Electronics HW Problem Set

1. Using the basics of how a voltage divider circuit works, compute the voltage output, current draw from the 9V battery and the power dissipated in a load resistor in these two circuits:

   Circuit 1: R1 = 10kΩ and R2 = 10kΩ

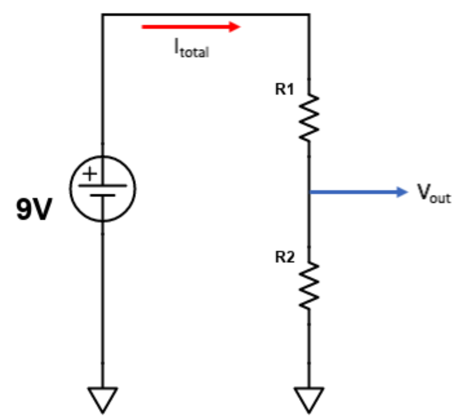

Figure 1a

   Compute V_{out} (the output/measured voltage) and I_{total} for the circuit shown in Fig 1a.

   Circuit 2: R1 = 10kΩ, R2 = 10kΩ and R3 = 5kΩ

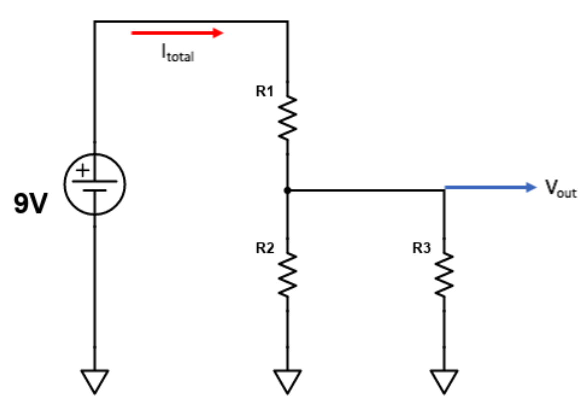

Figure 1b

   Compute V_{out} and I_{total} for the circuit shown in Fig 1b. Using these results, compute the dissipated power in load resistor R3.

2. Show that it is not possible to exceed the power rating of a ¼ watt resistor of resistance greater than 1kΩ, no matter how you connect it, in a circuit operating from a 15 volt battery. (*Hint: think of at least two arrangements that could cause the maximum current to flow through the resistor*)
3. A current varies a function of time as shown in Figure 2. Predict and plot the voltage produced by this current flowing in an uncharged 1μF capacitor. Show clearly your calculations for the two temporal regimes: 0 < t < 3msec and 3msec < t < 5msec

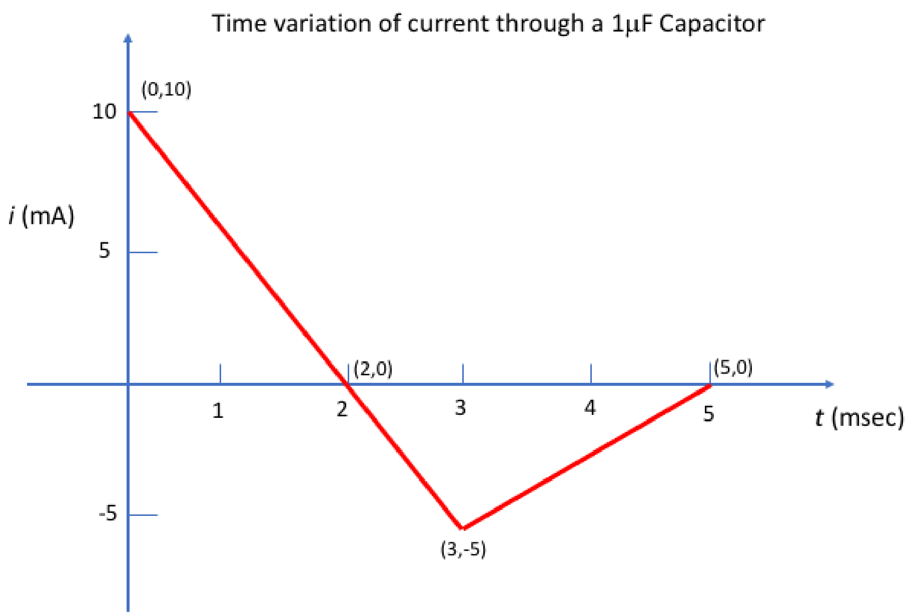

Figure 2: Current flowing into a 1μF capacitor. Useful coordinates are shown in parenthesis

4. A current flowing through the resistor-inductor combination shown in Fig. 3 has the functional form of ***i=5exp(-2t)*** *A*, where t is time in seconds. R4 = 4Ω and L1 = 1H. Calculate the total voltage across both passive elements as a function of time between 0< t < 2s. Plot both current and total voltage for this regime.

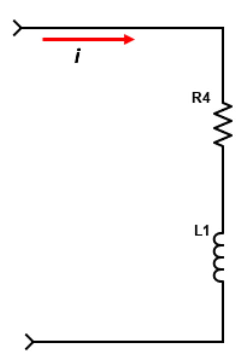

Figure 3: Resistor and Inductor in series (R4=4Ω and L1 = 1H) for Problem 4

5. Current flowing through the capacitor from a sinusoidal source shown in Fig. 4 has the following functional form: $i = i_0 \cos(\omega t)$ where ω is the angular frequency. Prove that this circuit consumes no power when averaged over an entire cycle.

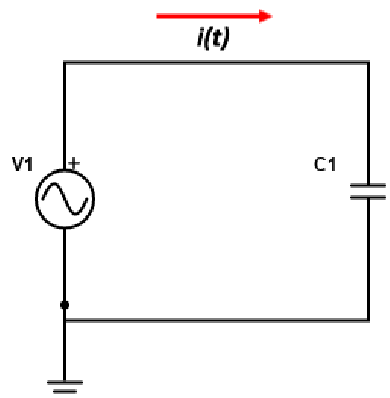

Fig 4: Voltage source V1 drives the capacitor C1 with a sinusoidal waveform

6. To work on this problem, you are encouraged to review Chapter 3 of the text (Experiments in Modern Physics by Melissinos and Napolitano), particularly Section 3.1.

   Suppose you wish to detect a rapidly changing voltage signal. However, this signal is superimposed on a large DC voltage level that would damage your measuring instrument if it were in contact with it. The recommendation is to build a simple passive circuit that allows only the high-frequency signal to pass through.

   a. Sketch a circuit using only a resistor *R* and a capacitor *C* that would solve the problem. Indicate the points at which you can measure the input and output voltages
   b. Show that the magnitude of the output voltage equals the magnitude of the input voltage multiplied by

$$\frac{1}{\sqrt{1 + 1/(\omega RC)^2}}$$

   where ω is the angular frequency of the signal.

   c. Suppose that R=1kΩ and the signal frequency is 1MHz (=10^6 cycles/s), suggest a value for the capacitor and the rationale for the choice.