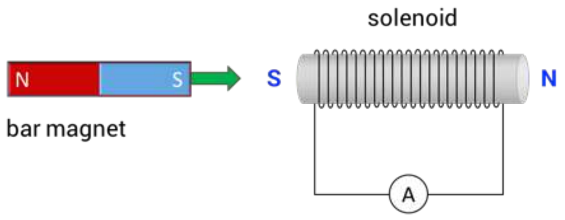
**0 1** A permanent bar magnet is moved towards a solenoid which is connected to a sensitive centre-zero ammeter, as shown below.



**0 1 . 1** While the magnet is being moved towards the solenoid, the needle of the ammeter flicks one way. Explain why this happens.

The magnetic field lines (flux lines) of the bar magnet are cutting through the wire of the solenoid [1]. When the magnetic flux through a conductor changes, a potential difference will be induced across its ends (and a current will flow through it if it is connected to a complete circuit) [1].

**0 1 . 2** Write down two ways in which the needle of the ammeter could be made to flick further from its zero position.

Move the magnet faster / use a stronger magnet / increase the number of turns on the coil / increase the area of the coil. Any TWO points [2].

**0 1 . 3** A magnetic field is generated around the solenoid while the magnet is being moved towards it. Label the north and south poles of the magnetic field around the solenoid on the above diagram using the letters **N** and **S**.

**0 1 . 4** Describe the effect which the magnetic field of the solenoid will have on the motion of the magnet towards it.

It will make it more difficult to move the magnet / increase the force required to move the magnet towards the solenoid (because there will be a repulsive force between the south pole of the bar magnet and the *induced* south pole of the solenoid) [1].

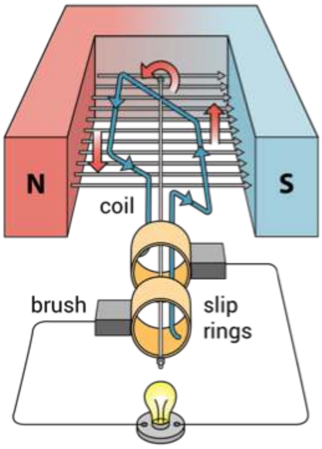
**Remember** that the magnetic field which is generated by induced current always acts so as to opposed the change that caused it.

**0 1 . 5** The magnet is then held at rest inside the coil. Describe and explain the effect which this will have on the ammeter reading.

The ammeter reading will fall to zero [1] because the magnetic flux through the solenoid will no longer be changing / the rate of change of magnetic flux through the solenoid will fall to zero [1].

**0 2**

An alternator is being used to power a filament bulb, as shown below.



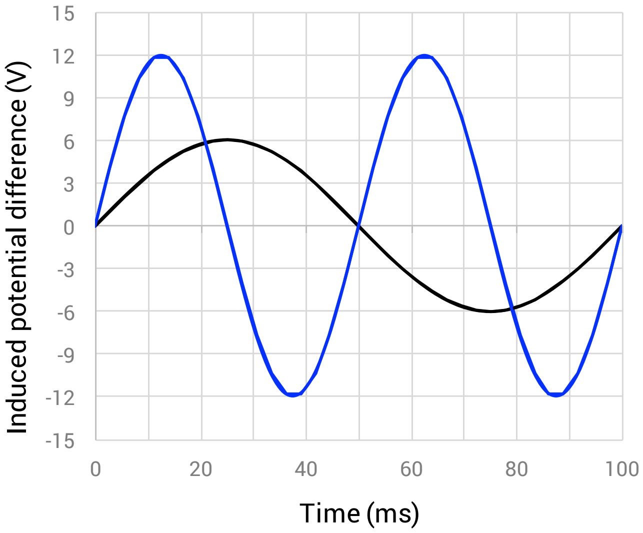
**0 2 . 1**

Explain the function of the slip rings in the above alternator, and how they allow for an alternating current to be supplied to the bulb.

The slip rings allow for a permanent electrical connection between the coil and the non-rotating parts of the circuit (including the bulb and its connecting wires) [1]. Each slip ring is *permanently attached* to one end of the rotating coil; when one end of the coil moves upwards through the magnetic field, current flows in one direction, and when the same end of the coil moves downwards, current flows in the opposite direction through the bulb [1].

**0 2 . 2**

The potential difference across the bulb varies with time as shown below.



Show that the coil is rotating at a frequency of 10 Hz.

Period (time for one complete oscillation of potential difference:
T = 100 ms = (100 ÷ 1000) s = 0.1 s [1]
f = 1 ÷ T = 1 ÷ 0.1 = **10 Hz** [1]

**0 2 . 3** On the above axes, sketch the graph which would have been obtained had the coil been rotated at a frequency of **20 Hz**.

Varying (*sinusoidal*) potential difference with a peak value of ±12 V [1] and a period of 50 ms [1], as shown.

This is a very demanding question (sorry, but I thought it was better that you see it here first rather than in the exam).

When the frequency of the coil is *doubled*, it goes through *twice* the number of rotations in 100 ms (which is which is why there are two full cycles shown on the blue graph). Notice that the period of the potential difference induced by the faster-moving coil (in other words, the time it takes to go through one complete cycle/oscillation) is 50 ms (which makes sense because T = 1 ÷ f = 1 ÷ 20 = 0.05 seconds, which is equal to 50 ms).

*Doubling* the frequency also *doubles* the rate at which the coil passes through the magnetic field lines, which is why the maximum induced p.d. *doubles* also. This is very similar to what happens when we increase the speed at which a magnet is pushed into a coil, except that here, it is the coil that is moving and not the magnet.

I told you it was tough, but if you can fully understand this question, you're unlikely to be too worried by anything they might throw at you in the exam.