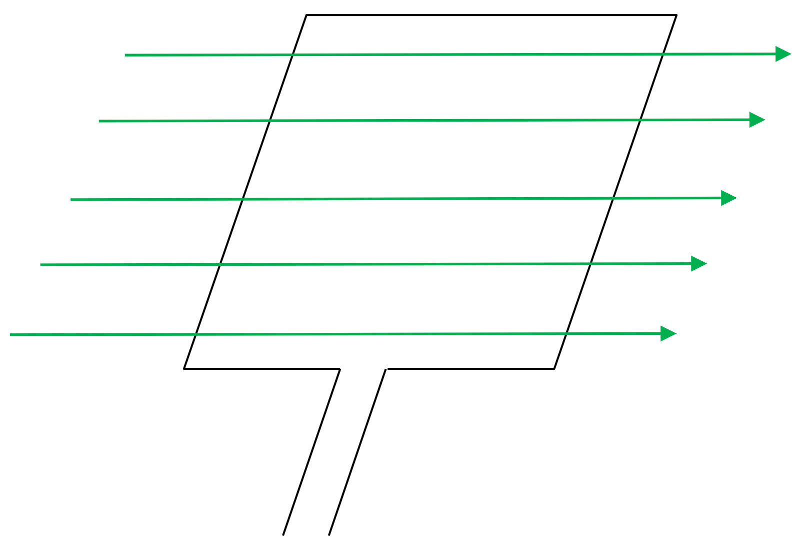
Teacher notes
Topic D

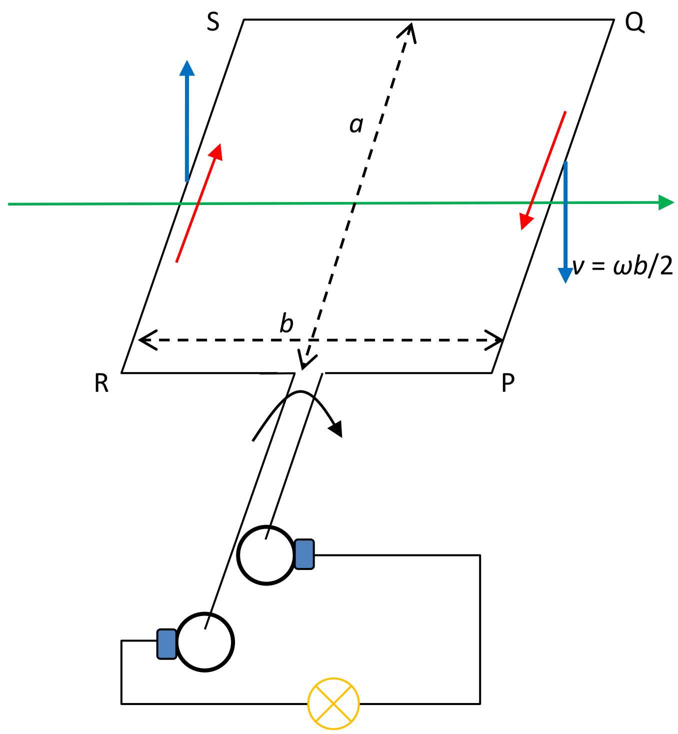
Induced emf in a rotating coil

The loop of area *A* is rotating in magnetic field *B* with angular speed *ω*. At the position shown the flux through the loop is zero.



In general, the flux will be given by $\Phi = BA\cos(\omega t)$ and so the induced emf in the loop will be $\varepsilon = -\frac{d\Phi}{dt} = BA\omega\sin(\omega t)$. The maximum induced emf is thus $\varepsilon_{\max} = BA\omega$. How can we get this result without calculus?

The sides PQ and RS of the loop have angular speed *ω* and so linear speed $v = \omega R$ where *R* is the distance of the sides from the axis of rotation. This is given by $R = \frac{b}{2}$ and so $v = \frac{\omega b}{2}$.



Think of the "rod" PQ that moves with speed v cutting magnetic field lines. We know that in this case there is a motional emf BvL. Thus the induced emf across PQ is $\varepsilon_{PQ} = Bva = B\frac{\omega b}{2}a = \frac{B\omega A}{2}$. End P is positive and end Q is negative. This means the induced current is from Q to P (right red arrow).

Across RS, similarly, it is $\varepsilon_{RS} = Bva = B\frac{\omega b}{2}a = \frac{B\omega A}{2}$. End R is negative and end S is positive. This means the induced current is from R to S (left red arrow). The current flows in the same sense in the loop which means that the total induced emf is $\varepsilon_{total} = \frac{B\omega A}{2} + \frac{B\omega A}{2} = B\omega A$ just as we found before.