

Conceptual Modelling of AC Generator (Rotating Coil)

Name: _____ () Class: _____ Date: _____

1. Components of AC generator

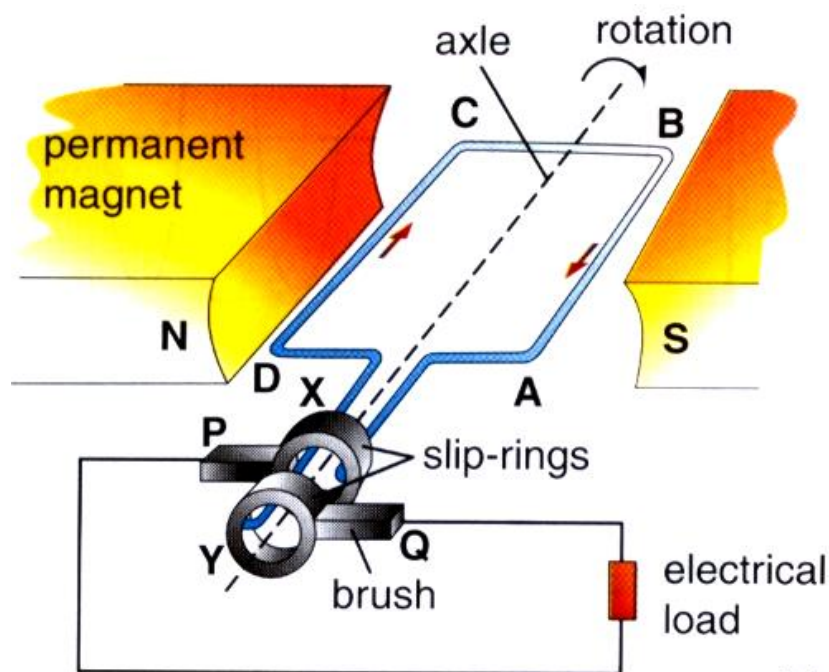


Figure 2: An AC generator

Activity:

Identify all components of a DC motor.

Please put a tick against the important learning points.

Learning Points	Yes	No
1.1. The single coil with slip rings is a combined object (Understand that the coil with the slip rings rotates as a unit).		
1.2. A permanent magnet to produce a uniform magnetic field.		
1.3. The carbon brush material used to provide almost frictionless contact		
1.4. The spring loaded design of carbon brushes to provide continuous good electrical contact.		
1.5. Aware that carbon brushes will wear out and need to be replaced		

2. How current is induced in an AC generator?

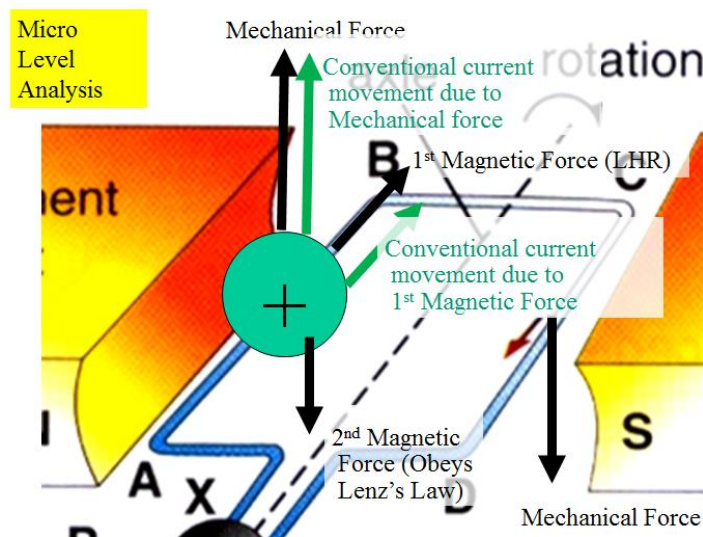


Figure 2.1: The 3 Forces and 2 conventional currents

Activity:

- Use a sticker provided to represent a positive charge and stick it to one side of the coil along AB.
- Move segment AB upwards. Visualized the relative motion of the charge upwards.
- Use the concentric magnetic field pattern card to represent the magnetic field generated by this relative motion of the positive charge.
- Use the parallel magnetic field pattern card to represent the magnetic field generated by the permanent magnet.
- Orientate the two magnetic field pattern cards according to the set up Figure 2.1. Use superposition method to obtain the resultant magnetic force acting on the charge.
- Use Fleming's Left Hand Rule to verify the direction of this Magnetic force acting on the charge. Call this magnetic force 1. Note that it is this magnetic force 1 that produces the induced current.
- Use Fleming's Right Hand Rule as a short cut to obtain the direction of induced current instead of using procedures a to f.
- Now with this induced current produced. Use Fleming's Left Hand Rule to obtain the direction of magnetic force produced by this induced current, call this magnetic force 2. Note that this magnetic force 2 is always present in generator; it is this magnetic force 2 that opposes the mechanical force.

Please put a tick against the important learning points.

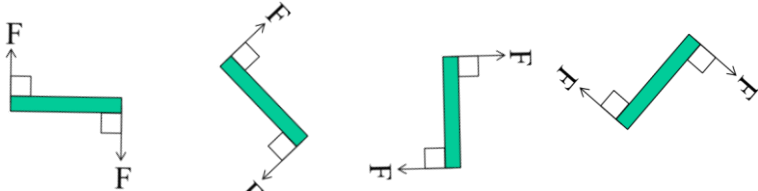
Learning Points	Yes	No
2.1. Focussing on a positive charge in the coil, if the coil moves up, the charge moves up.		
2.2. The relative upward movement of the positive charge produces conventional current. This conventional current generates magnetic field around it.		
2.3. Able to use right hand grip rule to determine the direction of the magnetic field due to this relative motion of this positive charge.		
2.4. The interaction of magnetic field between the magnetic field from the permanent magnet and the magnet field around the current due to the relative motion of the positive charge produces a resultant magnetic force 1 acting on this positive charge.		
2.5. Able to determine the direction of this resultant magnetic force 1 using Fleming's Left Hand Rule .		
2.6. It is this magnetic Force 1 that induces the current/ makes the positive charge moves (Conventional current)		
2.7. Able to use Fleming's Right Hand Rule as a short cut to obtain the direction of induced current.		
2.8. Aware that this induced current also produces a magnetic force 2 that opposes the Mechanical force.		
2.9. Aware that there are forces involve when the AC generator is in operation. (a) Magnetic force 1, (b) Magnetic force 2, and (c) Mechanical force.		
2.10. Aware that there are two conventional current(see Fig 2.1)		
2.11. The mechanical force is tangential to the path of motion of the side AB or CD of the coil. (see Fig 2.2) <div style="text-align: center;">  <p>The diagram illustrates the forces on a coil in a magnetic field at four different orientations. In the first stage, the coil is horizontal; force F acts upwards on the left side and downwards on the right side. In the second stage, the coil is tilted upwards; force F acts perpendicular to the coil's length. In the third stage, the coil is vertical; force T acts to the right on the top side and to the left on the bottom side. In the fourth stage, the coil is tilted downwards; force F acts perpendicular to the coil's length.</p> </div>		

Fig 2.2: The direction of mechanical force acting on the coil

3(i) How Alternating Current is produced?

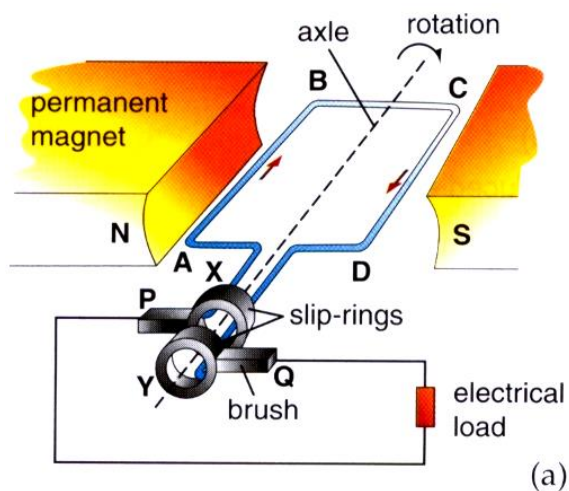


Figure 3.1: Initial Position

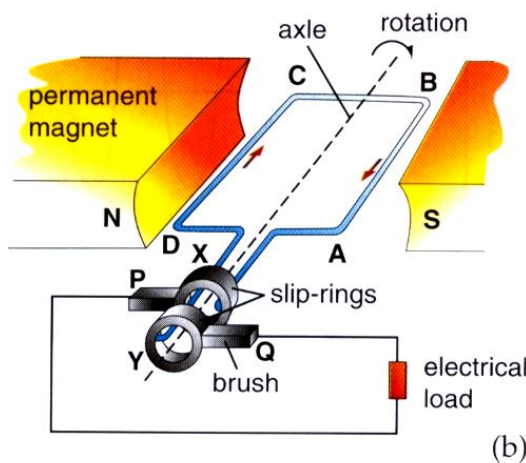


Figure 3.2: Position 180° from Initial Position

Activity:

- Position the model according to Figure 3.1. Use Fleming's Right Hand Rule to determine the direction of induced current. Use the galvanometer model to indicate the direction of induced current (making the assumption that that the direction of induced current is the same as the direction of deflection of the galvanometer)
- Orientate the model according to Figure 3.2. Use Fleming's Right Hand Rule to determine the direction of induced current. Use the galvanometer model to indicate this new direction of induced current.
- In Figure 3.1 and Figure 3.2, draw the mechanical forces acting on the coil, verified the direction of induced current using Fleming's Right Hand Rule and draw the direction of the induced current through the electrical load.
- What did you observe about the direction of induced current for this half revolution of the coil (180°)?

Physics Inquiry on AC generator through Effective Demonstrations

3(ii) The sinusoidal waveform of the induced e.m.f. (See Figure 3.3) can be obtained using voltage sensor and data logger connected to the output of a generator.

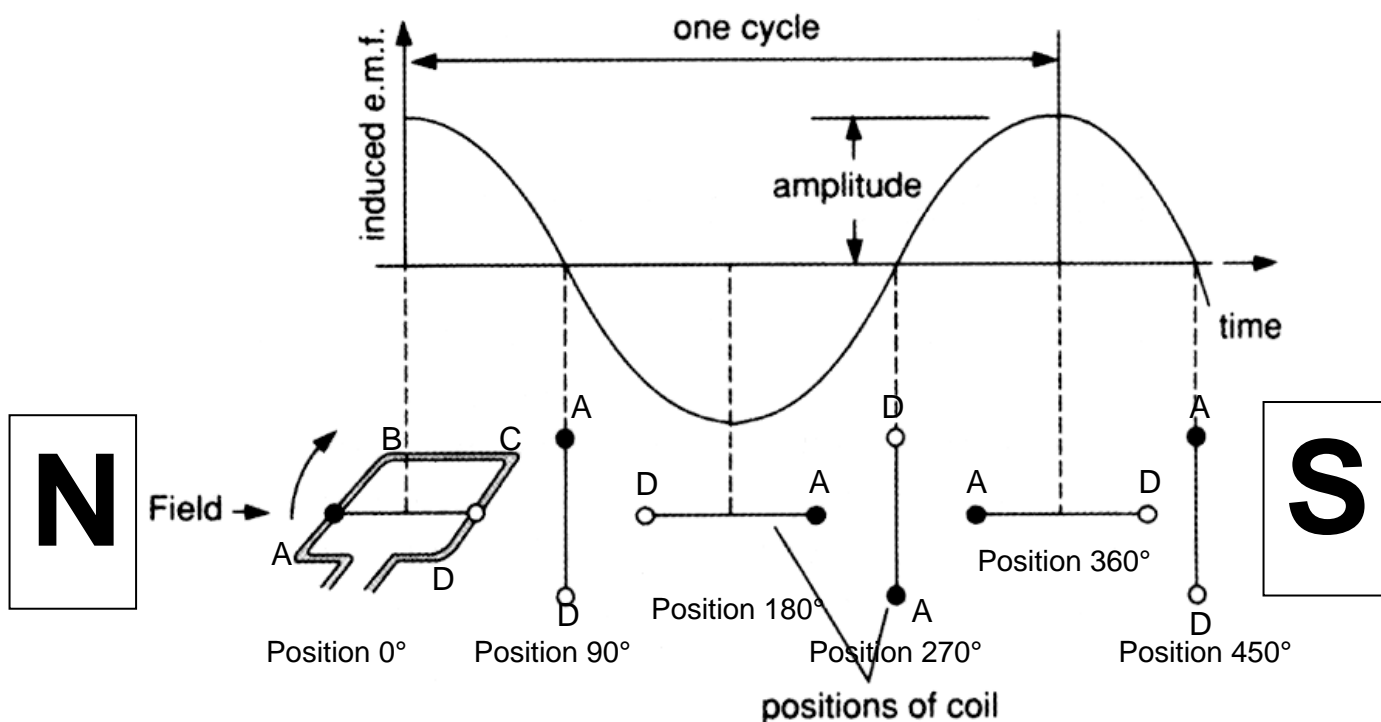


Figure 3.3: Shows the position of the coil with respect to the magnetic field.

(a) Draw the mechanical forces in the coils in Figure 3.3.

Complete the table

Position	0°	90°	180°	270°	360°
(b) Direction of mechanical force wrt magnetic field	perpendicular				
(c) Magnitude of induced current (Max or zero)	Max				
(d) Direction of induced current (+ or – or 0)	+ (based on graph)				

Please put a tick against the important learning points.

Learning Points	Yes	No
3.1. From part (i) able to see that the current changes direction by comparing the current through the electrical load in Figure 3.1 & 3.2		
3.2. From part (ii) able to understand that the current changes direction every time the coil crosses the point where the magnetic field (from permanent magnet) is parallel to the mechanical force.		
3.3. Use the relative direction and angle between magnetic field and mechanical force to deduce the magnitude and direction of induced current. i.e. 90° between the magnetic field and mechanical gives maximum magnitude of induced current.		

4. Function of slip rings

Activity: Connect the external circuit to two ends of the coil directly bypassing the slip rings. See teacher demonstration.

(a) Can an alternating current be produced in the external circuit without the slip rings with direct connections? Explain your answer.

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(b) What happens to the wire connected to the coil after one complete turn?

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(c) How can an AC be produced without the slip rings?

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Please put a tick against the important learning points.

Learning Points	Yes	No
4.1. Aware that the AC generator (rotating coil) can still produce alternating current without slip rings but the wires will be entangled		
4.2. The main function of slip rings is to prevent entanglement for rotating coil AC generator.		
4.3. An AC generator with fixed coil and rotating magnets can function without slip rings and carbon brushes.		