6 A single-turn copper square frame of length L is rotated with constant angular speed ω by an external torque in a constant magnetic field of flux density B. The frame rotates counterclockwise about the axis of rotation as shown in Fig. 6.1.

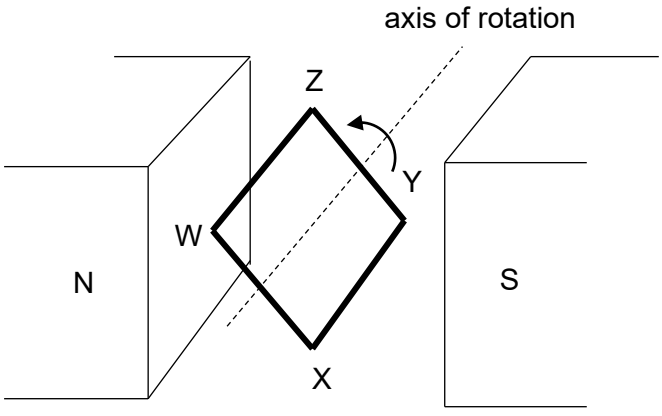

Fig. 6.1

Fig. 6.2 shows the side view of the coil when WX is at an angle θ above the horizontal.

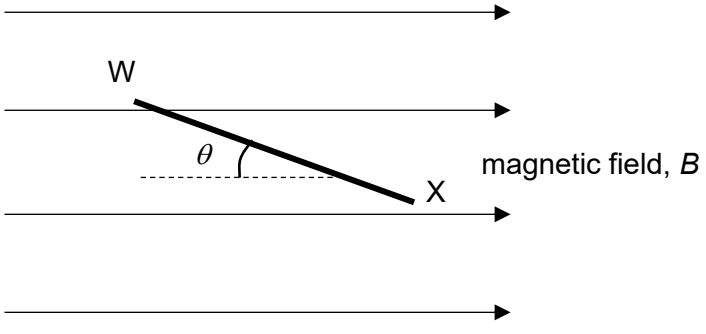

Fig. 6.2

(a) State the direction of the induced current in the frame.

.....[1]

(b) Explain why an external torque is required to maintain the rotation of the frame at a constant angular speed.

.....

.....

.....

.....[2]

(c) **(i)** At the instant shown in Fig. 6.2, write down an expression for the flux linkage in the coil in terms of B, θ and L.

[1]

(ii) Hence show that the magnitude of the induced e.m.f. in the coil at this instant is $|\varepsilon| = BL^2\omega\cos\theta$.

[2]

(d) The resistance of the frame is 5.0 Ω and the length L of the square frame is 0.20 m. The frame is rotated in the magnetic field of flux density 1.0 T at an angular frequency of 10 rad s^{-1}. Using your expression in **(c)(ii)**, calculate the average power dissipated in the frame.

average power dissipated = ...W [3]

[Total: 9]