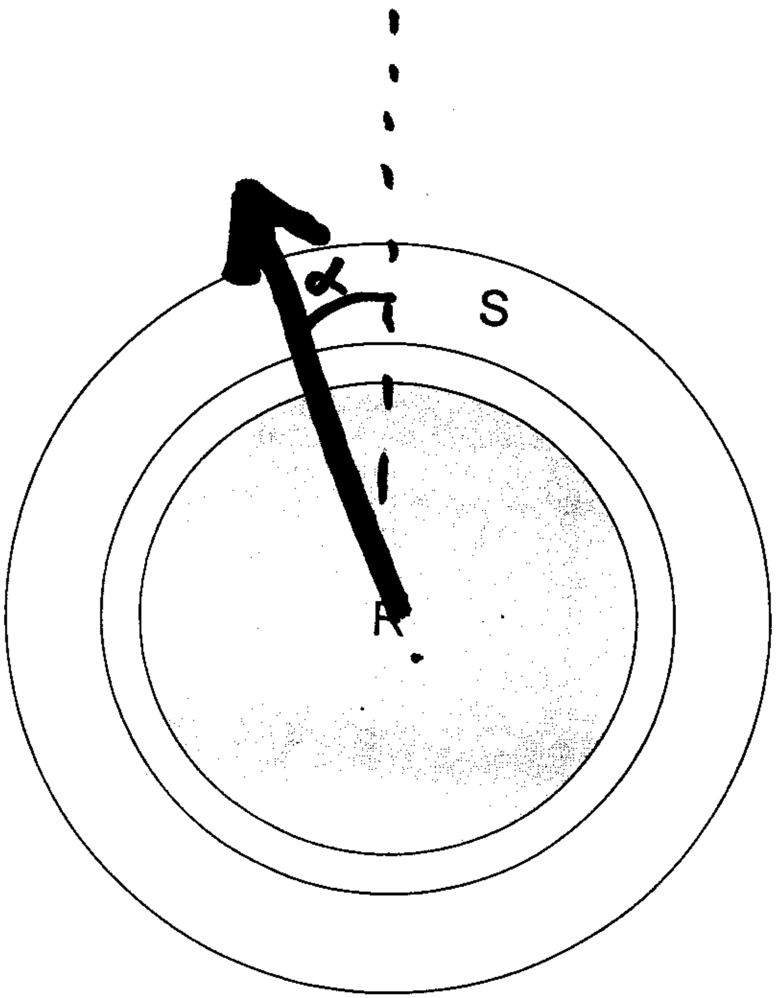
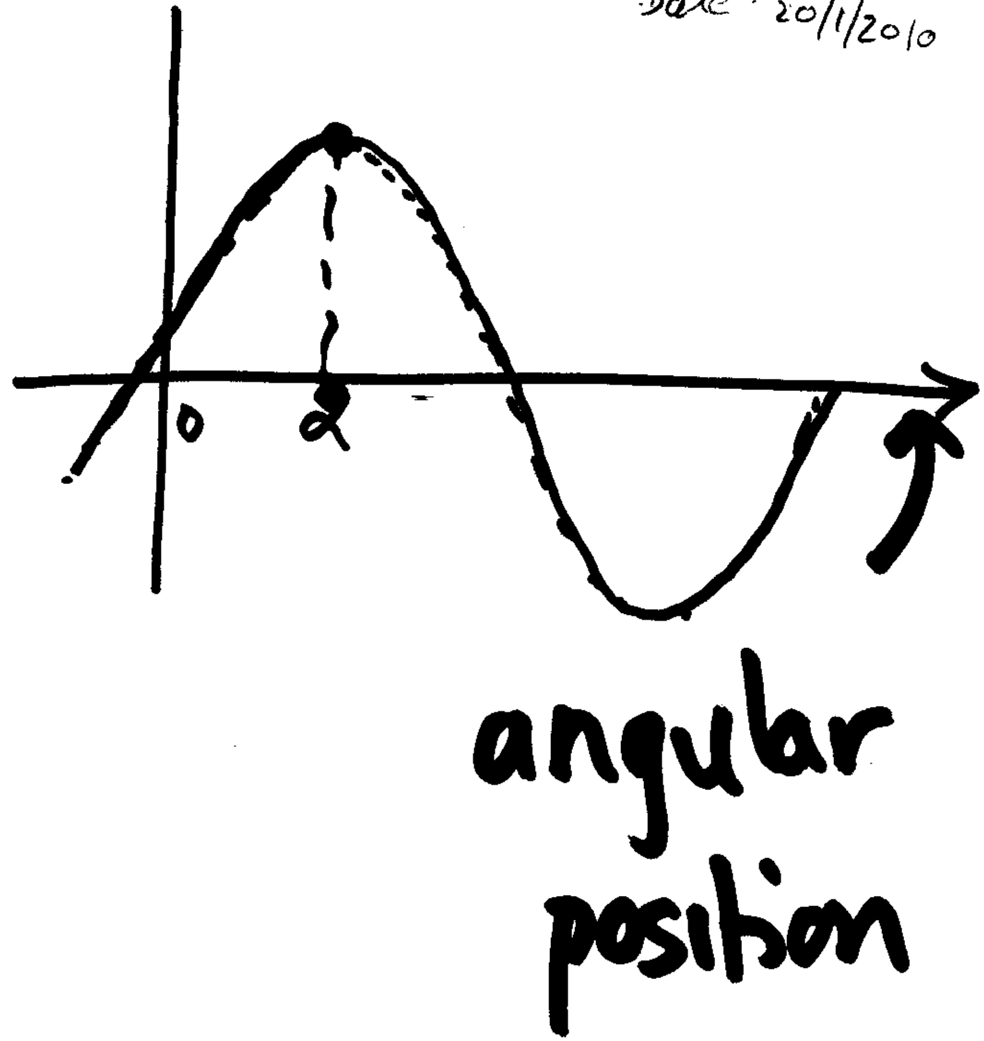
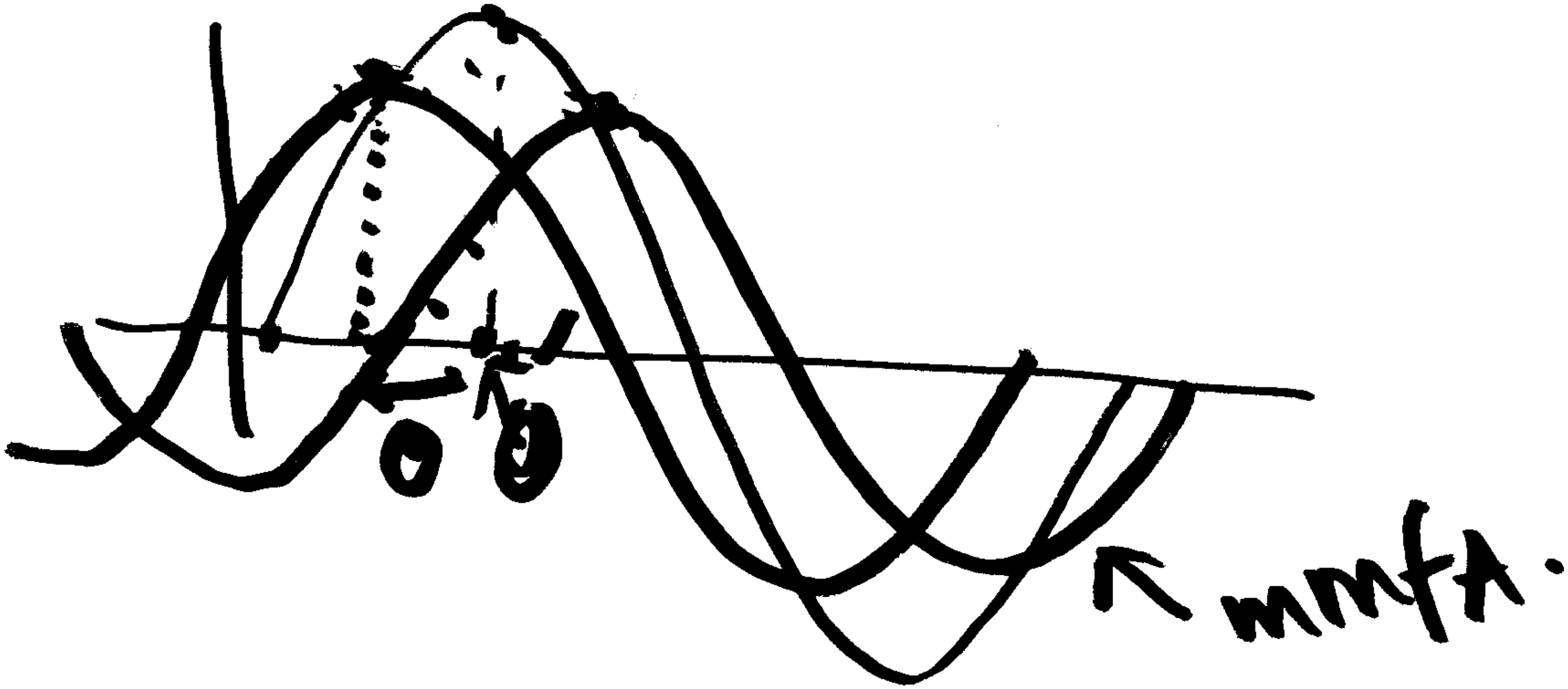
Prof. A. M. Kulkarni
Lec. No. 12
Date. 20/1/2010

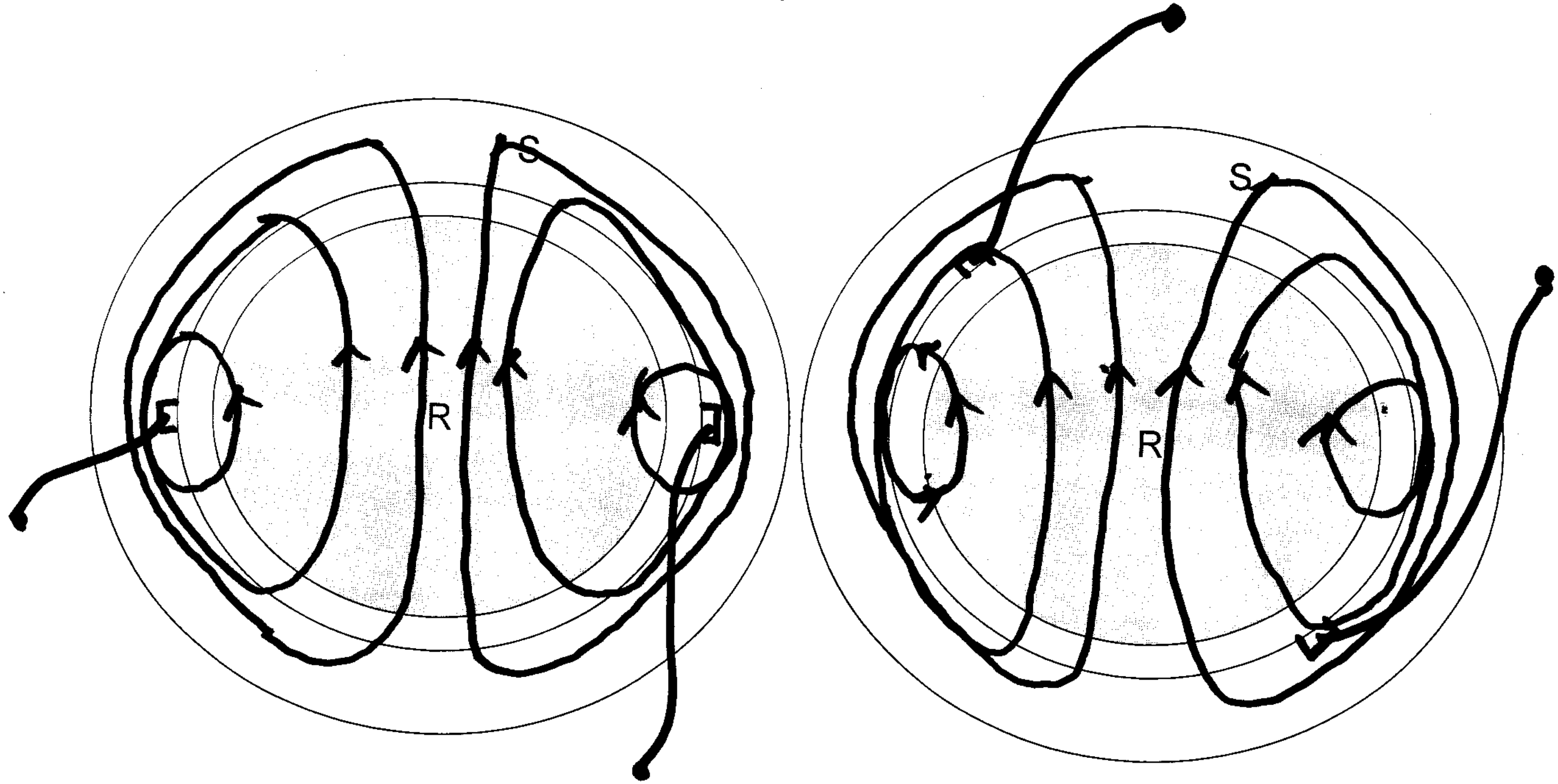


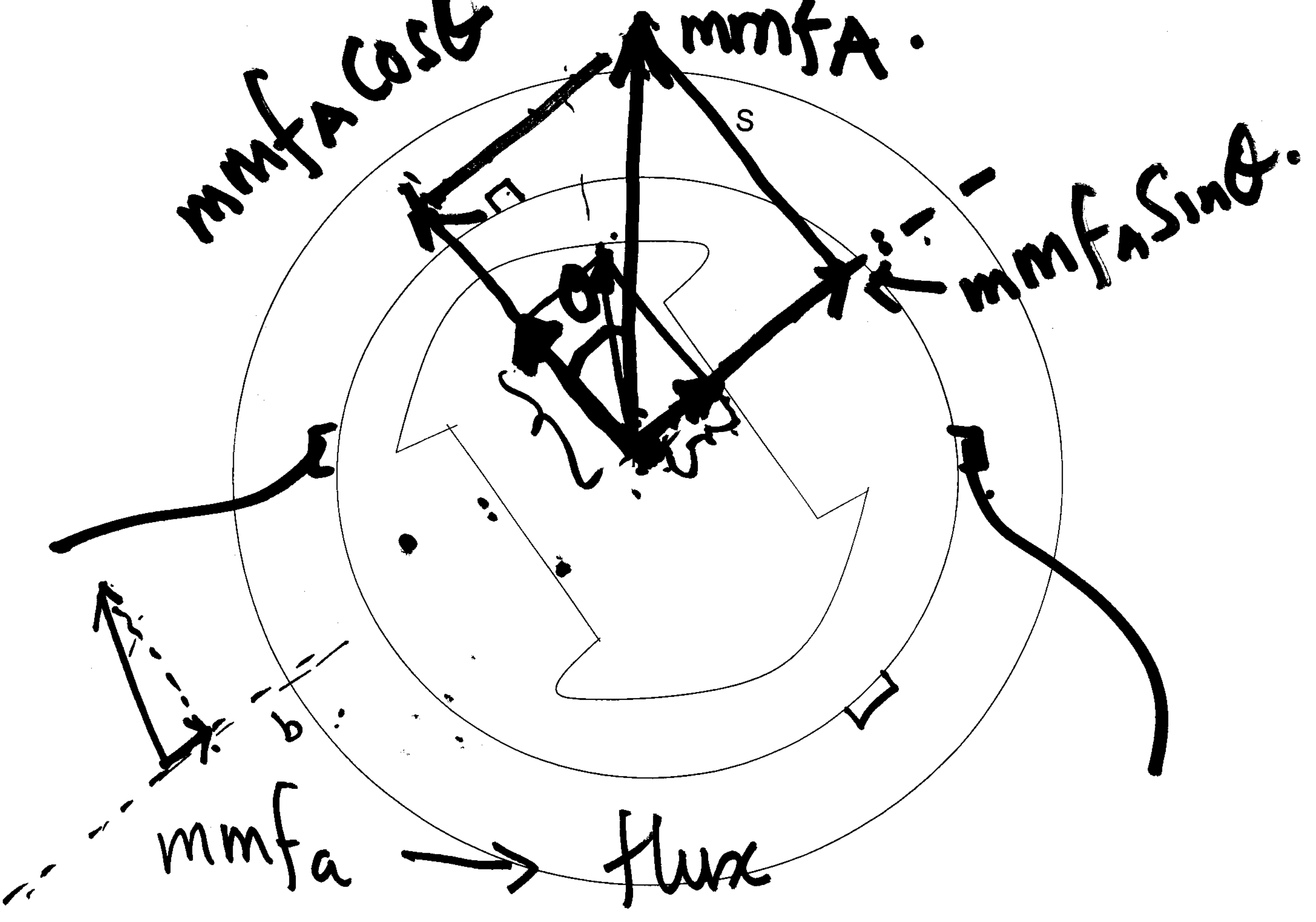



θ
θ
mmfA.

mmf → flux → flux linked

space space specific coil




mmfA cosθ
mmfA.
S
mmfA sinθ.
θ
b
mmfa → flux

$$L_{ss} = \begin{bmatrix} L_{aa0} & L_{ab0} & L_{ab0} \\ L_{ab0} & L_{aa0} & L_{ab0} \\ L_{ab0} & L_{ab0} & L_{aa0} \end{bmatrix} +$$

$$a2 \begin{bmatrix} \cos 2\theta & \cos\left(2\theta - \frac{2\pi}{3}\right) & \cos\left(2\theta + \frac{2\pi}{3}\right) \\ \cos\left(2\theta - \frac{2\pi}{3}\right) & \cos\left(2\theta + \frac{2\pi}{3}\right) & \cos 2\theta \\ \cos\left(2\theta + \frac{2\pi}{3}\right) & \cos 2\theta & \cos\left(2\theta - \frac{2\pi}{3}\right) \end{bmatrix}$$

$$L_{sr}^{d} = \begin{bmatrix} M_{af}\cos\theta & M_{ah}\cos\theta \\ M_{af}\cos\left(\theta - \frac{2\pi}{3}\right) & M_{ah}\cos\left(\theta - \frac{2\pi}{3}\right) \\ M_{af}\cos\left(\theta + \frac{2\pi}{3}\right) & M_{ah}\cos\left(\theta + \frac{2\pi}{3}\right) \end{bmatrix}$$

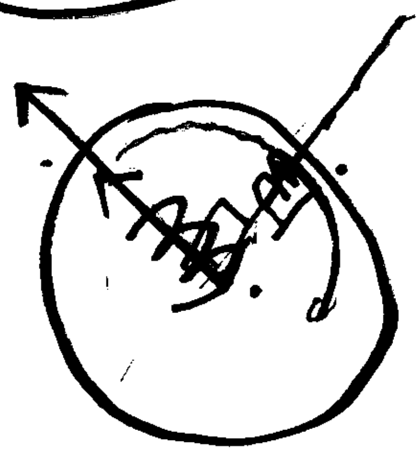
3×2.

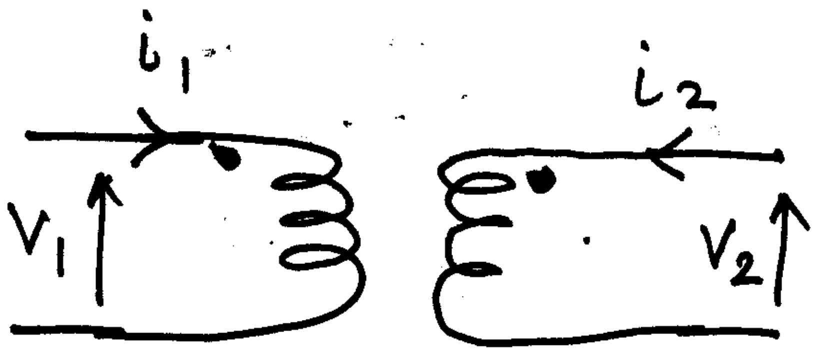
$$L_{sr} = L_{rs}^{T}$$

$$= \left[L_{sr}^{d} \;\vdots\; L_{sr}^{q} \right]$$

$$L_{sr}^{q} = \begin{bmatrix} M_{ag} \sin\theta & M_{ak} \sin\theta \\ M_{ag} \sin\left(\theta - \frac{2\pi}{3}\right) & M_{ak} \sin\left(\theta - \frac{2\pi}{3}\right) \\ M_{ag} \sin\left(\theta + \frac{2\pi}{3}\right) & M_{ak} \sin\left(\theta + \frac{2\pi}{3}\right) \end{bmatrix}$$

$$L_{rr} = \begin{bmatrix} L_f & L_{fh} & 0 & 0 \\ L_{fh} & L_h & 0 & 0 \\ 0 & 0 & L_g & L_{gk} \\ 0 & 0 & L_{gk} & L_k \end{bmatrix}$$





$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} L_{11} & L_{12} \\ L_{21} & L_{22} \end{bmatrix} \begin{bmatrix} \frac{di_1}{dt} \\ \frac{di_2}{dt} \end{bmatrix}.$$

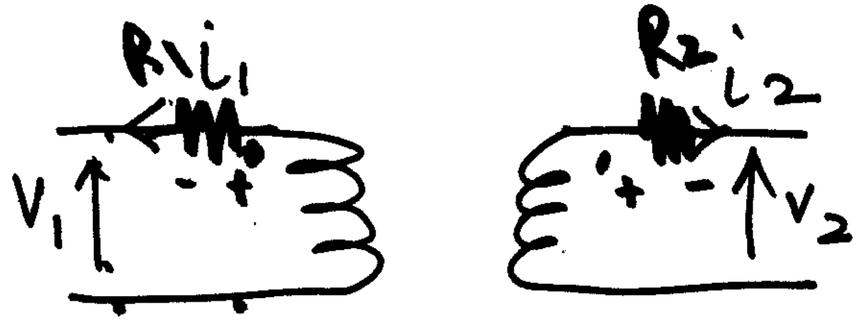
equivalently

$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = \begin{bmatrix} \frac{d\psi_1}{dt} \\ \frac{d\psi_2}{dt} \end{bmatrix}.$$

$$\begin{bmatrix} \psi_1 \\ \psi_2 \end{bmatrix} = \begin{bmatrix} L_{11} & L_{12} \\ L_{21} & L_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}.$$

$L_{11} > 0$

$L_{22} > 0.$



$$\begin{bmatrix} v_1 \\ v_2 \end{bmatrix} = -\begin{bmatrix} \frac{d\psi_1}{dt} \\ \frac{d\psi_2}{dt} \end{bmatrix} - \begin{bmatrix} R_1 i_1 \\ R_2 i_2 \end{bmatrix}$$

same as before.

$$\begin{bmatrix} \psi_1 \\ \psi_2 \end{bmatrix} = \begin{bmatrix} L_{11} & L_{12} \\ L_{21} & L_{22} \end{bmatrix} \begin{bmatrix} i_1 \\ i_2 \end{bmatrix}$$

$$\begin{bmatrix} \psi_s \\ \hdashline \psi_r \end{bmatrix} = \left[\begin{array}{c|c} L_{ss} & L_{sr} \\ \hline L_{rs} & L_{rr} \end{array}\right] \begin{bmatrix} i_s \\ \hdashline i_r \end{bmatrix}$$

$$-\frac{d\psi_s}{dt} - R_s i_s = V_s \; ?$$

$$-\frac{d\psi_r}{dt} - R_r i_r = V_r \; ?$$

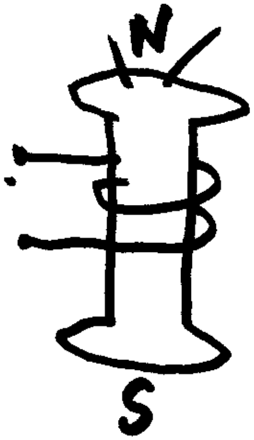
$$V_S = \begin{bmatrix} V_a \\ V_b \\ V_c \end{bmatrix}$$

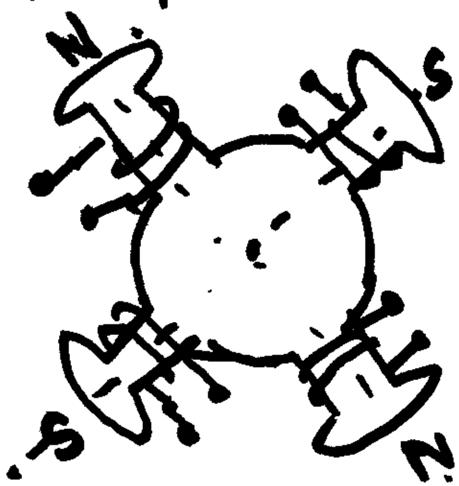
$$V_r = \begin{bmatrix} -V_f \\ 0 \\ 0 \\ 0 \end{bmatrix}$$

$$R_s = \begin{bmatrix} R_a & 0 & 0 \\ 0 & R_a & 0 \\ 0 & 0 & R_a \end{bmatrix}$$

$$R_r = \begin{bmatrix} R_f & 0 & 0 & 0 \\ 0 & R_h & 0 & 0 \\ 0 & 0 & R_g & 0 \\ 0 & 0 & 0 & R_k \end{bmatrix}$$

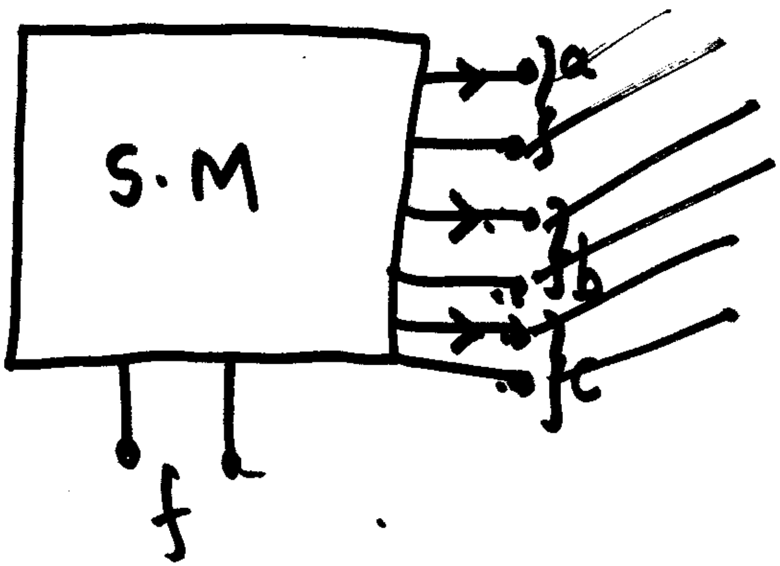
Number of poles $\neq 2$





flux reversal $\theta_m = 180^\circ$

flux reversal $\theta_m = 90^\circ$



L_{ss}, L_{sr}, L_{rs}

FUNCTIONS OF $\boxed{\theta}$

<u>Torque</u>

$$\boxed{J\frac{d\omega_m}{dt} = T_m - T_e.}$$

$$\boxed{T_e = -\frac{\partial W'}{\partial \theta_m}} = -\frac{P}{2}\frac{\partial W'}{\partial \theta} = -\frac{P}{2}T_e'.$$

$$W' = \frac{1}{2}\begin{bmatrix} i_s^T & i_r^T \end{bmatrix}\begin{bmatrix} L_{ss} & L_{sr} \\ L_{rs} & L_{rr} \end{bmatrix}\begin{bmatrix} i_s \\ i_r \end{bmatrix}$$

$$\therefore T_e' = -\frac{1}{2}\left[i_s^T \frac{\partial L_{ss}}{\partial \theta} \cdot i_s + 2\, i_s^T \frac{\partial L_{sr}}{\partial \theta} \cdot i_r \right]$$

$$T_e' = \frac{\partial W'}{\partial \theta}$$

$$= \frac{1}{2}\left[i_s^T \frac{\partial L_{ss}}{\partial \theta} \cdot i_s + i_s^T \frac{\partial L_{sr}}{\partial \theta} i_r \right]$$

$$J \cdot \frac{2}{P} \cdot \frac{d\omega}{dt} = T_m - \frac{P}{2} T_e'$$