The definition of magnetic flux $\Phi = BA$ applies specifically to a situation where the magnetic flux density B is normal to area A (as in Figures 17 and 18). However, in a situation where the magnetic flux density is not normal to the area of the coil (as in Figure 19a), it is often necessary to determine the component of the magnetic flux density at right angles to the coil area. If the angle between the direction of the magnetic field and the normal to the plane of the coil is θ (see Figure 19b), the component of B at right angles to the coil is $B\cos\theta$ and therefore the magnetic flux through the coil is

$$\Phi = BA\cos\theta$$

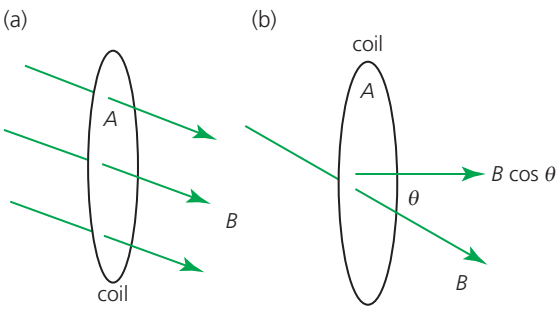

Figure 19 *Finding the component of B normal to an area A*

When we consider electromagnetic induction in Chapter 8, we will need to use the concept of magnetic **flux linkage**. This is defined as the product of the magnetic flux Φ passing through a conducting coil and the number of turns N of wire on the coil. Magnetic flux linkage does not have its own symbol, but is simply written as $N\Phi$. The unit is the 'Wb turn'.

QUESTIONS

14. Calculate the magnetic flux passing through a circular coil of diameter 2.0 cm if the magnetic flux density is 150 mT and the angle between the normal to the plane of the coil and the direction of the magnetic field is 40°.

15. Calculate the magnetic flux linkage through a 20-turn circular coil given that the magnetic flux density is 150 mT, the angle between the normal to the plane of the coil and the direction of the magnetic field is 16° and the radius of the coil is 5.0 mm.

A rotating coil

Consider a rectangular coil positioned in a magnetic field (Figure 20). If the coil is rotated to different orientations relative to the direction of the magnetic field, the magnetic flux linkage through the coil changes. For example, when the plane of the coil is parallel to the field lines (Figure 20a), the flux linkage is zero, but when the plane of the coil is at right angles to the field lines (Figure 20b), the magnetic flux linkage is a maximum.

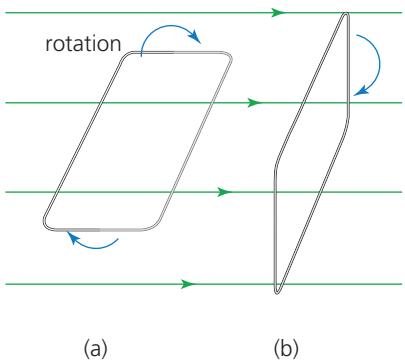

Figure 20 *Rotating a rectangular coil with respect to the field direction*

If the normal to the plane of the coil is at an angle θ to the direction of the magnetic field (Figure 21), the magnetic flux linkage through the coil is $N \times BA\cos\theta$. This is usually written as

$$N\Phi = BAN\cos\theta$$

If the coil is continuously rotated (with constant angular speed), the magnetic flux linkage varies as a cosine curve (Figure 22).

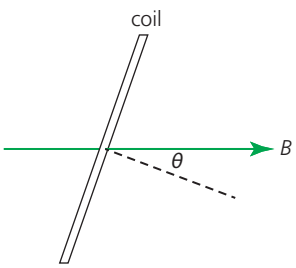

Figure 21 *Side view of a rectangular coil in a magnetic field*

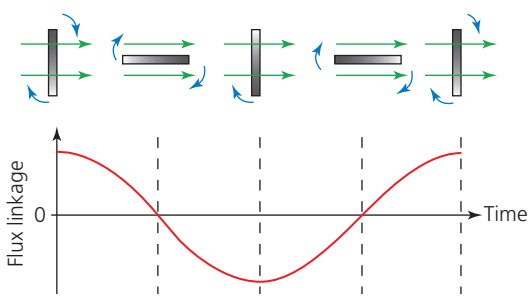

Figure 22 *Variation in flux linkage as a coil rotates*