# Semester 2 Examination

*Examination Time – 120 minutes*

**Instructions to students**

- *Please answer the questions in the spaces provided.*
- *A data sheet is provided.*
- *The figures in brackets are the number of marks.*
- *The figures in* **bold** *are the assessment points that you will find on the syllabus.*
- *You are expected to use a calculator as a matter of course.*
- *In numerical answers it is not sufficient to gain the correct numerical answer. All calculations must be shown. All relevant physics and electrical principles should be demonstrated. Answers must be to an appropriate number of significant figures.*
- *Answers may be illustrated by diagrams if you feel that they will help your answer. They will gain credit if they contain creditworthy material.*
- *Diagrams will be assessed on quality of presentation as well as content.*
- *In extended written answers, your quality of written communication will be assessed as well as your technical understanding.*
- *You are advised not to spend too long on any one answer.*
- *You are reminded of the need for good English and clear presentation in all your answers.*

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| 1. | Electrical engineers use the concepts of ideal constant voltage source and constant current sources to help them to analyse circuits | | | |
| | (a) | State what is meant by:<br>(i) A constant voltage source;<br>(ii) A constant current source. | **4.2** | (4) |
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| | (b) | In reality circuits are not ideal. Leon Thévenin devised simple a rule that enabled electrical engineers to analyse circuits that did not have idea voltage sources. Write down Thévenin's Theorem. | | (2) |
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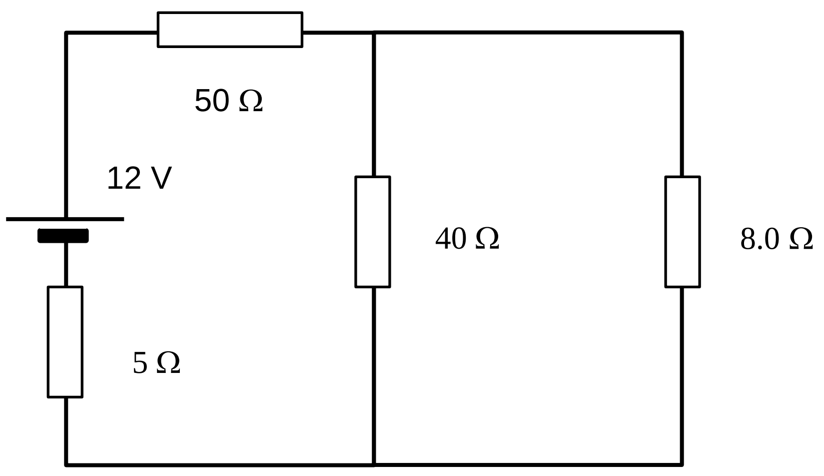
| | (c) | The diagram shows a circuit:<br><br><br>Show that the Thévenin Voltage is about 5 V | | (4) |
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| | (d) | Show that the Thévenin resistance is about 23 Ω | | (4) |
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| | (e) | Work out the current in the 8.0 Ω resistor. | | (3) |
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| | (f) | Work out the power dissipated in the 8.0 ohm resistor. | | (3) |
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| | (g) | A student says that the maximum **useful** power transfer occurs when the current is at a maximum (i.e. when the source is shorted out). Another student says that it occurs when the outside load resistance is the same as the Thévenin resistance. A third student suggests that the power transfer is much higher when the outside resistance is higher than the Thévenin resistance.<br><br>Using R = 0, 23 Ω and 50 Ω, demonstrate **with suitable supporting calculations** if necessary which student is correct. | **4.5** | (7) |
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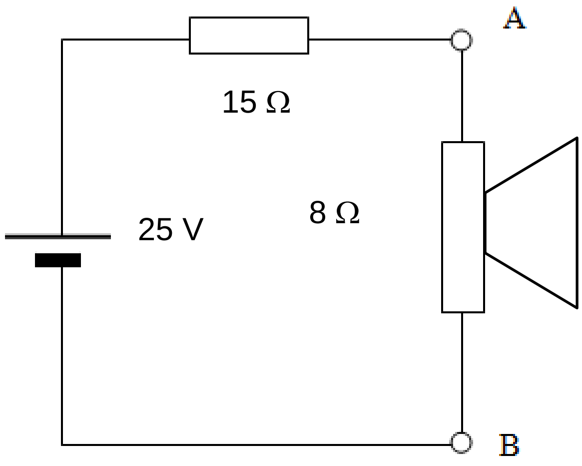
| | | | | *30 marks* |

2. The diagram shows an amplifier that is modelled using Thévenin’s theorem.




The output voltage is 25 V and the loudspeaker has an impedance of 8 ohms.
The internal impedance of the amplifier is 15 ohms.

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| | (a) | Explain why the term impedance is used instead of resistance. | (3) |
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| | In this question we are going to model the circuit as a DC source of potential difference 25 V and of internal resistance 15 ohms driving a load of 8 ohms | | |
| | (b) | Show that the current in the circuit is about 1.1 A. | (2) |
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| | (c) | Calculate the power given out by the speaker. | (2) |
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| | (d) | Calculate the total power given out by the source | | (2) |
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| | (e) | Work out the efficiency of the amplifier when driving an 8 ohm load. | | (2) |
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| | (f) | Theory tells us that the maximum power transfer occurs when the internal resistance and the load resistance are both equal. This can be achieved by the use of a load-matching transformer.<br><br>What should the resistance of the primary and secondary be to achieve this? | **4.6** | (2) |
| | Primary: | | | |
| | Secondary: | | | |
| | (g) | Work out the turns ratio for the matching transformer | **4.6** | (2) |
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| | (h) | The output transformer has a primary of 2000 turns. What is the number of turns on the secondary? | **4.6** | (2) |
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| | (i) | Show that the power transferred to the loudspeaker is now about 10 W. State what assumption you have made. | **4.6** | (4) |
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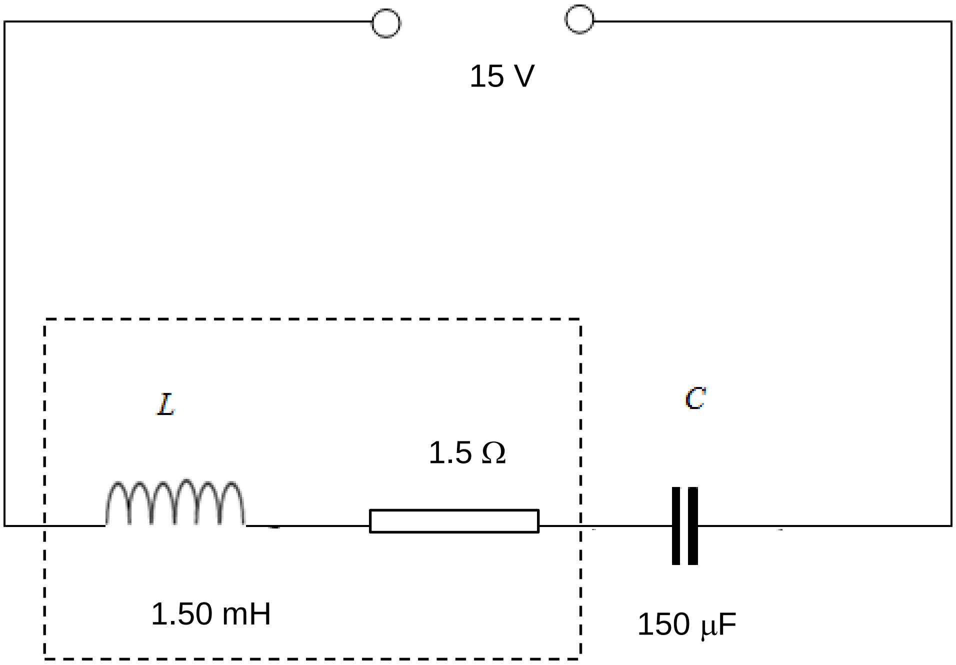
| | | | | *21 marks* |

3 An inductor of inductance 150 mH and of resistance 1.5 Ω is placed in series with a capacitor of 150 μF, as shown in this diagram:

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| | (a) | How do you model an inductor with a known resistance? | | (2) |
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| | (b) | Show that the resonant frequency for this combination is about 340 Hz | | (2) |
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| | (c) | Calculate the reactance of the inductor at resonance frequency. Give your answer to an appropriate number of significant figures. | | (3) |
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| | (d) | Write down the definition of the Q factor | **5.4** | (1) |
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| | (e) | Work out the Q factor for this circuit | **5.4** | (2) |
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| | (f) | What is the voltage across the inductor? | **5.4** | (2) |
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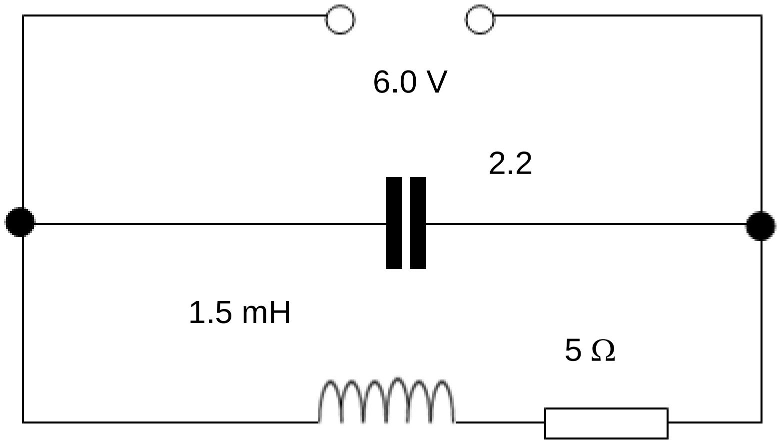
| 4. | The circuit below is used to investigate parallel resonance:<br><br> | | | |
| | (a) | Show that the resonant frequency of this circuit is about 2700 Hz. (Use the "exact" formula.) | **6.4** | (3) |
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| | (b) | A student looks at the formula you used to calculate your answer above, and decides to use the simpler formula below instead to work out the resonant frequency:<br>$$f = \frac{1}{2\pi\sqrt{(LC)}}$$<br>(i) What is the resonant frequency given by this formula?<br>(ii) Under what circumstance is the use of this formula justified?<br>(iii) What is the percentage error in the approximation? | **6.4** | (5) |
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| | (c) | Explain what happens when there is resonance and explain how the circuit above can act as a stable frequency source. | **6.6** | (4) |
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| | (d) | Give one other use for a resonant circuit. | | (1) |
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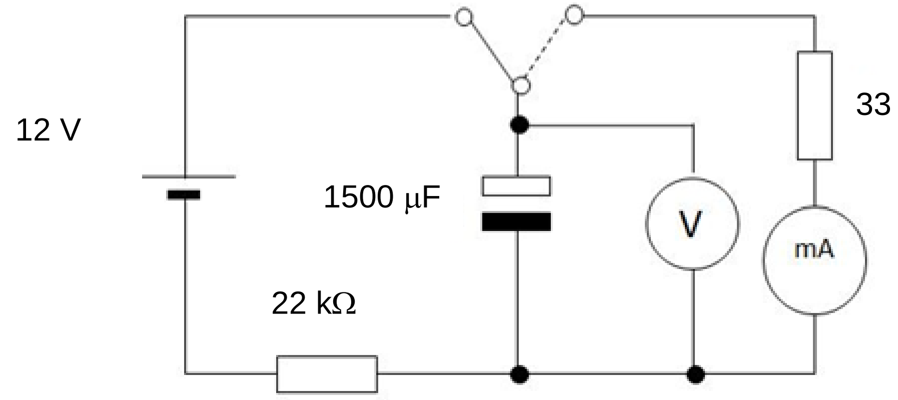
| 5. | The circuit below is being used to show the exponential charge or discharge of a capacitor through a resistor connected to a d.c. supply. The circuit as shown represents the **charging** of the capacitor.<br> | | | |
| | (a) | One reading you can take for both charging and discharging is time (which you do with a stopwatch). What one other reading can you take while the capacitor is charging? | **8.1** | (1) |
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| | (b) | Explain why reactance is not a relevant quantity in this question. | **8.1** | (1) |
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| | (c) | Define the time constant for the **charge** of the capacitor. Work out the time constant. | **8.3** | (3) |
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| | (d) | Sketch the graph of voltage against time for the charge of the capacitor. Put suitable values on your sketch graph. Mark on the time constant. | **8.2** | (3) |
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| | The capacitor is now **discharged** through the 33 kΩ resistor | | | |
| | (e) | Calculate the time constant for the discharge. | **8.3** | (2) |
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| | (f) | Calculate the current at the start of the discharge | **8.4** | (2) |
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| | (g) | Calculate the current after 30 s of the discharge. | **8.4** | (3) |
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| | (d) | Sketch the graph of voltage against time for the discharge of the capacitor. Put suitable values on your sketch graph. Mark on the time constant. | **8.2** | (3) |
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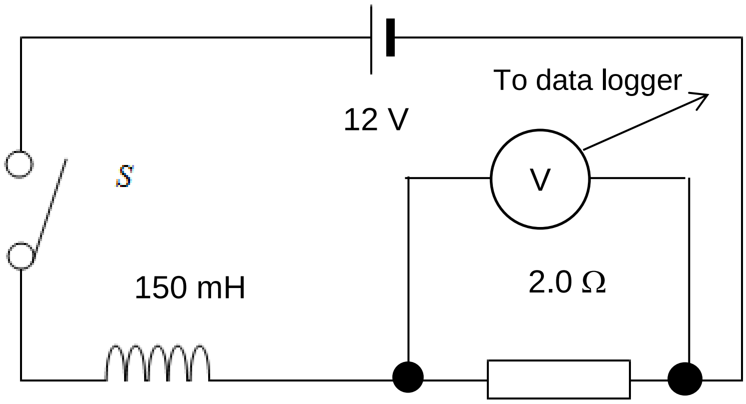
| 6. | A circuit consists of a pure inductor that is connected in series with a resistor as shown below.<br><br><br>Voltage is measured across the 2.0 Ω resistor. Switch S is closed. | | | |
| | (a) | Why is a data logger used? | **8.5** | (1) |
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| | (a) | Calculate the energy held in the inductor while the current is flowing through it. | **8.5** | (3) |
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| | (b) | When switch *S* is opened, the current falls to zero in 10 ms. Work out the EMF induced when switch S is opened. | **8.7** | (2) |
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| | (c) | Switch *S* is closed again. The voltage across the 2.0 ohm resistor is measured using a fast data-logger. An inductive rise is observed. Sketch a graph of the voltage against time that you would expect to see. No values are needed. Explain why it is this shape. | **8.5**<br>**8.6** | (4) |
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| | (d) | Show that the time constant for this inductor and resistor is 75 ms | **8.3** | (2) |
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| | (e) | A student suggests that a bigger resistor should be used to increase the time constant. Explain whether this would work. | **8.7** | (2) |
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| | (f) | Calculate the current 50 ms after the switch S is closed. | **8.7** | (3) |
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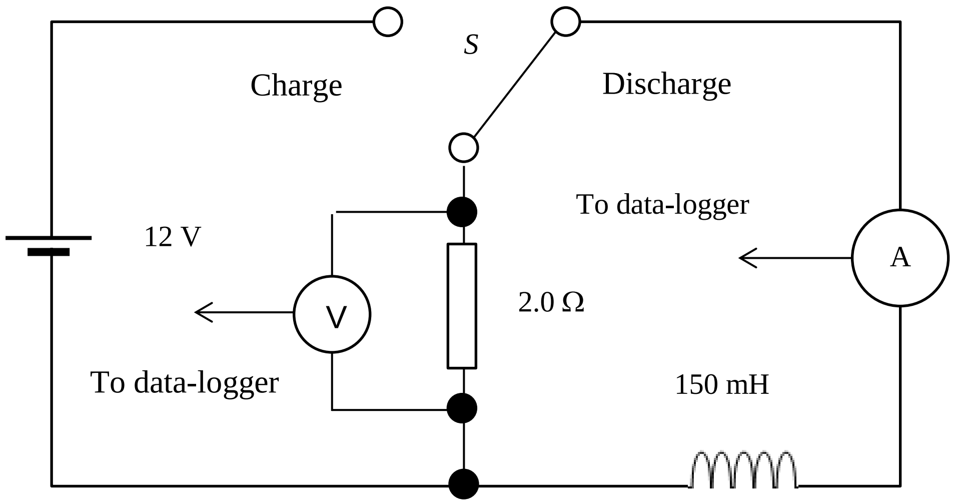
7. A student tried to investigate the exponential fall of voltage in an inductive circuit by using the circuit in Question 6. The reverse voltage spike that you worked out in 6 (b) was sufficient to ruin the voltage sensor. So he set up a different circuit:




The components are the same as in Question 6. The time constant is 75 ms.

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| | (a) | Suggest why this circuit should work better than the one in Question 6 when it's disconnected from the supply | **8.5** | (3) |
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| | (b) | Work out the time taken for the voltage to fall from 12.0 V to 6.0 V when switch *S* is moved to the discharge position. | **8.7** | (3) |
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| | (c) | In the space below, sketch the voltage-time graph from when the switch is moved to the discharge position. Put appropriate values on your sketch graph. | **8.6** | (3) |
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| | | | | *9 marks* |
| | | | | *Total = 120 marks* |

**End of Examination**
**Now go back and check your work**