Area of study – Electric power

Question 12 (4 marks)

Electric current flows through a straight conductor lying on a bench top, as shown in Figure 17.

a. On Figure 17, show the direction of the magnetic field produced by the current as it passes through the bench top on either side of the conductor. Use × to indicate a field directed into the page and • to indicate a field directed out of the page.

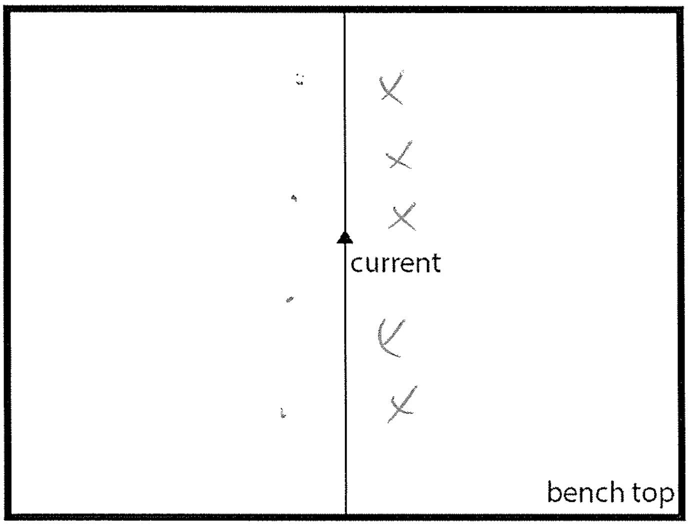


Figure 17

2 marks

SECTION A – Core studies – Question 12 – continued

b. As shown in Figure 18, an external magnetic field of 0.01 T is supplied to a 10 cm length of the conductor. If the conductor carries 5 A of current, calculate the magnitude of the force it experiences. Assume the magnetic field is entirely contained within the 10 cm length.

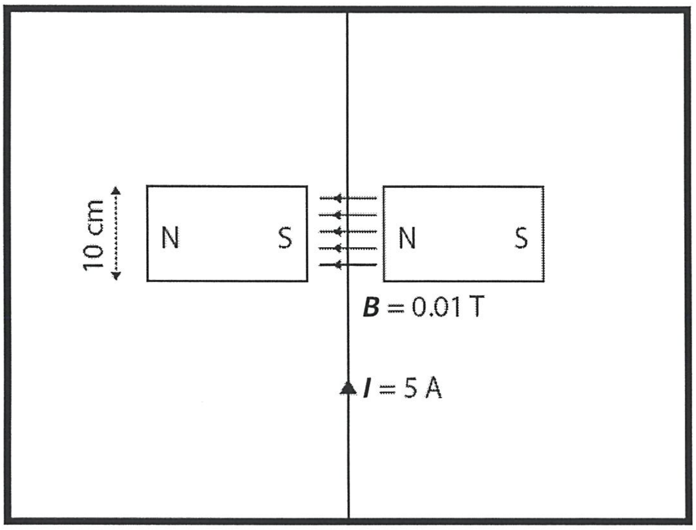


Figure 18

2 marks

$F = BIL$

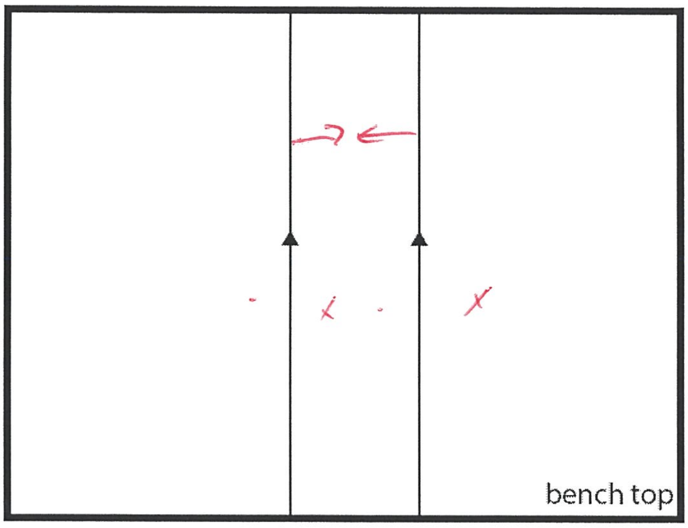
$= 0.01 \times 5 \times 0.1$

0.005 N

2

Question 13 (2 marks)

Two identical conductors are placed on a bench top, as shown in Figure 19. They each carry an identical current in the direction shown. Each conductor experiences a magnetic force. Draw an arrow on each conductor to show the direction of these forces.



Inwards

Figure 19

2 marks

Question 14 (6 marks)

A simple DC motor is constructed with 100 turns of wire within a magnetic field of 0.001 T. 12 V is supplied to the coil, which has a resistance of 50 Ω.

a. Figure 20 shows that the motor is connected to a power supply by a split-ring commutator. Complete the diagram by drawing the split in the commutator in the correct orientation.

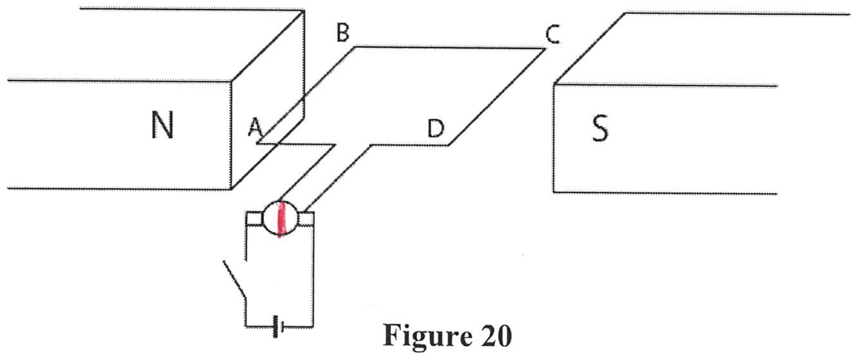


Figure 20

1 mark

When the switch is closed, the coil experiences a force that turns the coil from its initial perfectly horizontal position.

b. Calculate the magnitude of the force on side *AB* (of length 12 cm) at the instant the power is switched on.

3 marks

$I = \frac{V}{R} = 0.24 A$ ①

$F = nBIL = 100 \times 0.24 \times 0.12 \times 0.001$ ①

$= 0.00288$ ①

0.00288 N

2.9×10^{-3}

c. Explain why side *AB* experiences a magnetic force but side *BC* experiences no magnetic force at this instant.

2 marks

AB ~~perp.~~ perp. to field – hence force

BC parallel.

Question 15 (4 marks)

A solenoid is constructed by winding insulated copper wire around a soft iron core, as shown in Figure 21.

a. When the current is connected as shown, the solenoid acts as an electromagnet. Draw three lines to show the direction of the magnetic field around the solenoid.

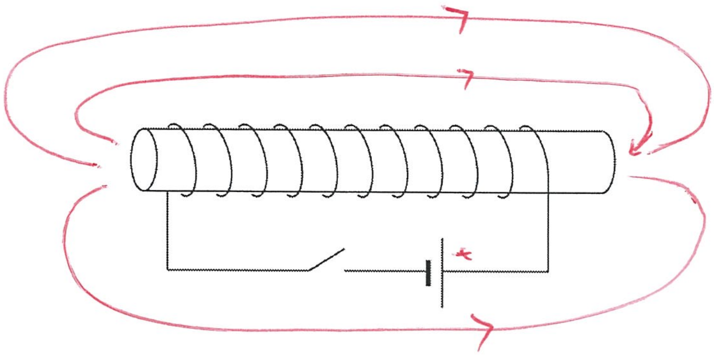


Figure 21

2 marks

2

A single loop of wire connected to a galvanometer is placed around the end of the iron core, as shown in Figure 22. When the current supplied to the solenoid is turned off, the galvanometer needle moves to the right before returning to its central position.

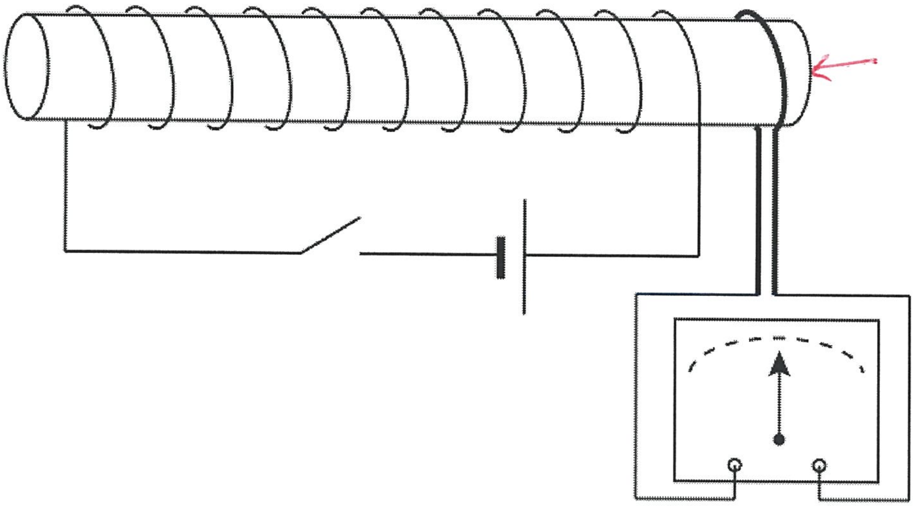


Figure 22

b. Describe how the galvanometer needle moves when the current to the solenoid is switched back on again.

2 marks

opposite – so left ①

then returns to centre. ①

SECTION A – Core studies – continued
TURN OVER

2

Question 16 (6 marks)

A generator consists of a rectangular loop of 25 turns within a magnetic field of 0.005 T. The loop has an area of 6.0×10^{-4} m^2. The generator is connected to a cathode ray oscilloscope through a set of slip rings, as shown in Figure 23.

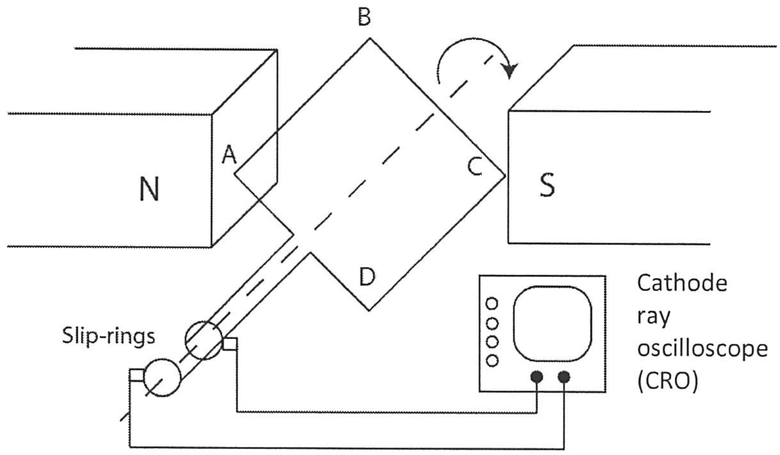


Figure 23

When the loop is rotated from the position shown, a current is induced, flowing from *A* to *B*.

a. Use Lenz's law to explain why a current flows in this direction.

3 marks

• Lenz's law → mag. field changes → induces current. – ~~opposite~~ oppose change
• coil rotates – flux increases
• current induced – opposes change

3

b. The loop is rotated at 50 Hz. Calculate the average emf induced in the loop by this rotation.

3 marks

$T = \frac{1}{50} = 0.02$

$t = \frac{0.02}{4} = 0.005$

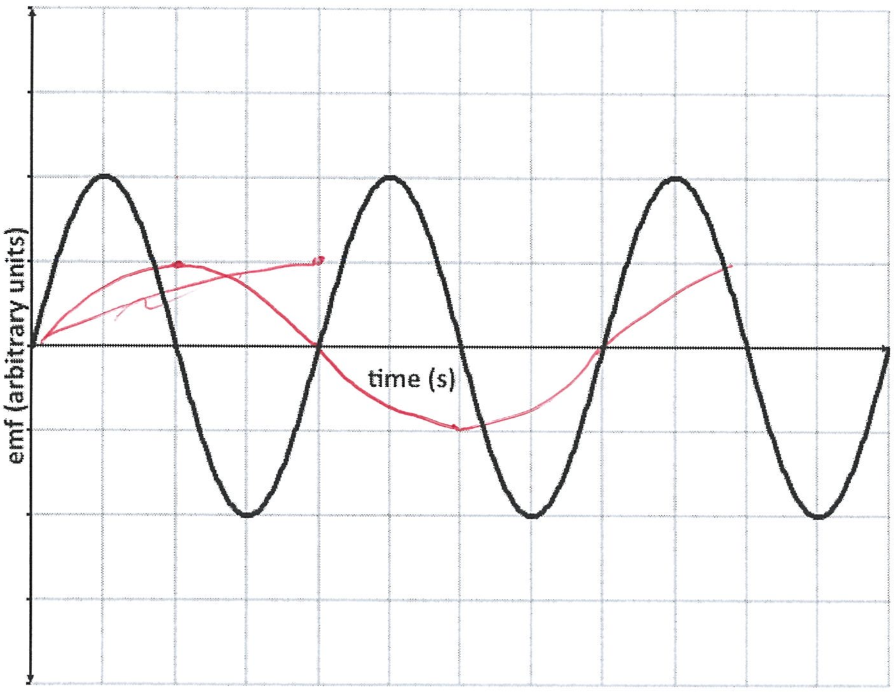
$\mathcal{E} = n\frac{\Delta\Phi}{\Delta t}$

$= 25 \times \frac{0.005 \times 6\times10^{-4}}{0.005}$

15 **mV**

Question 17 (4 marks)

a. The cathode ray oscilloscope trace observed when a generator with slip rings attached is rotated at 60 Hz is displayed in Figure 24. On the same axes, sketch the trace that would be observed if the loop was rotated at 30 Hz instead.



- period doubled
- amp. halved.

Figure 24

2 marks 2

b. In what way could this generator be changed if DC power output was required?

2 marks 2

slip rings removed & split-ring commutator added.

4

Question 18 (6 marks)

A ski lodge relies on mains electricity from a power line at the bottom of a hill 2 km away (Figure 25). The mains electricity is provided at 240 V_{RMS} from the power line and passes through wires with a total resistance of 3.0 Ω.

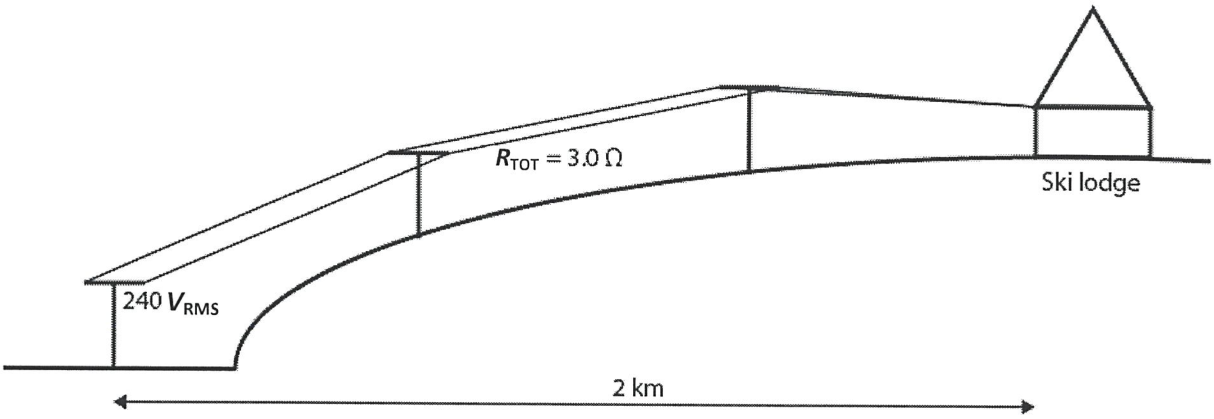


Figure 25

a. The lodge draws 30 A of current but the occupants notice that their electronic devices don't operate properly. What voltage is supplied to the lodge under these conditions?

3 marks

V = IR
= 30 × 3
= 90 V – v. drop.
240 – 90 = 150 V
available
or power loss.

150 V

3

A suggested solution to this problem is to run two more identical power lines up to the lodge so that each line carries 10 A.

b. What voltage reaches the lodge when delivered through three parallel lines totalling 30 A?

3 marks

$\frac{1}{R_T} = \frac{1}{3} + \frac{1}{3} + \frac{1}{3}$ $R_T = 1$ (1)

$V = IR$

$= 30 \times 1$

$= 30V$ (1)

$240 - 30 = 210$ (1)

210 V

3

Question 19 (7 marks)

An electrician is installing a temporary power line to a building site. He installs a transformer at each end of the transmission lines, as shown in Figure 26.

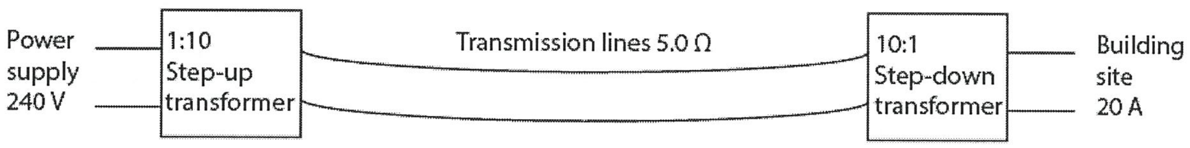


Figure 26

a. If there are 240 V in the primary coil of the step-up transformer, how many volts are in the secondary coil?

2 marks

$\frac{N_1}{N_2} = \frac{V_1}{V_2}$

$\frac{1}{10} = \frac{240}{V_2}$

2400 V

2

5

b. If there are 20 A in the secondary coil of the step-down transformer at the building site, what current is passing through the transmission lines?

2 marks

$\frac{N_1}{N_2} = \frac{I_2}{I_1}$

$\frac{10}{1} = \frac{20}{I_1}$

$I = 2A$

2

2 **A**

c. Find the power loss in the transmission lines under these circumstances and use this value to find the voltage provided to the workers on the building site.

3 marks

$P = I^2R$

$= 2^2 5 \quad = 20\ W$

$240 \times 20 - 20 = 4780$

$\frac{4780}{} = 20V$

$V = 239$

239 **V**

Question 2

Eighteen 10 W globes connected to the 240 V AC RMS mains supply are set up in the circuit as shown in Figure 3. One of the globes is labelled *G*. Each globe is operating at 10 W.

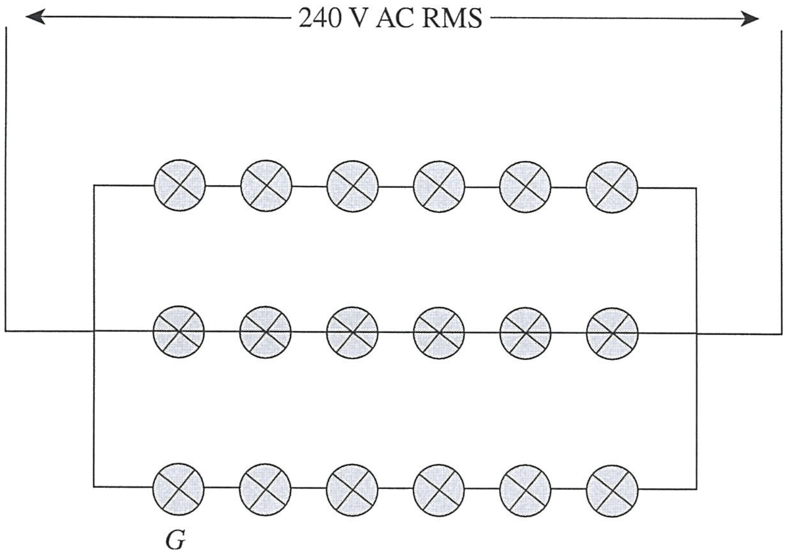


Figure 3

a. Calculate the RMS current through globe *G*. Show your working.

P = IV
10 = i × 60
I = 0.25

0.25 A

2 marks

b. Calculate the resistance of globe *G*. Show your working.

V = IR
40 = 0.25R

160 Ω

2 marks

c. Calculate the RMS current being drawn from the mains. Show your working.

0.75 A

2 marks

Question 5

Scientists studying Emperor penguins during 22 hour long nights in the Antarctic need a power source for their lighting system. To minimise the noise they use a 250 V AC 10 kW generator which is placed 400 m away from the lighting system (Figure 6). The total resistance of the two transmission wires between the generator and the lighting system is 2.0 Ω.

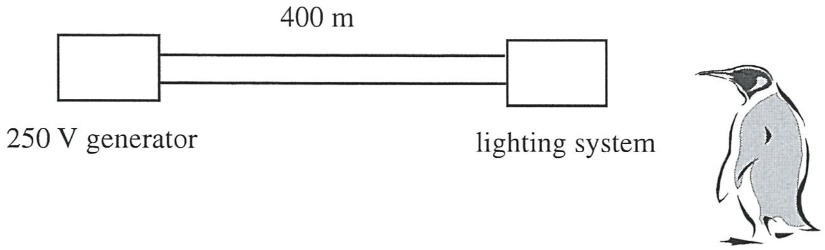


Figure 6

a. Calculate the current in the transmission wires. Show your working.

$P = VI$

$I = \frac{1 \times 10^4}{250}$

40 A

2 marks

b. Calculate the power lost in the transmission lines. Show your working.

3200 W

2 marks

c. Calculate the voltage available at the lighting system. Show your working.

$V = IR$ $40 \times 2 = 80$ V drop.

$250 - 80 = 170$

170 V

2 marks

d. The scientists note that there is not enough light produced by the lighting system to study the penguins properly. They have no transformers available but have another 2.4 km of the same type of wire that was used in the transmission lines available.

Explain how they can obtain more power at the lighting system. Support your answer with calculations.

put parallel strands.

~~400~~m. new R = 0.5 Ω

power loss 800 W instead of 3200

2 ✓

2 marks

END OF AREA OF STUDY 1

 2 ✓