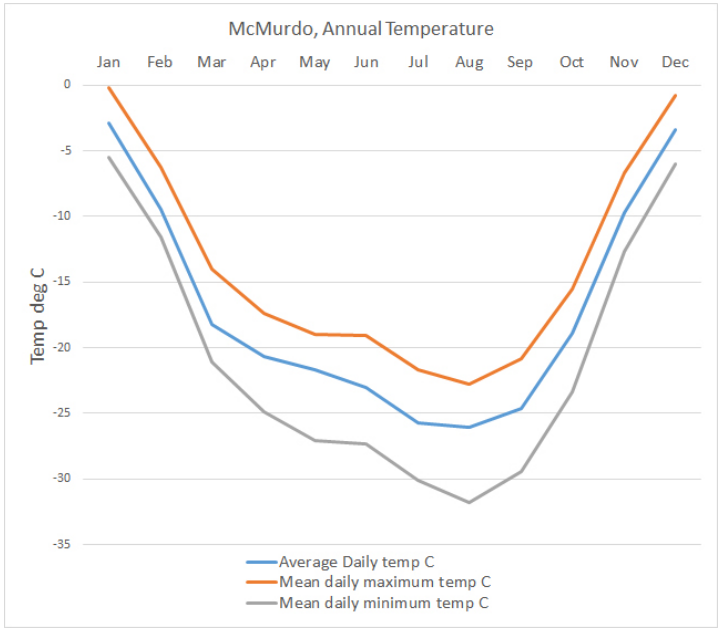
Prefix	Prefix Symbol	Factor	Prefix	Prefix Symbol	Factor
deca-	da	10^{1}	deci-	d	10^{-1}
hecto-	h	10^{2}	centi-	c	10^{-2}
kilo-	k	10^{3}	milli-	m	10^{-3}
mega-	M	10^{6}	micro-	μ	10^{-6}
giga-	G	10^{9}	nano-	n	10^{-9}
tera-	T	10^{12}	pico-	p	10^{-12}
peta-	P	10^{15}	femto-	f	10^{-15}
exa-	E	10^{18}	atto-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

2.04
Techniques for Graphing and Reporting Data

- When solving problems in physics, it is common to draw a free-body diagram, which summarizes all forces acting on an object using vectors on a set of x- and y-axes.
- It is also customary to plot quantities of interest with respect to time.

- Scientists use several tools to help organize the results of their experiments and communicate their findings with the rest of the world.
- Some of these tools are
  - data tables
  - graphs
  - lab reports
  - journal papers
  - labeled drawings
- Here are some examples:





Cool Antarctica. (n.d.). Retrieved from http://www.coolantarctica.com/Antarctica%20fact%20file/antarctica%20environment/vostok_south_pole_mcmurdo.php

1. The following table shows the relationship between the mass of an object hanging vertically from a spring and the displacement of the end of the spring. Draw a graph of the data on a set of axes, label each axis, and state the relationship between the two quantities.

Mass (kg)	Displacement (cm)
20	3
40	6
60	9
80	12

2.05
Vectors and Trigonometry

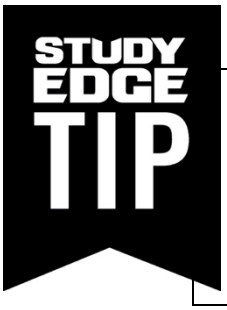
- A ***vector*** is a quantity that possesses both magnitude and direction.
- Vectors help scientists and engineers keep track of several measurements simultaneously.
- A common use for vectors in physics is keeping track of measurements in two and/or three dimensions.
- The following are all acceptable ways of expressing vector measurements in two dimensions:
  - $a\,\hat{\imath} + b\hat{\jmath}$
  - $a\,\hat{x} + b\hat{y}$
  - $\langle a, b \rangle$
  - Magnitude and angle
- Trigonometry is useful for relating the sides of a right triangle to its angles.
  - The Greek letter θ (theta) is typically used to represent an angle.
  - Other common Greek letters for angles include α, β, γ, and ϕ.
  - Angles are typically measured in either ***degrees*** or ***radians***.
- There are three primary trigonometric functions that are useful in the study of physics: sine, cosine, and tangent.
- Each of these trigonometric functions represents a ratio of two sides of a right triangle.
- A common mnemonic device for memorizing the relationships is "SohCahToa."

$$\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}} = \frac{o}{h}$$

$$\cos\theta = \frac{\text{adjacent}}{\text{hypotenuse}} = \frac{a}{h}$$

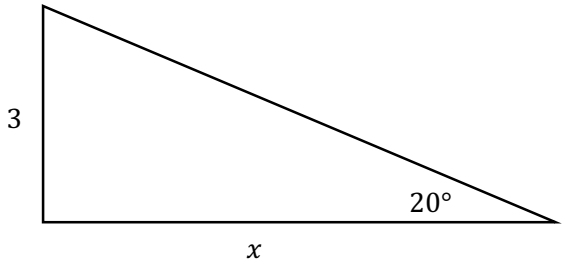
$$\tan\theta = \frac{\text{opposite}}{\text{adjacent}} = \frac{o}{a}$$

- These relationships are especially useful for finding the value of an unknown angle or side.
- Use a scientific calculator to help solve trigonometry problems.



Many scientific calculators give the option of computing with degrees or radians. Before typing in any numbers, make sure that your calculator is set appropriately.

1. Given the right triangle below, solve for x.



2. Given $\sin\theta = 0.8$ and the right triangle below, find y.