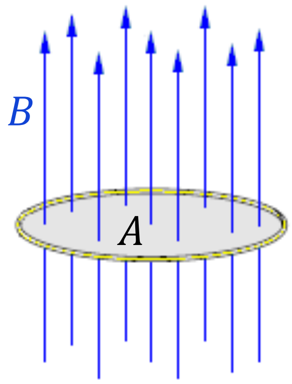
7.13 Magnetic flux

We have already come across magnetic flux density B, measured in tesla (T). It is a measure of the strength of the magnetic field.



If we look at the diagram on the left, we can see lines of flux passing through an area (A). Magnetic flux density is a measure of the concentration of field lines per unit area. The greater the concentration, the stronger the field.

[Unlike the density of material, which is the mass per unit volume, magnetic flux density is the magnetic flux per unit area.]

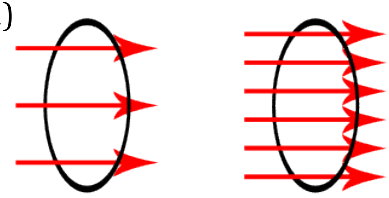
Magnetic flux (ϕ) is related to magnetic flux density:

$$\phi = BA$$

The SI unit of magnetic flux is the weber (Wb).

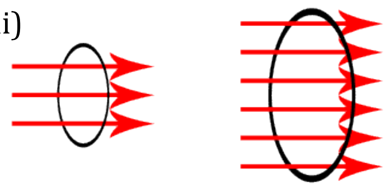
Consider the following diagrams:

i)



(1)✎ In diagram i), which has the greatest magnetic flux? Why?

ii)

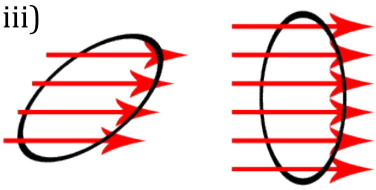


(2)✎ In diagram ii), which has the greatest magnetic flux? Why?

In the diagrams above we have only considered areas at right angles to the lines of magnetic flux. In the area is at an angle θ to the lines of flux, then the expression for the magnetic flux is given by:

$$\phi = BA\sin\theta$$

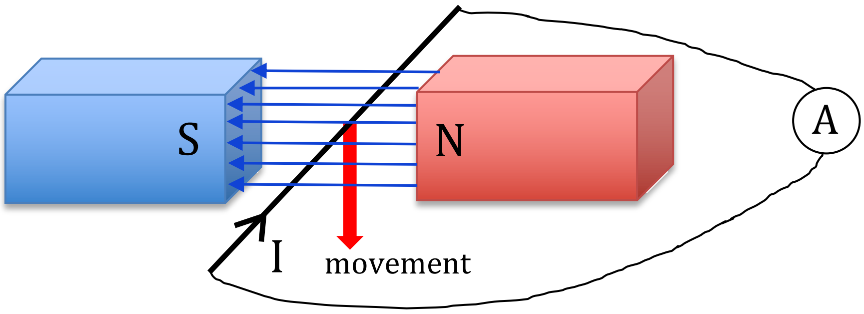
iii)



(3)✎ In diagram iii), which has the greatest magnetic flux? Why?

Electromagnetic induction

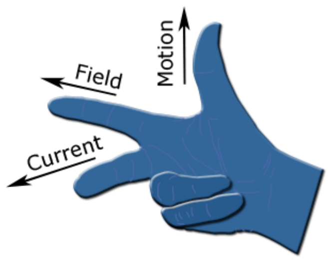
When a conducting wire is moved in a magnetic field a potential difference can be developed across the wire, which can cause a current (*I*) to flow.



It is found that the size of the current is dependent on 1) the strength of the magnetic field, 2) the length of the conductor in the field, and 3) the speed at which the conductor is moved. The effect is related to the 'rate of cutting' of the lines of flux.

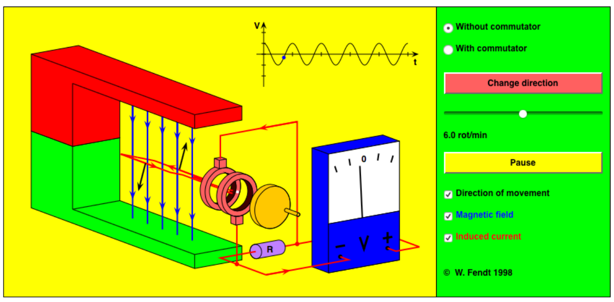
(4) What would happen if the movement was in the opposite direction, in the diagram above?

(5) What would happen if the wire was moved from side to side, in the diagram above? Why?



We can determine the direction of the current using Flemming's Right Hand Rule for induction.

Run the following simulation:
http://www.walter-fendt.de/html5/phen/generator_en.htm



In this simulation, we have a square loop turning in a magnetic field.

(6) At what point is the maximum emf generated? Why?

(7)✏At what point is zero emf generated? Why?

(8)✏How would you describe the voltage output from this simple dynamo?

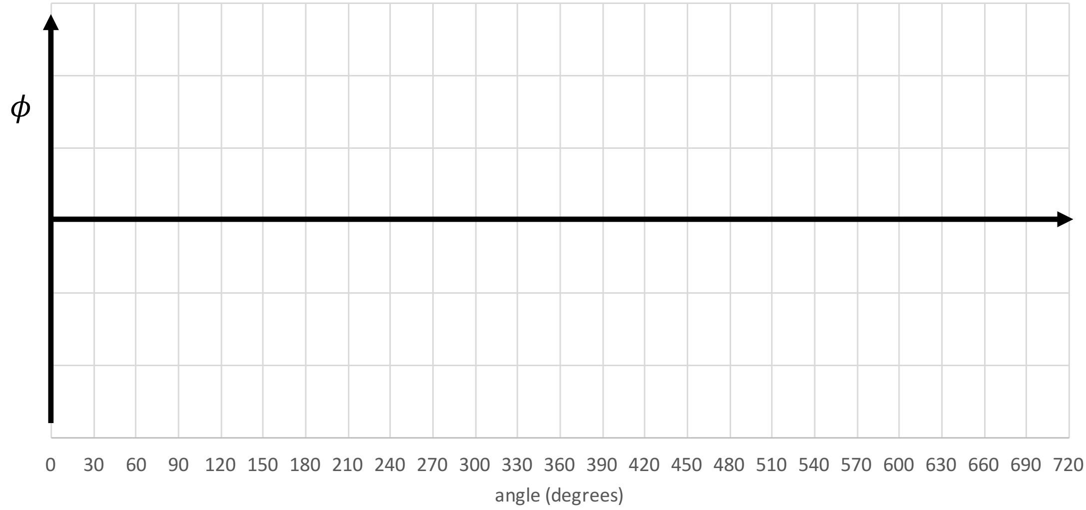
(9)✏List three things that could be done to increase the peak voltage output.

Let us consider the flux through the square loop of wire in the simple dynamo, above. The flux is given by the formula:

$$\phi = BA\sin\theta$$

The maximum flux through the loop occurs when $\theta = 90°$. This is when the loop is at right angles to the lines of magnetic flux.

(10)✏Sketch a graph to show how the magnetic flux changes as the loop is turned.



It is found that the emf (ε) across the loop is related to the rate of change of the magnetic flux through the loop.

(11)✏On your sketch graph, above, indicate where the maximum emf would be generated. (Assume that the coil is being turned at a steady rate.). As an extra challenge, you could draw a complete sketch graph of the emf generated.

(12)✏Apart from increasing the strength of the magnetic field and the area of the loop, how could you increase the peak emf generated?