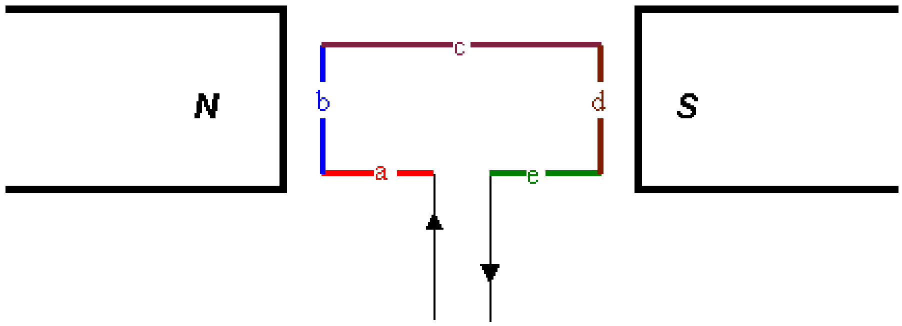
Note-A-Rific: Galvanometers & Motors

A galvanometer is a device used to measure a small current (it can be used to make either a voltmeter or ammeter)

- If we were to look down on a galvanometer it would look like this...



- I've coloured the wire segments to make it easier to follow our analysis of the forces on the different sections.
- In this picture there is a single loop of wire (in a rectangular shape) inside the magnetic field.
- Usually a galvanometer is made by winding the wire up as a coil around a light weight rectangular frame many times.
- One end of the wire will be connected to positive, the other to negative.
  - Just to make it interesting, let's do this problem assuming that we are using conventional current.
  - This just means we will be using right hand rules… your answers for electron flow would be using left hands.

When a conventional current starts to flow...

- What is the force exerted on the wire at point (a)?
  Using the 3rd right hand rule isn't possible at this point, since the current is parallel to the magnetic field at this point… so the force on the wire is zero!

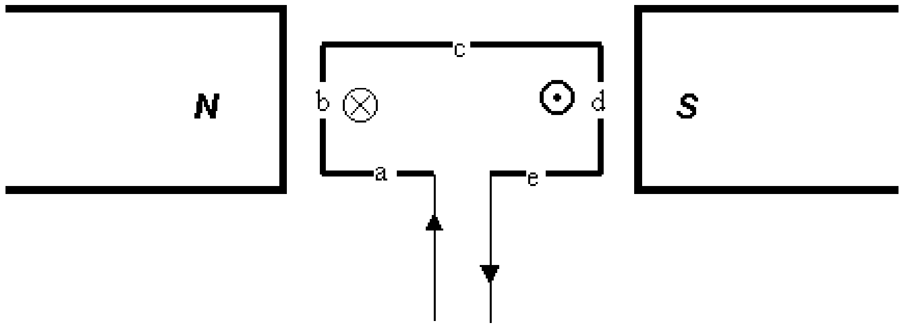
- What is the force exerted at point (b)?
  Now you can use the 3rd right hand rule. You should find that the force is into the page at that point.

- What is the force exerted at point (c)?
  Again, since the current is parallel to the magnetic field, the force is zero.

- What is the force exerted at point (d)?
  Using the right hand rule, the force is out of the page.

- What is the force exerted at point (e)?
  Guess what… the current is parallel to the magnetic field again, so zero force.

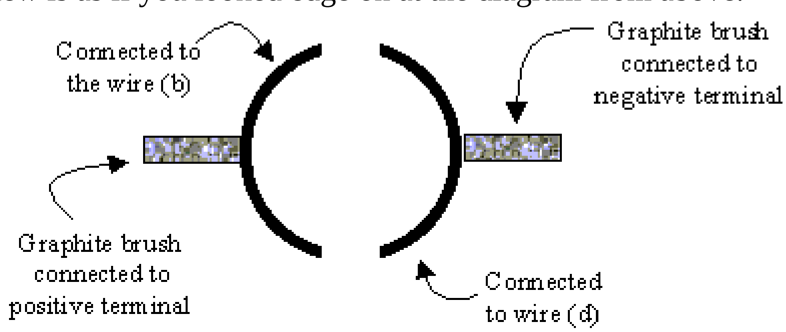
If I was to show where the forces are present, my diagram would look like…



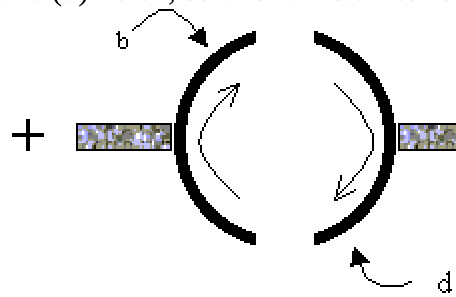
- The only place there is force on the wire is at (b) and (d).
- Since the wire loop is pushed down on one side, and up on the other, it will start to spin.
- If this is hooked up to a needle on a meter, the needle will show how much current is flowing through.
- Keep in mind that with the simple design shown here, the thing would keep spinning until the left side is up out of the page and the right side is down into the page.
- At this point the forces are still pushing (respectively) up and down, so it won't turn any more… how can we get it to turn further?

This is the problem that needed to be solved in order to be able to build **electric motors**.
- A motor must be able to rotate lots of times.
- This leaves us with two solutions:
    1. Reverse the magnetic field every half turn.
       Not really practical. We would have to set up an electromagnet that we could switch every ½ turn, keeping it in sync with the rotating coils. Also, switching the polarity in an electromagnet is not instantaneous.
    2. Reverse the current in the wire every half turn.
       This is done by using a **split ring commutator**.

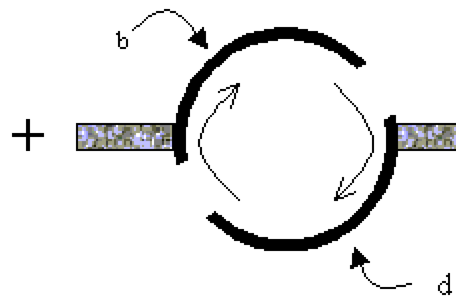
The next set of images show what would happen if this was allowed to rotate freely
- The view is as if you looked edge on at the diagram from above.



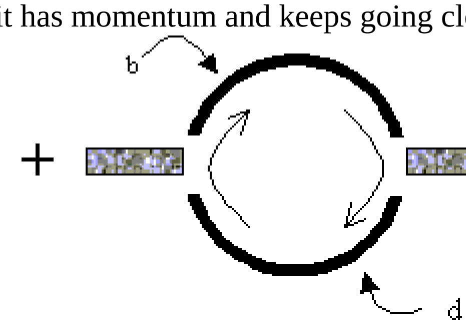
- This shows the set up at the start. Remember in the diagrams from before (b) was pushed up and (d) down, so this will start to rotate clockwise.



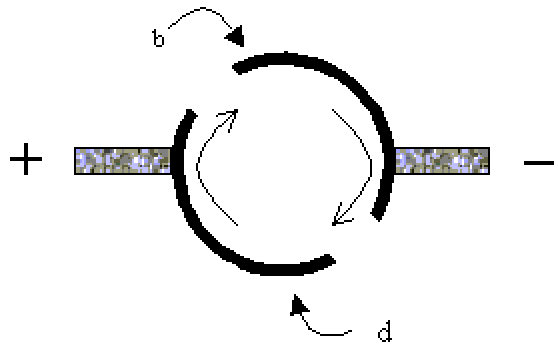
- The positive brush is still touching wire (b), but just barely. The wire (d) is also still in contact with the negative terminal.



- At this split instant, neither of the terminals is in contact with the wires. This is when the wires are at their maximum and minimum points. Since it is already spinning, it has momentum and keeps going clockwise.



- Now (d) is touching the positive terminal, and (b) is touching negative, so they keep spinning clockwise… on and on…



In a real motor, instead of one loop of wire, you loop the wire around many times.

- Since there is now a greater length of wire in the field, the force increases resulting in a stronger motor.
- Call these loops an **armature**.
- You can use the formula…

$$F_m = n\,I\,l\,B$$

where "n" is the number of complete loops of wire that make up the armature.