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Batch 2

20211214

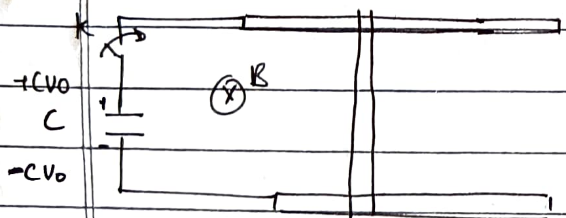
Dt. ____

Rail gun

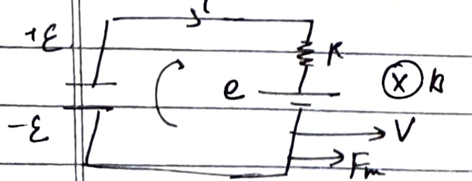
Concepts and assumptions

1. Lorentz force $F_m = ILB$ (on the rod)
1. Lenz's law
3. Faraday's law
4. Motional EMF for a rod in $\perp$ field $e = vBL$
   $v \to$ velocity
   $B \to$ B Magnetic field
   $e \to$ PD across rod.
5. Kirchoff's law
6. $\lambda = \left(\frac{B^2L^2}{mR} + \frac{1}{RC}\right)$

initial setup



intermediate time t.



Current as a function of time

$$i = -\frac{dq}{dt} \quad \text{— ①}$$

$$F_m = m\frac{dv}{dt} = iLB \quad \text{— ②}$$

By kirchoff's law

$$\frac{q}{C} - iR - vBL = 0 \quad \text{— ③}$$

differentiating equation ③ wrt t

$$\frac{1}{C}\frac{dq}{dt} - R\frac{di}{dt} - BL\frac{dv}{dt} = 0$$

from eq① and eq②

$$\frac{-i}{C} - R\frac{di}{dt} - \frac{iL^2B^2}{m} = 0$$

& $R\frac{di}{dt} = -i\left(\frac{B^2L^2}{mR} + \frac{1}{RC}\right)$

$$\frac{di}{dt} = -i\lambda$$

$$\int_{i_0}^{i}\frac{di}{i} = -\lambda(t)\Big|_0^t$$

$$\ln\left(\frac{i}{i_0}\right) = -\lambda t$$

$$\ln\frac{i}{i_0} = -\lambda t$$

$$i = i_0 e^{-\lambda t} \quad \text{— ④}$$

$$i_0 = \frac{V_0 e^{\cancel{A}}}{R} \quad \text{— ⑤}$$

Force as a function of time

$F_m = iLB$

~~$F_m =$~~ from eq ④

$F_m = i_0 e^{-\lambda t} LB$

$$= \frac{V_0 LB}{R} e^{-\lambda t} \quad \text{— ⑥}$$

Velocity as a function of time

from eq ②

$$m\frac{dv}{dt} = i \cdot LB$$

put i from eq④ in eq②

$$m\frac{dv}{dt} = i_0 e^{-\lambda t} LB$$

$$\int_0^v dv = \frac{i_0 LB}{m}\int_0^t e^{-\lambda t}\,dt$$

$$v = \frac{i_0 LB}{m(-\lambda)}\left(e^{-\lambda t}-1\right)$$

$$v = \frac{i_0 LB}{m\lambda}\left(1-e^{-\lambda t}\right) \quad \text{--- (7)}$$

putting the value of λ in eq (4) eq (6) and eq (7)

$$i = \frac{V_0}{R} e^{-\left(\frac{B^2L^2}{mR}+\frac{1}{RC}\right)}$$

$$F_m = \frac{V_0 LB}{R} e^{-\left(\frac{B^2L^2}{mR}+\frac{1}{RC}\right)}$$

$$v = \frac{V_0 LB}{Rm}\frac{mRC}{(CB^2L^2+m)}\left(1-e^{-\left(\frac{B^2L^2}{mR}+\frac{1}{RC}\right)}\right)$$

$$= \frac{V_0 LBC}{(CB^2L^2+m)}$$

$$v = \frac{V_0 LBC}{(CB^2L^2+m)}\left(1-e^{-\left(\frac{B^2L^2}{mR}+\frac{1}{RC}\right)}\right)$$