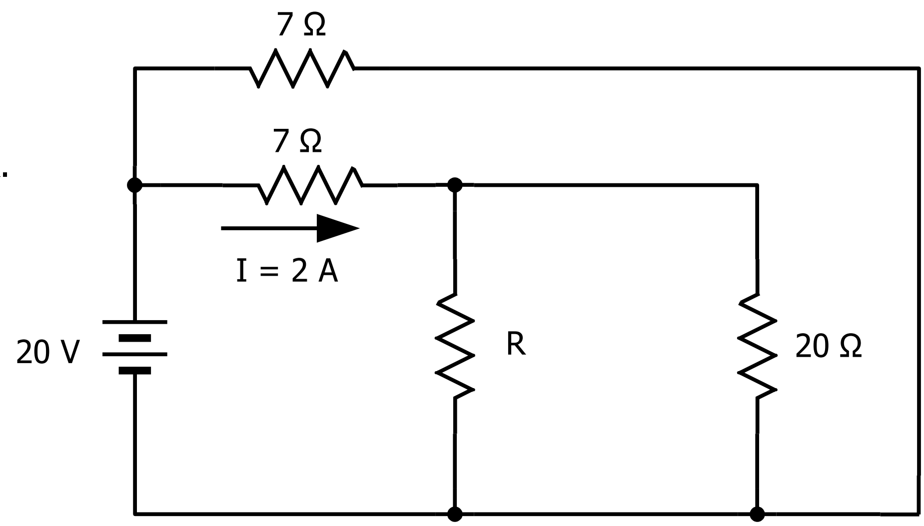
EE3 Fall 2020
Practice Problems 6

1. Determine the value of R.

NOTE:
If you think a bit before you start, this problem becomes A LOT easier.



$$V_R = 20-(2)(7) = 6 \text{ V}$$

$$I_R = 2-\frac{6}{20} = \frac{34}{20} = 1.7 \text{ A}$$

$$R = \frac{6}{1.7} = 3.53 \ \Omega$$

*******OR*******

$R \| 20$ must be 3.

$$\frac{20\text{R}}{20+R} = 3$$

$$20\text{R} = 3\text{R}+60$$

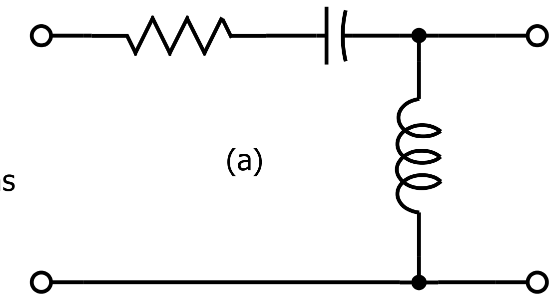
$$R = 3.53 \ \Omega$$

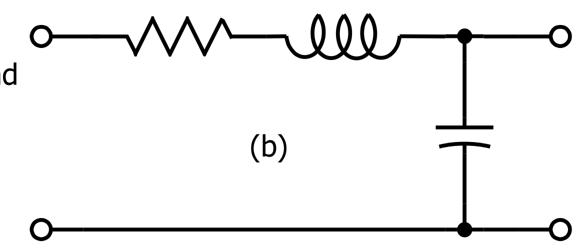
EE3 Fall 2020
Practice Problems 6

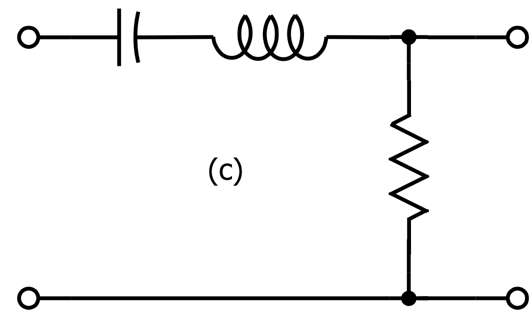
2.

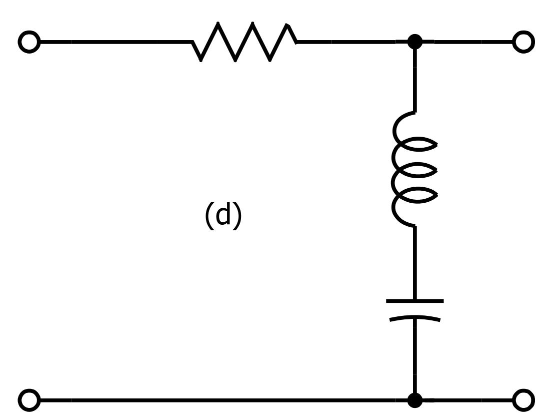
Consider the series RLC circuit. Let R=100 Ω, C=1 μF, and L=0.2 H. Questions (a) – (d) are answered intuitively by using the two questions that I gave you in lecture. Questions (e) and (f) are answered numerically. Question (g) is answered symbolically.

(a) If the output is taken across the inductor, what kind of filter is it?
(b) If the output is taken across the capacitor, what kind of filter is it?
(c) If the output is taken across the resistor, what kind of filter is it?
(d) If the output is taken across the capacitor and inductor, what kind of filter is it?
(e) If f=300 Hz, what impedance is given by the circuit?
(f) What is the resonant frequency of the circuit?
(g) In (d), what is the ratio v_{out}/v_{in} at resonance?









(a) High pass
(b) Low Pass
(c) Band pass
(d) Band stop
(e) 100 – j 153.5
(f) 356 Hz
(g) 0

(e) $Z_T = 100 + j2\pi(300)(0.2) - j\dfrac{1e6}{2 * pi(300)}$

$Z_T = 100 + j377 - j530.5 = 100 - j153.5$

(f) $f_0 = \dfrac{1}{2\pi\sqrt{LC}} = \dfrac{1}{\sqrt{(0.2)(1e6)}} = 355.9$ Hz

(g) At resonance, $j\omega L = \dfrac{1}{j\omega C}$.

Therefore, $j\omega L - j\dfrac{1}{\omega C} = 0$.

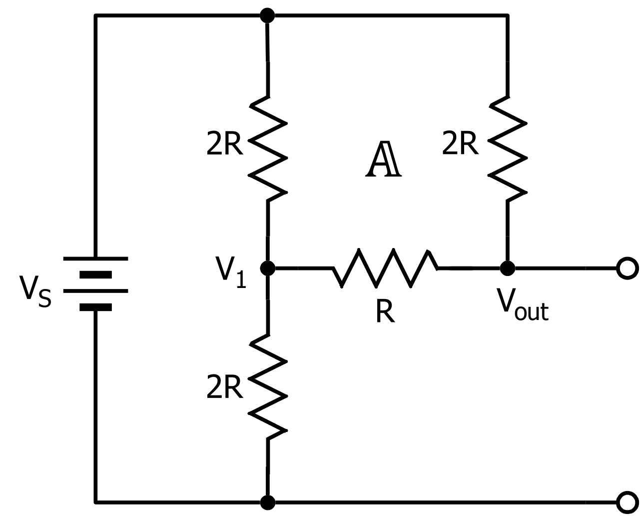
Therefore, all of the input voltage appears across the resistor, and the ratio is zero.

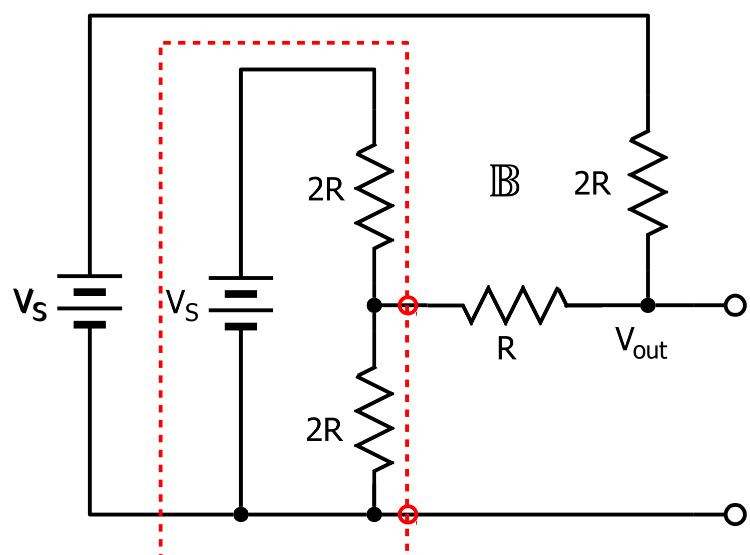
EE3 Fall 2020
Practice Problems 6

3. Circuit $\mathbb{A}$ is a portion of a digital-to-analog converter (DAC) circuit. The point of this problem is to see how the use of a Thévenin Equivalent can simplify a circuit and make it easier to analyze.

   The first step is not obvious: disconnect the upper two resistors from each other and add a battery to maintain electrical equivalence (Circuit $\mathbb{B}$).

   Note that the circuit fragment inside the red box is now a one-port, and can be replaced with its Thévenin Equivalent. That is your task, and after doing so, find V_{out} as a function of V_S.





Thévenin Equivalent circuit: it is obvious that

$$V_{th} = \frac{V_S}{2}$$

$$R_{th} = R$$

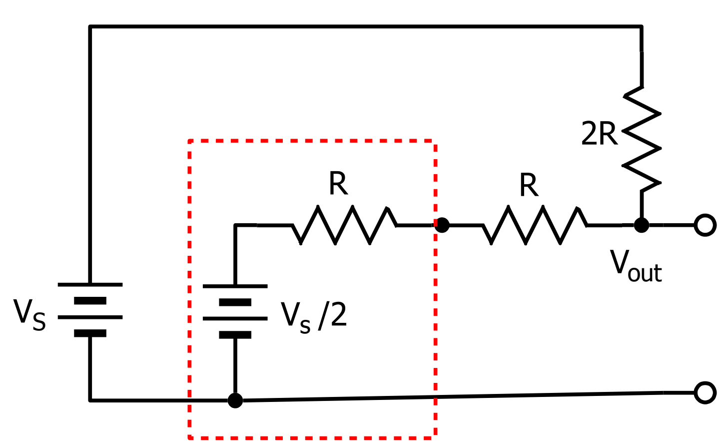
Solving for V_{out}:

$$\frac{V_{out} - V_S}{2R} + \frac{V_{out} - V_S/2}{2R} = 0$$

$$2V_{out} = \frac{3V_S}{2}$$

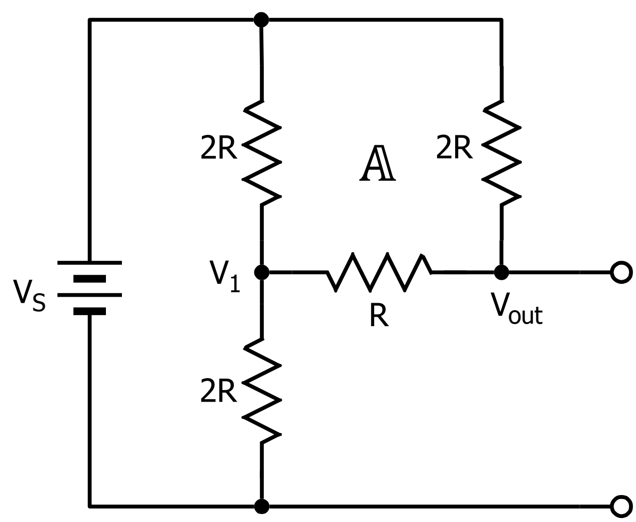
$$V_{out} = \frac{3V_S}{4}$$

For analysis of circuit $\mathbb{A}$, see next page.



EE3 Fall 2020
Practice Problems 6

ANALYSIS OF ORIGINAL PROBLEM 3 CIRCUIT



$$①\ \frac{V_1 - V_S}{2R} + \frac{V_1 - V_{out}}{R} + \frac{V_1}{2R} = 0$$

$$②\ \frac{V_{out} - V_1}{R} + \frac{V_{out} - V_S}{2R} = 0$$

$$①\ 4V_1 - 2V_{out} = V_S$$

$$②\ -2V_1 + 3V_{out} = V_S$$

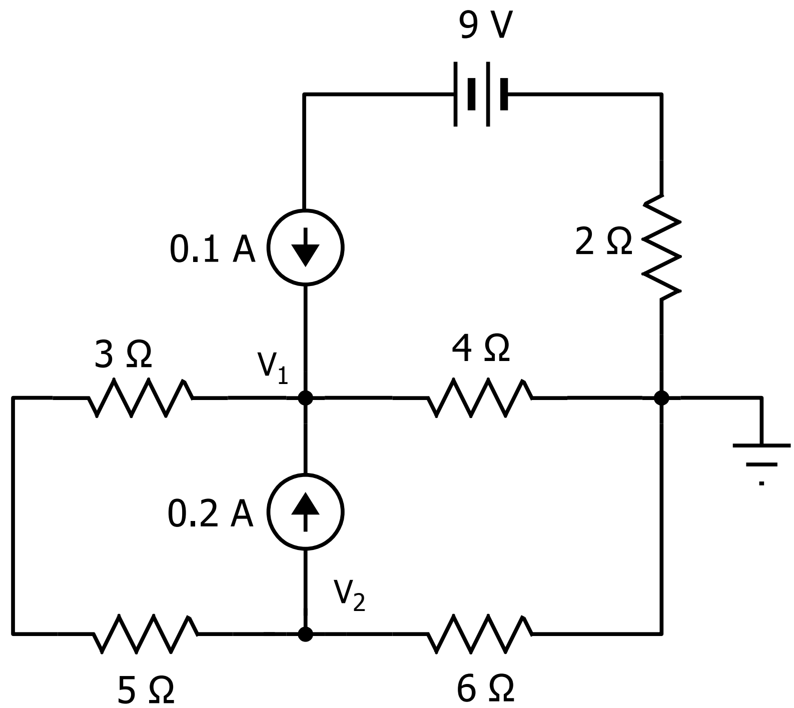
$$V_1 = \frac{5}{8}$$

$$V_{out} = \frac{3V_s}{4}$$

EE3 Fall 2020
Practice Problems 6

4. Find the power provided or absorbed by the 0.1 A current source. Is it providing or absorbing?

HINT: find V_1 and V_2 first. Then write a KVL equation around the upper loop.



Node V_1: $\frac{V_1 - V_2}{3+5} - 0.1 - 0.2 + \frac{V_1}{4} = 0$

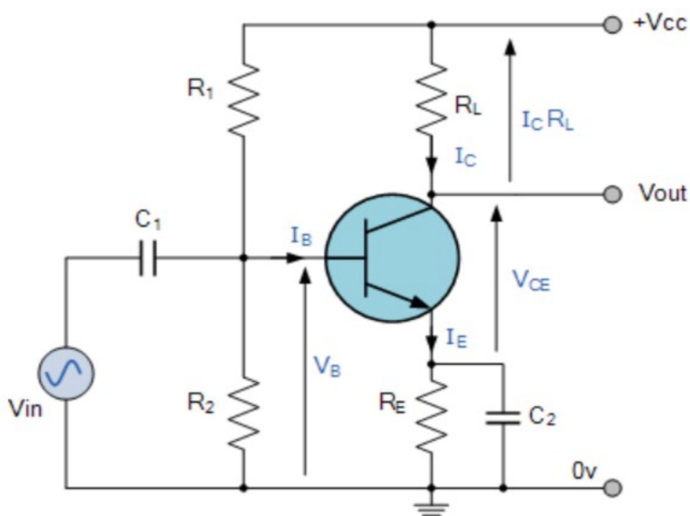
Node V_2: $\frac{V_2}{6} + \frac{V_2 - V_1}{8} + 0.2 = 0$

$V_1 = 0.667\ \text{V}$, and $V_2 = -0.4\ \text{V}$

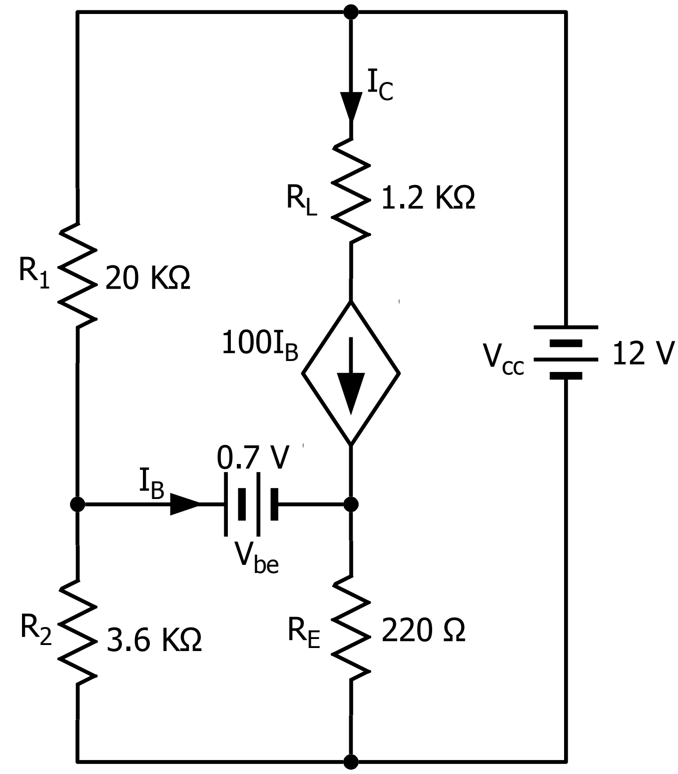
KVL counter-clockwise around upper loop:
$-9 + V_{0.1} + V_1 + (0.1)(2) = 0$
(Assumes $V_{0.1}$ is + at top.)
$V_{0.1} = 8.133\ \text{V}$
$P_{0.1} = +(0.1)(8.133) = +0.8133\ \text{W}$ (absorbing)

Power Balance:
$P_9 = -(9)(0.1) = -0.9\ \text{W}$
$P_{0.2} = -(V_1 - V_2)(0.2) = -0.213\ \text{W}$
$P_2 = (2)(0.1)^2 = 0.02\ \text{W}$
$P_4 = \frac{V_1^2}{4} = 0.111\ \text{W}$
$P_6 = \frac{V_2^2}{6} = 0.027\ \text{W}$
$P_{53} = \frac{(V_1 - V_2)^2}{8} = 0.142\ \text{W}$
$P_{0.1} + P_{0.2} + P_9 + P_2 + P_4 + P_6 + P_{53} = 0\ (\text{balanced})$

EE3 Fall 2020
Practice Problems 6



https://www.electronics-tutorials.ws/amplifier/amp_2.html



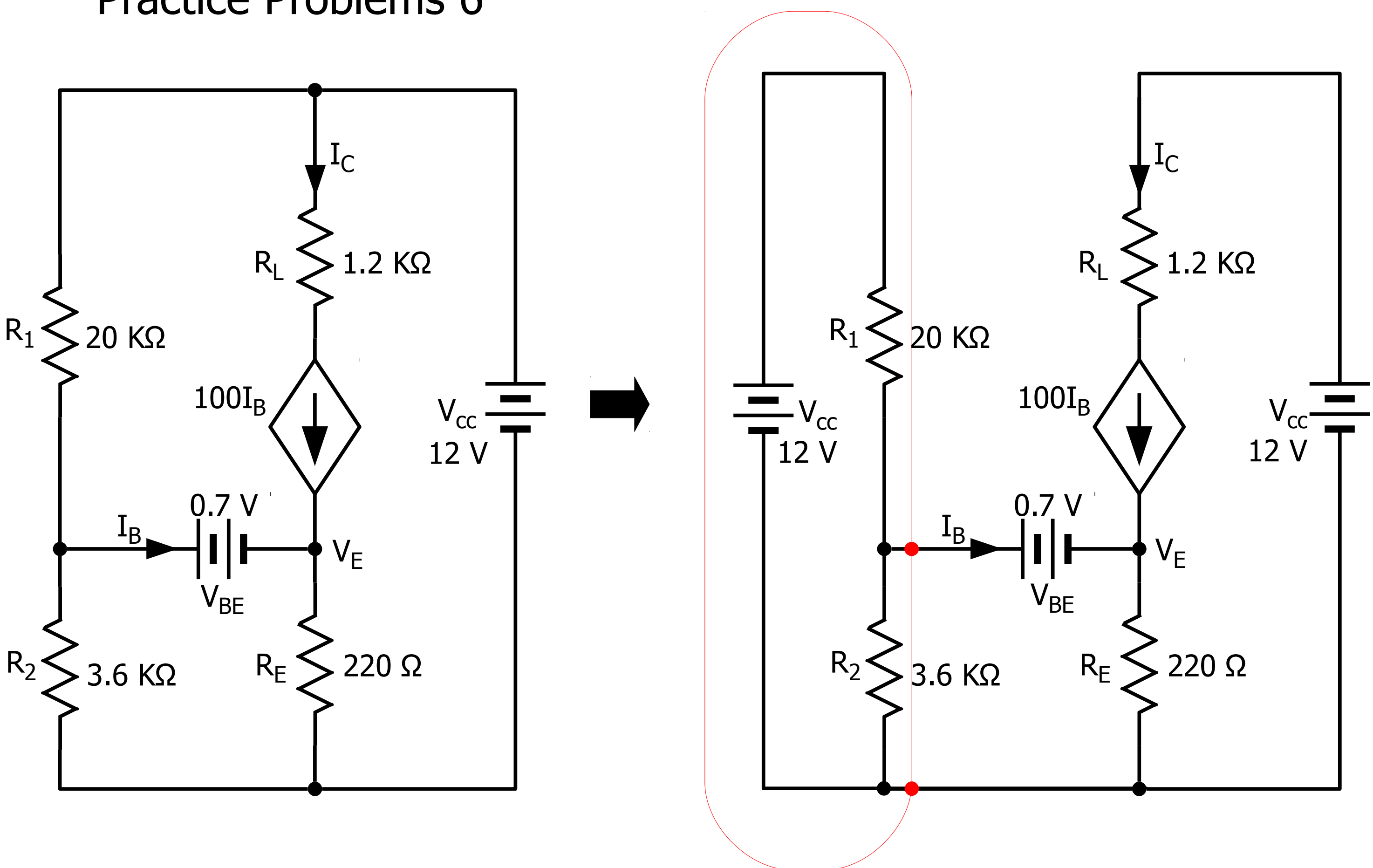
5. On the left is a typical NPN Common Emitter amplifier circuit. On the right is a linearized equivalent circuit without the capacitors and input voltage. The key to analyzing the equivalent circuit is finding the base current, I_B.

   You will be able to find I_B by using an Ohm"s Law expression and the ideas that you have learned earlier in this problem set. In particular, you will be able to simplify the circuit by using the same Thévenin Equivalent circuit trick that is in Problem 3 and you will know how to deal with the dependent source from working Practice Problems 4, #5.

   Your task is to simplify the circuit with a Thévenin Equivalent, and find I_B by solving the KCL equation that will become obvious after the simplification.

SOLUTION NEXT PAGE

EE3 Fall 2020
Practice Problems 6



Voltage Divider outlined in red:

$$V_{oc} = 12\left(\frac{3.6e3}{20e3+3.6e3}\right) = 1.83\ \text{V}$$

$$I_{sc} = \frac{12}{20e3} = 60e\text{-}3\ \text{A}$$

$$R_{th} = \frac{V_{oc}}{I_{sc}} = \frac{1.83}{606-3} = 3.05\ \text{K}\Omega$$

KCL at V_E:

$$① \ -I_B + \frac{V_E}{220} - 100 I_B = 0$$

$$① \ V_E = 220(101\, I_B)$$

$$② \ I_B = \frac{1.83-0.7-V_E}{3.05e3}$$

$$① \text{ into } ② \ I_B = \frac{1.83-0.7-220(101\, I_B)}{3.05e3}$$

$$(3.05e3)\, I_B + 22200\,(I_B) = 1.13$$

$$I_B = \frac{1.13}{25271} = 44.74\ \mu\text{A}$$