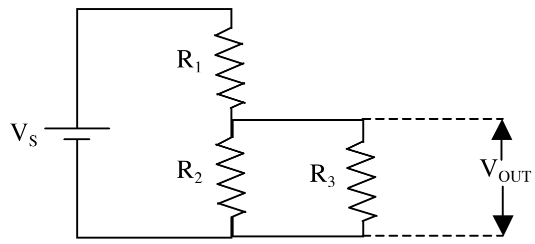
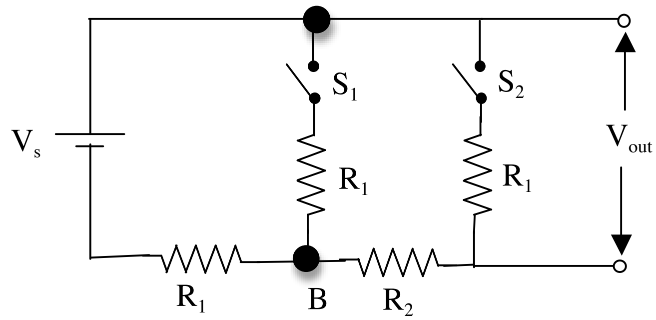
PHY2250 HW3 Answers

1. Find a formula for a *loaded* voltage divider, i.e. find V_{OUT} as a function of V_S, R_1, R_2, and R_3:



$$V_{OUT} = V_S \frac{R_{23}}{R_1 + R_{23}}, \quad R_{23} = \left(\frac{1}{R_2} + \frac{1}{R_3}\right)^{-1}$$

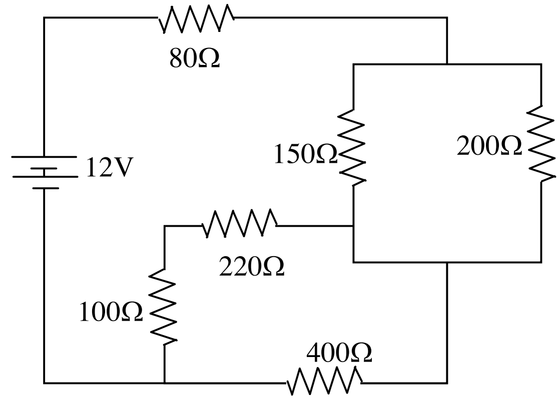
2. Shown below is a circuit for providing a variety of output voltages using two switches, labeled S_1, S_2. Find the output voltage for all possible combinations of switch settings. Let V_s=120V, R_1=100Ω and R_2=200Ω.



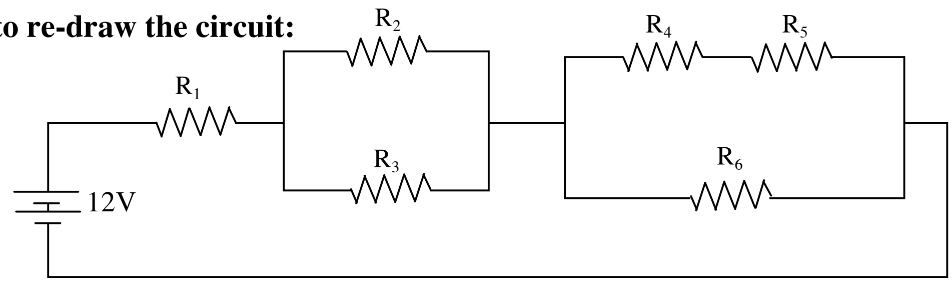
S_1 & S_2 open: 120V
S_1 closed, S_2 open: 120V/2 = 60V
S_1 open, S_2 closed: $V_{out} = V_S R_1 / (R_1 + R_2 + R_1)$ = 120 * 100 / 400 = 30V
S_1 & S_2 closed:

$R_T = R_1 + R_{AB} = R_1 + (1/R_1 + 1/(R_1 + R_2))^{-1}$ = 100 + 75 = 175Ω
$V_{AB} = V_S R_{AB} / R_T$ = 120 * 75 / 175 = 51.4V
$V_{OUT} = V_{AB} R_1 / (R_1 + R_2)$ = 51.4 * 100 / 300 = 17.1V

3. Given the schematic shown, calculate…
   a. The total power dissipated
   b. the voltage across the 100Ω resistor
   c. The current through the 400Ω resistor



It may help, conceptually, to re-draw the circuit:



a. $\mathbf{R_{23} = (150^{-1} + 200^{-1})^{-1} = 85.7\ \Omega.}$
$\mathbf{R_{45} = R_4 + R_5 = 220 + 100 = 320\ \Omega.}$
$\mathbf{R_{456} = (400^{-1} + 320^{-1})^{-1} = 178.57\ \Omega.}$
$\mathbf{R_T = R_1 + R_{23} + R_{456} = 80 + 85.7 + 178.57 = 344.27 = 344\ \Omega.}$
$\mathbf{I_T = V_S / R_T = 12 / 344 = 0.03488\ A}$
$\mathbf{P_T = I_T^2\ R_T = (0.03488)^2\ (344) = 0.419\ W}$

b. $\mathbf{I_{45} = I_T * R_{456} / R_{45}}$ **(Current divider)**
$\mathbf{= (0.03488)\ (178.57)/320 = 0.0195\ A = 19.5\ mA}$
$\mathbf{V_4 = I_{45}\ R_4 = 1.95\ V}$

c. $\mathbf{I_6 = I_T * R_{456} / R_6 = 0.015557\ A = 15.6\ mA}$

4. In Greg's new studio, he runs a cable from his expensive, vintage mic preamp from the control room into the tracking room. The open-circuit voltage across the cable is 48V, but he finds that when he plugs it into the mic, he only gets 41V across the mic. He decides to turn up the voltage on the mic pre in order to compensate for the internal resistance of the preamp and the resistance of the cable. What output voltage should he set the preamp to in order to get "exactly" 48V across the mic?

By the "voltage divider, the ratio of the mic's resistance R_M to the total resistance R_T is the same as the ratio of voltage across the mic to the total voltage of the power supply:

$$\frac{R_M}{R_T} = \frac{V_M}{V_T}.$$

Since the mic's resistance and the total resistance don't change, then the ratio of the voltages won't change when the voltage is turned up, so

$$\frac{R_M}{R_T} = \frac{41\text{V}}{48\text{V}} = \frac{48\text{V}}{\text{V}_{\text{T, New}}},$$

where $V_{T,New}$ is the new voltage of the power supply. Cross-multiplying yields

$$\text{V}_{\text{T, New}} = \frac{(48\text{V})^2}{41\text{V}} = 56.2\text{V}.$$