Measurement and Uncertainty

Name: ______________________

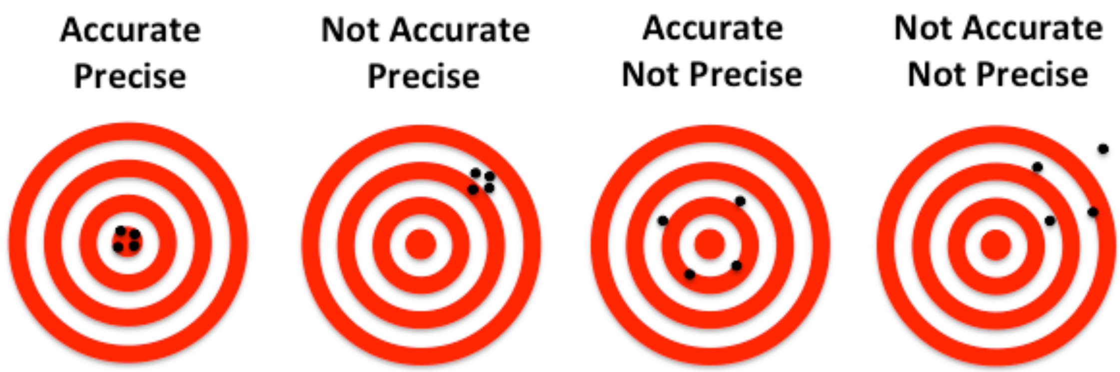
Date: ________________

Block: ________

There is uncertainty in every measurement due to limitations of accuracy and precision.

Accuracy: how close the instrument measures to an accepted standard (known) values.

Precision: how closely two or more measurements of the same thing agree when measured with equal care by the same instrument.

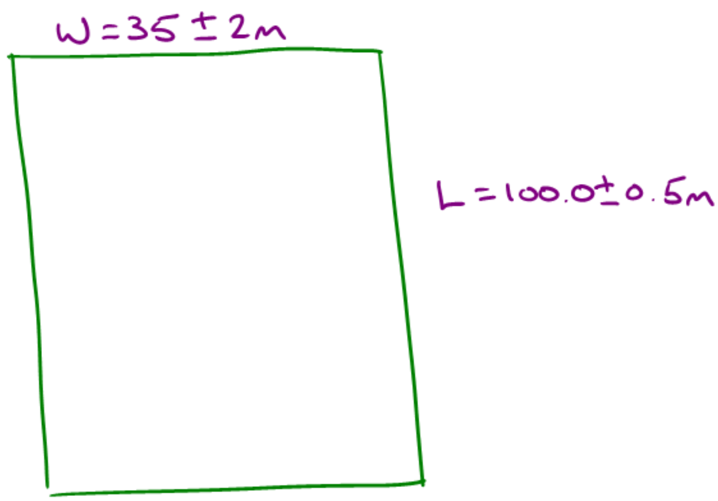


Each instrument has its own actual uncertainty that can only be obtained by experiment (i.e. finding the variation in values from repeated measurements).

How to record a measurement:

Record all digits that are certain plus one uncertain digit (i.e. all the significant figures). Then express the uncertainty as a number occupying the same decimal place as the estimated figure.

Example: Rockridge Rugby Field



Value: Any measured number. Example: 100.0m

Absolute Error: Error in a value that has the same units as the value. Example: ± 0.5m

Relative Error: % error (***does not contain units!)*** = $\frac{\text{abs error}}{\text{value}} \times 100\%$

$$\frac{0.5\,\text{m}}{100.0\,\text{m}} \times 100\% = 0.5\%$$

Rules for calculating with uncertainties:

1. Adding or Subtracting Values (Measurements)
    a. Add the absolute errors
2. Multiplying or Dividing Values (Measurements)
    a. Add the relative errors
3. Exponents
    a. Multiple the Value (Measurement) by the exponent

Perimeter	**Area**
P = L + L + W + W $P = 100 + 100 + 35 + 35$ $P = 270m$ $error = 0.5 + 0.5 + 2 + 2 = 5m$ $P = 270 \pm 5m$	A = L x W $A = (100.0)(35)$ $A = 3500 m^2$ $\%L = \frac{0.5m}{100.0m} \times 100\% = 0.5\%$ $\%W = \frac{2m}{35m} \times 100\% = 5.7\%$ $\%error = 0.5\% + 5.7\% = 6.2\%$ $abs\ error = Area \times \%error$ $= (3500 m^2)(6.2\%/100\%)$ $= 217.5 m^2$ $3500 \pm 217.5 m^2$

If Mr. Lawson can mow the rugby field covering 10 +/- 1 m^2 every second, how long will it take him to mow the entire field?

$A = 3500 \pm 217.5 m^2$

$A/t = 10 \pm 1 m^2/s$

$t = \frac{A}{A/t} = \frac{3500 m^2}{10 m^2/s} = 350s$

$t = 350 \pm 56.7s$

$\%A = \frac{217.5 m^2}{3500 m^2} = 0.062$

$\%A/t = \frac{1 m^2/s}{10 m^2/s} = 0.10$

$\%t = \%A + \%A/t = 0.062 + 0.10$

$= 0.162$

$abs\ t = (350s)(0.162) = 56.7s$

Taking Measurements

Name:

Date:

Partners:

Purpose:

Procedure:

1. Using a meter stick determine how large of a step you would have to take for it to be 1 m long.
2. Measure the length of the tennis court by counting your steps. ***While doing so think of the uncertainty in this method of measurement.***
3. Measure the width of the tennis court using a measuring tape. ***While doing so think of the uncertainty in this method of measurement.***
4. Calculate the perimeter and surface area of the tennis court.

Data:

- Data should be written neatly.
- Include a clear description of the data being taken.
- If more than a few data points are taken, use a data table.
- All measurements must include error and appropriate units!

Length of tennis court: ________ ± _______ **m**
Width of tennis court: ________ ± _______ **m**

Calculations:

Calculate the perimeter and area of the tennis court. (you will calculate the error below!)

Uncertainty Analysis:

- Whenever we take measurements they include a certain amount of error. If we use these values in further calculations then the calculated values contain all of the original error. To determine how much error is carried through a calculation we use a process called **error propagation**.
- Error propagation should always be done under separate heading of your lab manual **showing all** of your steps!

Perimeter:

- Use the addition rules to determine the absolute error in the perimeter.

Perimeter:
___________ ± _______ m

Area:

- Relative error for length:

- Relative error for width:

- Use the multiplication rule to find the relative error for the area:

- Generally we want to express the final answer with an absolute error. Determine a method to convert from relative error to absolute error and report your final answer. Don't forget to include correct units!

Area: ___________ ± _______ m^2

Conclusion:

- Before an experiment can be considered legitimate it must be repeated by other scientists. They must then compare their results to determine if they **agree within uncertainty**.

Compare your results with at least two other groups and determine whether or not your results agree.
In *one sentence* describe what it means for results agree within uncertainty.

SIGNIFICANT FIGURES

Name: Pepe Le KEY
Date: ______
Block: ______

are "born" from

All ***Measurements*** have some degree of uncertainty to them (due to the instrument used.)

To indicate the degree of certainty in a measurement (or a number derived from a measurement), scientists use ***significant figures***. Or numbers they know to be 100% accurate.

* There is NO rounding errors in SCIENCE, as their is NEVER a measured value that is "PERFECT".

**** Significant figures are important in the way we report different kinds of data!**

- A significant figure is a **measured** or **meaningful digit**

A. What is Not Significant?

Defined or counting numbers: A number which involves things which cannot realistically be subdivided.

Example:
1 book; 4 students (cannot have 1.5 books or 4.78 students)
Conversion factors are assumed to be an exact relationship (cannot have 1 kg = 1000.5 kg)

* "PERFECT" NUMBER

Rules for identifying # of sig figs:

a) An exact number (e.g. 25 students) has an infinite number of significant figures because the number was not rounded off. Exact numbers are not used to determine the significant digits.
b) For all measurements, the following rules apply to count the number of significant figures a number has.

1. Any digit between 1-9 is significant.

   e.g. 234.566 has ***6*** sig figs

   7.4586 has __5__ sig figs

2. A '0' at the beginning of a number is ***not significant*** because it only holds the decimal place. ***Leading zeros are NOT significant***

   e.g. 0.00045 has ***2*** sig figs

   0.02333 has __4__ sig figs

   * Zeroes give the NUMBER "meaning"! makes it small... 0.000003 ; makes it big... 300000

3. A '0' between two other sig figs is significant.

   e.g. 50034.03 has ***7*** sig figs

   e.g 534.034201 has __9__ sig figs

4. A '0' at the end of a number is only significant IF a decimal point occurs in the number otherwise it is not significant. ***Be careful with this one!***

   Trailing zeroes are NOT significant UNLESS there's a decimal!

   e.g. 750000 has **2** sig figs   20000000 has __1__ sig fig

   e.g. 750.000 has __6__ sig figs

Example:

If a balance gives a reading of 97.53 g when a beaker is placed on it, the reading is considered to have 4 significant figures. If the beaker is then put on a different balance and gives a reading of 97.5295 g, there are more significant figures to the measurement (6 significant figures).

How many significant figures do each of the following measurements have?

1. 1.25 kg ___3___
2. 1255 kg ___4___
3. 11s ___2___
4. 150 m ___2___

4b. 150.00 m = ___5___

5. 1.283 cm ___4___
6. 365.249 days ___6___
7. 2 000 000 years ___1___
8. 17.25 L ___4___

8(b). −17.25 L = 4

* if it is greater than |1| … → if there is a decimal, then ALL digits are significant!

* it does NOT matter if the value is (+) or (−)!

B. Scientific Notation

Scientific Notation is a way of writing numbers for values too large or small to be conveniently written in standard decimal notation.

#.##… x 10?

Example:

$10 = 1.0 \times 10^{1}$

$25 = 2.5 \times 10^{1}$

$250 = 2.5 \times 10^{2}$

$0.000\ 0350\ 000 = 3.5000 \times 10^{-5}$

→ proper scientific notation

Write the following numbers in scientific notation:

1. 3570 ___3.57×10^{3}___ (= +3)
2. 41,400 ___4.1400×10^{1}___ (= +1)
3. 0.000 572 ___5.72×10^{-4}___ (= −4)
4. 41.50×10^{-4} ___4.150×10^{-3}___ (= −4 + 1 = −3)
5. $0.000\ 410 \times 10^{7}$ ___$4.10 \times 10^{+3}$___ (= +7 − 4 = +3)

SHOULD ONLY include digits that are SIGNIFICANT!!!

Bad scientific notation!

C. Adding or Subtracting Significant Figures

When adding or subtracting significant figures, round off the answer to the least number of decimal places contained in the calculation.

Example:

12.56 cm *(2 SF after decimal)* + 125.8 cm *(1 SF after decimal)* = 138.36 cm → 138.4 cm *(1 SF after decimal)*

Exercise:

1. 15.1 + 75.32 ______
2. 178.904 56 – 125.8055 ______
3. 4.55 10^{-5} + 3.1 x 10^{-5} ______
4. 1.805 x 10^{4} + 5.89 x 10^{2} ______

Multiplying or Dividing Significant Figure

When multiplying or dividing significant figures, round off the answer to the least number of significant figures contained in the calculation.

Example:

2.00 *(3 SF)* x 3.000 00 *(6 SF)* = 6.00 *(3 SF)*

Exercise:

1. 12.5 x 0.50 ______
2. 0.15 x 0.0016 ______
3. 40.0 / 30.000 ______
4. 2.5 x 7.500 / 0.150 ______
5. (6.40 x 10^{8}) x (5 x 10^{5}) ______
6. 4.37 x 103 / 0.008 560 0 ______
7. 0.51 x 10 $^{-4}$ / 6 x 10 $^{-7}$ ______
8. 0.000 01 / 0.1000 ______

Summary Practice Exercises:

In the following mixed calculations, perform multiplications and divisions before doing the additions and subtractions. Keep track of the number of significant figures at each stage of a calculation.

BEDMAS

1. 25.00 x 0.100 – 15.87 x 0.1036 **0.86**

   2.50 – 1.644132 = 2.50 – 1.644132 = 0.855868

   (or 2.50 – 1.644)

2. 35.0 x 1.525 + 50.0 x 0.975 **102.2**

   53.4 + 48.8

3. (0.865 – 0.800) x (1.593 + 9.04) **0.69**

   0.065 x 10.63 =

4. (0.3812 - 0.4176) / (0.0159 – 0.0146) **–28**

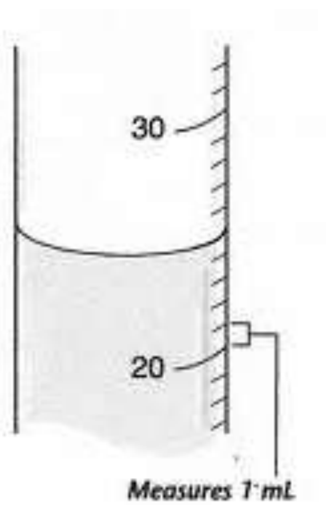
   –0.0364 ÷ 0.0013 =

5. 9.34 x 0.071 46 – 6.88 x 0.081 15 **0.109**

   0.667 – 0.558 ⇒ 0.667 – 0.558 = 0.109

D. Reading A Scale

The number of significant figures is equal to all the certain digits PLUS the first uncertain digit.



In the figure to the left, the liquid level is somewhere between 24 mL and 25 mL. You know that it is at least 24 mL so you are “certain” about the first two digits.

As a guess, it could be 24.9 mL. There is some significance to the last digit but but not completely certain. For example, there are the reading is not 24.1 mL. As a result, there are two certain digits, (2 and 4) and one uncertain (9).

* MORE PRACTICE TO COME… LOTS MORE PRACTICE :)

Significant Figures Worksheet Key

1. Indicate how many significant figures there are in each of the following measured values.

246.32	5	1.008	4	700000	1
107.854	6	0.00340	3	350.670	6
100.3	4	14.600	5	1.0000	5
0.678	3	0.0001	1	320001	6

Instructors Initials ________

2. Calculate the answers to the appropriate number of significant figures.

```
  32.567          246.24           658.0
 135.0            238.278           23.5478
+  1.4567        + 98.3          + 1345.29
 169.0            582.8           2026.8
```

Instructors Initials ________

3. Calculate the answers to the appropriate number of significant figures.

a) 23.7 x 3.8 = 90.

b) 45.76 x 0.25 = 11

c) 81.04 g x0.010 = 0.81

d) 6.47 x 64.5 = 417

e) 43.678 x 64.1 = 2.80×10^3

f) 1.678 / 0.42 = 4.0

g) 28.367 / 3.74 = 7.58

h) 4278 / 1.006 = 4252

i) (6.8 + 4.7) x 17.44 = 201 (11.5)

j) (320. - 22.7) x 3.8 = 1.1×10^3 (297)

k) $\frac{(14.86 + 13.7) \times (65.346 - 4.10)}{(43.888 - 32.888)}$ = 159 (28.6, 61.25, 11.000)

AP Physics

Name ____________________
Date ______________ Per. _____

#

Sig Figs & Units Worksheet

1. How many significant figures are there in each of the following?
   a. 273.16 __5__
   b. 186,000 __3__
   c. 505 __3__
   d. 1000 __1__
   e. 2,000,000 __1__
   f. 13.8 __3__
   g. 0.00928 __3__
   h. 60.080 __5__
   i. 5280. __4__
   j. 708.003 __6__
   k. 0.0652 __3__
   l. 3.040×10^5 __4__

2. In the following, convert numbers in common notation to scientific notation, or vice versa.
   a. 93,000,000 __9.3×10^7__
   b. 0.000019 __1.9×10^{-5}__
   c. 606.39 __6.0639×10^2__
   d. 2.997×10^{10} __29,970,000,000__
   e. 6.02×10^{-5} __0.0000602__
   f. 2.5359×10^2 __253.59__

3. In the following, how many decimal places will the solution have? DO NOT SOLVE.
   a. 6.0 m + 10.73 m + 111.250 m __1__
   b. 4050 L – 2.06 L __0__
   c. 96.75 km + 108.43 km + 77 km __0__
   d. 93.4 cm + 10.975 cm __1__
   e. 0.005070 cm + 6.90 cm + 2000.860 cm __2__
   f. 10.970 mL – 5.0 mL __1__

4. In the following, how many digits should be in the solution to have the proper number of sig figs? DO NOT SOLVE.
   a. (797.6 m)(54 m) __2__
   b. (851 cm)(24.3 cm) __3__
   c. 1075 kg ÷ 15 L __2__
   d. 93.4 m ÷ 10.975 m __3__
   e. $(6.02 \times 10^{23}$ m)(12.00 m)$(1.660 \times 10^{-24}$ m) __3__
   f. (453.6 m)$(9.050 \times 10^4$ m)(239.1 m) __4__

Solve the following problems, expressing the answer in the proper number of sig figs.

5. Express the sum of 20.6 mm, 49.5 cm and 5.03 m in meters

   0.0206m   0.495m

   5.03 + 0.495 + 0.0206 = 5.5456

   5.55m

6. If 22.5 L of gasoline is drawn from a tank originally containing 65 L of gasoline, what volume of gasoline remains in the tank?

   65 − 22.5 = 42.5

   43L

7. What is the area of the bottom of a tank 30.0 cm long and 15.0 cm wide?

   $30.0\text{cm} \times 15.0\text{cm} = $ **$450.\text{cm}^2$** or $4.50 \times 10^2\text{cm}$

8. If the tank in Problem 7 has a volume of 2.25×10^4 cm^3, what is its height?

   $h = \frac{V}{A} = \frac{2.25 \times 10^4 \text{cm}^3}{450.\text{cm}^2} = $ **50.0cm**

9. How many centimeters are there in 35.0 inches? 1 inch = 2.54cm

   $35.0 \text{ inches} \times \frac{2.54\text{cm}}{1 \text{ inch}} = $ **88.9 cm**

10. What is the distance, in kilometers, of a 2.5 mile cross-country course? 1 mi = 1.6 km

   $2.5\text{mi} \times \frac{1.6\text{km}}{1\text{mi}} = $ **4.0 km**

Math Review

Fill in the following table for the following quantities and their symbols:

Quantity	Unit	Symbol
length	meters	m
mass	Kilograms	Kg
time	seconds	s
force	Newtons	N
energy	Joules	J
power	Watts	W
speed	meters per second	m/s
frequency	Hertz	Hz

Complete the following conversions

1. 4 km = 4000 m
2. 54 mm = 0.054 m
3. 0.394 Mg = 394 000 g
4. 4000 ms = 4 s
5. 4 dl = 0.4 l
6. 70 dam (deka meters) = 700 m
7. 4 Gg = 4×10^{11} cg
8. 9 000 000 µm = 0.009 km
9. 4000 s = 1.11 h
10. 67 m^2 = 670 000 cm^2

Example 1:
3000 cm = __________ km

$$3000\text{ cm} \times \frac{1\text{ m}}{100\text{ cm}} \times \frac{1\text{ km}}{1000\text{ m}} = \boxed{0.03\text{ km}}$$

Example 2:
3 m^3 = __________ cm^3

$$3\text{ m}^3 \times \frac{(100\text{ cm})^3}{(1\text{ m})^3} = 3\text{ m}^3 \times \frac{1\,000\,000\text{ cm}^3}{1\text{ m}^3} = \boxed{3\,000\,000\text{ cm}^3}$$

Rounding:

5 and up → round up   4.55 → 4.6
4 and down → round down   4.54 → 4.5

Significant Figures:

All non-zero numbers count.
Zeros to the left never count.
Zeros in the middle always count.
Zeros to the right count only if there is a decimal in the number.

Example: 0.00050600 This number has 5 sig figs because the four zeros to the left of the 5 don't count. The 5 and 6 count. The 0 in the middle counts. The two zeros to the right of the 6 count because there is a decimal in the number.

Example: 567, 000 This number has 3 sig figs because the 5,6,and 7 count, but the zeros to the right do not count since there is no decimal in the number.

Round the following numbers to 2 sig figs:

1. 35.67 → 36
2. 0.0004567 → 0.00046
3. 2.34 x 10^4 → 2.3×10^4
4. 4.777 x 10^{-6} → 4.8×10^{-6}
5. 23.333 → 23
6. 0.0102 → 0.010
7. 99536 → 1.0×10^5
8. 1.0326 → 1.0
9. 156.21 → 160
10. 9.75 → 10.

Multiplication / Division: This is the most common rule for sig figs we will be using. Use this for all multiplication or multifunction equations. Use the **lowest number of total sig figs** in your equation for your answer.

Example: 6.5 m x 687.3 m = 4467.645 m, but because of sig figs, your answer will be $\boxed{4.5\times10^3\ m}$
(2) (4) (7) (2)

Addition / Subtraction: If you have a situation where you are only using addition and / or subtraction you should use this rule for sig figs. Look at the number of **decimal places** and use the smallest number of decimal places in your answer.

Example: 3.456 s + 22.55 s = 26.006 s, but because of sig figs, your answer will be $\boxed{26.01\ s.}$
(3) (2) (3) (2)

Solve the following equations and leave the answers with the correct number of sig figs:

1. 23 + 4.8 = 28
2. 234.67 x 34 = 8.0×10^3
3. 4567 / 2.45 = 1860
4. 2.56 + 0.89 = 3.45
5. 2345.8 x 23.2 = 54400

<u>Percent Uncertainty:</u>

If something is measured to be 12.3 cm +/- 0.5 cm. What is its percent uncertainty?

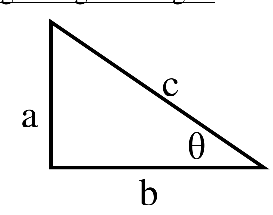
$\frac{0.5\ cm}{12.3\ cm} \times 100\% = 4\%$ uncertainty

It is important to know how big the uncertainty is compared to the actual measurement. 0.5 cm error would be a lot if your measurement was only 2.1 cm! That would amount to an error of 24% instead of only 4%
(0.5 / 2.1) x 100% = 24%

To emphasize this point, consider this; 1 cm error when you are measuring 100 000 cm isn't much, therefore almost negligible. Your calculated % error would be low. 1 cm error when you are measuring only 10 cm is a concern. Your % error would be much higher.

<u>Trigonometry:</u>

a) <u>Right Angle Triangles</u>

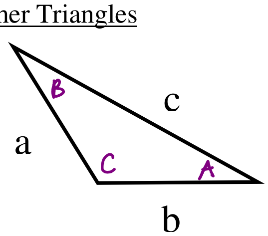


$\sin\theta = a/c$
$\cos\theta = b/c$
$\tan\theta = a/b$

Pythagorean Theorem:

$c^2 = a^2 + b^2$

b) <u>Other Triangles</u>



Sine Law: $\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$

Cosine Law:

$c^2 = a^2 + b^2 - 2ab\cos C$

Entering very big and very small numbers into your calculator.

Say this… " **…times ten to the…**".
Pressing | 2n | | EE | on your calculator is the equivalent of saying " times ten to the".

So, how do you enter 4×10^5 into your calculator.
You would say this in the following way " 4 times ten to the 5".
You would enter into your calculator the following….

4	2nd	EE	5

Enter these problems into your calculator…

$(3.9 \times 10^7) \times (2 \times 10^2)$

3	.	9	2nd	EE	7	x	2	2nd	EE	2	enter

Your answer should be….? 7.8×10^9

$(3.9 \times 10^{-7}) \times (2 \times 10^2)$

3	..	9	2nd	EE	(-)	7	x	2	2nd	EE	2	enter

Your answer should be….? 7.8×10^{-5}

$(-3.9 \times 10^{-7}) \times (2 \times 10^2)$

(-)	3	..	9	2nd	EE	(-)	7	x	2	2nd	EE	2	enter

Your answer should be….? -7.8×10^{-5}

Use your calculator to answer the following….

$(3 \times 10^3) \times (2 \times 10^2)$ = 6×10^5

$(3 \times 10^3) + (2 \times 10^{-2})$ = 3.00002×10^3

$(-3 \times 10^{-3}) / (2 \times 10^2)$ = -1.5×10^{-5}

$(3 \times 10^3) - (2 \times 10^2)$ = 2.8×10^3

$(3 \times 10^3) \times (2 \times 10^{-2})$ = 6×10^1

$(-3 \times 10^{-3}) \times (2 \times 10^2)$ = -6×10^{-1}

AP Physics 1 Summer Assignment

1. Scientific Notation:

The following are ordinary physics problems. Write the answer in scientific notation and simplify the units (π=3).

a. $T_s = 2\pi\sqrt{\dfrac{4.5\times10^{-2}\,kg}{2.0\times10^{3}\,kg/s^2}} =$ T_s= 0.0298 s

b. $F = \left(9.0\times10^{9}\,\dfrac{N\cdot m^2}{C^2}\right)\dfrac{\left(3.2\times10^{-9}C\right)\left(9.6\times10^{-9}C\right)}{\left(0.32m\right)^2}$ F= 2.7×10^{-6} N

c. $\dfrac{1}{R_p} = \dfrac{1}{4.5\times10^{2}\Omega} + \dfrac{1}{9.4\times10^{2}\Omega}$ R_p= 304.3 Ω

d. $K_{max} = \left(6.63\times10^{-34}\,J\cdot s\right)\left(7.09\times10^{14}\,s\right) - 2.17\times10^{-19}\,J$ K_{max}= 2.53×10^{-19} J

e. $\gamma = 1\Big/\sqrt{1-\dfrac{2.25\times10^{8}\,m/s}{3.00\times10^{8}\,m/s}}$ γ= 2

f. $K = \dfrac{1}{2}\left(6.6\times10^{2}\text{ kg}\right)\left(2.11\times10^{4}\text{ m/s}\right)^2 =$ K= 1.46×10^{11} $\dfrac{kgm^2}{s}$

g. $(1.33)\sin 25.0^\circ = (1.50)\sin\theta$ θ= 2.20°

2. Solving Equations:

Often problems on the AP exam are done with variables only. Solve for the variable indicated. Don't let the different letters confuse you. Manipulate them algebraically as though they were numbers.

a. $K = \frac{1}{2}kx^2$, $x =$ $\pm\sqrt{\frac{2K}{k}}$

b. $T_p = 2\pi\sqrt{\frac{\ell}{g}}$, $g =$ $\frac{4\pi^2 \ell}{T_p}$

c. $F_g = G\frac{m_1 m_2}{r^2}$, $r =$ $\pm\sqrt{\frac{Gm_1m_2}{F_g}}$

d. $mgh = \frac{1}{2}mv^2$, $v =$ $\sqrt{2gh}$

e. $x = x_o + v_o t + \frac{1}{2}at^2$, $t =$ ______________ $t = \frac{-v_o \pm\sqrt{v_o^2 - 4(x_o - x)\frac{a}{2}}}{a}$

$0 = (x_o - x) + v_o t + \frac{1}{2}at^2$ ← quadratic

f. $B = \frac{\mu_o}{2\pi}\frac{I}{r}$, $r =$ $\frac{\mu_o I}{2\pi B}$

g. $x_m = \frac{m\lambda L}{d}$, $d =$ $\frac{m\lambda L}{x_m}$

h. $pV = nRT$, $T =$ $\frac{pV}{nR}$

i. $\sin\theta_c = \frac{n_1}{n_2}$, $\theta_c =$ $\sin^{-1}\left(\frac{n_1}{n_2}\right)$

j. $qV = \frac{1}{2}mv^2$, $v =$ $\sqrt{\frac{2qV}{m}}$

3. Conversion

Science uses the ***KMS*** system (***SI***: System Internationale). ***KMS*** stands for kilogram, meter, second. These are the units of choice of physics. The equations in physics depend on unit agreement. So you must convert to ***KMS*** in most problems to arrive at the correct answer.

kilometers (*km*) to meters (*m*)	and meters to kilometers	gram (*g*) to kilogram (*kg*)
centimeters (*cm*) to meters (*m*)	and meters to centimeters	Celsius (^oC) to Kelvin (*K*)
millimeters (*mm*) to meters (*m*)	and meters to millimeters	atmospheres (*atm*) to Pascals (*Pa*)
nanometers (*nm*) to meters (*m*)	and metes to nanometers	liters (*L*) to cubic meters (m^3)
micrometers (μm) to meters (*m*)		

Other conversions will be taught as they become necessary.

What if you don't know the conversion factors? Colleges want students who can find their own information (so do employers). Hint: Try a good dictionary and look under "measure" or "measurement". Or the Internet? Enjoy.

a. 4008 *g* = 4.008 *kg*

b. 1.2 *km* = 1200 *m*

c. 823 *nm* = 8.23×10^{-7} *m*

d. 298 *K* = 25 ^oC

e. 0.77 *m* = 77 *cm*

f. 8.8×10^{-8} *m* = 8.8×10^{-5} *mm*

g. 1.2 *atm* = 1.22×10^{5} *Pa*

h. 25.0 μm = 25.0×10^{-6} *m*

i. 2.65 *mm* = 0.00265 *m*

j. 8.23 *m* = 0.00823 *km*

k. 40.0 *cm* = 0.400 *m*

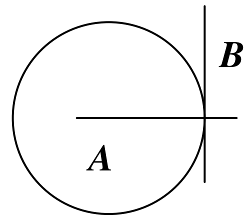
l. 6.23×10^{-7} *m* = 623 *nm*

m. 1.5×10^{11} *m* = 1.5×10^{8} *km*

4. Geometry

Solve the following geometric problems.

a. Line ***B*** touches the circle at a single point. Line ***A*** extends through the center of the circle.



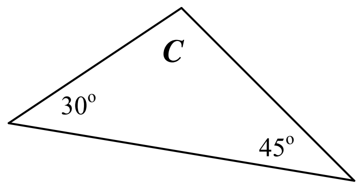
i. What is line ***B*** in reference to the circle?

tangent

ii. How large is the angle between lines ***A*** and ***B***?

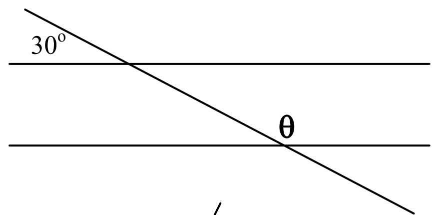
90°

b. What is angle ***C***?



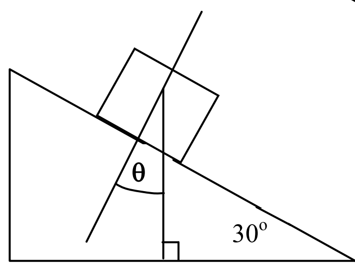
105°

c. What is angle θ ?



150°

d. How large is ***θ***?



30°

e. The radius of a circle is 5.5 *cm*, → 0.055m

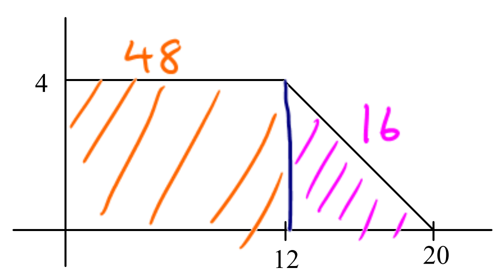
i. What is the circumference in <u>meters</u>?

0.35m

ii. What is its area in <u>square meters</u>?

$9.5\times10^{-3}\ m^2$

f. What is the area under the curve at the right?



$64\ unit^2$