

ECE 110 Cramming Carnival Review

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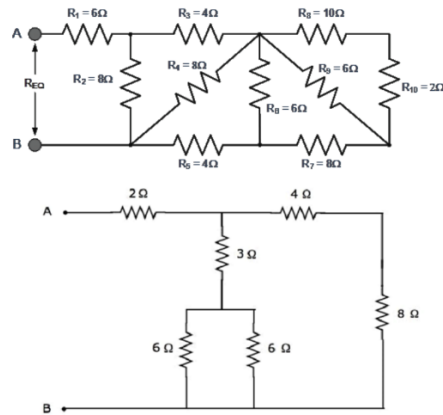
Fall 2024

Introduction

This worksheet does not cover content in lectures after November 25th and is not meant to be a replacement for any practice exams or section reviews. Use this worksheet as a quick refresher for various topics throughout the semester and for slightly different questions than the homeworks.

Formulas not on the help sheet

Note: All formulas required for the questions are assumed to be known, as they are not provided in this sheet.



Power Efficiency & Capacitors

Question 1: Consider a car that has 400 kJ of energy at a specific speed. The car's regenerative brakes are 40% efficient at converting kinetic energy to energy stored in a battery. What is the energy added when the car brakes to half speed?

Solution:

$$KE_o = \frac{1}{2}mv^2$$

$$KE_{\text{half}} = \frac{1}{2}m\left(\frac{v}{2}\right)^2 = \frac{1}{2}m \cdot \frac{v^2}{4} = \frac{1}{4} \cdot \frac{1}{2}mv^2 = \frac{1}{4} \times KE_o$$

$$\Delta KE = KE_o - KE_{\text{half}} = KE_o - \frac{1}{4}KE_o = \frac{3}{4}KE_o$$

$$= \frac{3}{4} \cdot 400kJ = 300kJ$$

$$E_{\text{added}} = \%_{\text{eff}} \cdot \Delta KE = 0.40 \cdot 300kJ$$

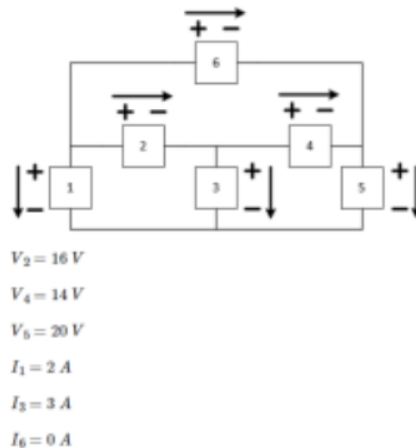
$$= \boxed{120kJ}$$

Question 2: If a 15 kWh battery has to be recharged using a 60% efficient generator with peak power of 500 W, how long does the generator need to run to fully charge the battery?

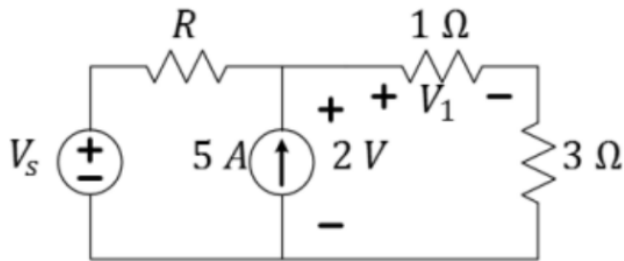
Question 3: What is the energy stored in a 4 nF capacitor charged to 9V?

Question 4: What voltage is needed to charge the capacitor from the above question enough to lift a 2-gram mass 15 cm?

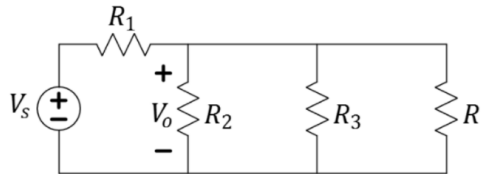
Kirchoff's Laws/Dividers



Question 5: Given the above circuit and information, find V1, V3, V6, I2, I4, and I5.



Question 6: Find V_1 in the above circuit.



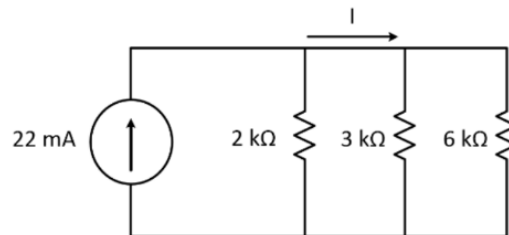
$$R_1 = 9 \, \Omega$$

$$R_2 = 10 \, \Omega$$

$$R_3 = 15 \, \Omega$$

$$V_s = 4 \, V$$

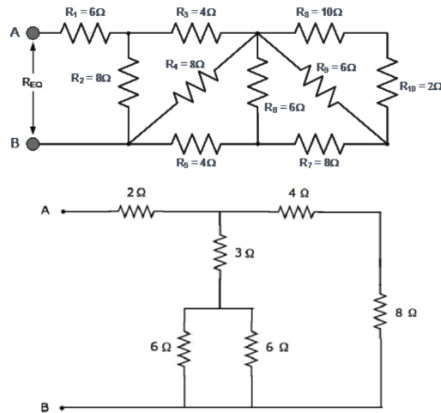
Question 7: What value of R will result in $V_o = 1 \, V$?



Question 8: Find I in the above circuit.

Equivalent Resistance / Power

Question 9: Find equivalent resistance for the circuits below.



Question 10: If the voltage between nodes A and B in the second circuit is 9V...

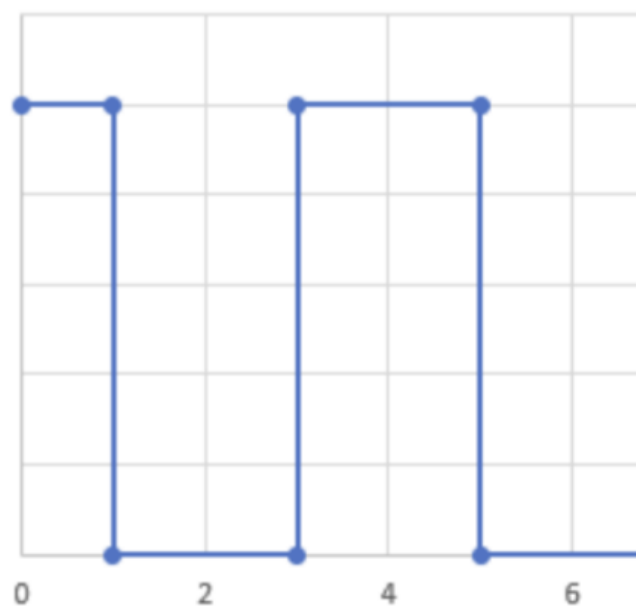
1. What is the current through the 3 ohm resistor?
2. What is the power through the 3 ohm resistor?
3. What is the power through the 8 ohm resistor?
4. What resistor has the highest power output?

PWM

Question 11: Imagine a square wave that outputs 15W from 0 to 12 seconds and 5W from 12 to 20 seconds. This square wave corresponds to a 10 ohm resistor.

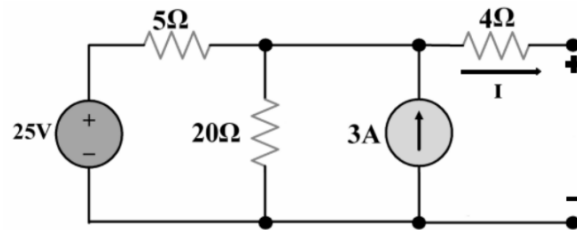
1. What is the Average Power of this waveform?
2. What is the RMS Voltage of this waveform?

Question 12: Given a limited portion of this graphed waveform, what is its duty cycle?



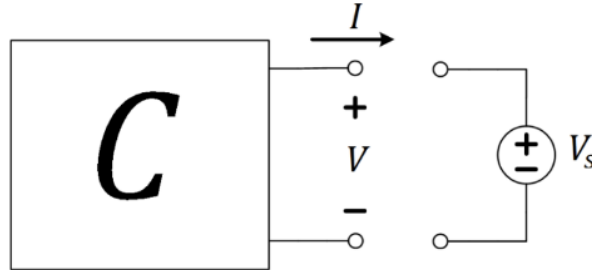
I-V Equations

Question 13: What is the short circuit current and the open circuit voltage for the circuit below?



Question 14: If this circuit were to be placed in series with another circuit with an IV equation of $I = 0.005V - 0.025$, assuming the same polarities given above, what would be the operating current and voltage?

Question 15: If the open circuit voltage of a circuit containing ideal sources and resistors is measured at $V_{oc} = 8\text{ V}$, while the current through the short circuit across the circuit is $I_{sc} = 200\text{ mA}$, what would be the power in watts absorbed by an ideal voltage source, $V_s = 4$, placed across the terminals?

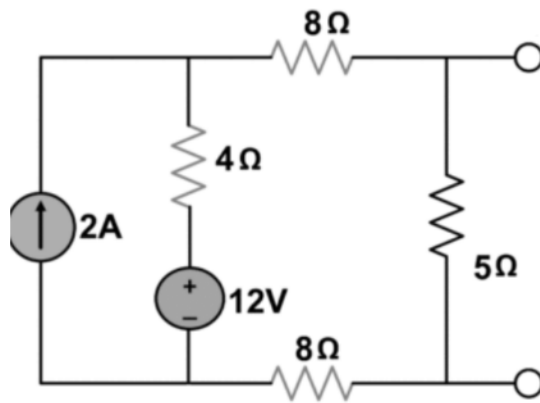


Norton and Thevenin

Question 16: Give Norton and Thevenin Forms for the subcircuit shown on the previous page.

Question 17: What is the Norton resistance of the circuit below? What is the Thevenin Resistance?

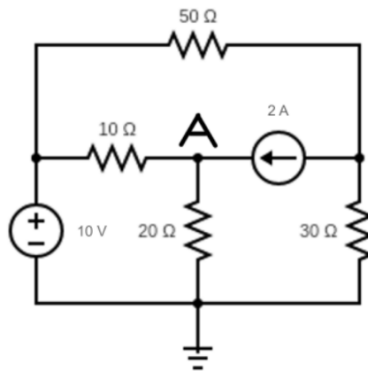
Question 18: Draw the Thevenin and Norton Equivalents.



Nodal Analysis

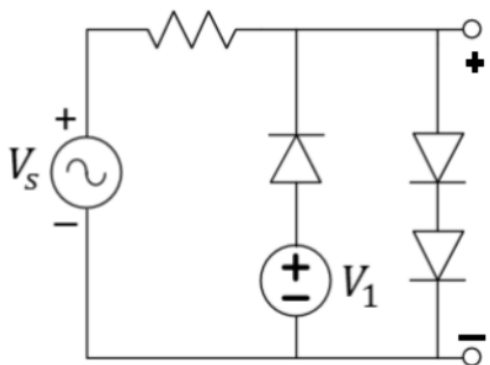
Question 19: Find the voltage at node A for this circuit.

Question 20: Find the voltage drop across the 10, 30, and 50 ohm resistors.

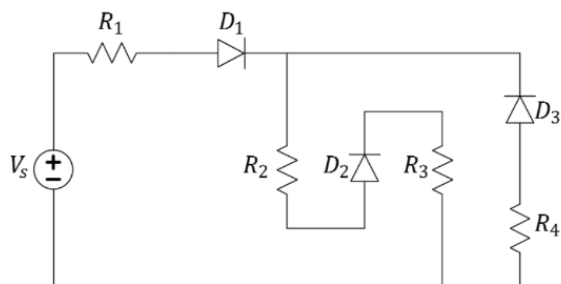


Diodes

Question 21: Assume an ideal-offset model and $V_{on} = 1$ volt. If $V_s = 5 \cos(\omega t)$ volts and $V_1 = 2$ volts, what are the maximum and minimum voltages across the open nodes?

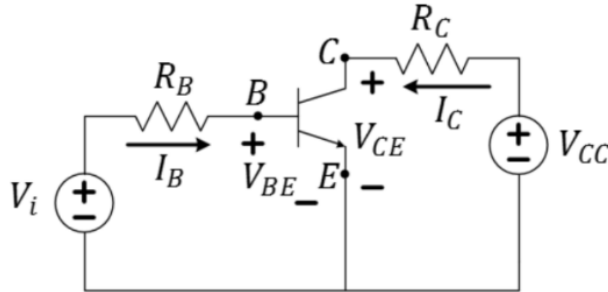


Question 22: In the circuit below, which diodes are on? Furthermore, if $V_s = 10$ V, all the diodes have $V_{on} = 2$ V under the offset ideal model, and the voltage drop over R_1 is also 2 V, what is the voltage drop across the other resistors, assuming they have an equal resistance?



BJTs

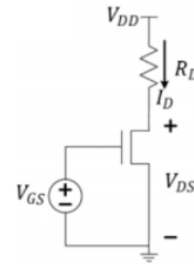
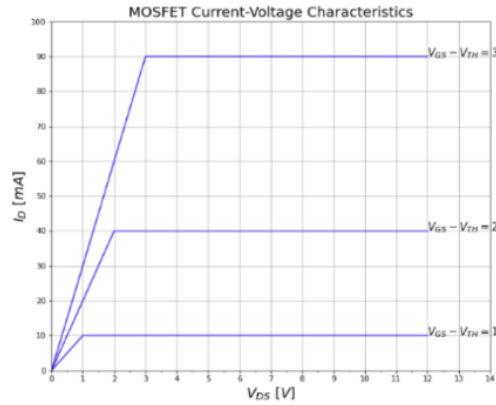
Question 23: The properties of the transistor are that V_{BE} on is 1V, β is 120, and $V_{CE\text{ sat}}$ is 0.2 V. In this circuit, V_{CC} is 9V, R_C is 150Ω , and R_B is 30000Ω . What are the maximum and minimum values for V_{CE} if V_i 's output is variable between 0V and 9V?



Question 24: If V_i was set to 5V, what would V_{CE} be?

MOSFETs/cMOS logic

Question 25: An IC dissipates 110W. If the IC has a 5% activity factor α , frequency of 10GHz, and 1nF gate capacitance, what is the maximum number of transistors that can be in the IC if it can operate at up to 9V?



Question 26: The given circuit with a MOSFET in series with a voltage source of 6V and a resistor with a resistance of 120Ω . Find the transistor parameter k and a value for V_{DS} that results in $I = 30\text{ mA}$, given that $V_{GS} - V_{TH} = 2$.

Bonus Questions

Question 27: Give the IV equation, Norton equivalent, and Thevenin Equivalent for the circuit below.

