4 Fig. 4.1 shows the cross-sectional view of a long solenoid. A small copper disc spins via a copper axle which lies along the axis of the solenoid. The ends of the solenoid are connected in series with resistor *R* to a d.c. supply.

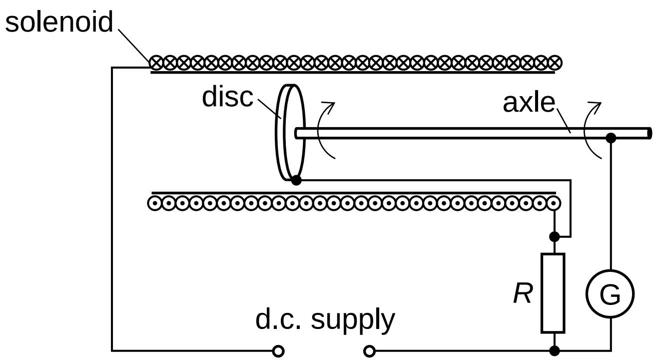

Fig. 4.1

The edge of the copper disc maintains electrical contact with resistor *R* by means of carbon brushes. A galvanometer connects the copper axle to the other end of resistor *R*.

(a) Using Faraday's law of electromagnetic induction,

(i) explain why an e.m.f. is generated between the axle and the rim of the disc when the copper disc rotates about the axle,

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.... [3]

(ii) show that the e.m.f. described in **(a)(i)** is given by

$$E = BAf$$

where B is the magnetic flux density inside the long solenoid,
A is the circular area of the copper disc, and
f is the frequency of revolution of the copper disc.

[2]

(b) **(i)** Using **(a)(ii)**, show with clear explanation that the resistance R when the galvanometer registers null deflection is given by

$$R = \mu_0 n A f$$

where n is the number of turns per unit length of the solenoid.

[1]

(ii) Hence, suggest the advantage in using this method for finding resistance.

....

.... [1]

(c) The copper disc has a radius of 0.20 m and is rotated at 5.0 revolutions each second. When the galvanometer meter registers null deflection, the current flowing through the resistor R of $10\ \Omega$ is found accurately to be 1.0 mA.

Determine B.

B = ... T [1]

[Total: 8]