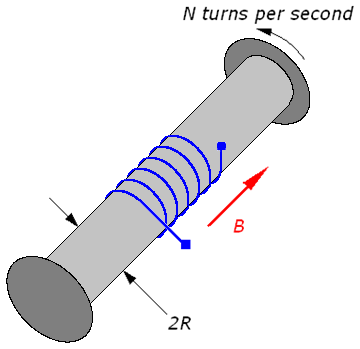
Electromagnetism

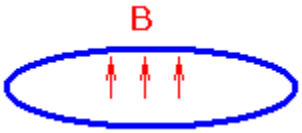
Faraday's Law

Problem 1.- A solenoid is being wound around a plastic cylinder of radius R. There is a magnetic field of magnitude B parallel to the axis of the cylinder. Calculate the *emf* induced between the open ends of the wire knowing that the rate of winding is N turns per second.



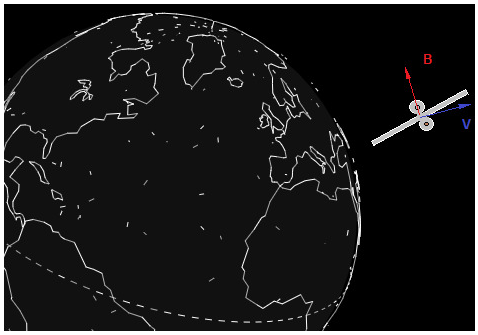
Solution: Faraday's law: $emf = -\dfrac{d\phi}{dt} = -\dfrac{dNBA\sin\angle_A^B}{dt} = -NB\pi R^2$

Problem 2.- A copper ring has resistance R = 0.15Ω, radius r = 0.25m and it is in a constant magnetic field B = 0.9 T perpendicular to the plane of the ring. Then, the magnetic field is reduced to zero, which induces a current in the ring. Calculate the total charge that passes through a given point in the ring.



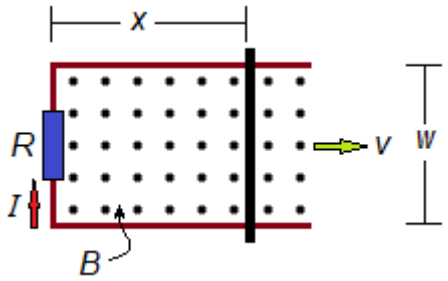
Solution: $emf = IR = \dfrac{dQ}{dt}R = \dfrac{d\phi}{dt} \rightarrow Q = \dfrac{\Delta\phi}{R} = \dfrac{NBA}{R} = \dfrac{0.9\times\pi\times0.25^2}{0.15} = \mathbf{1.18\ C}$

Problem 3.- Consider a solar panel that has a length L = 40m, in orbit moving at a speed of 7,900 m/s. Calculate the voltage difference between the ends of the panel if the magnetic field of the earth at a certain instant is 30μT and makes 90 degrees with the panel and its velocity.



Solution: $emf = BvL = (30\times10^{-6}\text{T})(7900\text{m/s})(40\text{m}) = 9.48\text{ V}$

Problem 4.- A circuit is built by connecting a resistance R = 2Ω to a conducting wire in the shape of a U with width w = 0.5 m, and a sliding conducting bar that closes the circuit. Consider that this circuit is in a region where the magnetic field is B = 1 T perpendicular to the plane of the circuit and the resistances of the wire and bar are negligible.



a) Calculate the *emf* if the bar moves to the right at a speed v = 10m/s

b) Calculate the induced current in case (a). Is the direction indicated in the drawing correct?

c) Calculate the speed v necessary to induce a current of 0.5 A

d) Is it reasonable to ignore the magnetic field created by the induced current in each case?