Name: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_



**PHYSICS**

**Level 3**

91526 Demonstrate understanding of electrical systems

Credits: Six

Answer **ALL** the questions in the spaces provided.

If you need more space for any answer, use the pages provided at the back of this booklet and clearly number the question.

For all numerical answers, full working should be shown and the answer should be rounded to the correct number of significant figures and given with an SI unit.

For all ‘describe’ or ‘explain’ questions, the answer should be in complete sentences with all logic fully explained.

**YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE ASSESSMENT.**

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| --- | --- | --- |
| For Assessor’s use onlyAchievement Criteria | | |
| Achievement | **Achievement** **with Merit** | **Achievement With Excellence** |
| Demonstrate understanding of electrical systems. | Demonstrate in-depth understanding of electrical systems. | Demonstrate comprehensive understanding of electrical systems. |

You may find the following formulae and data useful.

   

  

   

  

  

   

    



Charge on the electron = –1.60 × 10–19 C

Permittivity of free space = 8.85 × 10–12 F m–1

Assessor’s use only

It is recommended that you take 60 minutes to complete this assessment.

##### QUESTION ONE: DC CURRENT IN A CAPACITOR

Darrell builds the following circuit.

Variable resistor, maximum value 1.50 kΩ

0.100 F

12.0 V

A

V

(a) Calculate the time constant for the circuit when the resistor is set to maximum.

(b) Use your answer to (a) to sketch a graph which shows how the voltage across the capacitor would vary with time for five minutes (300 s) after the capacitor was connected.

(c) Calculate the maximum current which flows while the capacitor is charging and state when this maximum current occurs.

Assessor’s use only

(d) The charging current can be kept steady by gradually reducing the resistance from 1.50 kΩ while the capacitor is being charged. Calculate the time taken to fully charge the capacitor, if the current is kept steady throughout the charging period.

(e) When the capacitor is fully charged Darrel changes the resistance of the variable resistor. Describe and explain the effect (if any) on the ammeter and voltmeter readings.

**Question two: comparing capacitors and inductors**

Assessor’s use only

Darrel builds another circuit, using an inductor as well as a capacitor, with two identical lamps labelled “12 V, 1.2 A”. When the switch is closed, lamp A lights straight away, but B is not lit. Lamp A then gets dimmer, and Darrel notices that lamp B is coming on and gradually getting brighter. Eventually A is off and B is fully bright.

:.

0.200 F

12.0 V

A

“12.0 V

1.2 A”

B

20 H

“12.0 V

1.2 A”

1. Explain why lamp B does not light up immediately.

The circuit has been designed so that each branch of the circuit has the same time constant. Explain why this makes one come on while the other is going off.

Assessor’s use only

1. The circuit has been designed so that each branch of the circuit has the same time constant. By calculating the resistance of the lamp, show that the numerical value of the inductance of the inductor must be about one hundred times the numerical value of the capacitance of the capacitance.

1. Lamp B is on and lamp A is off for a few minutes. Darrel then switches the circuit off and notices that lamp A lights up, followed by both lamps fading out together. Explain why this happens.

**Question Three: metal detector**

Some types of metal detector use an inductor. The circuit below is designed so that the light comes on if a piece of suitable metal is close to the inductor coil.

Assessor’s use only

12.0 V rms

Inductor coil

Resistor 90.0 Ω

Lamp 10.0 Ω

metal

Capacitor

1. Explain why the inductance of the coil increases as the metal gets closer to the coil. In your answer you should consider:
   1. what inductance is and what causes a coil to have inductance
   2. what effect the presence of a suitable piece of metal would have on the inductance of the coil

1. With the metal in position, as shown, the inductor has an inductance of 6.0 mH and a reactance of 30Ω in this circuit. Calculate the frequency of the supply.

(c) The circuit is designed so that, with the metal in the position shown, the current is maximum. State the reactance of the capacitor in the circuit and hence determine the capacitance of the capacitor.

Assessor’s use only

1. Darrel uses an oscilloscope to investigate the circuit He finds that when the metal is close to the inductor, and the lamp is on, the voltage across the resistor *V*R has the same size as, and is in phase with, the voltage across the supply *V*S. This situation is illustrated in the phasor diagram below.   
   Describe and explain how the size and phase of *V*R and *V*S would change as the metal is moved away from the inductor coil. You may find it useful to illustrate your answer using the blank diagram below.

**Question four: capacitors in defibrillators**

Assessor’s use only

During a heart attack the patient’s heart may need to be corrected using a short electric shock. Machines which are designed to deliver the right type of shock are called defibrillators.

A defibrillator typically contains a bank of capacitors which can store 200 J of energy and deliver it in a short, controlled pulse to the patient’s chest. .

1. .Explain why the capacitor bank cannot be charged directly from an AC electricity supply.

Capacitor bank

12.0 V

1. A capacitor bank is charged from a 12.0 V battery. Calculate the capacitance required to store 200 J and describe how this could be obtained using 0.93 F capacitors. .

Assessor’s use only

If you need more space for any answer, continue here. Clearly number the question.

Question Number