# Charles Darwin University

Final Examination

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| Family Name | | | | | | |
| Given Name/s | | | | | | |
| Student Number | | | | | | |
| Teaching Period | Semester 2, 2018 | | | | | |

| ENG174 – Electrical Engineering | DURATION | |
|---|---|---|
| | | |
| | Reading Time: | 10 minutes |
| | Writing Time: | 120 minutes |
| | | |

## INSTRUCTIONS TO CANDIDATES

1. The exam consists of Five (5) questions.
2. Note that questions ARE NOT of equal value.
3. Read ALL questions carefully.
4. Show all diagrams, units and workings necessary to justify your answers. Insufficient working will result in a loss of marks.
5. Do not write your answers on the question sheet. Answers on the question sheet will not be marked.

## EXAM CONDITIONS

You may begin writing from the commencement of the examination session. The reading time indicated above is provided as a guide only.

This is a RESTRICTED OPEN BOOK examination

Any non-programmable calculator is permitted

Two A4 sheets of handwritten double-sided notes permitted

No dictionaries are permitted

| ADDITIONAL AUTHORISED MATERIALS | EXAMINATION MATERIALS TO BE SUPPLIED |
|---|---|
| None | 1 x 20 Page Book |

THIS EXAMINATION IS PRINTED DOUBLE-SIDED.

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## Question 1 (10 Marks)

For the circuit shown below in Figure 1, answer the following:

a) Calculate the equivalent resistance between nodes x and y. **(2 Marks)**

b) What is the voltage at node x with respect to node y? **(2 Marks)**

c) Calculate the power absorbed by each resistor (hint: you can check your result as the total power absorbed should be the same as the power produced by the 120V source.) **(6 Marks)**

Be sure to redraw the diagram on your answer sheet and add any notation you rely on in your answers.

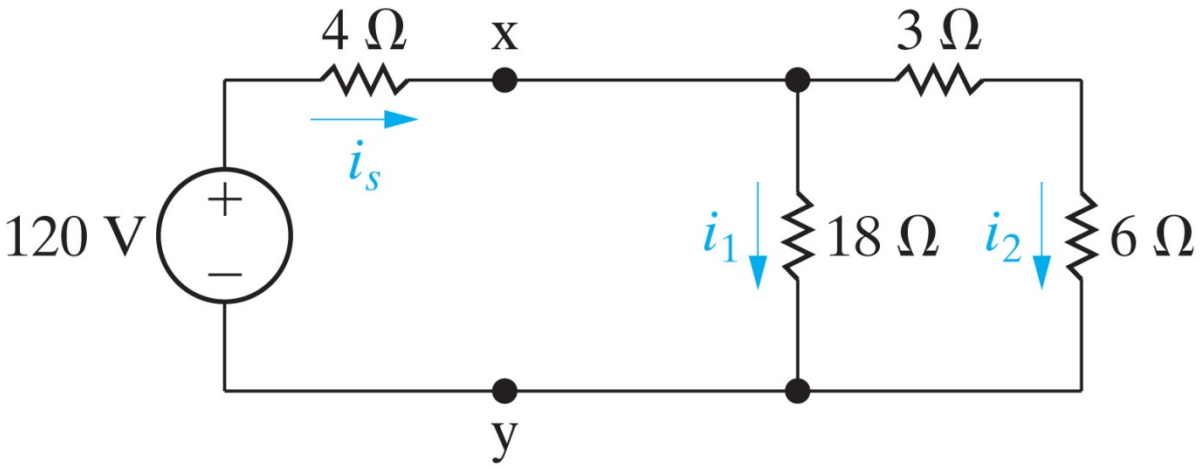


Figure: 03-09EX3.1



Figure 1.

## Question 2 (7 Marks)

The step down transformer shown in Figure 2 below has a voltage of $V_1$=240Vrms supplied the primary side. The secondary side of the transformer is connected to a load consisting of 3 lights (B1, B2 and B3), each connected in parallel. A current, $I_2$, of 2.4Arms flows through the secondary winding. The transformer has a turns ratio of 24:1. Assume the transformer is ideal.

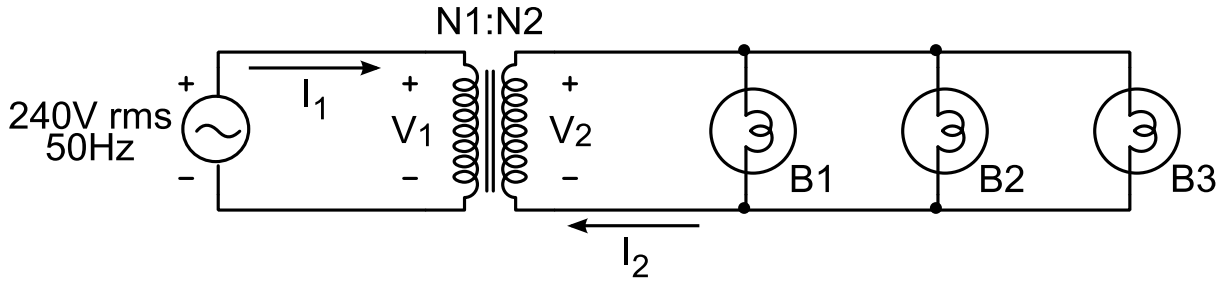


Figure 2.

a) What is the voltage across the secondary coil? **(1Mark)**

b) What current is flowing in the primary coil? **(1Mark)**

c) What is the resistance of the load? **(1Mark)**

d) If the primary coil has 9600 turns, how many turns does secondary coil have? **(1Mark)**

e) If the output of the power supply is a sinusoid, what is the peak value of $V_1$? **(1Mark)**

f) If the voltage on the power supply is reduced from 240Vrms to 12Vrms, what current will now flow in the primary coil? (Assume the resistance of the bulbs is constant) **(2 Marks)**

## Question 3 (9 Marks)

a) What two criteria must be met before a rectifier diode like the ones discussed in class will conduct conventional current? Be specific about polarities, values and directions. **(2 Marks)**

b) Consider the circuit shown below in Figure 3. Determine the values of I and V when:

i. Vin = -8V

ii. Vin = 0.3V

iii. Vin = 10V

Show all necessary working and state any assumptions you make in order to determine your solutions. **(3 Marks)**

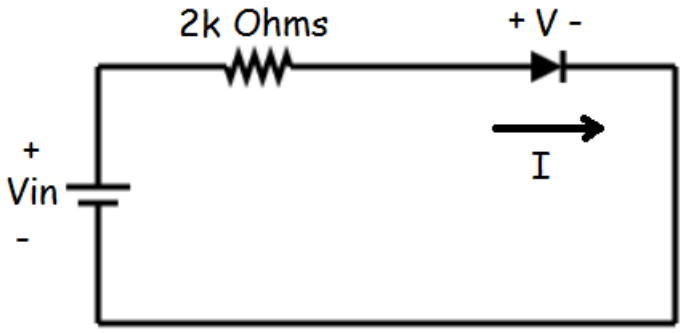


Figure 3.

c) The voltage as shown below in Figure 4 is now applied to the circuit in Figure 3 ( as Vin). On two separate diagrams, sketch the voltage across the diode (V) as well as the current flowing through it (I) versus time from time = 0 seconds to time = 1 second. **(4 Marks)**

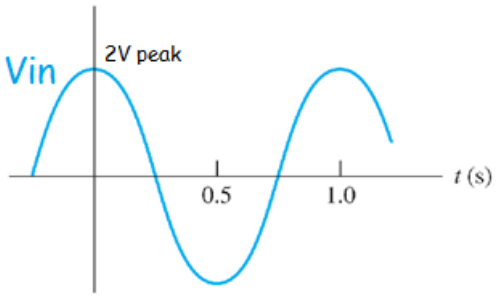


Figure 4

## Question 4 (10 Marks)

The equivalent circuit for a brushed DC motor is shown below in Figure 5. The torque produced by the motor at its output shaft, $T_O$, is proportional to the current flowing into the motor, $I_O$. This relationship can be expressed by the following formula:

$$T_O = kI_O \text{ where k is the motor constant.}$$

When the motor is turning and its coils are passing through a magnetic field, a voltage, $E_O$, (or Back EMF) is created in the circuit. This back EMF is proportional to the speed at which the motor rotates (measured in radians per second):

$$E_O = k\omega_m \text{ where k is again the motor constant.}$$

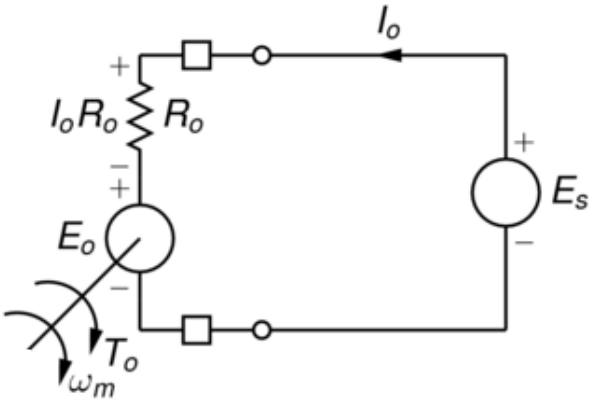


Figure 5.

a) From the motor specification sheet, you determine that k has a value of 0.4. In order to test this value of k, you conduct an experiment where you replace the voltage source $E_S$ with a voltmeter and use a second powered motor to spin this motor at a constant 20 radians per second.

   i) What voltage does the value on the voltmeter represent and why? **(2 Marks)**

   ii) What value would you expect to see on the volt meter if the given value for k is correct? **(1 Mark)**

b) Having confirmed the value for k you remove the second motor and attach a torque sensor to the motor shaft. You then reattach the power supply, $E_S$, and increase the voltage of $E_S$ until the motor is now spinning under its own power at 15 radians per second. The power supply $E_S$ needs to be set to 8V to achieve this speed and the torque meter is reading 0.5 Newton metres. Determine the current flowing out of the power supply, $I_O$, and the equivalent resistance of the motor $R_O$. **(3 Marks)**

c) If you then keep the voltage supplied to the motor from $E_S$ at 8V, and increase the load on the motor until the torque meter reads 1.5 Newton metres, what is the power being supplied by the voltage source $E_S$ and what is the efficiency of the motor, in terms of electrical power to mechanical power, when it is run this way? (Mechanical power = $T_O$ x $\omega_m$, Efficiency = 100% x (Power out)/(Power in)) **(4 Marks)**

For each question, show all necessary working and state clearly any assumptions you make.

## Question 5 (4 Marks)

An AC voltage supply which is set to output $V_{out} = 2\sin(\omega t + 45°)$ is connected in series to a load with an impedance of $(2 + j2)\Omega$ .

a) Calculate the current, $I_{out}$, which flows from the supply. **(1 Mark)**

b) Does the voltage, $V_{out}$, lead or lag the current, $I_{out}$? Justify your answer, don't just write lead or lag. **(1 Mark)**

c) The load consists of a single resistor in series with a single inductor. If the frequency of the supply, $\omega = 2000$ rad/sec, what is the resistance of the resistor and the inductance of the inductor? **(2 Marks)**