1. Significant Digits

Read the following paragraph and answer the questions.

In most technical classes significant digits are very important. The reason is to obtain needed accuracy in intermediate and final answers. These answers then go into designing systems. What if the headphone jack size on an ipod was rounded to one significant digit? Would you purchase an ipod if the ear buds keep falling out of the jack?

All FINAL answers, in a box, are given to THREE significant digits. Any calculation used to obtain the final answer will use FOUR OR MORE significant digits. When using a calculator, easiest to use all the significant digits in the calculator.

Example work.

a) Identify the number of significant digits for the following numbers
   i. 3.1415927
   ii. 23*10^-3
   iii. 4200.
   iv. 0.00056

b) Express the following numbers as FINAL answers.
   i. 3.1415927
   ii. 23*10^-3
   iii. 4200.
   iv. 0.00056

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2. Units

Read the Mars Climate Orbiter article and answer the following questions.

a) Explain why including units is very important.

b) Homework is an engineering document used to communicate information to other teams and team members designing a system. What if a report from another team had no units at all. Explain what you would do.

Example
3. SI Prefixes

Electrical and computer engineering make extensive use of SI prefixes. They appear in schematics, memory sizes in computer architecture, and electronic component values in vendor catalogs. Being able to convert quickly between SI prefixes, decimal, and scientific notation (for use with calculators) is very important. Typically a value will range between 1.00 and 999 (as final answers) before changing the SI prefix. One notable exception is capacitor values. Historically capacitor values are rarely expressed in millifarads or nanofarads. Capacitor values typically but not always appear from 0.1 to 10,000 pF and 0.01 to 1,000,000 µF. Skipping milli and nano is acceptable for capacitors and only for capacitors.

Express the following numbers using an appropriate SI prefix, of course, as final answers.

a) 0.0000000002345623 meters
b) 213471325 watts
c) 7.8*10^{-5} farads

Example same as problem 1.
4. Sides of equations

When writing equations, the placement of values, terms, and variables relative to the equal sign is important. The Left Hand Side (LHS) is used, typically, for the DEPENDENT variables. The Right Hand Side (RHS) is used for INDEPENDENT variables. In engineering, variables such as current, voltage, resistance that are being solved for (dependent variable) ALWAYS appear on the LHS. The calculated value appears on the RHS.

In computer engineering, programming makes extensive use of the equals sign. However, it is not really indicating equality but rather assignment. When assigning a value to a variable, the variable ALWAYS appears on the LHS and the value (or return value from an expression) is ALWAYS on the RHS. Writing equations this way will be helpful when programming.

Express and give the following appropriately as final answers.

a) $V_x$ is calculated to have a value of 4.5 volts.

b) The expression $2t^2+4t+8$ meters is the height, $h$, of a rocket in meters as a function of time in seconds.

c) $C_x$ has a calculated value of $45.26 \times 10^{-7}$ F.

Example
5. Labeling Voltages and Currents

Labeling voltage polarity across circuit elements and current direction through circuit elements along with a variable name when solving circuits is very important. Variable names for current are always “i” or “I”, and “v” or “V” for voltage, each with a subscript. The reason is to have the correct sign (for voltage and current) when writing KVL and KCL equations for voltages and currents. Variable names written on the circuit diagram (NO VALUES, ever) eases the KCL and KVL equation writing process. Labeling a voltage consists of a writing plus (+) sign, minus (-) sign written along with a variable name. Place the polarity signs (+' and '-' ) at distinct and separate nodes where the element ends and wires start. Place the variable name that starts with the letter ‘v’ between the ‘+’ and ‘-’ signs. Labeling current is done by drawing an arrow and place the variable name that starts with ‘i’ beside the arrow.

The following resistor are label correctly. The left one has voltage labeled (V\textsubscript{A}) and right current labeled (I\textsubscript{C}).

![Diagram of voltage and current labeling]

Labeling a voltage on a wire, like the following, is meaningless because the voltage across a segment of wire is always zero (for this class). The following is an example of INCORRECT labeling. V\textsubscript{B} is label on wires and has a voltage of zero volts.

![Incorrect voltage labeling example]

Labeling a current that includes a junction is meaningless because the current could be different in each wire. The following is an example of INCORRECT labeling. The current through the 100\,\Omega resistor is certainly not equal to the current through the 600\,\Omega resistor and therefore the value of I\textsubscript{A} is unclear.

![Incorrect current labeling example]

a) For the following circuit, correctly label the current through all circuit elements.
b) For the following circuit, correctly label the voltage across all circuit elements.

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6. Working with Circuits

(Do NOT) Relabel
Components that are given numerical values should NOT be relabeled (as variables) for calculations. Using the values greatly simplifies analyzing the circuit and calculating values. Only unknown component values should use variables. The following example is INCORRECT. Just use the given values. Circuits with given values do not need to be solved algebraically, just use the numeric values.

Shorthand Notation with Equivalent Resistance
When simplifying circuits with equivalent resistance, use short-hand notation for series and parallel. A plus sign ‘+’ indicates that elements are in series. Two vertical bars ‘||’ indicate elements in parallel. Each step is clearly shown. Work is written beside the simplified element. Since no calculator was allowed on this problem, the actual math is shown on the side. At each step, the circuit MUST be redrawn.

Variable Definitions
Voltage variables always start with ‘v’ or ‘V’. Current variables always start with ‘i’ or ‘I’. Resistance variables always start with upper case ‘R’. In this class (not true for other classes), variable names for voltages and currents are case insensitive. Each voltage, current, or resistance is followed by one or more letters, in subscript, to distinguish each from others. Resistance at terminals is identified by the letter ‘R’ followed by the two terminal letters as subscripts as shown in the example above. Terminal letters are not always ‘A’ and ‘B’.

Labeling and Circling Nodes
A good technique to identify elements in series and parallel is to circle and label nodes. Circle nodes by drawing a closed loop around each node (the wires). Turn around when an element is encountered. A multimeter used to measure equivalent resistance counts as an element but only at the connecting terminals. Then number each unique node by placing the number, in a circle, beside each node, as shown on the next page. Nodes are circled and labeled 1 through 5.

Final answer,
Boxed, Units, SI
Prefix, LHS/RHS,
Appears after work is shown.
Circling and labeling nodes is very useful when identifying elements in series and parallel. Explain how nodes, in general and NOT applied to the circuit above, can be used to identify each of the following.

a) Open
b) Short
c) Series
d) Parallel

**Identifying Methods**
Writing the method used for each step can be useful when reviewing work before an exam but not required. Methods we know about are: KVL, KCL, Ohm’s Law, Voltage Division, Equivalent Resistance (Simplify).

Example
7. Sketches

Sketches convey visual information to other engineers. Clear sketches are important. Every sketch shall include an X label, X units, X ticks (all), Y label, Y units, Y ticks (all). The function being sketched should be a good representation of the function or data. For RC circuits, the shape of the sketch should be exponential and sketched from $-\tau < t \leq 5\tau$.

8. Solve for and give the equivalent resistance at terminals A and B.

![Resistance Circuit Diagram]

9. Solve for and give the current through the 100 Ω resistor

![Current Through RESistor Diagram]

10. Give $v_c(t)$ for all time. Switch D is open and E is closed for a long time before time $t=0$s, then at $t=0$s, switch D closes and E opens. Show all of your work in detail. Sketch the capacitor voltage from $-\tau < t \leq 5\tau$.

![Capacitor Voltage Sketch]

11. A competent technician measures the resistance of a resistor using a multimeter. The multimeter reads (exactly) 100 kΩ. The technician then solders the resistor onto a PCB. The value of the resistor is measured again while in place on the PCB using the same multimeter on the same settings. The
resistance of the resistor now reads 57.6 kΩ. Explain why the multimeter does not display the correct value. Both the multimeter and technician are functioning correctly. The resistor is not damaged. Soldering and cleaning is perfect.

12. Give the resistance for the following resistor color code. Show your work.
   **Blue Yellow Orange Gold**

13. Give the equivalent resistance of the following circuit between A and B using our shorthand notation. Do not simplify.