PHYS605

HOMEWORK 1

DUE WEDNESDAY FEB 7, 2024.

RECOMMENDED READING:

Practical Electronics chapter 2, specifically 2.12 through 2.19, and chapter 4.2 on diodes.

For each problem the number of points are indicated in the square brackets [ ].

PROBLEMS:

RESISTORS

1) Some exercises with resistors:

   a) [5] Consider the circuit in figure 1 on the right. Compute the voltages V2 and V3 and compute the current through each of the resistors.

   b) [5] Calculate the power consumed in each of the resistors in Figure 1.

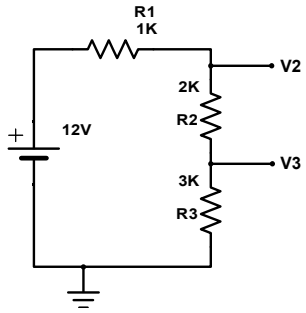


Figure 1

   c) [5] You now add a load resistor of 1kΩ to the V3 output, see Figure 2. What are now the voltages V2 and V3?

   d) [5] What are the currents through resistors R1, R2, R3 and R4?

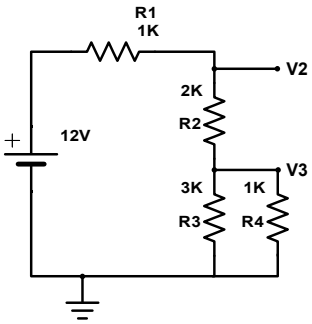
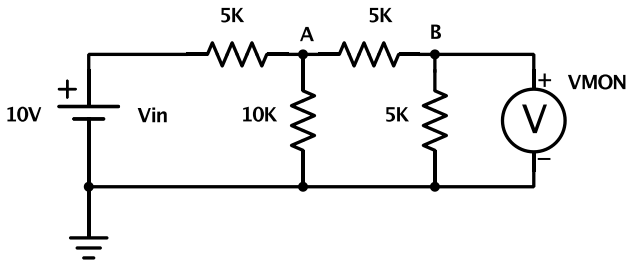


Figure 2

2) You want to connect a blue LED (max current 20mA, voltage drop 2.5 V) to the 110V net using only a simple resistor. For simplicity, consider the 110V to be constant (in reality it is AC, or alternating current, and the 110V is the RMS voltage.).
   a) [10] What value resistor do you need so that the LED is at full brightness, without burning out?
   b) [10] What is the power used in the resistor, and what is the power used in the LED?
   c) [10] What is the energy efficiency of your solution, if the LED converts 80% of the power in the LED to light?

3) Consider the circuit shown here of an R2R ladder, with two output terminals, to which a voltmeter is connected, as shown in the figure.
   a) [10] Sketch the Thévenin equivalent of the R2R ladder, as seen by the voltmeter. Find the correct values for V_{th} and R_{th}.
   b) [10] Sketch the output voltage (Vmon), as seen by the voltmeter, versus the input voltage (Vin) from the power supply.



4) For a circuit in the lab you need a resistor that has the value of 5.4 kΩ, and which needs to have a power rating of at least ½ Watt. Your resistor kit only has 1/8 Watt, 1% accurate, resistors, and only has the values that are given in the table to the right.
   a) [20] Design a circuit combining resistors that has the correct properties for what you need, accurate to 1%.
      i) Use some first principles: What is the minimum number of resistors that could do this, if you could use any value you wished?
      ii) Hint: the simplest solution I found has 9 resistors!
      iii) You may use a Python code, but then you need submit the code.
   b) [10] What is the maximum voltage that you can put across this combined resistor network and not burn out any of the resistors?

10 Ω	100 Ω	1.0 kΩ	10 kΩ
15 Ω	150 Ω	1.5 kΩ	15 kΩ
22 Ω	220 Ω	2.2 kΩ	22 kΩ
33 Ω	330 Ω	3.3 kΩ	33 kΩ
47 Ω	470 Ω	4.7 kΩ	47 kΩ
68 Ω	680 Ω	6.8 kΩ	68 kΩ