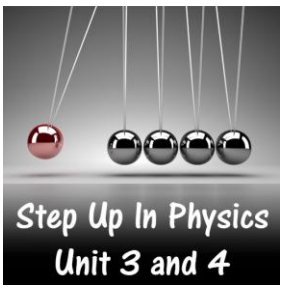
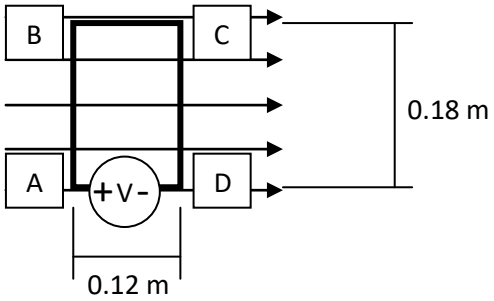
Generators

Problems Worksheet



1. The single loop of conducting wire in the diagram below is steadily rotating about a central axis so that side AB is coming out of the page. The coil completes a 90.0^0 rotation about its central axle in 22.0 ms. The magnetic flux density of the externally provided magnetic field is 3.60×10^{-1} T.



   a. Does the current in the coil flow from A to D or D to A?

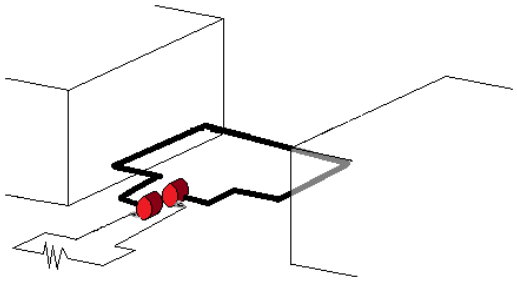
   b. Does the voltmeter measure a positive or negative potential difference?

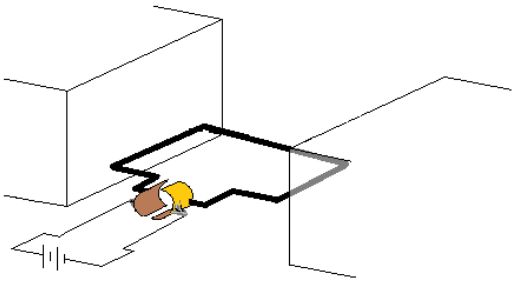
   c. Explain why an EMF and current exist within the coil during the rotation.

   d. Calculate the average voltage as measured by the voltmeter throughout the 90.0^0 rotation.

   e. Does the coil produce its largest EMF at the starting position shown in the diagram or towards the end of the 90.0^0 rotation? Justify your choice.

2. An undergraduate engineer is sent by the project manager to pick up the isometric schematics of the generator they are about to install. The undergraduate engineer sees two schematics on the table (shown below), neither of which have any titles. Explain how the engineer could distinguish which schematic is for the generator and which is for a motor.





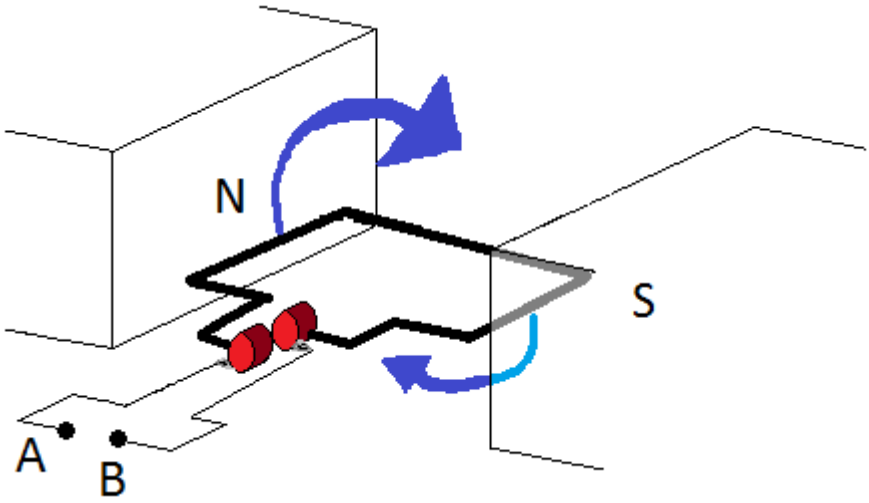
3. The armature of a generator is made up of 300 turns of a square coil with a 15.0 cm^2 area. The generator coils rotate 180 times every minute while the external magnetic flux density is 10.0 T.

    a. Calculate the max EMF output of the generator.

    b. Calculate the average EMF output of the generator.

    c. Find the ratio of the max EMF to the average EMF of the generator. Make an argument why the average EMF is not simply half of the max EMF.

4. The generator below is connected to an external circuit through terminal A and B which use carbon brushes to connect to the slip rings. The coil starts with its area parallel with the external magnetic field.



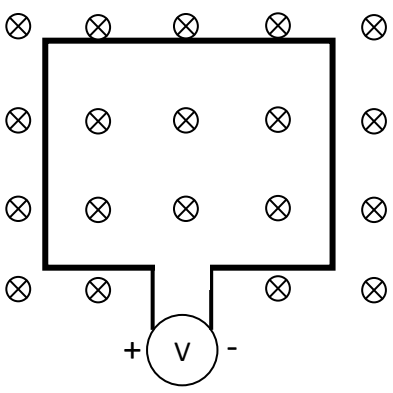
   a. Which direction (A to B or B to A) will the current flow within the armature coil as the generator rotates from the position shown in the diagram?

   b. Which terminal (A or B) is the positive terminal of the generator based on the current position of the coil?

   c. How many degrees does the coil need to rotate until the next maximum absolute value EMF is produced?

   d. How many degrees does the coil need to rotate until the terminals swap polarity?

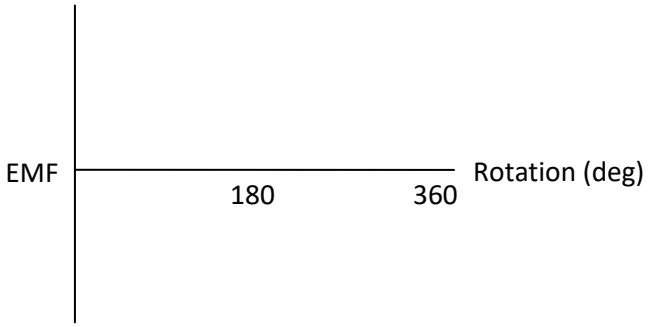
5. A simplified model of single coil AC generator is shown below The coil has 0.300 m^2 area. The coil is rotating at 8.00 Hz and the magnetic flux density is 2.50 T. Plot the EMF profile as measured by the voltmeter for two complete rotations of the coil. Include the units and key values on both axes.



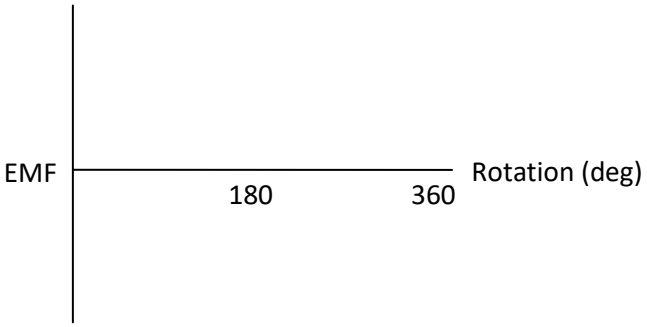
6. Show, starting from the basic principle of electromagnetic induction ($emf = -\frac{N(\Phi_2 - \Phi_1)}{t}$) that the average EMF produced by a generator is equivalent to $-4BANf$.

7. Show, starting from the formula for the induced EMF in a straight conductor moving through a magnetic field ($emf = lvB$) that the peak EMF produced by a generator is equivalent to $-2\pi BANf$.

8. Explain the function of a split ring commutator compared to slip rings in generators. Sketch the EMF profile of a generator that uses a split ring commutator compared to a similar generator that uses slip rings.



Split ring commutator



Slip rings

9. An engineering firm is tasked with improving the EMF output of a backup generator used in a hospital. Other than buying a new generator, what design changes could be made to increase the average EMF produced by the generator? List at least four changes.

10. A 3.20 m thin, wax coated copper wire is formed into a solenoid with exactly 40 circular loops. The two ends of the wire are connected to slip rings and then an external circuit. The solenoid is made to rotate within a 12.0 mT uniform magnetic field at 72.0 rpm.

    a. Calculate the average EMF produced by this generator.

    b. Calculate the maximum EMF produced by this generator.