Voltage Divider Circuits

AC Electric Circuits

Question 1

Don't just sit there! Build something!!

Learning to mathematically analyze circuits requires much study and practice. Typically, studer practice by working through lots of sample problems and checking their answers against those provided by the textbook or the instructor. While this is good, there is a much better way.

You will learn much more by actually *building and analyzing real circuits*, letting your test equip provide the "answers" instead of a book or another person. For successful circuit-building exe follow these steps:

1. Carefully measure and record all component values prior to circuit construction.
2. Draw the schematic diagram for the circuit to be analyzed.
3. Carefully build this circuit on a breadboard or other convenient medium.
4. Check the accuracy of the circuit's construction, following each wire to each connection verifying these elements one-by-one on the diagram.
5. Mathematically analyze the circuit, solving for all values of voltage, current, etc.
6. Carefully measure those quantities, to verify the accuracy of your analysis.
7. If there are any substantial errors (greater than a few percent), carefully check your circuit construction against the diagram, then carefully re-calculate the values and re-measure.

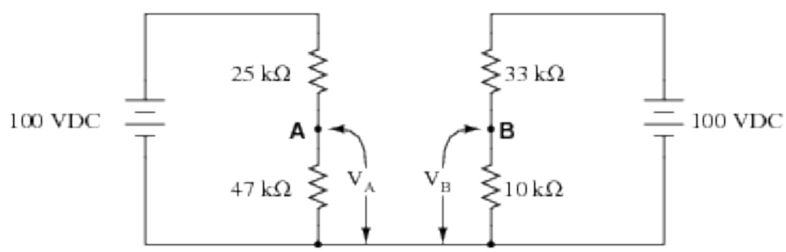
Avoid very high and very low resistor values, to avoid measurement errors caused by meter "lo I recommend resistors between 1 kΩ and 100 kΩ, unless, of course, the purpose of the circuit illustrate the effects of meter loading!

One way you can save time and reduce the possibility of error is to begin with a very simple cir
incrementally add components to increase its complexity after each analysis, rather than buildi
whole new circuit for each practice problem. Another time-saving technique is to re-use the sa
components in a variety of different circuit configurations. This way, you won't have to measure
component's value more than once.

Reveal answer

Question 2

Calculate the output voltages of these two voltage divider circuits (V_A and V_B):



Now, calculate the voltage between points **A** (red lead) and **B** (black lead) (V_{AB}).

Reveal answer

Question 3

We know that the current in a series circuit may be calculated with this formula:

$$I = \frac{E_{total}}{R_{total}}$$

We also know that the voltage dropped across any single resistor in a series circuit may be cal with this formula:

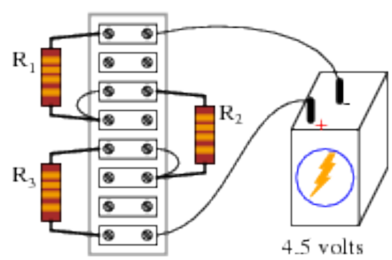
$$E_R = I\ R$$

Combine these two formulae into one, in such a way that the I variable is eliminated, leaving or expressed in terms of E_{total}, R_{total}, and R.

Reveal answer

Question 4

Determine the amount of voltage dropped by each resistor in this circuit, if each resistor has a code of Brn, Blk, Red, Gld (assume perfectly precise resistance values - 0% error):



Also, determine the following information about this circuit:

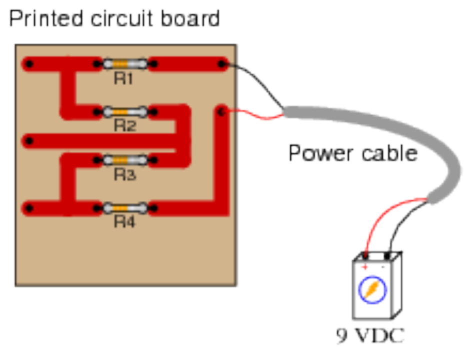
Current through each resistor
Power dissipated by each resistor
Ratio of each resistor's voltage drop to battery voltage ([$(E_R)/(E_{bat})$])
Ratio of each resistor's resistance to the total circuit resistance ([$R/(R_{total})$])

Reveal answer

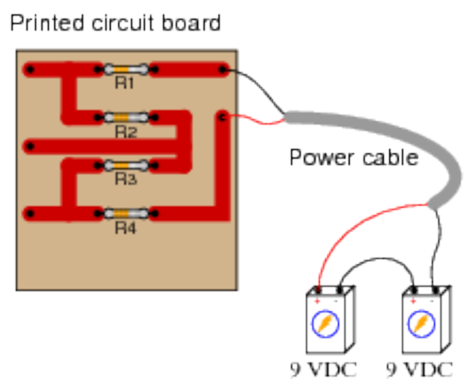
Question 5

Calculate the voltage dropped by each of these resistors, given a battery voltage of 9 volts. Th resistor color codes are as follows (assume 0% error on all resistor values):

R_1 = Brn, Grn, Red, Gld
R_2 = Yel, Vio, Org, Gld
R_3 = Red, Grn, Red, Gld
R_4 = Wht, Blk, Red, Gld



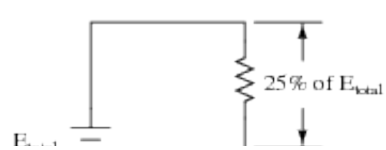
Now, re-calculate all resistor voltage drops for a scenario where the total voltage is different:

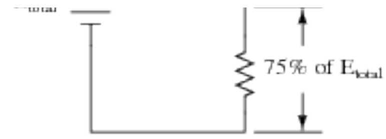


Reveal answer

Question 6

Design a voltage divider circuit that splits the power supply voltage into the following percenta

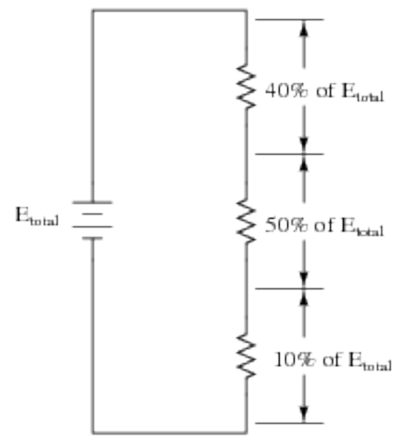




Reveal answer

Question 7

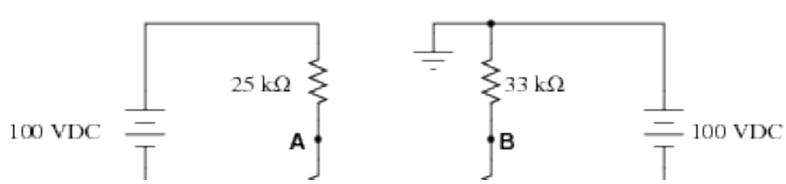
Design a voltage divider circuit that splits the power supply voltage into the following percenta



Reveal answer

Question 8

Calculate V_A (voltage at point **A** with respect to ground) and V_B (voltage at point **B** with respect ground) in the following circuit:

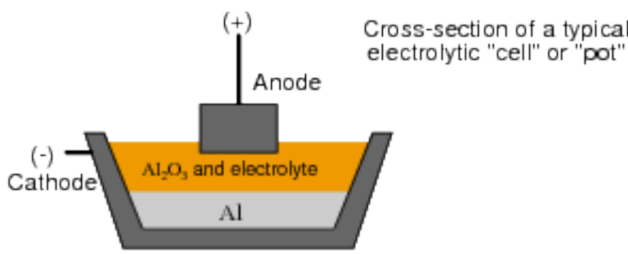


Now, calculate the voltage between points **A** and **B** (V_{AB}).

Reveal answer

Question 9

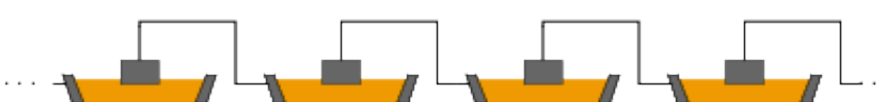
Many manufacturing processes are *electrochemical* in nature, meaning that electricity is used t promote or force chemical reactions to occur. One such industry is aluminum smelting, where l amounts of DC current (typically several *hundred thousand* amperes!) is used to turn alumina (/ into pure metallic aluminum (Al):



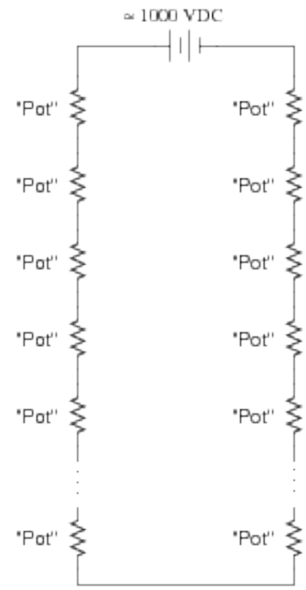
The alumina/electrolyte mixture is a molten bath of chemicals, lighter than pure aluminum itself Molecules of pure aluminum precipitate out of this mix and settle at the bottom of the "pot" wh molten metal is periodically pumped out for further refining and processing. Fresh alumina pow periodically dropped into the top of the pot to replenish what is converted into aluminum metal

Although the amount of current necessary to smelt aluminum in this manner is huge, the voltag across each pot is only about 4 volts. In order to keep the voltage and current levels reasonabl large smelting facility, many of these pots are connected in series, where they act somewhat lik resistors (being energy *loads* rather than energy *sources*):

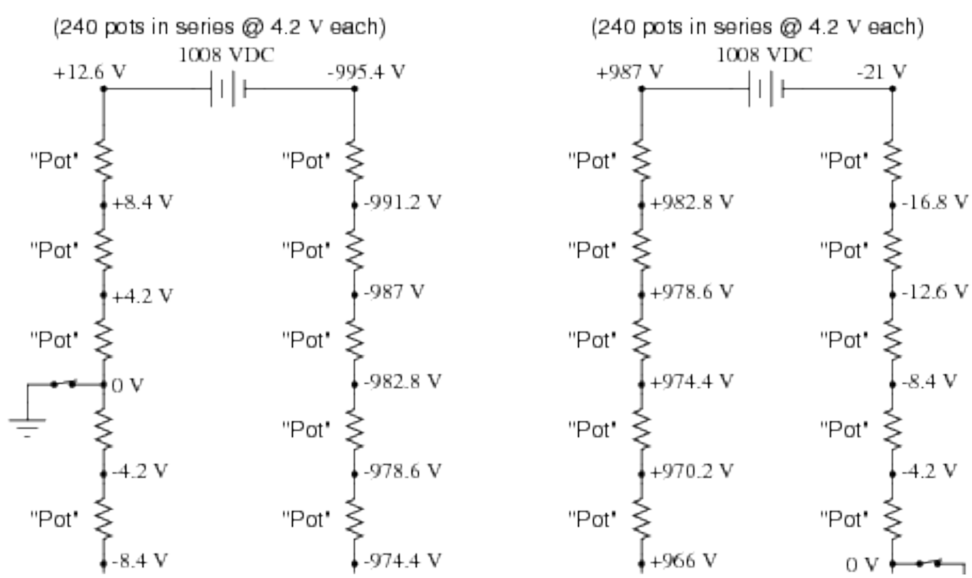
Multiple "pots" connected in series



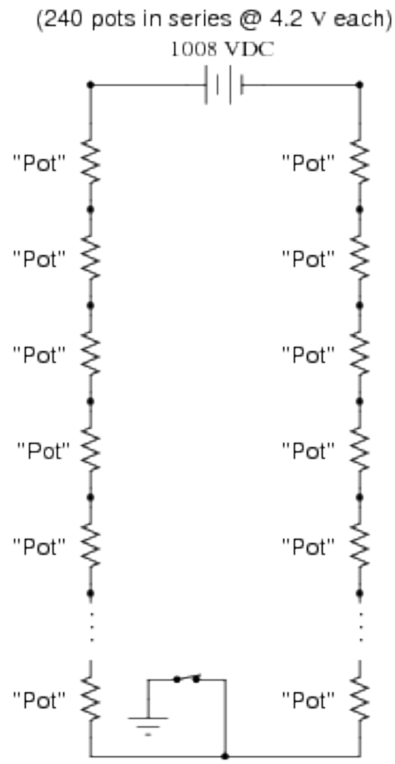
A typical “pot-line” might have 240 pots connected in series. With a voltage drop of just over 4
apiece, the total voltage powering this huge series circuit averages around 1000 volts DC:



With this level of voltage in use, electrical safety is a serious consideration! To ensure the safety
personnel if they must perform work around a pot, the system is equipped with a “movable gro
consisting of a large switch on wheels that may be connected to the steel frame of the shelter (
concrete pilings penetrating deep into the soil) and to the desired pot. Assuming a voltage drop
exactly 4.2 volts across each pot, note what effect the ground’s position has on the voltages ar
the circuit measured with respect to ground:



Determine the voltages (with respect to earth ground) for each of the points (dots) in the followi schematic diagram, for the ground location shown:



Reveal answer

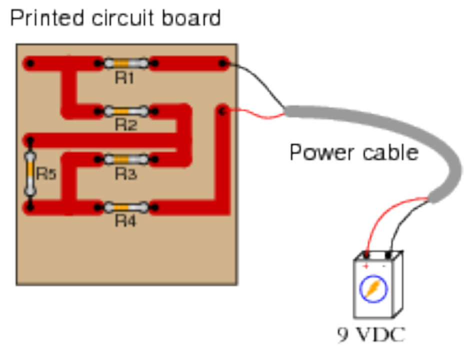
Question 10

Draw an equivalent schematic diagram for this circuit, then calculate the voltage dropped by ea these resistors, given a battery voltage of 9 volts. The resistor color codes are as follows (assu error on all resistor values):

R_1 = Brn, Grn, Red, Gld

R_2 = Yel, Vio, Org, Gld

R_2 = Yel, Vio, Org, Gld
R_3 = Red, Grn, Red, Gld
R_4 = Wht, Blk, Red, Gld
R_5 = Brn, Blk, Org, Gld



Compare the voltage dropped across R1, R2, R3, and R4, with and without R5 in the circuit. W general conclusions may be drawn from these voltage figures?

Reveal answer

Question 11

The formula for calculating voltage across a resistor in a series circuit is as follows:

$$V_R = V_{total}\left(\frac{R}{R_{total}}\right)$$

In a simple-series circuit with one voltage source and three resistors, we may re-write this form be more specific:

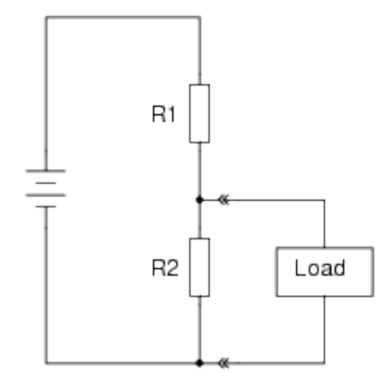
$$V_{R1} = V_{source}\left(\frac{R_1}{R_1 + R_2 + R_3}\right)$$

Suppose we have such a series circuit with a source voltage of 15 volts, and resistor values of kΩ and R_2 = 8.1 kΩ. Algebraically manipulate this formula to solve for R_3 in terms of all the oth variables, then determine the necessary resistance value of R_3 to obtain a 0.2 volt drop across R_1.

Reveal answer

Question 12

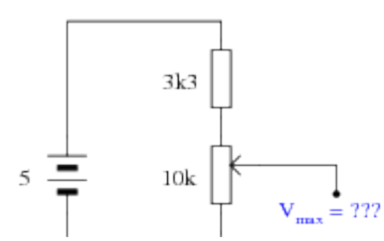
What will happen to the voltages across resistors R1 and R2 when the load is connected to the circuit?

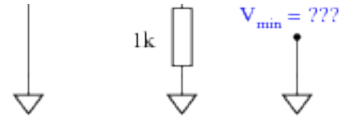


Reveal answer

Question 13

Calculate both the maximum and the minimum amount of voltage obtainable from this potentic circuit (as measured between the wiper and ground):

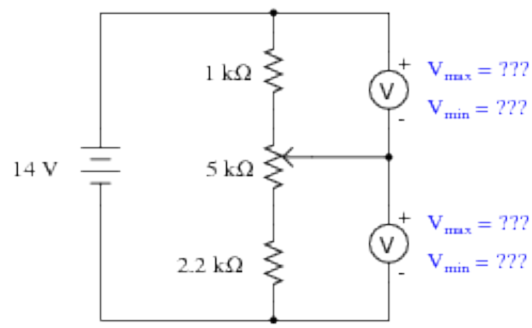




Reveal answer

Question 14

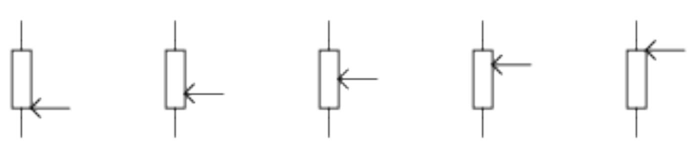
Calculate both the maximum and the minimum amount of voltage that each of the voltmeters w
register, at each of the potentiometer's extreme positions:



Reveal answer

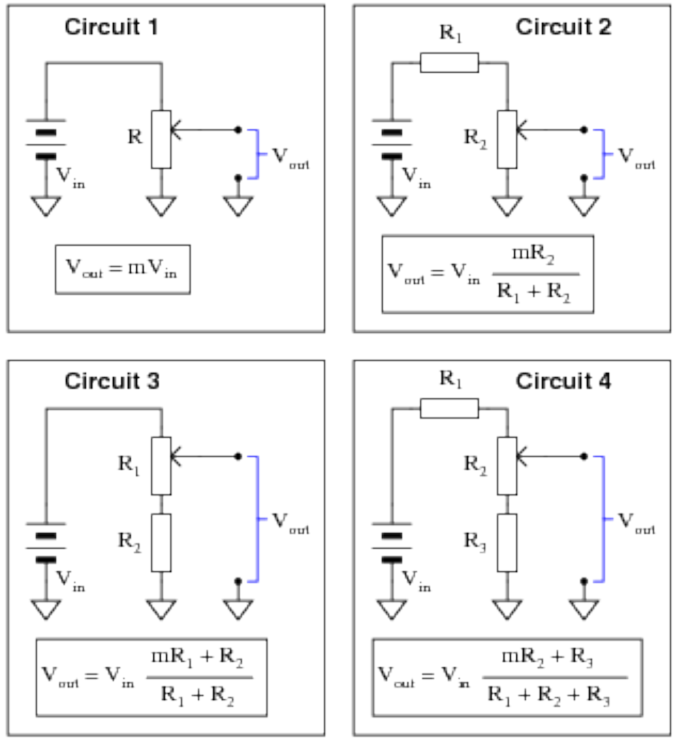
Question 15

As adjustable devices, potentiometers may be set at a number of different positions. It is often
to express the position of a potentiometer's wiper as a *fraction* of full travel: a number between
1, inclusive. Here are several pictorial examples of this, with the variable m designating this tra
value (the choice of which alphabetical character to use for this variable is arbitrary):



$m = 0$ $m = 0.25$ $m = 0.5$ $m = 0.75$ $m = 1$

Using an algebraic variable to represent potentiometer position allows us to write equations de the outputs of voltage divider circuits employing potentiometers. Note the following examples:

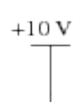


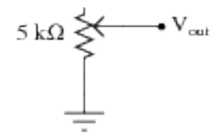
Algebraically manipulate these four equations so as to solve for m in each case. This will yield equations telling you where to set each potentiometer to obtain a desired output voltage given input voltage and all resistance values (m = …).

Reveal answer

Question 16

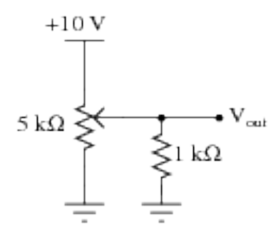
When the 5 kΩ potentiometer in this circuit is set to its 0%, 25%, 50%, 75%, and 100% positi following output voltages are obtained (measured with respect to ground, of course):





At 0% setting, V_{out} = 0 V
At 25% setting, V_{out} = 2.5 V
At 50% setting, V_{out} = 5 V
At 75% setting, V_{out} = 7.5 V
At 100% setting, V_{out} = 10 V

Calculate what the output voltages will be if a 1 kΩ load resistor is connected between the “V_{ou}
terminal and ground:

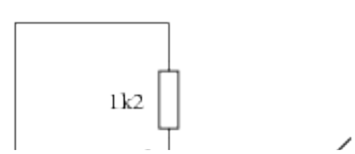


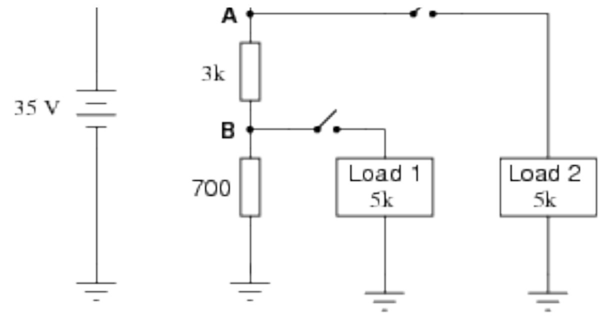
At 0% setting, V_{out} =
At 25% setting, V_{out} =
At 50% setting, V_{out} =
At 75% setting, V_{out} =
At 100% setting, V_{out} =

Reveal answer

Question 17

Determine the voltages (with respect to ground) at points **A** and **B** in this circuit under four diffe
conditions: both loads off, load 1 on (only), load 2 on (only), and both loads on:



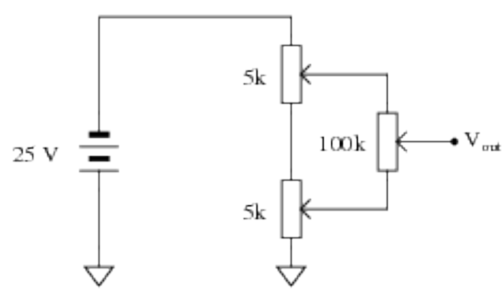


Voltage	Both loads off	Load 1 on (only)	Load 2 on (only)	Both loads on
V_A				
V_B				

Reveal answer

Question 18

Calculate both the total resistance of this voltage divider circuit (as “seen” from the perspective 25 volt source) and its output voltage (as measured from the V_{out} terminal to ground):

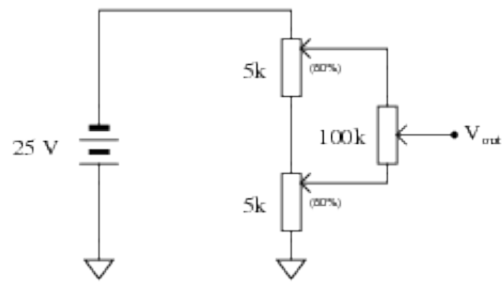


Note that all potentiometers in this circuit are set exactly to mid-position (50%, or m = 0.5).

Reveal answer

Question 19

Calculate both the total resistance of this voltage divider circuit (as ßeen" from the perspective 25 volt source) and its output voltage (as measured from the V_{out} terminal to ground):

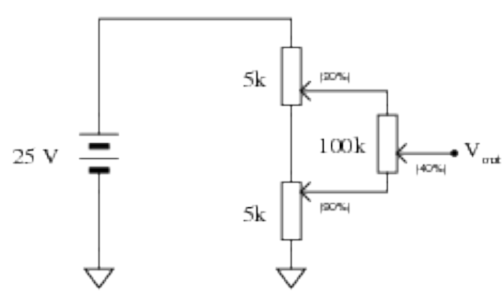


Note that the two 5 kΩ potentiometers are set to their 80% positions (m = 0.8), while the 100 k potentiometer is set exactly to mid-position (50%, or m = 0.5).

Reveal answer

Question 20

Calculate both the total resistance of this voltage divider circuit (as ßeen" from the perspective 25 volt source) and its output voltage (as measured from the V_{out} terminal to ground):

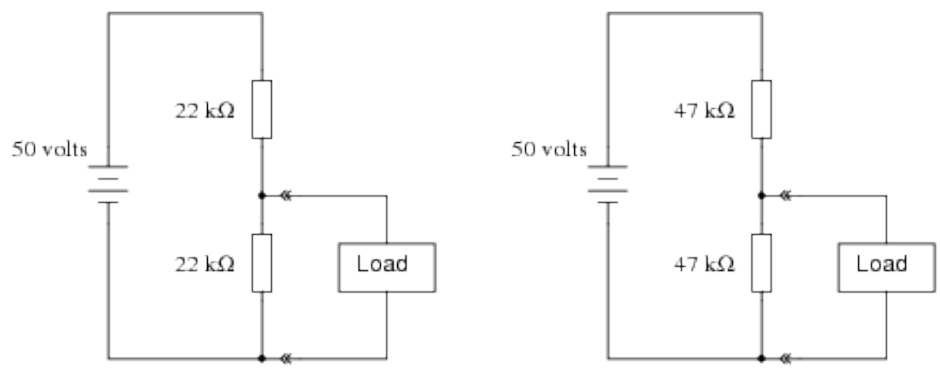


Note that the upper 5 kΩ potentiometer is set to its 20% position (m = 0.2), while the lower 5 k
potentiometer is set to its 90% position (m = 0.9), and the 100 kΩ potentiometer is set to its 40
position (m = 0.4).

Reveal answer

Question 21

Which voltage divider circuit will be *least* affected by the connection of identical loads? Explain answer.

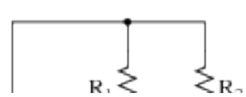


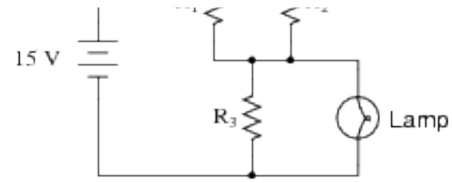
What advantage does the other voltage divider have over the circuit that is least affected by the connection of a load?

Reveal answer

Question 22

A student builds the following voltage divider circuit so she can power a 6-volt lamp from a 15-
power supply:



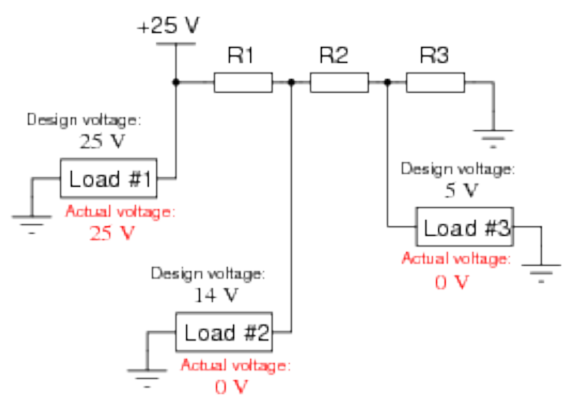


When built, the circuit works just as it should. However, after operating successfully for hours, the lamp suddenly goes dark. Identify all the possible faults you can think of in this circuit which co account for the lamp not glowing anymore.

Reveal answer

Question 23

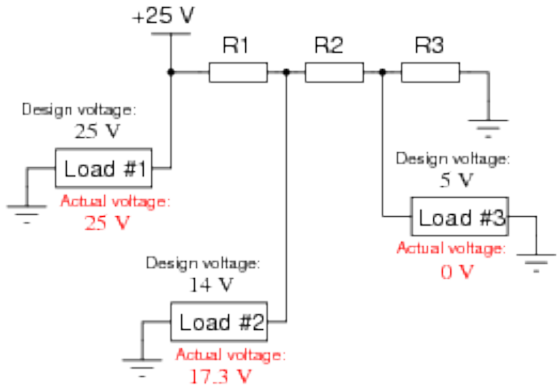
One of the resistors in this voltage divider circuit is failed open. Based on the voltage readings at each load, determine which one it is:



Reveal answer

Question 24

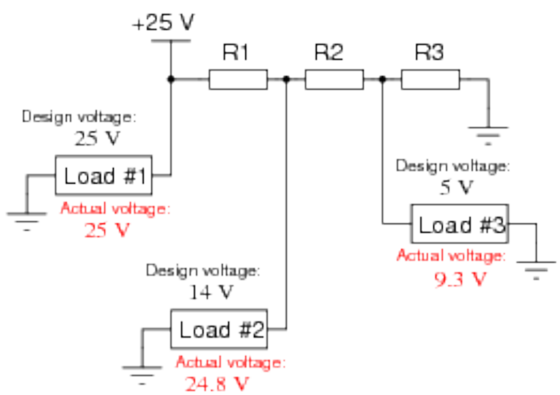
One of the resistors in this voltage divider circuit is failed open. Based on the voltage readings at each load, determine which one it is:



Reveal answer

Question 25

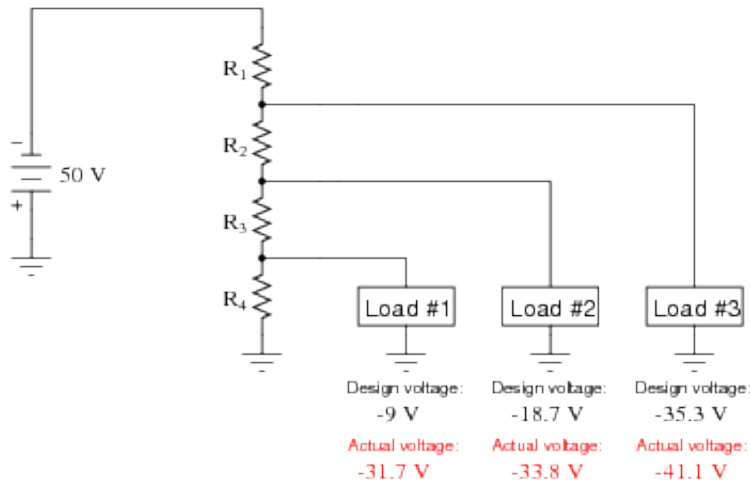
One of the resistors in this voltage divider circuit is failed (either open or shorted). Based on the voltage readings shown at each load, determine which one and what type of failure it is:



Reveal answer

Question 26

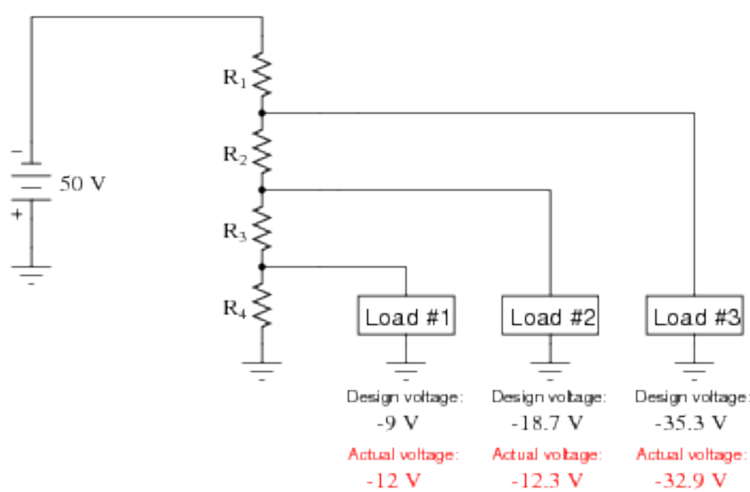
One of the resistors in this voltage divider circuit has failed (either open or shorted). Based on t
voltage readings shown at each load, comparing what each load voltage is versus what it shou
determine which resistor has failed and what type of failure it is:



Reveal answer

Question 27

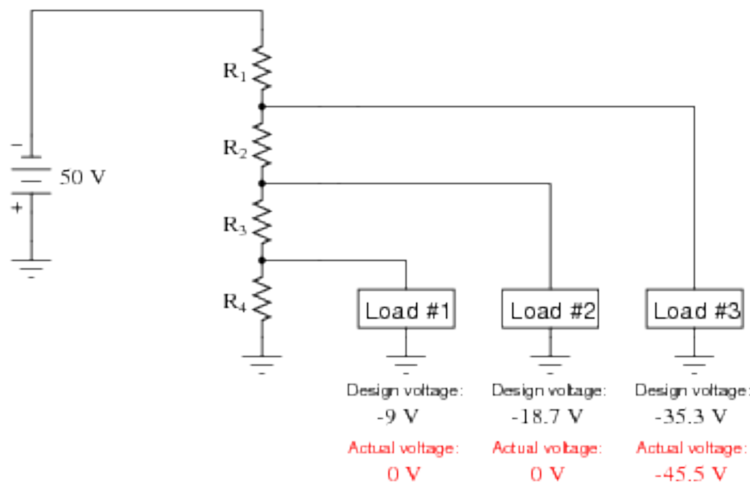
One of the resistors in this voltage divider circuit has failed (either open or shorted). Based on t
voltage readings shown at each load, comparing what each load voltage is versus what it shou
determine which resistor has failed and what type of failure it is:



Reveal answer

Question 28

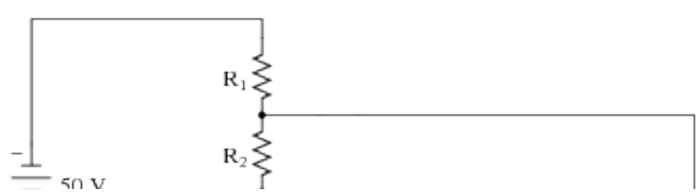
One of the resistors in this voltage divider circuit has failed (either open or shorted). Based on t voltage readings shown at each load, comparing what each load voltage is versus what it shou determine which resistor has failed and what type of failure it is:

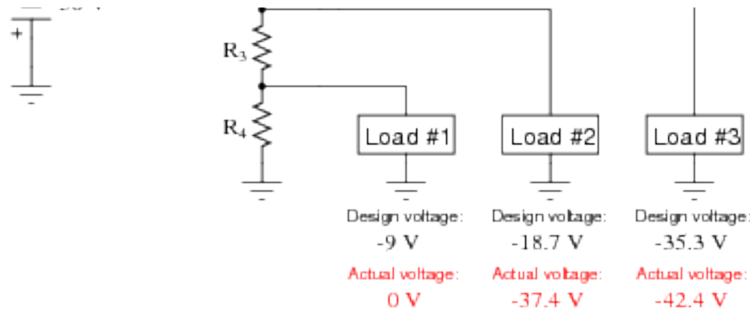


Reveal answer

Question 29

One of the resistors in this voltage divider circuit has failed (either open or shorted). Based on t voltage readings shown at each load, comparing what each load voltage is versus what it shou determine which resistor has failed and what type of failure it is:

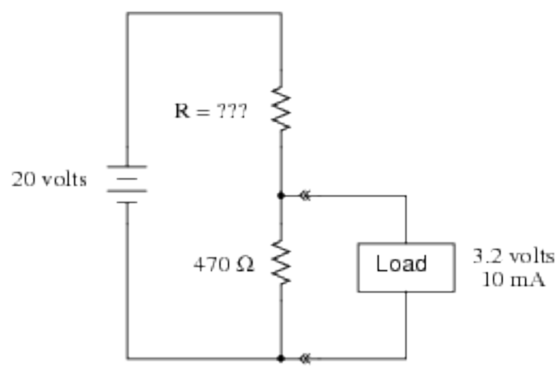




Reveal answer

Question 30

Size the resistor in this voltage divider circuit to provide 3.2 volts to the load, assuming that the will draw 10 mA of current at this voltage:

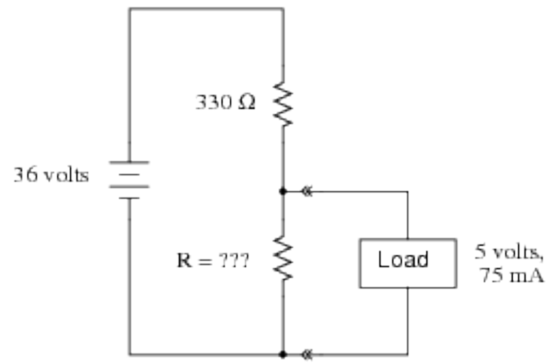


As part of your design, include the power dissipation ratings of both resistors.

Reveal answer

Question 31

Size the resistor in this voltage divider circuit to provide 5 volts to the load, assuming that the l draw 75 mA of current at this voltage:

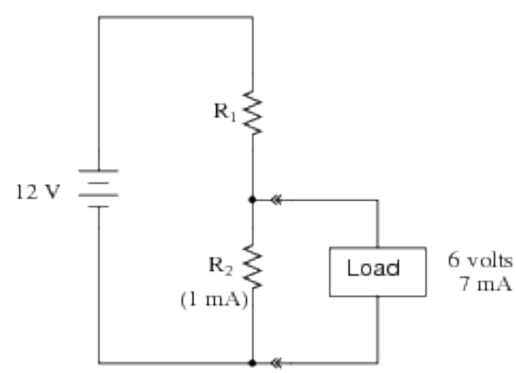


As part of your design, include the power dissipation ratings of both resistors.

Reveal answer

Question 32

Size both resistors in this voltage divider circuit to provide 6 volts to the load, assuming that th
will draw 7 mA of current at this voltage, and to have a “bleeder” current of 1 mA going througl

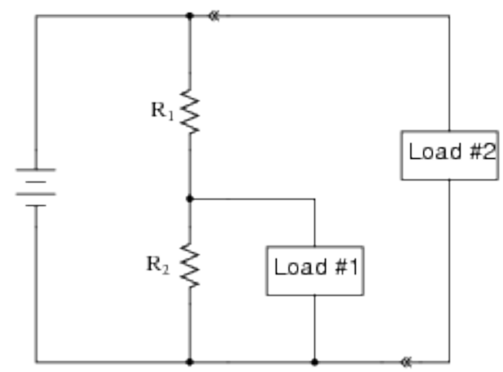


As part of your design, include the power dissipation ratings of both resistors.

Reveal answer

Question 33

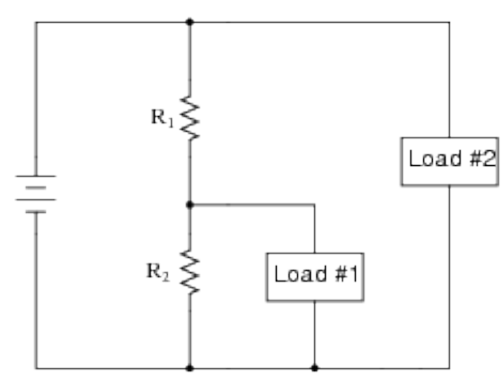
Explain what will happen to the first load's voltage and current in this voltage divider circuit, as second load is connected as shown:



Reveal answer

Question 34

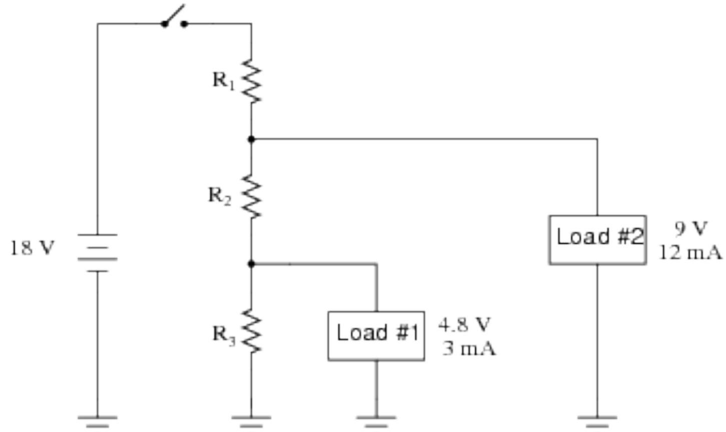
Explain what will happen to the first load's voltage and current in this voltage divider circuit if th second load develops a short-circuit fault:



Reveal answer

Question 35

Size all three resistors in this voltage divider circuit to provide the necessary voltages to the loa
given the load voltage and current specifications shown:



Assume a bleed current of 1.5 mA. As part of your design, include the power dissipation rating
resistors.

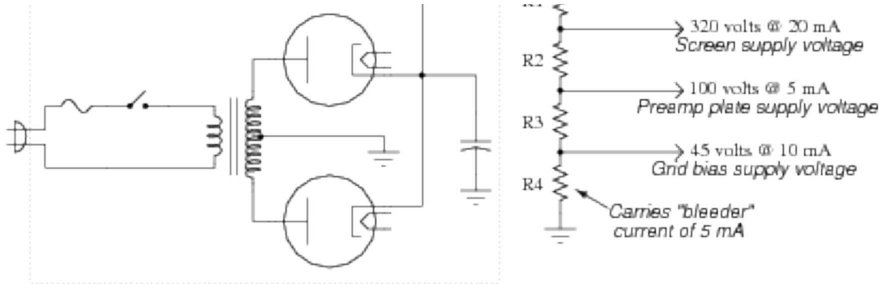
Reveal answer

Question 36

Old vacuum-tube based electronic circuits often required several different voltage levels for prc
operation. An easy way to obtain these different power supply voltages was to take a single, hi
voltage power supply circuit and "divide" the total voltage into smaller divisions.

These voltage divider circuits also made provision for a small amount of "wasted" current throu
divider called a *bleeder* current, designed to discharge the high voltage output of the power su
quickly when it was turned off.

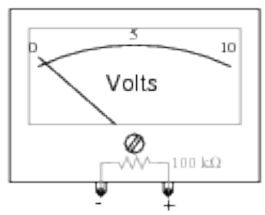
Design a high-voltage divider to provide the following loads with their necessary voltages, plus
"bleeder" current of 5 mA (the amount of current going through resistor R4):



Reveal answer

Question 37

Suppose a voltmeter has a range of 0 to 10 volts, and an internal resistance of 100 kΩ:



Show how a single resistor could be connected to this voltmeter to extend its range to *0 to 50*
Calculate the resistance of this “range” resistor, as well as its necessary power dissipation ratir

Reveal answer

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