TAP 414-3: Sketching flux patterns

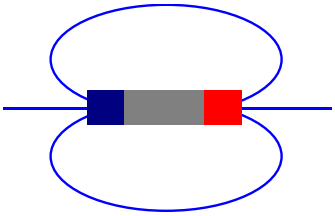
Learning typical shapes of magnetic fields

Use the examples and guidelines suggested below to learn how to make a rough sketch of the expected shape of the magnetic fields of magnets and coils.

Flux goes with the flow

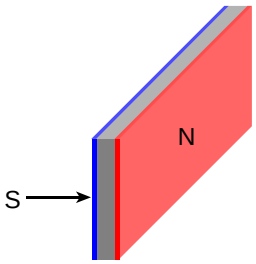
Inside a magnet or a piece of magnetised material, the flux just follows the direction of magnetisation. It emerges from, and enters into, the iron at the poles. So start sketching at the poles, all flux lines are continuous. A line which emerges (conventionally at a north pole) enters the material again at the south pole. Flux lines never cross. Think of flux as like a fluid pumped out of N poles and sucked into S poles (although nothing is actually flowing or physically connected to the magnet etc)

Here is a sketch of the flux from a short bar magnet:



1. Sketch the flux from a longer magnet, like this:

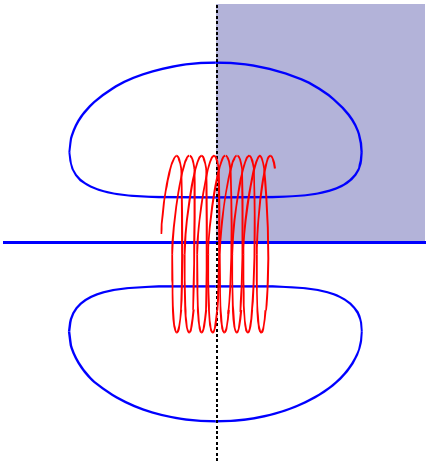
2. Sketch the flux from a thin flat magnet, such as a Magnadur magnet, like this:



3. Sketch the flux from a horseshoe magnet, like this:

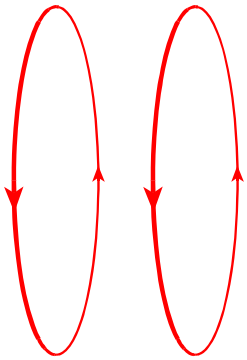
Use symmetry

Magnetic fields are usually very symmetrical. Think about which parts must be just like others, or perhaps their mirror reflections when drawn in two dimensions. For example, the field of the coil below can be divided into four quarters, each a copy (reflected or inverted) of the others. So you only need to draw one bit of the field.



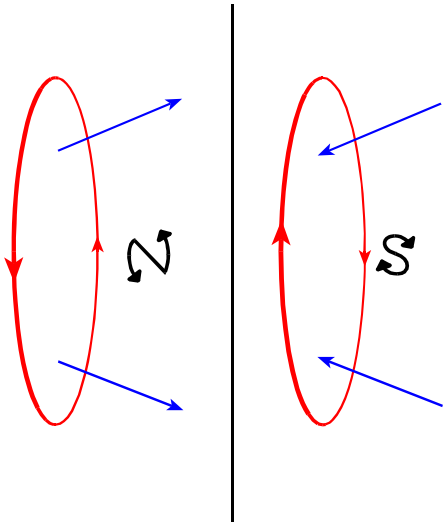
4. Identify the similarly shaped regions of the field between a N and a S pole.

5. Identify the similarly shaped regions of the field around a pair of coils with currents going in the same direction round them. Sketch the field around and in between them.

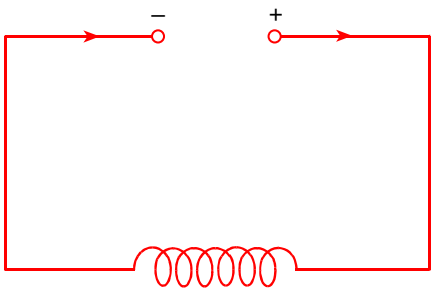


N and S poles of coils

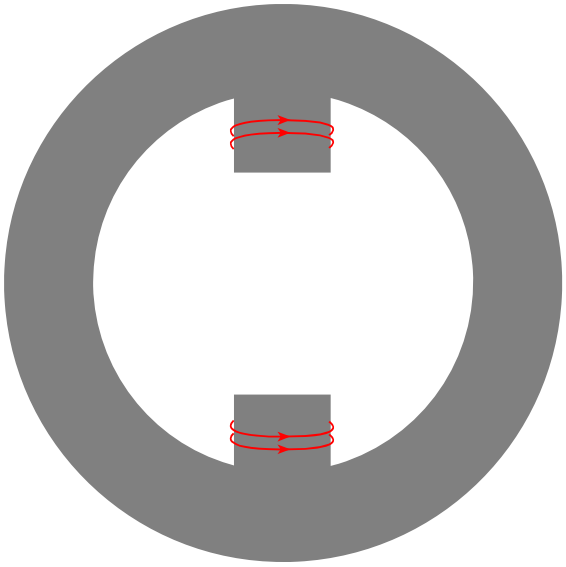
Looking at a coil face on, if the current goes anticlockwise that face is like a N pole and flux emerges from it. If the current goes clockwise that face is like a S pole and flux goes into it. Arrows drawn on the letters N and S help to remember this rule.



6. Identify N and S poles of this long coil:



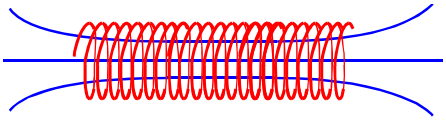
7. Identify N and S poles of this electric motor winding:



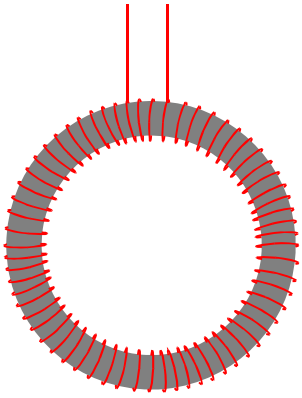
Same environment, same flux

If the pattern of current turns around one place is the same as that around another, the flux pattern in those places will be the same.

8. State how this principle tells you that the flux in a long narrow coil will be straight and uniform, like this:



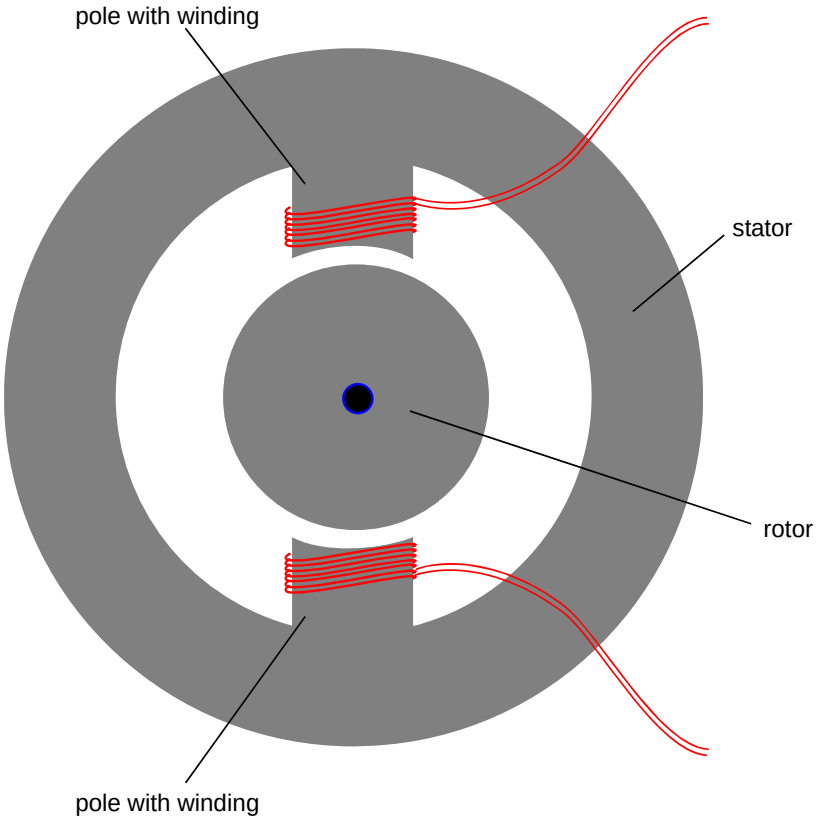
9. Sketch the flux inside this doughnut shaped coil:



Put it all together

Use all these ideas together to guess the shape of the flux.

10. Sketch the flux in the air and in the iron of this electric motor:


pole with winding
stator
rotor
pole with winding

Practical advice

These questions are intended to be simple sketching exercises. Only the general shape of the field need be right. Often three flux lines are enough to capture the shape. The main purpose, in an approach that starts with flux and electromagnetic induction, is to help magnetic flux seem as real as possible to students.

Alternative approaches

Plenty of experimenting with flux patterns, shown for example by iron filings or compass needles, is even more important than making sketches.

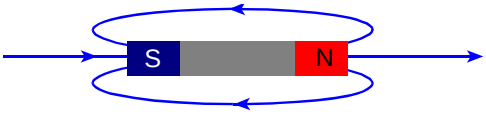
Social and human context

A lot of the mathematics of field patterns is similar to the mathematics of flow in fluids.

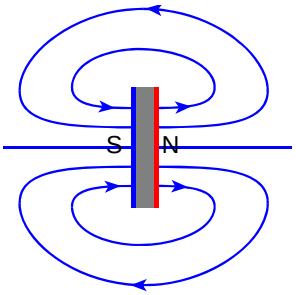
Answers and worked solutions

Sketching flux patterns

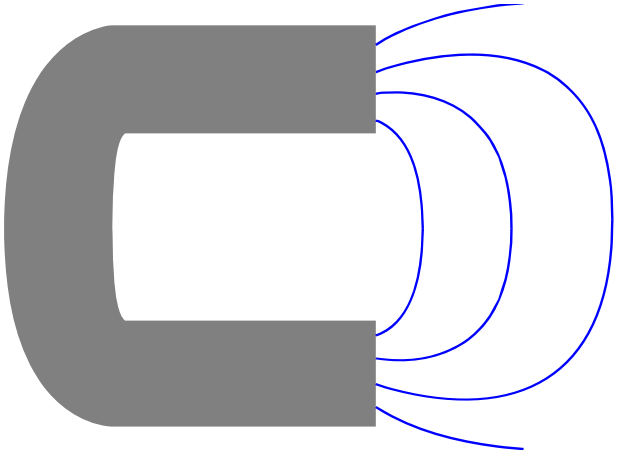
1 The flux from a long magnet looks like this:



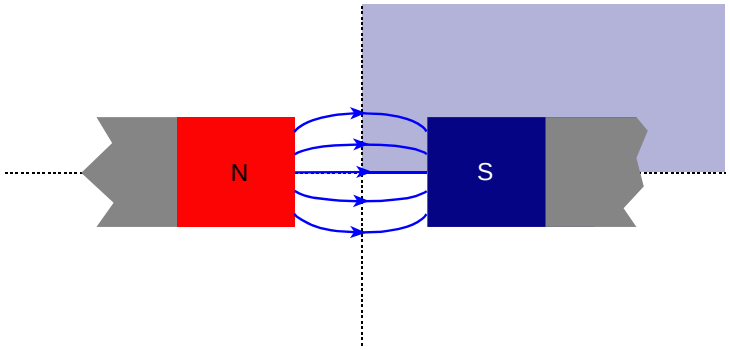
2. The flux from a flat thin magnet looks like this:



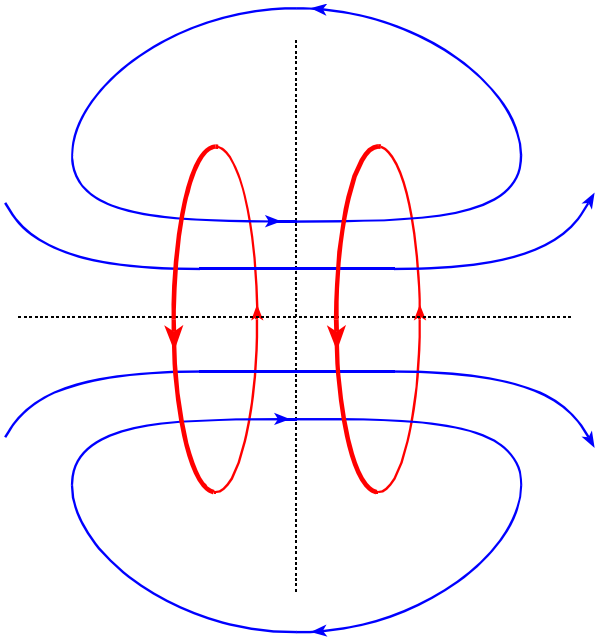
3. The flux from a horseshoe magnet looks like this:



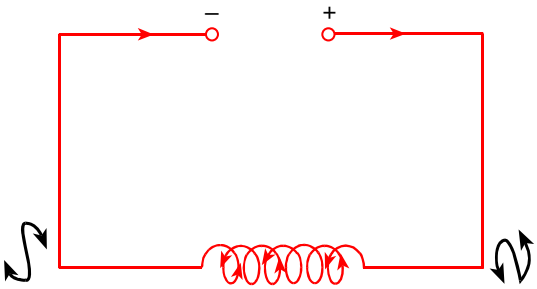
4. The flux pattern is symmetrical about the line dividing the poles and about the line joining their centres:



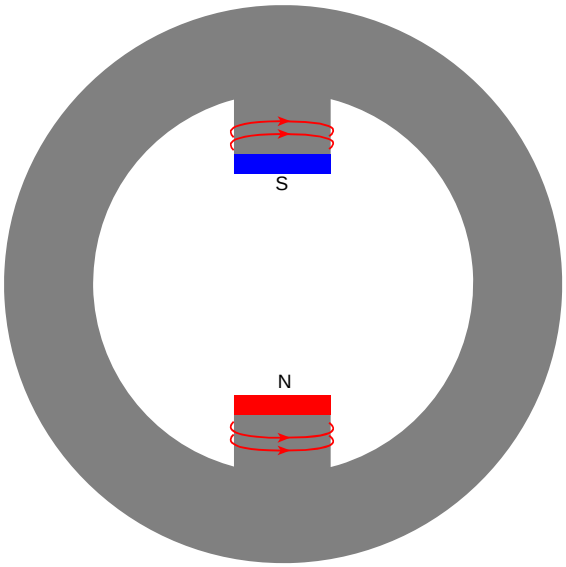
5. The flux pattern is symmetrical about the line dividing the coils and about the line through their centres:



6. The poles are as shown:

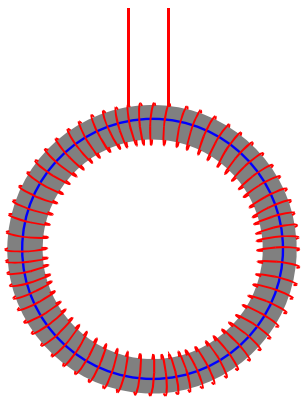


7. The poles are as shown:

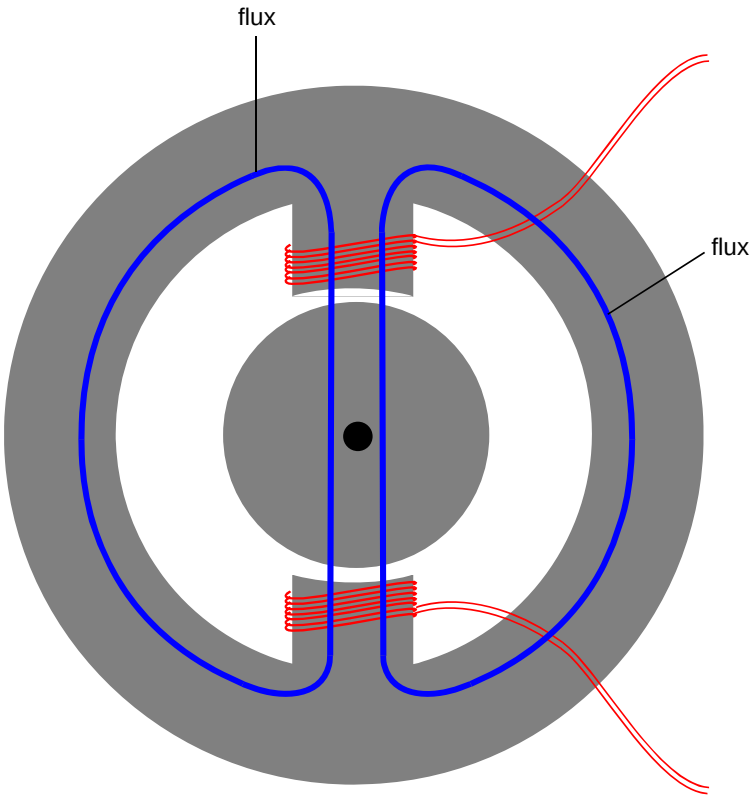


8 Because the coil is long, the current turns at places along its length surround each place in much the same way. A fly at each point would just see coils around it in all directions. So the field is the same along all the central part of the length (not near the ends). Thus it must be straight and uniform.

9. The flux just runs in circles round inside the coil:



10. The flux crosses the air gaps, goes through the rotor, and joins up by going round the casing of the stator:



External reference

This activity is taken from Advancing Physics chapter 15, 40S