Electromagnetic Induction

11.2.1 Describe the production of an induced e.m.f by relative motion between a conductor and a magnetic field (motionally induced e.m.f.).

When a conductor is moved through a magnetic field an electric current is induced in the conductor. Which makes sense, before we discussed how a moving electric charge feels a force due to a magnetic field, by moving the conductor we are moving the charges… Faraday found that the strength of the induced e.m.f. was proportional to:

1. The speed of the movement
2. The strength of the magnetic field
3. The number of turns on the coil
4. The area of the coil.

11.2.2 Derive the formula for the e.m.f. induced in a straight conductor moving in a magnetic field

The force on the electrons in wire due to a magnetic field is:

(1)
$F = qvB\sin\theta$

Thus we can say the potential difference (induced e.m.f.) between the two ends of a conductor of length l is equal is defined as:

(2)
$\epsilon = Ep/q = work/q = Fd\,/\,q$

(3)
$\epsilon = qvB\sin\theta l^{\cdot}\,/\,q = Blv\sin\theta$

If the angle between the conductor and the magnetic field is 90° then the formula simplifies to:

(4)
$\epsilon = Blv$

This last equation is in your IB formula handbook.

11.2.3 Define magnetic flux and flux linkage.

11.2.4 Describe the production of an induced e.m.f. that is produced by a time-changing magnetic flux

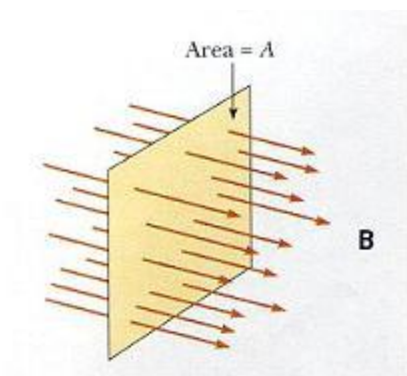
11.2.5 State Faraday's law.

11.2.6 Explain how a motionally induced e.m.f. can be equated to a rate of change of magnetic flux.

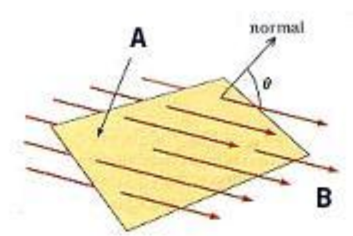
Magnetic flux is defined at the magnetic field strength times the area swept out by a conductor. Or in simpler terms it can be thought of as the number of magnetic field lines (which don't really exist…) passing through a region. Mathematically we define magnetic flux as:

(5)
$\Phi = AB\cos\theta$

Where A is the area swept out, B is the magnetic field strength and θ is the angle between the direction of motion and the magnetic field lines. The unit of magnetic flux is the Weber, Wb.



$\Phi = BA$



$\Phi = BA\cos\theta$

The area swept out by a moving straight conductor (a wire) is:

(6)
$A = l\Delta x$

Where l is the length of the wire and Δx is the distance the wire moves, substituting into the magnetic flux equation:

(7)
$\Phi = l\Delta x B \cos\theta$

Therefore the change in magnetic flux per time is equal to, assuming the angle is zero:

(8)
$\Delta\Phi/\Delta t = l\Delta x B\cos\theta/\Delta t = Blv$

Which we can recognize from above as the induced e.m.f.

(9)
$\epsilon = -\Delta\Phi/\Delta t$

This last equation is called Faraday's law.

The flux linkage is defined as the number of loops (N) multiplied by the induced e.m.f.

11.2.7 State Lenz's law.

The emf induced in an electric circuit always acts in such a direction that the current it drives around the circuit opposes the change in magnetic flux which produces the emf.

If you move a conductor through a magnetic field a small current will be generated. The current will create a magnetic field, the current will always be in the direction so as to generate a force in the opposite direction as the motion. Almost like inertia.

Source: http://ibphysicsstuff.wikidot.com/electromagnetic-induction