6 A toroidal solenoid is used to determine the presence of alternating currents in cables without being electronically connected to it. It consists of a wire being wound on a plastic ring. The alternating current carrying cable is placed along the axis through the centre of the device as shown in Fig. 6.1.

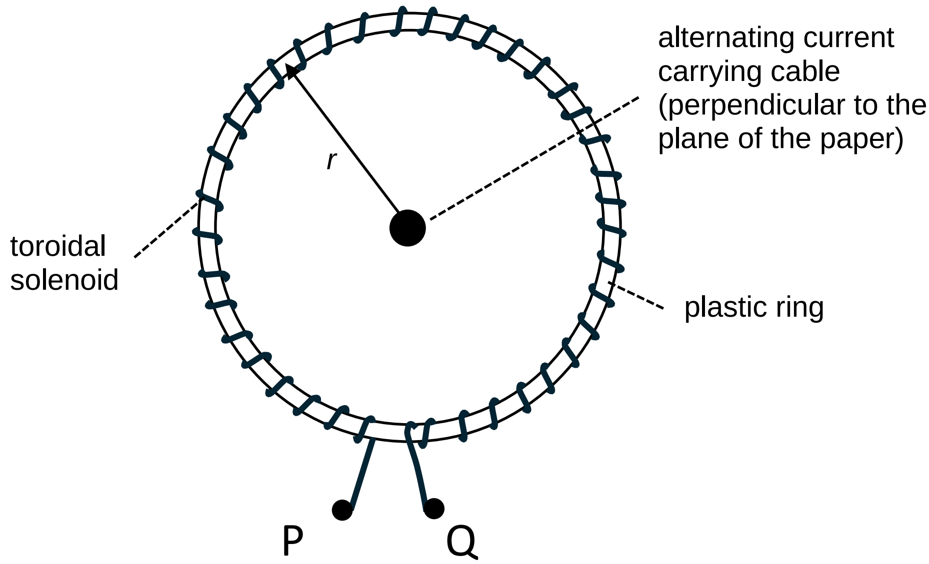

Fig. 6.1

The radius of the plastic ring *r* is 20 cm. The solenoid has a total of 1500 turns, and each turn has a radius of 0.50 cm.

The sinusoidal current I flowing in the cable is given by the expression $I = 1.2 \sin 377t$, where time t is in seconds and current I is in amperes.

(a) **(i)** Determine the maximum magnetic flux density that is induced by the cable in the plastic ring. You may assume that the magnetic flux density in the plastic ring is uniform.

maximum magnetic flux density = …………………… T [2]

(ii) Hence, calculate the maximum magnetic flux linkage at the toroidal solenoid.

maximum magnetic flux linkage = …………………… Wb [2]

(b) The terminals P and Q are connected to a multimeter to measure the electromotive force, e.m.f., induced in the toroidal solenoid.

(i) Using the laws of electromagnetic induction, explain why there is an e.m.f. induced in the toroidal solenoid.

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(ii) The multimeter usually measures the root-mean-square value of the e.m.f. when connected to an alternating voltage source.

Explain the significance of the root-mean-square value for the e.m.f. of the alternating voltage source in terms of energy considerations.

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[Total: 8]