SKILLS NEEDED FOR THE FIRST APRIL TEST (2000, L-H)

1. Use algebra to solve an equation for its unknown and then plug in given data to determine the numerical value and units of that unknown quantity (rounding off properly) as on previous tests.

2. Use RS II to estimate the uncertainty of a sum, difference, product, quotient, or square root.

3. Given some data points, calculate the slope of a linear graph.

4. Use Newton's 2nd law of motion and the definition of "total force" as we did in Ch. VI and VII.

5. Transform a graph of velocity vs time into a graph of acceleration vs time or displacement vs time as we did in chapters II and VII.

6. Given the amplitude and frequency of a sinusoidal function, determine the amplitude of its derivative or integral. (See RS VII.)

7. Use the formulas for gravitational potential energy, elastic potential energy, & kinetic energy. Use the "work and energy theorem" and "energy conservation law" on RS VI.

8. Use the definitions of "series" and "parallel" on RS VIII. Given a description of a circuit, draw a circuit diagram showing the leads and terminals of each component clearly. Indicate the direction of electron flow in the leads of each component.

9. Use the beginner's definitions of "voltage" and "resistance" as on pages 83, 83R, 84, 85, 86, 87, and RS IX. Use the voltmeter and ammeter connection rules on RS IX. Use the relationship among voltages in a series or parallel circuit as in #5 on RS IX.

10. Use the definition of "power" on RS VI. Use the electric power formula and the electric energy formulas in #14 & 15 on RS IX and #8 & 12c on RS X.

11. Sketch a voltage vs. current graph as on RS X. Use it to predict a change in current or voltage.

12. Use the definitions of "static resistance" and "dynamic resistance" on RS X. Use Ohm's equation as in pages 90-95 and 99-103. Use #9 on RS X to calculate the resistance or conductance of a series or parallel combination of resistors.

13. Use the definitions of galvanometer sensitivity, FSD voltage, and FSD current on RS X. Given a complete description of a galvanometer's behavior, show how to convert it into a voltmeter or an ammeter and how to predict the range of such an instrument as in #13 & 14 on RS X.

14. Use the definition of "average current" as we did on page 99, 99R, and 103.

15. Predict the behavior of a simple circuit made with resistors, capacitors, voltmeters, ammeters, and a battery as we did on pages 96-103.

16. Use the definition of "capacitance" and the "capacitor laws" on RS XI.

17. Use the definition of "percentage change" as in #10 & 13 on RS XI and as on RS I.

First April Test (2000, Level H) name:________________

1. On the back of this paper draw four resistors connected to a battery so that cutting any *one* of them will leave *two* of them still working, as in #9 on p. 79. Label them 10Ω, 20Ω, 30Ω, and 40Ω. (Decide for yourself which is which. Remember that an "Ω" is a resistance unit.) The currents through these resistors will cause them to heat up. Label the one that becomes *hottest* and the one that heats the *least*. (sk. 8-11)

2. A certain 500-ohm galvanometer gives a reading of 0.25 FSD when connected to a 1.5-Volt flashlight cell with a 7500-ohm resistor in series.
   a. Using SI units, calculate the current in the galvanometer. (Skill 12)
   b. Calculate this galvanometer's sensitivity. (Skill 13)
   c. We want to use this galvanometer to construct a voltmeter with a range of 0 - 30 V. How much resistance must we connect to it, and how must we connect it? (Skill 13)
   d. Calculate this galvanometer's FSD voltage. (Skill 13)

3. Draw a voltmeter and a capacitor connected in series to a battery. Put appropriate signs on the capacitor plates to indicate the kind of charges they will have when the capacitor has charged up. Then draw a light bulb connected across the capacitor. Connect it to the capacitor's *terminals*, not to its plates. Make the capacitor leads and the voltmeter leads at least one cm. long in your diagram. When you tried this you saw the bulb light up briefly, indicating that there was a significant current in its leads at that time. Since the voltmeter had great resistance, we knew that the current in its leads was *insignificant*. Put dots on ALL of the wires in your diagram that carried insignificant currents. Draw arrows indicating the direction of electron flow on each of the wires that carried significant currents. **Each** wire must have a dot **or** an arrow, *but not both.* (sk. 15)

4. A resistor and a capacitor are connected in series in a complicated circuit. The current in the wire between them steadily *increases* from 0.32 ± 0.01 A to 0.40 ± 0.01 A in 25.0 sec.
   a. How much charge flows through the wire during that time interval? Use SI units. (14)
   b. Sketch the resistor's voltage vs time graph for the interval described. (skills 12, 16)
   c. Sketch the capacitor's charge vs time graph for that interval. Start at zero. (skill 16)
   d. Calculate the slope of the current vs time graph and estimate its percentage uncertainty. (Use skills 2 & 3)

5. A certain capacitor is initially uncharged. For 2.0 seconds its leads carry a steady 0.30-A current. During the next two seconds the current is 0.60 A in the same direction. During the final two seconds the current is zero.
   a. Sketch the current vs time graph. (gift point)
   b. Sketch the capacitor's voltage vs time graph. (Use skill 16)

6. A certain capacitor's voltage vs time graph is a sine curve with an amplitude of 2.00 volt and a period of 1.00 second. The capacitance is 0.500 farad.
   a. Calculate the maximum rate at which this capacitor voltage changes. (skill 16)
   b. Sketch the capacitor's *current vs time* graph. (skill 16)
   c. Calculate the maximum capacitor current. (skill 16)
   d. Sketch the capacitor's *charge vs time* graph. (skill 16)
   e. Calculate the maximum charge on this capacitor. (skill 16))

7. A certain voltage decreases by 2.00% every ten seconds.
   a. Sketch a graph of that voltage vs time. (skill 17)
   b. How much time will be needed for the voltage to decrease to 2/3 of its initial value?
   c. A tangent line is drawn on the curved graph at the "2/3" point described in 7b. The slope of that tangent line is -0.27 V/s. What is the slope of another tangent line drawn at the *beginning* of the curve, at t = 0? (skill 17)
   d. Calculate the initial voltage. (One point for a reasonable estimate, 2 if within 2%)

ANSWER SPACE

1) *on the back*

2a) ________

2b) ________

2c) ________

2d) ________

3) *Use bottom marg*

4a) ________

4b) ________

4c) ________

4d) ________

5a) ________

5b) ________

6a) ________

6b) ________

6c) ________

6d) ________

6e) ________

7a) ________

7b) ________

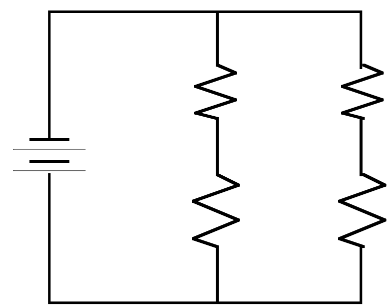
7c) ________

7d)

First April Test Solutions

1. Draw four resistors connected to a battery so that cutting any *one* of them will leave *two* of them still working. Label them 10Ω, 20Ω, 30Ω, and 40Ω. Label the one that becomes *hottest* and the one that heats the *least*. (3 points)

   In the diagram at the right any placement of the four given resistance values is acceptable. The series pair with the least resistance will draw the greatest current. The member of that pair with the greater resistance will be the hottest. The smallest-resistance member of the other pair will be the one which heats the least.



2. A certain 500-ohm galvanometer gives a reading of 0.25 FSD when connected to a 1.5-Volt flashlight cell with a 7500-ohm resistor in series.
   a. Using SI units, calculate the current in the galvanometer. (2 points)

      By Ohm's equation, $I = emf/(R_L + R_i) = (1.5\ V)/(7500 + 500\ ohms) =$ $\mathbf{1.88 \times 10^{-4}\ A}$

   b. Calculate this galvanometer's sensitivity. (2 points)

      Sensitivity = deflection/current = 0.25 FSD/(1.88 x 10^{-4} *A) =* $\mathbf{1.33 \times 10^{3}}$ ***ohms per volt***

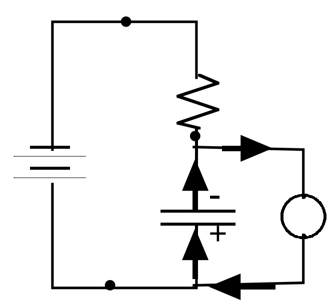
   c. We want to use this galvanometer to construct a voltmeter with a range of 0 - 30 V. How much resistance must we connect to it, and how must we connect it? (3 points)

      Combined resistance = (30 V)(1.33 x 10^3 *ohms per volt) = 40 x* 10^3 *ohms .*
      External resistance needed = 40 x 10^3 *ohms - 0.50 x* 10^3 *ohms =* $\mathbf{39.5 \times 10^{3}}$ ***ohms in series***

   d. Calculate this galvanometer's FSD voltage. (2 points)

      FSD Voltage = Resistance x FSD Current = Resistance/sensitivity
      = 500 ohms/1.33 x 10^3 *ohms per V =* ***0.375 V***

3. Draw a voltmeter and a capacitor connected in series to a battery. Put signs on the plates to indicate the kind of charges they will have when the capacitor has charged up. Then draw a light bulb connected across the capacitor. Make the capacitor leads and the voltmeter leads at least one cm. long in your diagram. When you tried this you saw the bulb light up briefly, indicating that there was a significant current in its leads at that time. Since the voltmeter had great resistance, we knew that the current in its leads was *insignificant*. Put dots on ALL of the wires in your diagram that carried insignificant currents. Draw arrows indicating the direction of electron flow on each of the wires that carried significant currents. **Each** wire must have a dot **or** an arrow. (3 points)

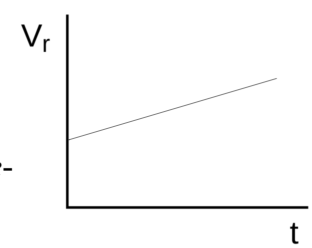


4. A resistor and a capacitor are connected in series in a complicated circuit. The current in the wire between them steadily *increases* from 0.32 ± 0.01 A to 0.40 ± 0.01 A in 25.0 sec.
   a. How much charge flows through the wire during that time interval? Use SI units. (3 points)

      Charge = average current x time interval
      = (0.36 ± 0.01 A*)(25.0 s) =* ***9.0 ± 0.25 coulombs***

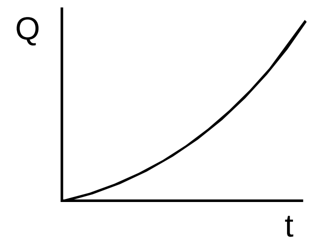
   b. Sketch the resistor's voltage vs time graph for the interval described. (1 point)

      Resistor voltage is proportional to current, so the resistor voltage-time graph has the same shape as the current-time graph.



First April Test Solutions, continued

4c. Sketch the capacitor's charge vs time graph for that interval. Start at zero. (1 point)



Capacitor current is the slope of the capacitor charge vs time graph. Since that current is increasing from a positive initial value, the charge graph must have a slope that increases gradually from a positive initial value; it gets steeper as time goes on.

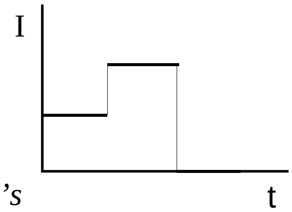
d. Calculate the slope of the current vs time graph and estimate its percentage uncertainty. (3 points)

$\Delta I/\Delta t = [(0.40 \pm 0.01\ A) - (0.32 \pm 0.01\ A)]\ /(25.0\ sec) = [0.08 \pm 0.02A]/(25.0\ sec)$
$[0.08\ A \pm 25\%]/(25.0\ sec) = \mathbf{0.0032\ A/s \pm 25\%}$

5. A certain capacitor is initially uncharged. For 2.0 seconds its leads carry a steady 0.30-A current. During the next two seconds the current is 0.60 A in the same direction. During the final two seconds the current is zero.

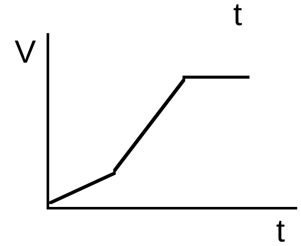
a. Sketch the current vs time graph. (1 gift point)

Using the given description, we get the following graph:



b. Sketch the capacitor's voltage vs time graph. (3 points)

According to the second capacitor law, the slope of the capacitor's voltage-time graph is proportional to the capacitor current, which is given. For the first 2 seconds the current is constant and positive, and so is the slope. During the next two seconds the slope and current are twice the previous value, and during the final 2 seconds the slope must be zero. The graph must begin at the origin because the capacitor is initially uncharged.



6. A certain capacitor's voltage vs time graph is a sine curve with an amplitude of 2.00 volt and a period of 1.00 second. The capacitance is 0.500 farad.

a. Calculate the maximum rate at which this capacitor voltage changes. (2 points)

The steepest slope on a sine curve is $2\pi A/P = 2\pi(2.00\ V)/(1.00\ s) =$ ***12.56 volts per second***

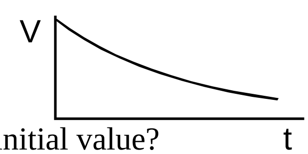
b. Sketch the capacitor's *current vs time* graph. (1 point)
Capacitor current is proportional to the slope of the capacitor's voltage-time graph. Differentiating a sinusoidal function shifts it 1/4 cycle to the left. The result in this case is a ***cosine curve****.*

c. Calculate the maximum capacitor current. (2 points) *(0.500 C/V)(12.56 V/s) =* ***6.28 A***

d. Sketch the capacitor's *charge vs time* graph.   (1 point)
Capacitor charge is proportional to capacitor voltage, so it must be a ***sine curve.***

e. Calculate the maximum charge on this capacitor. (2 points) *Q = CV = (0.500 F)(2.00 V) =* ***1.0 C***

7. A certain voltage decreases by 2.00% every ten seconds.



a. Sketch a graph of that voltage vs time. (1 point)
By definition, it must be an exponential decay.

b. How much time will be needed for the voltage to decrease to 2/3 of its initial value?
$(1 - 0.02)^x = 2/3$*, so x = 20 times. 20 x 10 sec =* ***200 seconds***   (2 points)

c. A tangent line on the curve at the "2/3" point in 7b has a slope of - 0.27 V/s. What is the slope of another tangent line at the *beginning* of the curve?   (2 points) *For exponential functions slope is proportional to value, so the slope is (-0.27 V/s)(3/2) =* ***-0.405 V/s***

d. Calculate the initial voltage. (2 pts) *0.02Vi/10s = 0.405 V/s (given) ..so Vi = 4.05/0.02 =* ***202 V***