Advanced Physics
Mr. LeBlanc
Summer Assignment

Objective: Review/learn required math concepts for the course. Also complete the first introductory chapter of the course.

This includes the following PDFs that are attached:

- Advanced Physics Chapter 1
- General Trig

For Advanced Physics Chapter 1 you must complete the following:

- Examples
- Assignments 1.4-1.7

For General Trig you must complete the following:

- Read/complete the notes
- Homework 4

Please let me know if you have any questions or problems with the content. Feel free to use resources to help you understand the content but make sure you fully understand how to solve the problems yourself. You will be tested on this content in the first week of the course, therefore you will be graded on completion for this assignment.

All of this content will be due August 28th, 2026.

Chapter 1 Notes

Advanced Physics

1 Introduction, Measurement, Estimating

1.1 The Nature of Science

Physics is the most basic of the sciences. It deals with the behavior and structure of matter and it is broken down into several categories. The most common two categories are:

- Classical Physics: motion, fluids, heat, sound, light, etc.
- Modern Physics: relativity, nuclear physics, elementary particles, astrophysics, etc.

Note 1. In this course we will be focusing on Classical Physics and its relationship to engineering.

Who is the father of Classical Physics? what about Modern Physics?

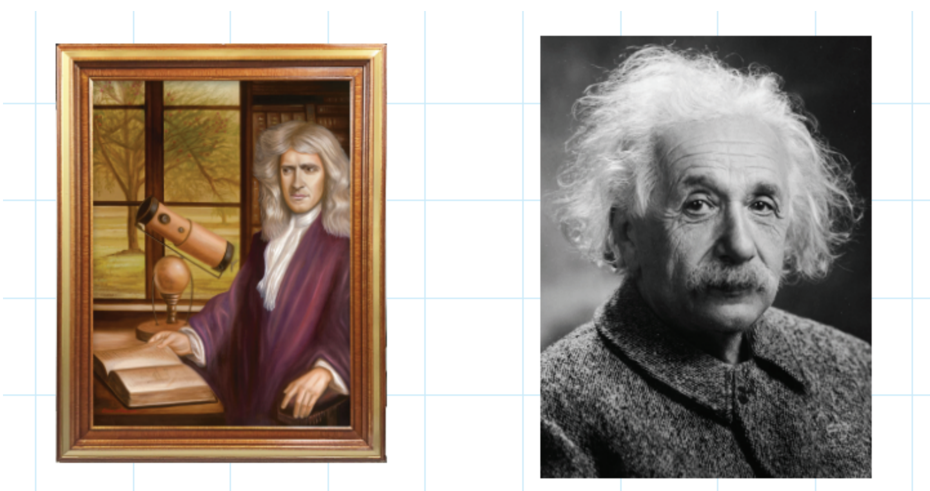


Figure 1: One is the father of Classical Physics the other is the father of Modern Physics

Science: A natural philosophy of unanswered questions about nature. They can be broken into:

- Life Sciences
- Physical Sciences

Figure 2: Biology, Botany, Zoology, Geology, Physics, Chemistry

Science is knowledge that is acquired and tested using a systematic procedure, this procedure is known as the **Scientific Method** (Galileo Galilei and Francis Bacon).

The **Scientific Method**

- Recognize a problem
- Make an educated guess - a hypothesis - about the answer
- Predict the consequences of the hypothesis
- Perform experiments to test predictions
- Formulate the simplest general rule that organizes the main ingredients: hypothesis, prediction, and experimental outcome.

Now lets define some of the terms we will be using this year:

- **Observation**: information that is known because it has been seen or experienced directly.
- **Inference**: a conclusion based upon known information or observations.
- **Hypothesis**: a possible solution of explanation for a problem or question that is based on observations.

- **Theory**: a hypothesis that has been tested many times and still explains the observations

In science there are plenty of theories that have changed throughout history as new information is gained.

Example 1: Horizontal Motion

- Aristotle (384-322 BC): natural state of object is at rest
- Galileo (1564-1642): motion would continue without friction

Example 2: Universe

- Ptolomy (100-170): geo-centric universe
- Copernicus (1473-1543): sun-centric universe

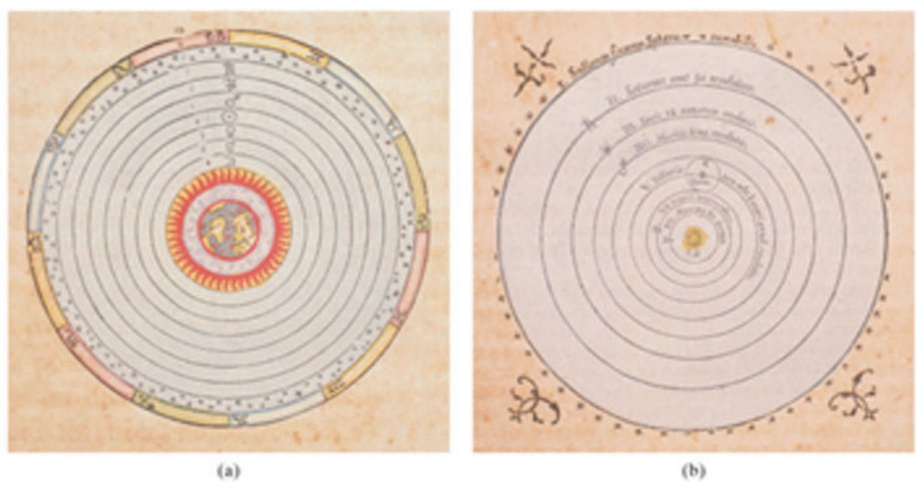


Figure 3: geo-centric vs. sun-centric universe

1.2 Physics and its Relation to Other Fields

Physics: the nature of basic things such as motion, forces, energy, matter, heat, sound, light, and the composition of atoms.

- Chemistry comes from Physics
- Biology comes from Chemistry
- The ideas of Physics are fundamental to these more complicated sciences.

Physics is used in many fields. What are some examples?

1.3 Models, Theories and Laws

Model: an analogy or mental image of the phenomena in terms of something else we are already familiar with. This is the definition that the textbook gives. A better way to say this is:

- A simplified description, especially a mathematical one, or a system or process to assist calculations and predictions.
- "All models are wrong, but some are useful"

Here are two models that an engineer/physicist might use to understand the movement of an object. We will be using models to describe objects so that we can apply equations to them to understand many different situations.

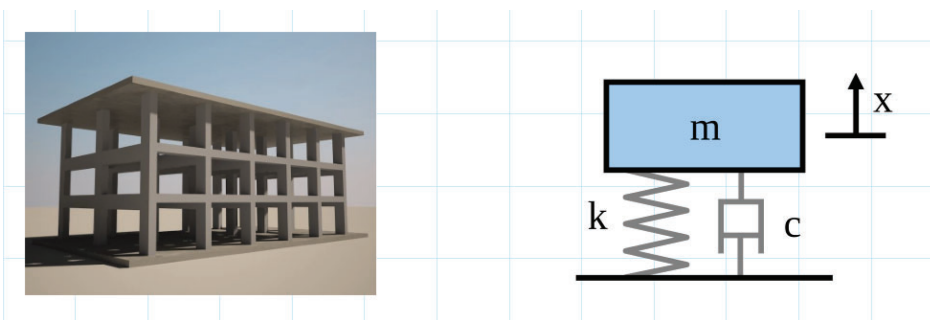


Figure 4: A CAD model and a Spring-Mass-Damper System

When might a scientist use a model?

Give an example of a model?

Theory: a broad detailed description of a phenomena that can give quantitatively testable predictions with great precision.

- Theory of Relativity
- Atomic Theory

Laws: concise but general statements about how nature behaves. Sometimes the statement takes the form of a relationship or equation between quantities. Must be found experimentally valid over a wide range of observed phenomena.

- Newton's Laws
- Conservation of Energy
- Conservation of Momentum

Principle: also known as an axiom. A basic element which applies to any object within the range of applicability of the model/theory

- Principle of Superposition
- Archimedes Principle

1.4 Measurement and Uncertainty; Significant Figures

No measurement is exact; there is always some uncertainty due to limited instrument accuracy and difficulty reading results. For example look at the figure below and try to determine the width of the board in the photo.

Figure 5: A rough measuring of a board

We might say that the board has an estimated width of 8.8 cm. However, we must include the uncertainty which is written with a ± sign; for example:

$$8.8 \pm 0.1 \text{ cm} \tag{1}$$

Percent uncertainty is the ratio of the uncertainty to the measured value, multiplied by 100.

$$\frac{\text{uncertainty}}{\text{measured value}} \text{ x}100\% \tag{2}$$

Therefore, our percent uncertainty of the piece of wood would be:

$$\frac{0.1}{8.8} \text{ x}100\% = 1.14\% \tag{3}$$

Now lets define the following terms:

Uncertainty: There is uncertainty associated with every measurement. For example when you use a centimeter ruler to measure, the result could be claimed to be precise to about 0.1 cm or 1mm.

Precision: repeatability of the measurement using a given instrument.

Accuracy: how close a measurement is to the true value.

Conceptual Question 1: is the diamond yours? A friend asks to borrow your precious diamond for a day to show her family. You are a bit worried, so you carefully have your diamond weighed on a scale which reads 8.17 grams. The scales accuracy is claimed to be ± 0.05 g. The next day you weigh the returned diamond again, getting 8.09 grams. Is this your diamond?

Significant figures: the number of reliably known digits in a number. There are four rules to follow:

1. Non-zero digits are always significant
   - 26.38 has 4 significant figures
2. Any zeros between two significant digits are significant
   - 406 has 3 significant figures
3. A final zero or trailing zeros in the decimal portion ONLY are significant
   - 0.00500 has 3 significant figures
4. Zeros to the left of the first nonzero digit are insignificant and just placeholders
   - 0.00456 has 3 significant figures

However, the number of significant figures may not always be clear. For example:

- about 80 km (1 or 2 significant figures)
- 80 ± 2 km (2 significant figures)
- 80 ± 0.1 km (3 significant figures)

When adding or subtracting, the answer is no more accurate than the least accurate number used. The same when multiplying or dividing numbers, the result has as many significant figures as the number used in the calculation with the fewest significant figures.

Note 2. The significant figures rule is only approximate and may underestimate the precision of the answer. It will be important to check the percent error.

Example 1: The area of a rectangle 4.5 cm by 3.25 cm is?

Example 2: Do 0.00324 and 0.00056 have the same number of significant figures?

Example 3: For each of the following numbers, state the number of significant figures and the number of decimal places:

- 1.23
- 0.123
- 0.0123

Scientific Notation can simplify any misunderstanding of significant figures by writing numbers in ”powers of ten”. For example:

- 36,900 = 3.69 x 10^4
- 0.0021 = 2.1 x $10^{-}3$

This removes the ambiguity of significant figures by removing the extra zeros.

Assignment 1.4

Advanced Physics

Name: ______________________

1. The age of the universe is thought to be about 14 billion years. Assuming two significant figures, write this in powers of ten in (a) years, (b) seconds

2. How many significant figures do each of the following numbers have (a) 214, (b) 81.60, (c) 7.03, (d) 0.03, (e) 0.0086, (f) 3236, and (g) 8700

3. Write the following numbers in powers of ten notation (a) 1.156, (b) 21.8, (c) 0.0068, (d) 27.635, (e) 0.219, (f) 444

4. Write out the following numbers in full with the correct number of zeros (a) $8.69 \text{ x } 10^4$, (b) $9.1 \text{ x } 10^3$, (c) $8.8 \text{ x } 10^{-1}$, (d) $4.76 \text{ x } 10^2$, (e) $3.62 \text{ x } 10^{-5}$

5. What, approximately, is the percent uncertainty for the measurement given as 1.57 m.

6. What is the percent uncertainty in the measurement 3.76 ± 0.25 m

7. Time intervals measured with a stopwatch typically have an uncertainty of about 0.2s, due to human reaction time at the start and stop moments. What is the percent uncertainty of a handtimed measurement of (a) 5s, (b) 50s, (c) 5 min

8. Add (9.2 x 10^3 s)+(8.3 x 10^4 s)+(0.008 x 10^6 s)

9. Multiply 2.079 x 10^2 m by 0.082 x 10^{-1}, considering significant figures.

10. What is the area, and its approximate uncertainty, of a circle of radius 3.8 x 10^4 cm

11. What, roughly, is the percent uncertainty in the volume of a spherical beach ball whose radius is r=2.86 ± 0.09 m?

1.5 Units, Standards, and the SI System

Unit: a particular standard that a measurement of any quantity is made relative to. It's specified along with a numerical value of the quantity.

Examples:

Note 3. A measurement without units is meaningless. 18.6 ... won't be sufficient

Standard: defines exactly how a unit is quantified. For example how long a meter or a second is. It is important that standards are readily reproducible to produce accurate measurements.

What would happen if there weren't standard measurements?

Length: the first truly international standard was the **meter (m)** established as the standard of length by the French Academy of Sciences in the 1790s.

- One ten-millionth of the distance from Earths equation to either pole. A platinum rod was made to represent the length.
- Today it's the length of path traveled by light in a vacuum during a time interval of 1/299,792,458 of a second.

TABLE 1–1 Some Typical Lengths or Distances (order of magnitude)	
Length (or Distance)	**Meters (approximate)**
Neutron or proton (radius)	10^{-15} m
Atom	10^{-10} m
Virus [see Fig. 1–8a]	10^{-7} m
Sheet of paper (thickness)	10^{-4} m
Finger width	10^{-2} m
Football field length	10^{2} m
Height of Mt. Everest [see Fig. 1–8b]	10^{4} m
Earth diameter	10^{7} m
Earth to Sun	10^{11} m
Earth to nearest star	10^{16} m
Earth to nearest galaxy	10^{22} m
Earth to farthest galaxy visible	10^{26} m

Figure 6: Typical Lengths

Time: standard unit of time is the **second(s)**

- Used to be defined as 1/86,400 of a mean solar day
- Now defined as the frequency of radiation emitted by cesium atoms when they pass between two states. Defined as 9,192,631,770 periods of this radiation.

TABLE 1–2 Some Typical Time Intervals	
Time Interval	**Seconds (approximate)**
Lifetime of very unstable subatomic particle	10^{-23} s
Lifetime of radioactive elements	10^{-22} s to 10^{28} s
Lifetime of muon	10^{-6} s
Time between human heartbeats	10^{0} s (= 1 s)
One day	10^{5} s
One year	3×10^{7} s
Human life span	2×10^{9} s
Length of recorded history	10^{11} s
Humans on Earth	10^{14} s
Life on Earth	10^{17} s
Age of Universe	10^{18} s

Figure 7: Typical Time Intervals

Mass: the standard unit of mass is the **kilogram(kg)**

- Defined as the mass of a particular platinum-iridium cylinder, kept at the International Bureau of Weights and Measures near Paris, France

TABLE 1–3 Some Masses

Object	Kilograms (approximate)
Electron	10^{-30} kg
Proton, neutron	10^{-27} kg
DNA molecule	10^{-17} kg
Bacterium	10^{-15} kg
Mosquito	10^{-5} kg
Plum	10^{-1} kg
Human	10^{2} kg
Ship	10^{8} kg
Earth	6×10^{24} kg
Sun	2×10^{30} kg
Galaxy	10^{41} kg

Figure 8: Typical Masses

Unit Prefixes: In the metric system, the larger and smaller units are defined in multiples of 10 from the standard unit.

TABLE 1–4
Metric (SI) Prefixes

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

[†] μ is the Greek letter "mu."

Figure 9: Unit Prefixes

For example:

- 1,000 m = 1 km
- 0.01 m = 1 cm
- 1,000,000 m = 1 Mm

Note 4. These prefixes can be applied not only to units of length, but to units of volume, mass, or any other metric unit

Systems of Units: when implementing laws and equations of Physics it is very important to use a consistent set of units. For this class we use:

- Systeme International (SI) also known as metric

We also have base vs. derived quantities:

Base Quantities: must be defined in terms of a standard. There are 7 base quantities.

Derived Quantities: defined in terms of these seven base quantities.

TABLE 1–5 SI Base Quantities and Units

Quantity	Unit	Unit Abbreviation
Length	meter	m
Time	second	s
Mass	kilogram	kg
Electric current	ampere	A
Temperature	kelvin	K
Amount of substance	mole	mol
Luminous intensity	candela	cd

Figure 10: Base Quantities

Assignment 1.5

Advanced Physics

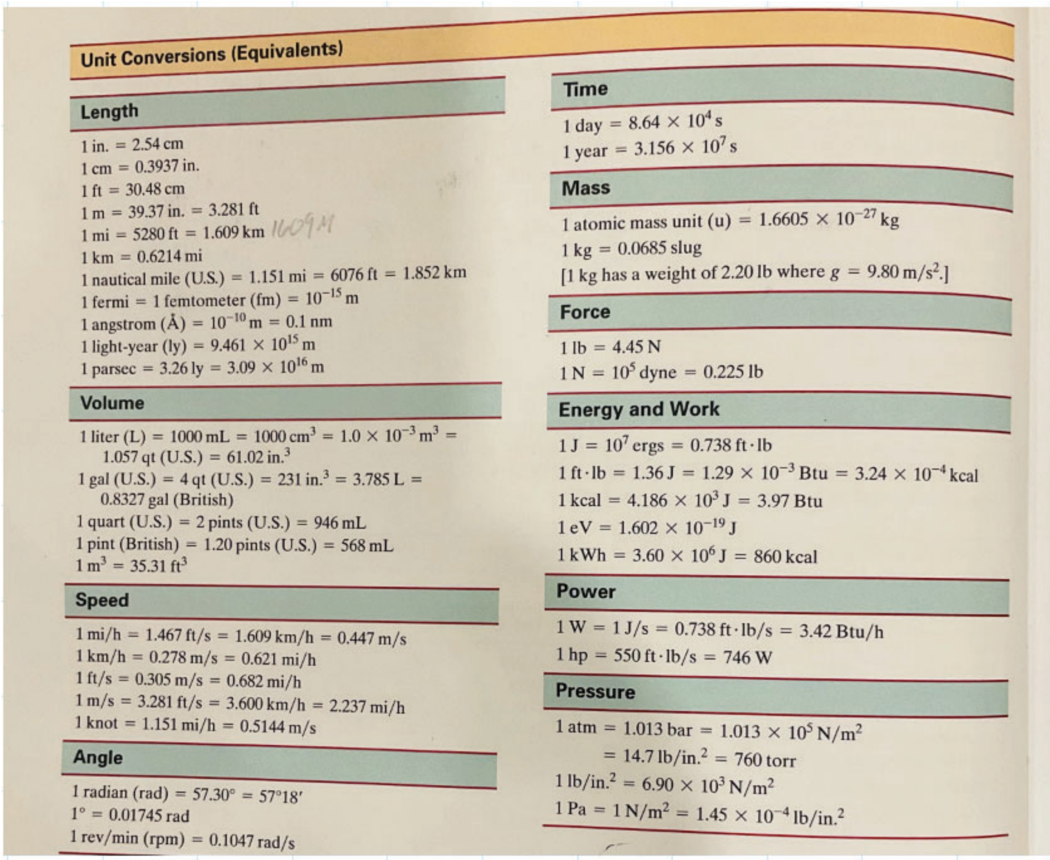
Name: ______________________

1. Write the following as full (decimal) numbers with standard units: (a) 286.6 mm, (b) 85 nV, (c) 650 mg, (d) 60.0 ps, (e) 22.5 fm, (f) 2.40 Gm.

2. Express, the following using the prefixes in Table 1-4: (a) 1 x 10^6 meters, (b) 2 x 10^{-6} meters, (c) 6 x 10^3 days, (d) 18 x 10^2 meters, (e) 8 x 10^{-9} seconds

1.6 Converting Units

Any quantity we measure consists of a number and a unit. However, often we are given a quantity in one set of units, but want it expressed as another set of units.



Unit Conversions (Equivalents)

Length

1 in. = 2.54 cm
1 cm = 0.3937 in.
1 ft = 30.48 cm
1 m = 39.37 in. = 3.281 ft
1 mi = 5280 ft = 1.609 km
1 km = 0.6214 mi
1 nautical mile (U.S.) = 1.151 mi = 6076 ft = 1.852 km
1 fermi = 1 femtometer (fm) = 10^{-15} m
1 angstrom (Å) = 10^{-10} m = 0.1 nm
1 light-year (ly) = 9.461×10^{15} m
1 parsec = 3.26 ly = 3.09×10^{16} m

Volume

1 liter (L) = 1000 mL = 1000 cm^3 = 1.0×10^{-3} m^3 = 1.057 qt (U.S.) = 61.02 $in.^3$
1 gal (U.S.) = 4 qt (U.S.) = 231 $in.^3$ = 3.785 L = 0.8327 gal (British)
1 quart (U.S.) = 2 pints (U.S.) = 946 mL
1 pint (British) = 1.20 pints (U.S.) = 568 mL
1 m^3 = 35.31 ft^3

Speed

1 mi/h = 1.467 ft/s = 1.609 km/h = 0.447 m/s
1 km/h = 0.278 m/s = 0.621 mi/h
1 ft/s = 0.305 m/s = 0.682 mi/h
1 m/s = 3.281 ft/s = 3.600 km/h = 2.237 mi/h
1 knot = 1.151 mi/h = 0.5144 m/s

Angle

1 radian (rad) = 57.30° = 57°18′
1° = 0.01745 rad
1 rev/min (rpm) = 0.1047 rad/s

Time

1 day = 8.64×10^4 s
1 year = 3.156×10^7 s

Mass

1 atomic mass unit (u) = 1.6605×10^{-27} kg
1 kg = 0.0685 slug
[1 kg has a weight of 2.20 lb where $g = 9.80$ m/s^2.]

Force

1 lb = 4.45 N
1 N = 10^5 dyne = 0.225 lb

Energy and Work

1 J = 10^7 ergs = 0.738 ft·lb
1 ft·lb = 1.36 J = 1.29×10^{-3} Btu = 3.24×10^{-4} kcal
1 kcal = 4.186×10^3 J = 3.97 Btu
1 eV = 1.602×10^{-19} J
1 kWh = 3.60×10^6 J = 860 kcal

Power

1 W = 1 J/s = 0.738 ft·lb/s = 3.42 Btu/h
1 hp = 550 ft·lb/s = 746 W

Pressure

1 atm = 1.013 bar = 1.013×10^5 N/m^2 = 14.7 lb/$in.^2$ = 760 torr
1 lb/$in.^2$ = 6.90×10^3 N/m^2
1 Pa = 1 N/m^2 = 1.45×10^{-4} lb/$in.^2$

Figure 11: Helpful unit conversions

Example 1: Suppose we measure that a table is 21.5 in wide, and we want to express this in cm:

Example 2: The 8000 m peaks. The 14 tallest peaks in the world are referred to as "eight-thousanders", meaning their summits are over 8000 m above sea level. What is the elevation in ft. of an elevation of 8000 m?

Example 3: Area of a semiconductor chip. A silicon chip has an area of 1.25 in^2. Express this in cm^2.

Example 4: WHen the speed is posted 55 mph (mi/hr), what is the speed (a) in meters per second (m/s), (b) in kilometers per hour (km/h).

Assignment 1.6

Advanced Physics

Name: ________________________

1. Determine the conversion factor between (a) km/h and mi/h, (b) m/s and ft/s, and (c) km/h and m/s.

1.7 Order of Magnitude: Rapid Estimation

We are sometimes interested only in an approximate value for a quantity....

- Not worth the time for additional accuracy
- Requires additional data that isn't available

We may want to make a rough estimate to check out solution....

- Correct order of magnitude?
- No calculator errors?

Order of magnitude estimate: a rough estimate is made by rounding off all numbers to one significant figure.

Example 1: Estimate how much water there is in a circular lake that is 1 km across and has an average depth of 10 m.

Example 2: Estimate the total number of heartbeats in a lifetime.

Assignment 1.7

Advanced Physics

Name: ________________________

1. Estimate how long it would take one person to mow a football field using an ordinary home lawn mower. Assume the mower moves with a 1 km/h speed, and has a 0.5 m width.

2. Estimate the number of liters of water a human drinks in a lifetime.

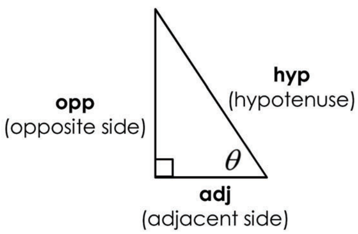
3. Make a rough estimate of the volume of your body (in cm^3)

Name:	**Date:**
Topic:	**Class:**

Main Ideas/Questions	Notes/Examples

TRIGONOMETRIC FUNCTIONS

- **Trigonometry** is the study of the relationships among the side and angle measures in triangles.
- A **trigonometric ratio** compares the lengths of two sides with respect to an acute angle, θ (theta), in a right triangle.
- A **trigonometric function** is a rule defined by the trigonometric ratios.



Use the triangle to the left to define the six trigonometric functions:

SINE	$\sin\theta =$	**COSECANT**	$\csc\theta =$
COSINE	$\cos\theta =$	**SECANT**	$\sec\theta =$
TANGENT	$\tan\theta =$	**COTANGENT**	$\cot\theta =$

RECIPROCAL FUNCTIONS

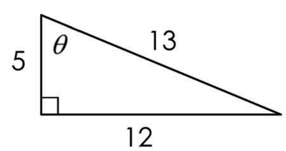
Because the cosecant, secant, and cotangent ratios are reciprocals of the sine, cosine, and tangent ratios, they are called **reciprocal functions** and can be defined as:

$\csc\theta =$ $\sec\theta =$ $\cot\theta =$

EXAMPLES

Find the exact values of the six trigonometric functions of θ.

1.



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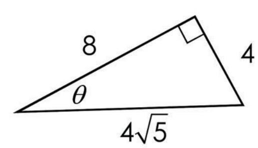
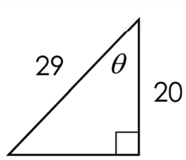
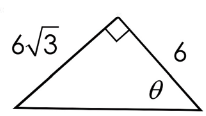


$\sin\theta =$	$\csc\theta =$	$\sin\theta =$	$\csc\theta =$
$\cos\theta =$	$\sec\theta =$	$\cos\theta =$	$\sec\theta =$
$\tan\theta =$	$\cot\theta =$	$\tan\theta =$	$\cot\theta =$

3.



4.



$\sin\theta =$	$\csc\theta =$	$\sin\theta =$	$\csc\theta =$
$\cos\theta =$	$\sec\theta =$	$\cos\theta =$	$\sec\theta =$
$\tan\theta =$	$\cot\theta =$	$\tan\theta =$	$\cot\theta =$

Use the given trigonometric value to find the remaining function values.

5. tan $\theta = \frac{7}{24}$

sin θ =	csc θ =
cos θ =	sec θ =
tan θ =	cot θ =

6. csc $\theta = \frac{37}{12}$

sin θ =	csc θ =
cos θ =	sec θ =
tan θ =	cot θ =

7. cos $\theta = \frac{5}{9}$

sin θ =	csc θ =
cos θ =	sec θ =
tan θ =	cot θ =

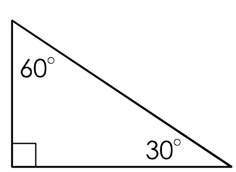
8. sec $\theta = 4$

sin θ =	csc θ =
cos θ =	sec θ =
tan θ =	cot θ =

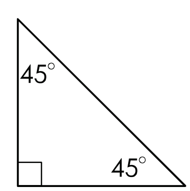
TRIG VALUES OF SPECIAL ANGLES

Angles of 30°, 60°, and 45° are used frequently in trigonometry.
You can use your knowledge of the side relationships in special right triangles to find the values of the trigonometric ratios.

30°-60°-90° Triangle



45°-45°-90° Triangle



θ	sin θ	cos θ	tan θ	csc θ	sec θ	cot θ
30°						
45°						
60°						

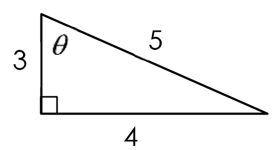
Name: ______________________________ **Unit 5:** Trigonometric Functions

Date: ______________________ **Per:** _______ **Homework 4:** Trigonometric Functions

**** This is a 2-page document! ****

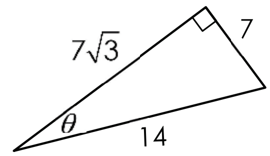
Directions: Find the exact values of the trigonometric functions of θ.

1.



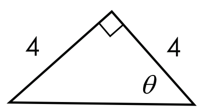
$\sin\theta$ =	$\csc\theta$ =
$\cos\theta$ =	$\sec\theta$ =
$\tan\theta$ =	$\cot\theta$ =

2.



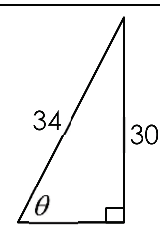
$\sin\theta$ =	$\csc\theta$ =
$\cos\theta$ =	$\sec\theta$ =
$\tan\theta$ =	$\cot\theta$ =

3.



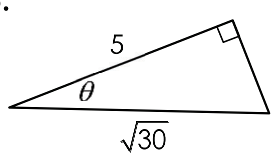
$\sin\theta$ =	$\csc\theta$ =
$\cos\theta$ =	$\sec\theta$ =
$\tan\theta$ =	$\cot\theta$ =

4.



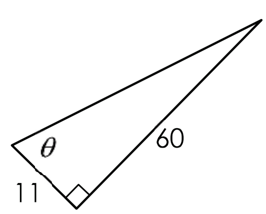
$\sin\theta$ =	$\csc\theta$ =
$\cos\theta$ =	$\sec\theta$ =
$\tan\theta$ =	$\cot\theta$ =

5.



$\sin\theta$ =	$\csc\theta$ =
$\cos\theta$ =	$\sec\theta$ =
$\tan\theta$ =	$\cot\theta$ =

6.



$\sin\theta$ =	$\csc\theta$ =
$\cos\theta$ =	$\sec\theta$ =
$\tan\theta$ =	$\cot\theta$ =

Directions: Use the given trigonometric function value of θ to find the exact values of the remaining functions.			
7. $\cos\theta = \frac{60}{61}$		**8.** $\csc\theta = 7$	
$\sin\ \theta =$	$\csc\ \theta =$	$\sin\ \theta =$	$\csc\ \theta =$
$\cos\ \theta =$	$\sec\ \theta =$	$\cos\ \theta =$	$\sec\ \theta =$
$\tan\ \theta =$	$\cot\ \theta =$	$\tan\ \theta =$	$\cot\ \theta =$
9. $\sin\theta = \frac{\sqrt{2}}{2}$		**10.** $\tan\theta = \frac{2}{3}$	
$\sin\ \theta =$	$\csc\ \theta =$	$\sin\ \theta =$	$\csc\ \theta =$
$\cos\ \theta =$	$\sec\ \theta =$	$\cos\ \theta =$	$\sec\ \theta =$
$\tan\ \theta =$	$\cot\ \theta =$	$\tan\ \theta =$	$\cot\ \theta =$
11. $\sec\theta = \frac{\sqrt{35}}{5}$		**12.** $\cot\theta = \frac{\sqrt{11}}{7}$	
$\sin\ \theta =$	$\csc\ \theta =$	$\sin\ \theta =$	$\csc\ \theta =$
$\cos\ \theta =$	$\sec\ \theta =$	$\cos\ \theta =$	$\sec\ \theta =$
$\tan\ \theta =$	$\cot\ \theta =$	$\tan\ \theta =$	$\cot\ \theta =$
Directions: Give the exact value of each function.			
13. $\cos 60^\circ$	**14.** $\tan 45^\circ$	**15.** $\csc 45^\circ$	**16.** $\cot 30^\circ$