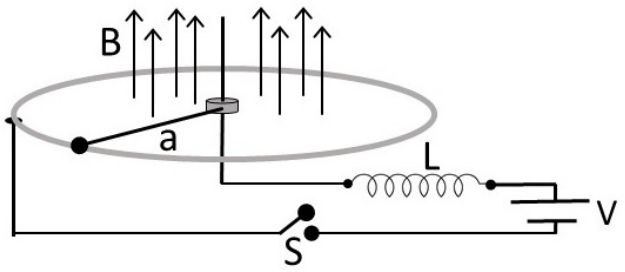
PH108 : Electricity & Magnetism : Tutorial 10

1. A motor and an inductor (L) are connected in series with a battery of constant voltage V as shown in the figure. The motor consists of a rotatable rigid rod of length a, mounted such that one end of it is always in electrical contact with the center and the other end moves around the circumference of the circle maintaining electrical contact with the rim. The rotational inertia of the rotor is J. A fixed magnetic field B is applied perpendicular to the plane of rotation as shown. At $t = 0$, the switch (S) is closed. Ignoring all frictional and resistive losses :



   (a) Write down an expression for the torque acting on the rotor if the instantaneous current in the circuit is $I(t)$.

   (b) What is the total mechanical and magnetic energy in the system when the current is $I(t)$ and the angular velocity of the motor is $\omega(t)$?

   (c) Now formulate a differential equation for $\omega(t)$ using the results of the two previous steps. The equation should have no other time dependent quantity.

   (d) Solve the equation fully using the initial (boundary) conditions at $t = 0$. What is the nature of the solution?

   (e) Obtain the frequency of oscillation in terms of J, L, B and a.

2. Watch the video uploaded with this problem set : `SimpleElectricTrainScienceProject.mp4`

   (a) Figure out the principle by which the battery keeps moving.

   (b) Make any reasonable idealisations and approximations, look up any number that you want - then come up with an estimate of the current flowing through the coil during the motion of the battery+magnet.