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NZQA

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 3 Physics 2024

91526 Demonstrate understanding of electrical systems

Credits: Six

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.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

Make sure that you have Resource Booklet L3–PHYSR.

In your answers use clear numerical working, words, and / or diagrams as required.

Numerical answers should be given with an appropriate SI unit.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–8 in the correct order and that none of these pages is blank.

Do not write in the margins (⁄⁄⁄). This area will be cut off when the booklet is marked.

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

QUESTION ONE: DC AND CAPACITORS

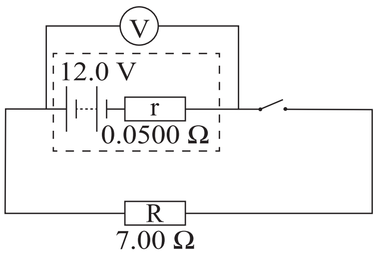
(a) Stefan's car battery recently needed replacing, so he investigated new and used batteries in different situations. His car has a new battery with an EMF of 12.0 V and an internal resistance of 0.0500 Ω.

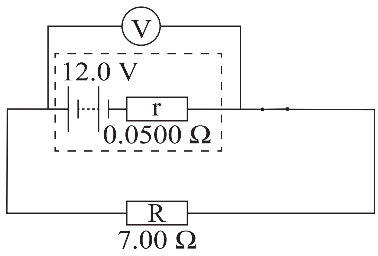
Explain the meaning of the term EMF.

(b) Stefan observes what happens to the voltmeter reading while opening and closing the switch.

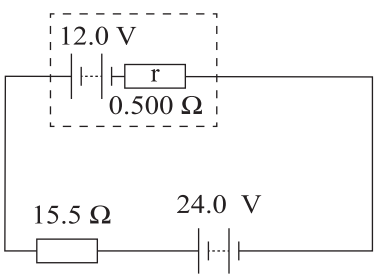
Explain why the readings are the same or different.

Values and calculations are not required.





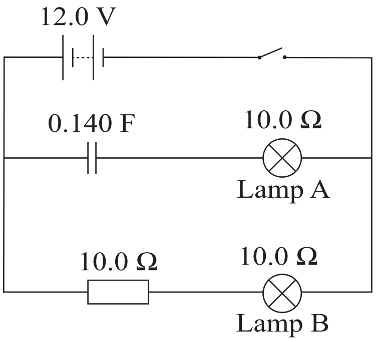
(c) After long use the internal resistance of the 12 V battery increases to 0.500 Ω. The discharged battery is charged by a 24.0 V DC supply with a 15.5 Ω resistor in series.



Calculate the terminal voltage across the car battery.

Begin your answer by calculating the circuit current while it is being charged.

(d) Stefan connects a 12.0 V DC supply to a 0.140 F capacitor, two lamps, and a resistor, as shown below. The resistor and the lamps each have a resistance of 10.0 Ω.



Give an in-depth explanation of what Stefan would observe by comparing the brightness of lamps A and B:

- as soon as the switch is closed
- ten seconds after the switch is closed.

QUESTION TWO: ELECTROMAGNETIC INDUCTION

Harry is experimenting with coils and magnets.

(a) Harry measures an average EMF of 250 μV that is induced in a coil when the current in it changes from 10.0 A to 6.00 A in 0.400 s.

Calculate the self-inductance of the coil.

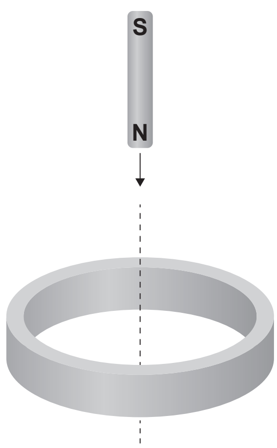
(b) The coil has 25 turns and an area of 1.60 cm^2 (1.60×10^{-4} m^2). This coil is inserted into a magnetic field of flux density 1.80 Wb m^{-2}, such that its plane is perpendicular to the lines of flux of the field. It takes 0.300 s for the coil to be placed in the magnetic field.

Calculate the EMF induced in the coil.

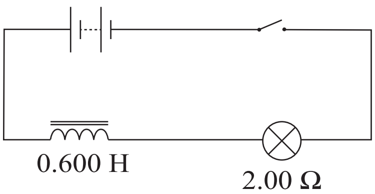
(c) Harry then drops a bar magnet through a metal ring.

Explain why its acceleration will not be equal to "g" = 9.81 m s^{-2}.

In your answer, include ideas about what happens when the magnet enters the ring, as well as when the magnet leaves the ring.



(d) Harry next connects a 0.600 H inductor and a lamp whose resistance is 2.00 Ω, in series to a battery through a switch. Harry notices that the lamp takes some time to reach full brightness once the switch is closed.

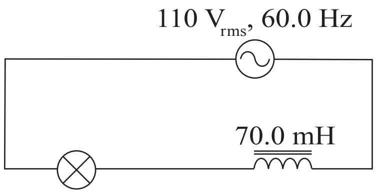


Calculate the current through the lamp after 0.600 seconds.

Begin by calculating the time constant of the circuit.

QUESTION THREE: ALTERNATING CURRENT

Rachel is experimenting with AC circuits. She connects a 70.0 mH inductor with a soft iron core and a 40.0 Ω bulb in series to a 110 V_{rms}, 60.0 Hz supply.



(a) Calculate the peak voltage of the power supply.

(b) Calculate the phase difference between the supply voltage and the circuit current, and state which one leads.

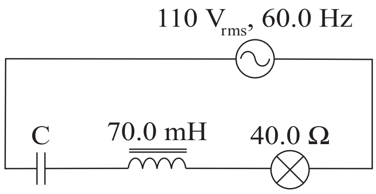
Begin your answer by showing that the reactance of the inductor is 26.4 Ω.

Space for phasor diagram if needed.

(c) The inductor has a soft iron core.

Explain what Rachel would observe in the brightness of the lamp when she slowly removes the iron core from the inductor.

(d) Rachel then reinserts the iron core and adds a capacitor to the circuit, in order to achieve resonance.



Explain why the reactance of the capacitor needs to be 26.4 Ω.

Begin your answer by describing what happens at resonance.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

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