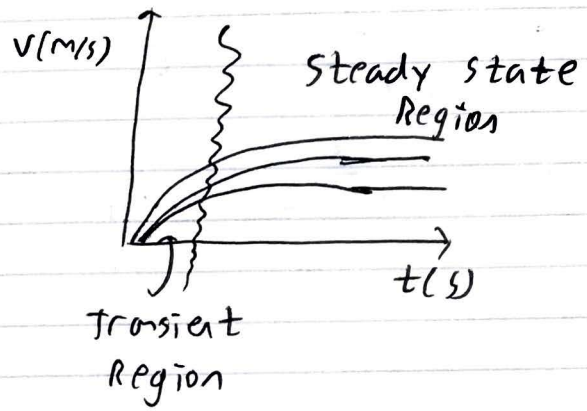
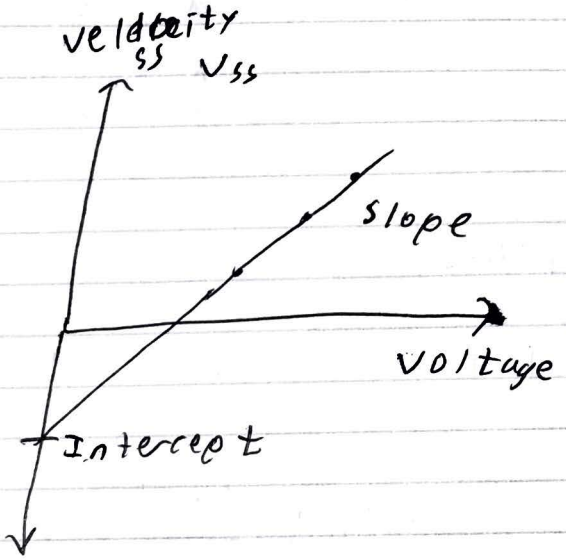
PH132 Team Design

Tues, March 24, 2020

## Train Data




## Mechanical Model

$$\tau_m - \tau_f - \frac{\mu_K m g r_w}{\gamma} = I_{eq}\left(\frac{a}{r_w}\right)$$

$\tau_f = Kv$ (K: constant, v: vel of train)

$\tau_m = C_i$ ($C_i$: constant, i: current)

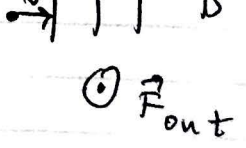
## Electrical Model

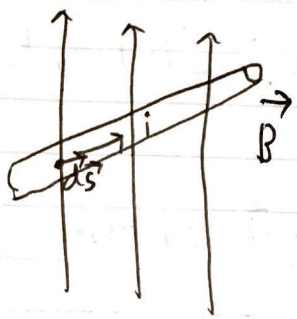
Force on a charge in $\vec{E}$

$$F = q\vec{E}$$

- moving charges experience a force in a magnetic field

$$\boxed{\vec{F} = q[\vec{v} \times \vec{B}]}$$



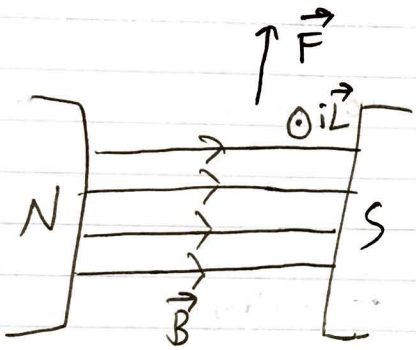


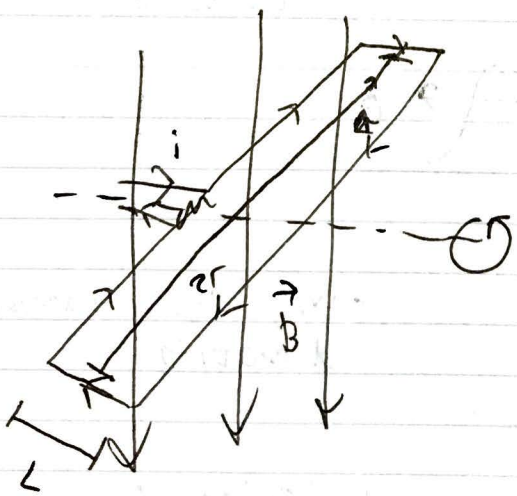

$$\vec{F} = q\frac{d\vec{s}}{dt} \times \vec{B}$$

$$\boxed{\vec{F} = i\vec{L} \times \vec{B}}$$

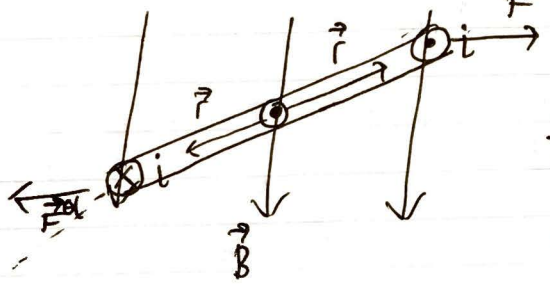
external in all cases

- Force on a current-carrying wire in an external magnetic field



Redraw down rot. axis

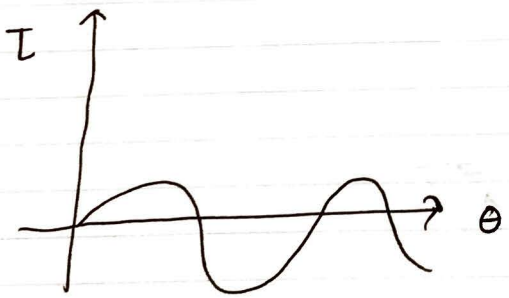



$\vec{F} = i\vec{L} \times \vec{B} = iLB\sin\theta$ ($\theta = 90°$) $= iLB$

$\vec{\tau} = \vec{r} \times \vec{F} = rF\sin\theta$

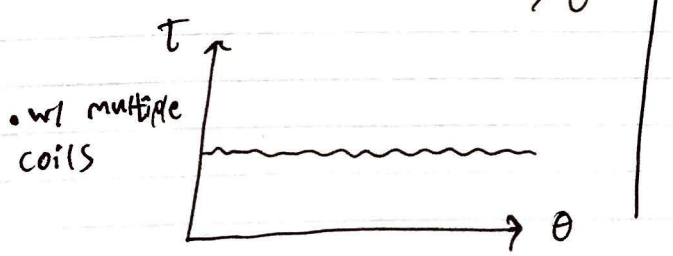
$= r(iLB)\sin\theta$

- current will change direction to create a constant rotation in motor




- w/o changing current direction


- w/ changing current direction




- w/ multiple coils

Looking down coil

$$\vec{\tau}_{motor} = 2rNiLB\sin\theta$$

(Area)

$$\boxed{\vec{\tau}_{motor} = iAB\left[\sin\theta\right]_{avg}}$$

$$\tau_m = Ci$$

$C$ = constant $= AB\left|\sin\theta\right|_{avg}$

$$V = iR$$

$R$ = resistance of train and track

$$\tau_m = \frac{CV}{R}$$

Motion of Train

$$\frac{CV}{R} - KV - \frac{\mu_K m g r_w}{\gamma} = \frac{I_{eq}}{r_w} a$$

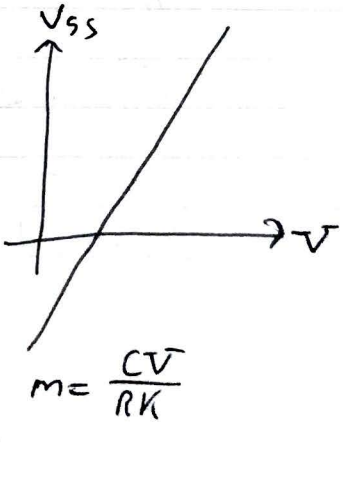
$$\boxed{\frac{CV}{RK} - v - \frac{\mu_K m g r_w}{\gamma K} = \frac{I_{eq}}{r_w K}\left(\frac{dv}{dt}\right)}$$

General motion of Train Eqn

steady State

$$\frac{CV}{RK} - V - \frac{\mu_K m g r_w}{rK} = 0$$

$$\boxed{V_{ss} = \frac{CV}{RK} - \frac{\mu_K m g r_w}{rK}}$$



$m/s^2$

$m/s \quad m/s \quad s \quad m/s$

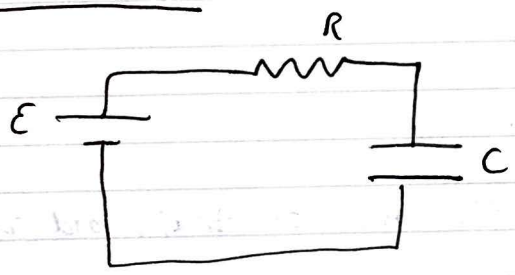
$$B - V = A\frac{dV}{dt}$$

$A$: const.

$$B = \frac{C}{RK}$$

$$A \neq RC$$

## RC Circuit




$$\mathcal{E} - \frac{dq}{dt}R - \frac{q}{C} = 0$$

$$\mathcal{E}C - \frac{du}{dt}\boxed{RC} - q = 0$$

↑ Time constant

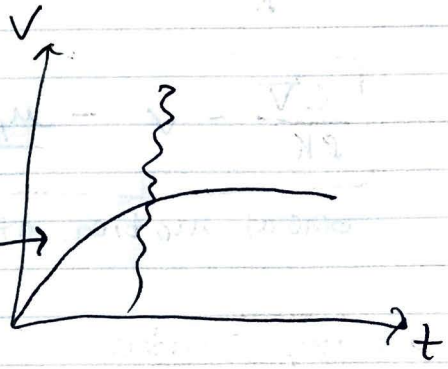
$$\int \frac{-dt}{A} = \int \frac{dV}{V-B} \quad \text{// Let } u = V - B,\ du = dV$$

$$\frac{-t}{A} = \int \frac{du}{u}$$

$$\frac{-t}{A} = \ln\left(\frac{V-B}{0-B}\right)$$

$$e^{-t/A} = \frac{V(t)-B}{0-B}$$

$$\boxed{V(t) = B\left(1 - e^{-t/A}\right)}$$



$$\frac{-t}{A} = \ln\left(\frac{V(t) - B}{0 - B}\right)$$

$$B = V_{ss}$$

$$\ln\left(\frac{V(t) - B}{0 - B}\right) = -\frac{1}{A}t$$