7 A uniform magnetic field of flux density B makes an angle θ with a rectangular metal frame PQRS of area A, as shown in Fig. 7.1.

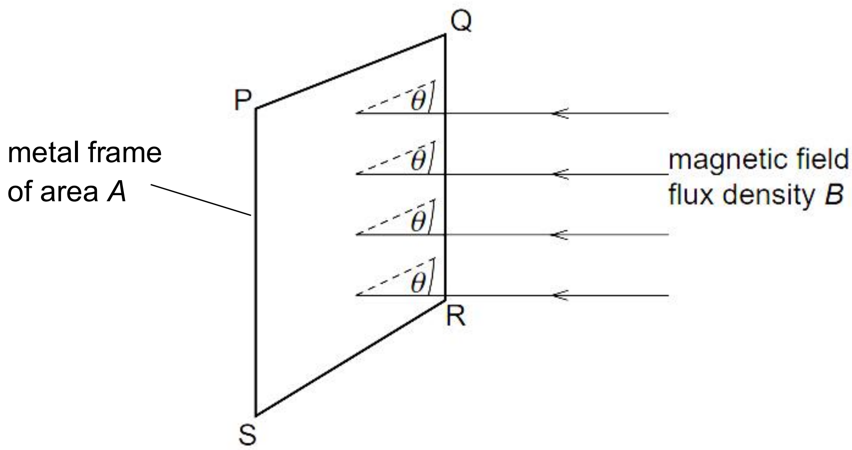

Fig. 7.1

(a) Distinguish between magnetic flux density and magnetic flux.

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....

....

.... [3]

(b) Write an expression, in terms of A, B and θ, for the magnetic flux ϕ linking the frame PQRS.

.... [1]

(c) The frame PQRS has width PQ = 52 cm and length QR = 95 cm. It is suspended by two non-conducting rods as shown in Fig. 7.2. The frame is rotated at a constant angular speed ω about the vertical axis through the rods.

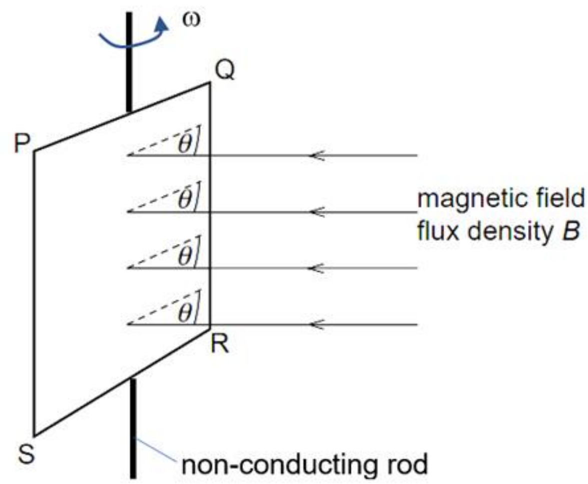

Fig. 7.2

The magnetic field density B is 1.8 T.

(i) Calculate the magnetic flux ϕ linking the metal frame when θ = 90°.

ϕ = ... Wb [2]

(ii) Explain, using the laws of electromagnetic induction, why there is an induced e.m.f. in the frame.

....

....

....

....

.... [2]

(iii) State the sides of the frame PQRS between which the e.m.f. is induced.

side .... and .... [1]

(iv) The graph in Fig. 7.3 shows how the induced e.m.f. varies over one cycle of rotation of the coil.

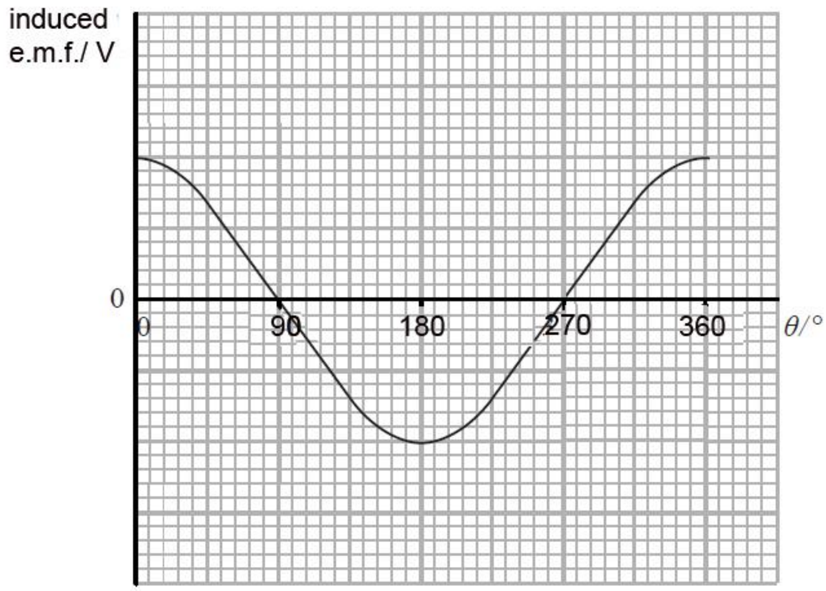

Fig. 7.3

1. Explain why the magnitude of the induced e.m.f. is maximum and zero at the values of θ shown in the graph.

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.... [3]

2. Explain why the shape of the graph is sinusoidal.

....

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....

.... [2]

3. The angular speed ω is 4π rad s^{-1}.

Calculate the maximum value of the induced e.m.f. in the frame.

e.m.f. = ... V [2]

4. The resistance of the frame PQRS is 4.8 Ω.
Calculate the r.m.s current in the frame.

r.m.s current = ... A [2]

(vi) State and explain how the graph in Fig. 7.3 would differ if the frame rotated at a slower angular speed.

....

....

....

.... [2]

[Total: 20]