4 (a) A revolving aluminium disc has small magnets equally spaced around its rim as shown in Fig. 4.1. The magnets are all aligned in the same direction with the north poles on the same side of the disc. The disc rotates at a constant angular velocity.

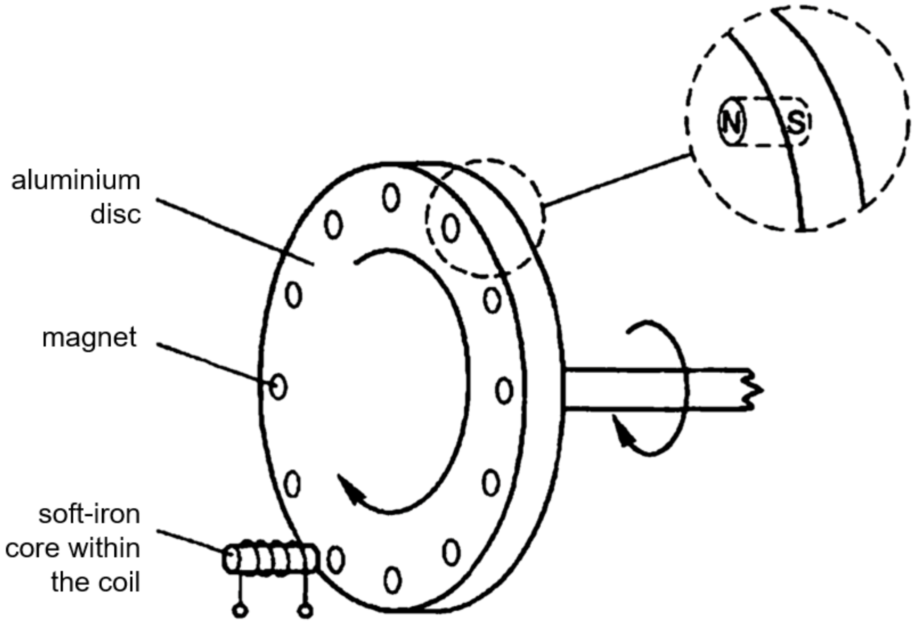

Fig. 4.1

A coil, wound on a soft-iron core, is fixed such that the north poles of the magnets pass close by the end of the coil without touching it. The terminals of the coil are connected to a detector which monitors the e.m.f. induced in the coil.

(i) As one magnet passes the coil, use the laws of electromagnetic induction to explain

1. why there is an induced e.m.f. in the coil,

....

....

....

....

....

....

....

.... [2]

2. why there is a reversal in the direction of the induced e.m.f.

____

____

____

____ [1]

(ii) On Fig. 4.2, sketch a graph to show the variation with time of the e.m.f. induced in the coil as one magnet passes the coil.

Fig. 4.2 [1]

(b) Fig. 4.3 and Fig. 4.4 show two views of a rectangular coil of height h and width d rotating with an angular speed ω about a vertical axis in a horizontal magnetic field of flux density B. At a certain instance of time t, the normal to the plane of the coil makes an angle of ωt with the magnetic field.

There are N turns in the coil.

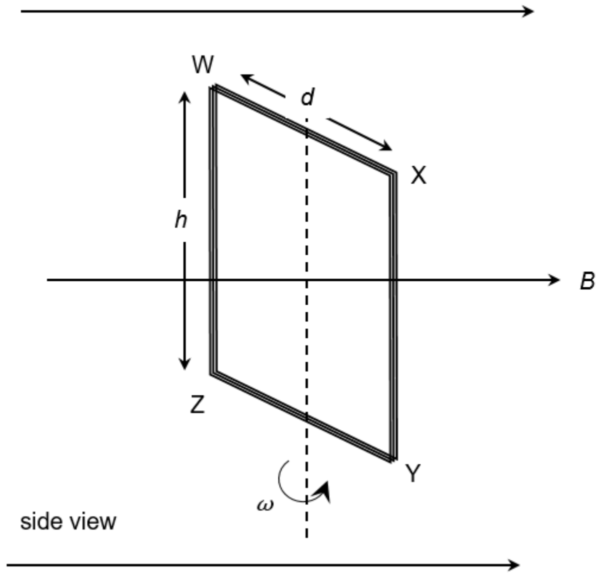

Fig. 4.3

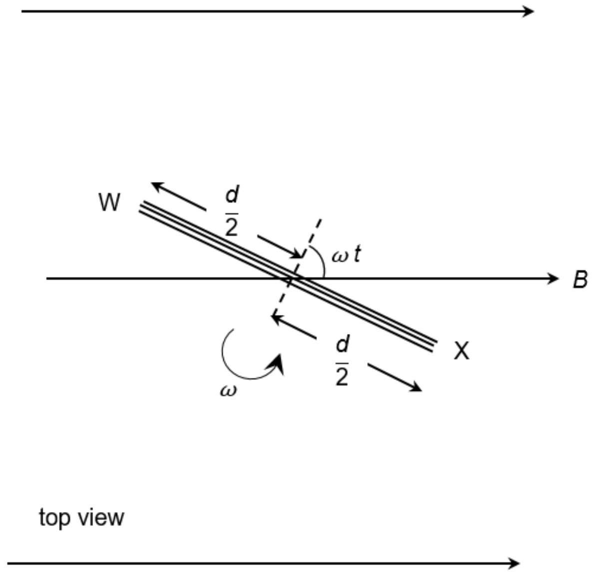

Fig. 4.4

(i) At time $t = 0$, the plane of the coil is perpendicular to the magnetic field.

Show that the magnitude of the induced e.m.f. E in the coil is given by

$$E = NBdh\omega \sin(\omega t)$$

[2]

(ii) The coil has dimension 30 cm by 24 cm and has 15 turns and the uniform magnetic field has flux density of 0.018 T.

The coil rotates with a frequency of 25 Hz.

Determine, for the coil,

1. the maximum induced e.m.f.,

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

2. the root-mean-square value of the induced e.m.f.

root-mean-square e.m.f. = ... V [1]

[Total: 9]