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Lec. No. 11
Date : 13/1/2010

# SYNCHRONOUS MACHINE

→ ARMATURE → Three phase

→ FIELD → DC

armature – laminated

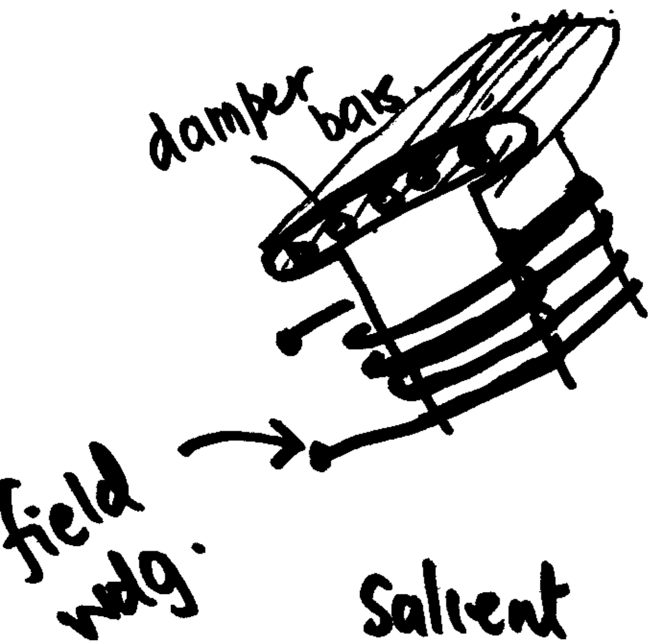
$$\omega_e = \frac{P}{2}\,\omega_m$$

P : poles.

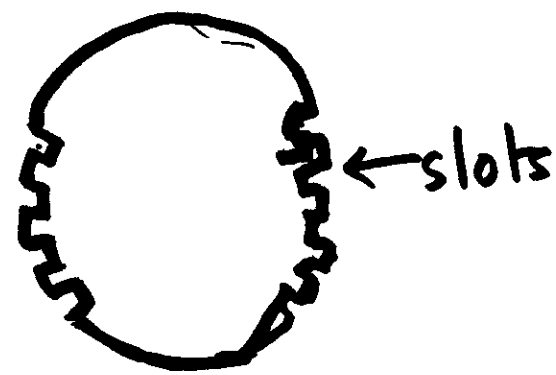
hydro – low speed → SALIENT POLE
damper windings on pole face

STEAM / gas – high speed – ROUND rotor
(cylindrical pole)

solid steel forgings.
( eddy currents in rotor during transients.




Salient pole




cylindrical rotor.

eg. 210 MW machine typical parameters.

MVA : 247 , Rated voltage : 15.75 kV

Rated current : 9050 A , 50 Hz

<u>Field</u> : Rated current : 2600A Rated voltage = 310 V

Efficiency : 98.55 %

hydrogen cooling.

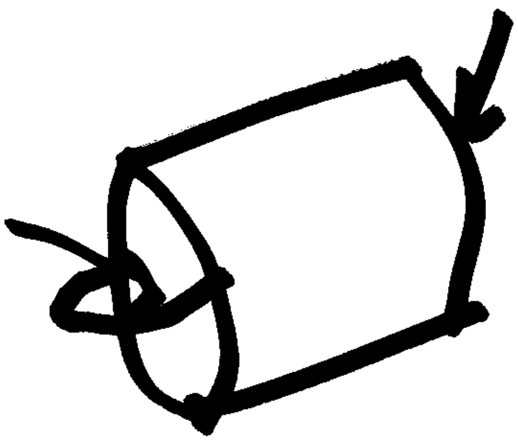
Equipment limits : Armature heating, Rotor winding (Field) heating

"Core-end heating".

1. Armature current
2. Field current

} heating

3. Core-end heating.
   └ higher axial flux



"Field Excitation in Relation to machine & system operation"

FARNHAM & SWARTHOUT

AIEE – 1953

1215 - 1223

## MODELLING

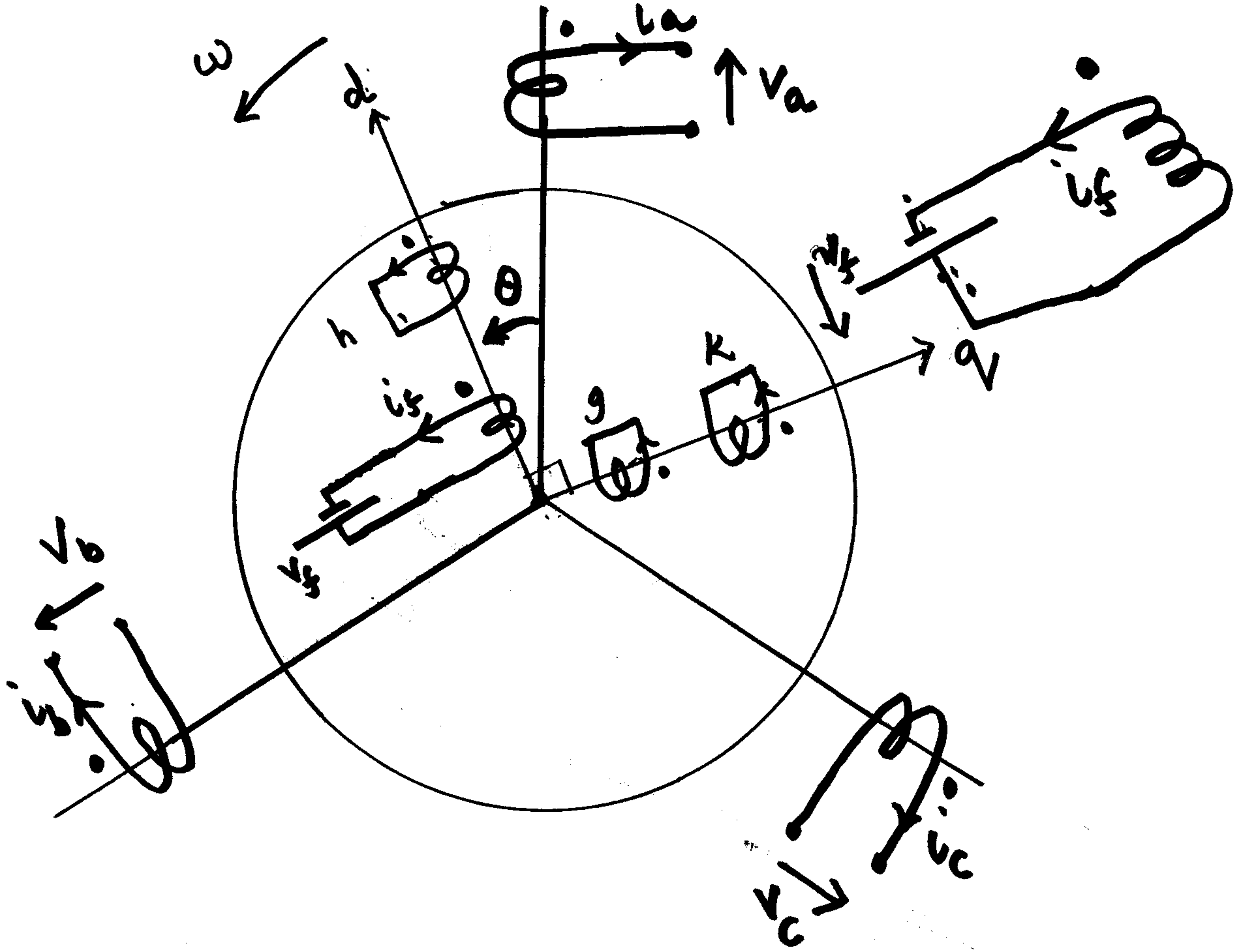
① Sinusoidal distribution of mmf in airgap.

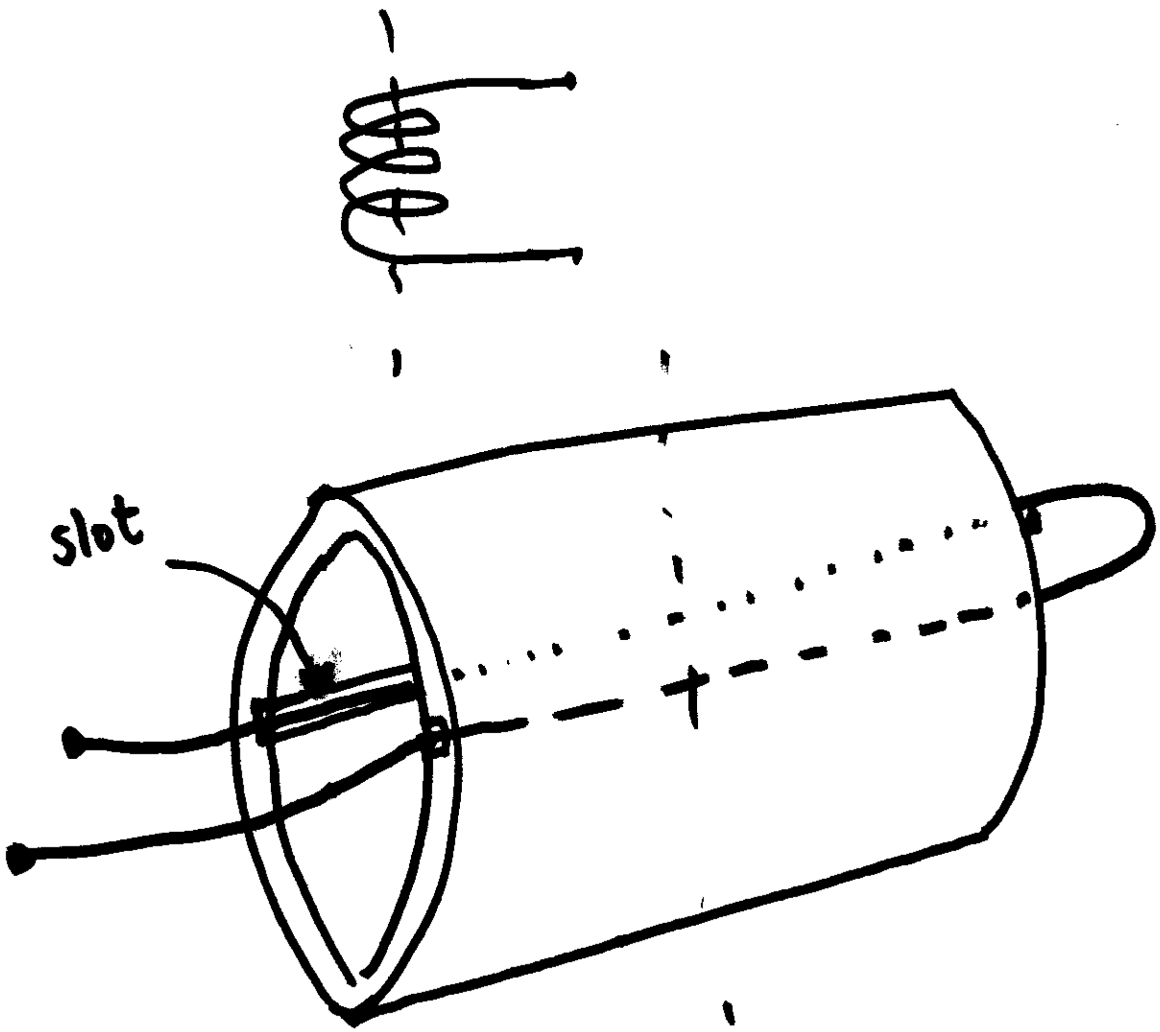
② Salienecy is restricted to the rotor

③ Saturation & Hysteris are ignored.

'lumped circuit model'

$$\theta = \frac{P}{2}\theta_m \qquad \omega = \frac{P}{2}\omega_m$$


ia
Va
ω
d
θ
h
if
vf
g
K
q
if
vf
Vb
ib
Vc
ic


slot

$$\psi_s \rightarrow \begin{bmatrix} \psi_a \\ \psi_b \\ \psi_c \\ \hdashline \psi_f \\ \psi_h \\ \psi_g \\ \psi_k \end{bmatrix} \leftarrow \psi_r \quad = \quad L \begin{bmatrix} i_a \\ i_b \\ i_c \\ \hdashline i_f \\ i_h \\ i_g \\ i_k \end{bmatrix} \begin{matrix} \leftarrow i_s \\ \\ \leftarrow i_r \end{matrix}$$

$$L = \left[\begin{array}{c:c} L_{ss} & L_{sr} \\ \hdashline L_{rs} & L_{rr} \end{array}\right]$$

$L_{ss} \rightarrow 3 \times 3$

$L_{sr} \rightarrow 3 \times 4$

$L_{rs} \rightarrow 4 \times 3$

$L_{rr} \rightarrow 4 \times 4$

mutual inductance 'a' - 'f'.

$i_a$

↓

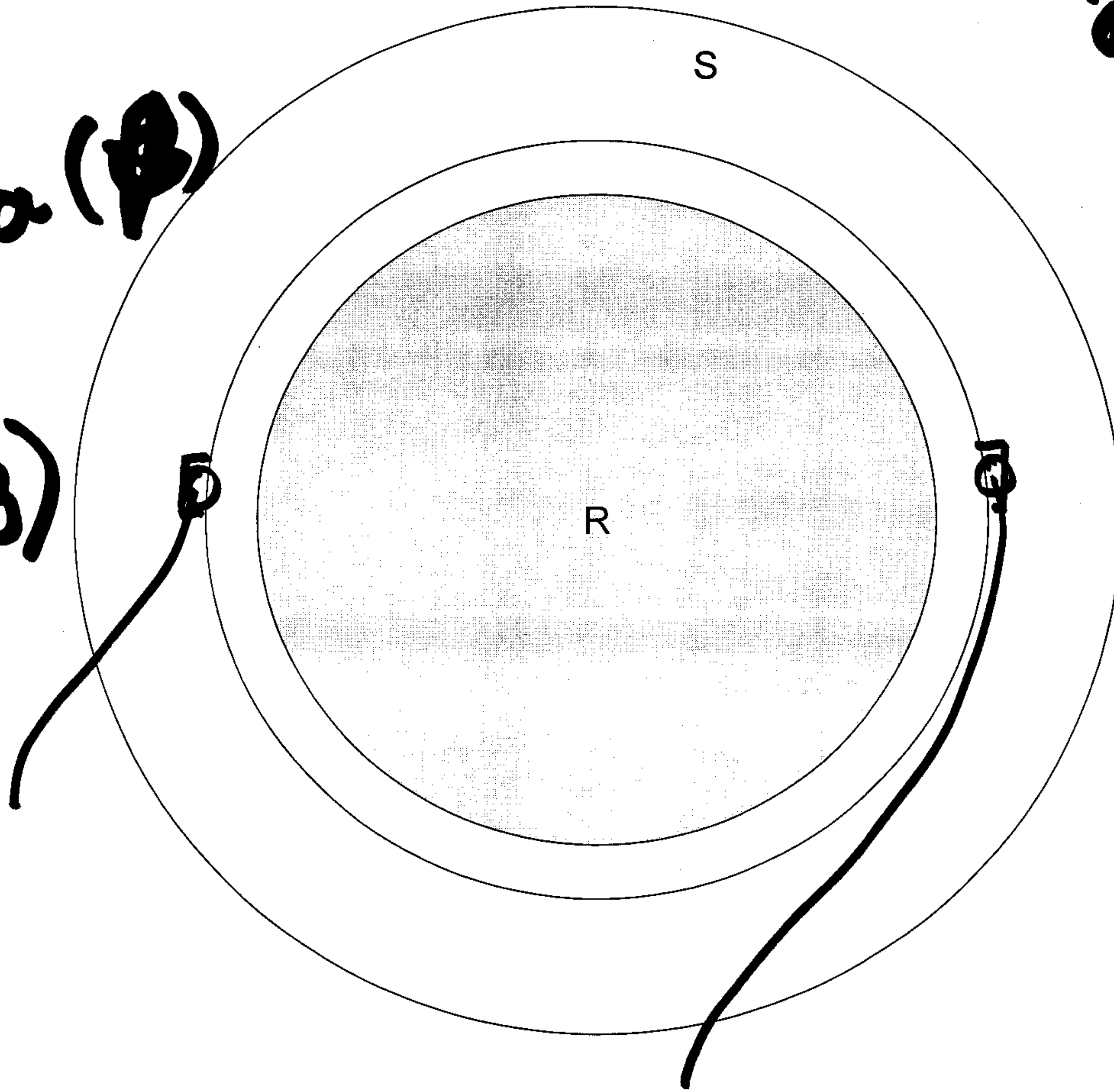
$N_a i_a(\beta)$

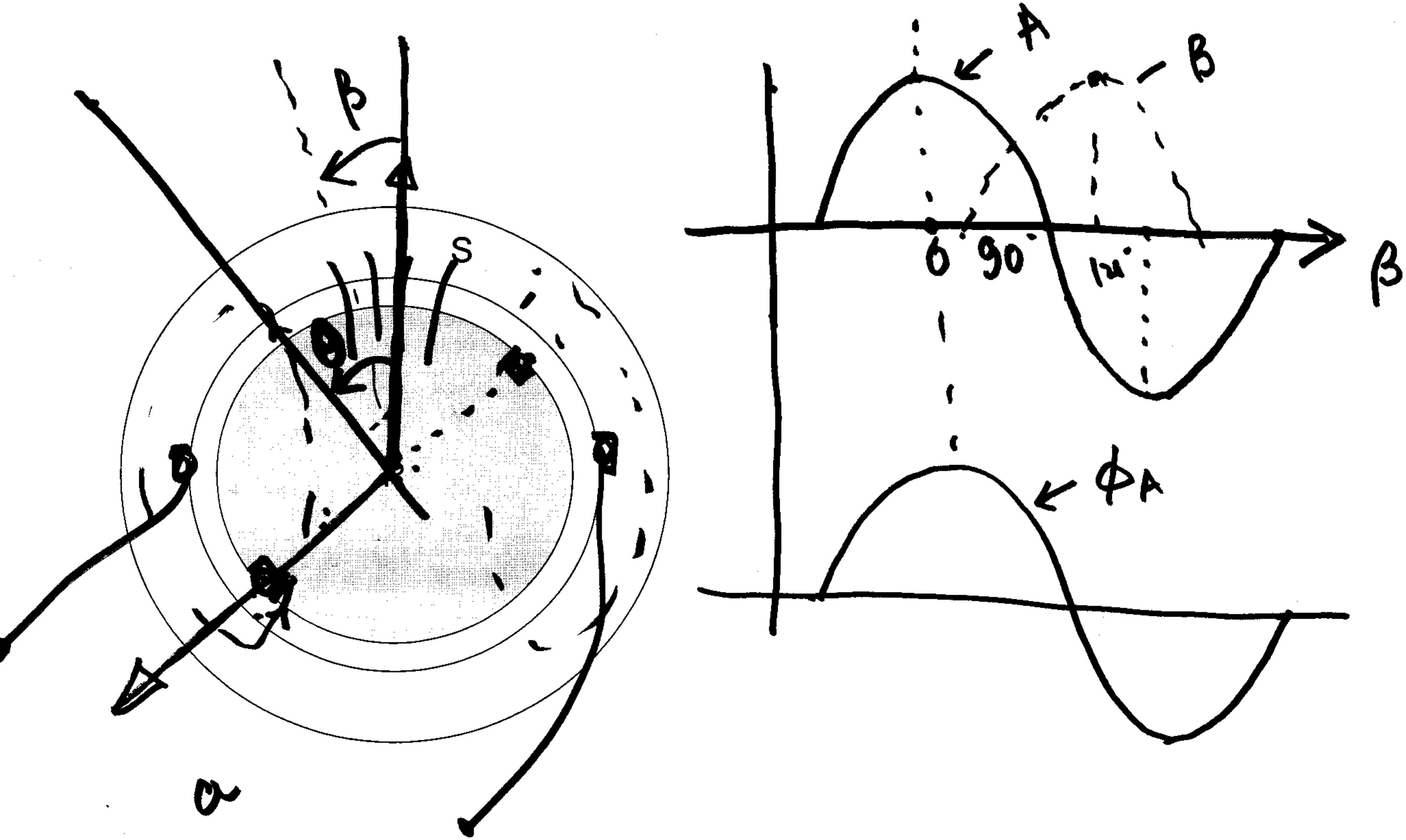
↓

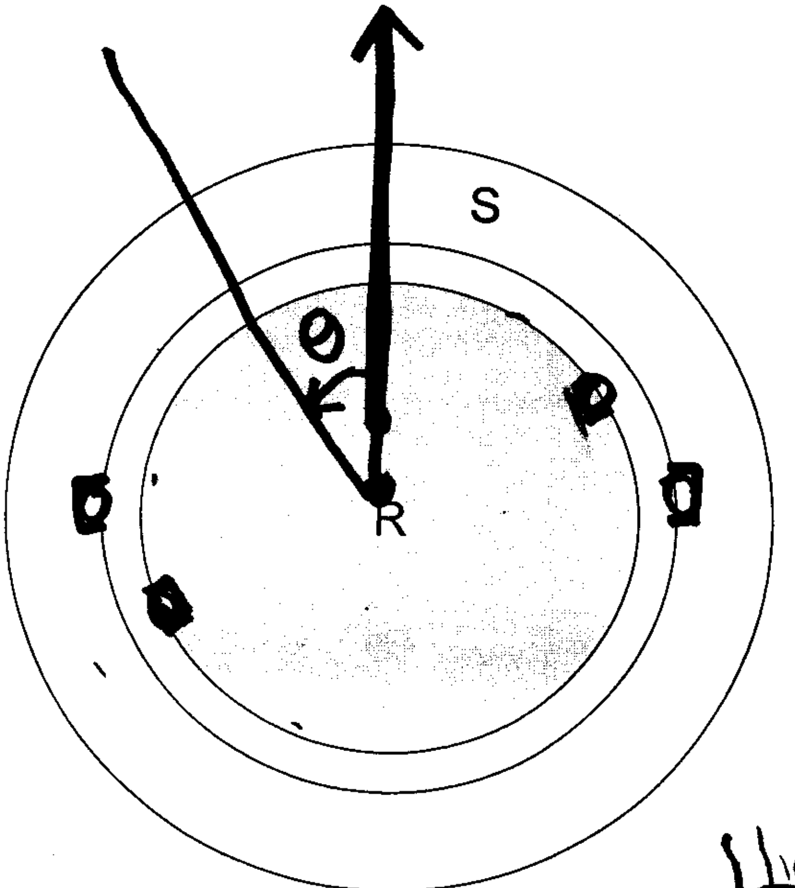
$\phi(\beta)$

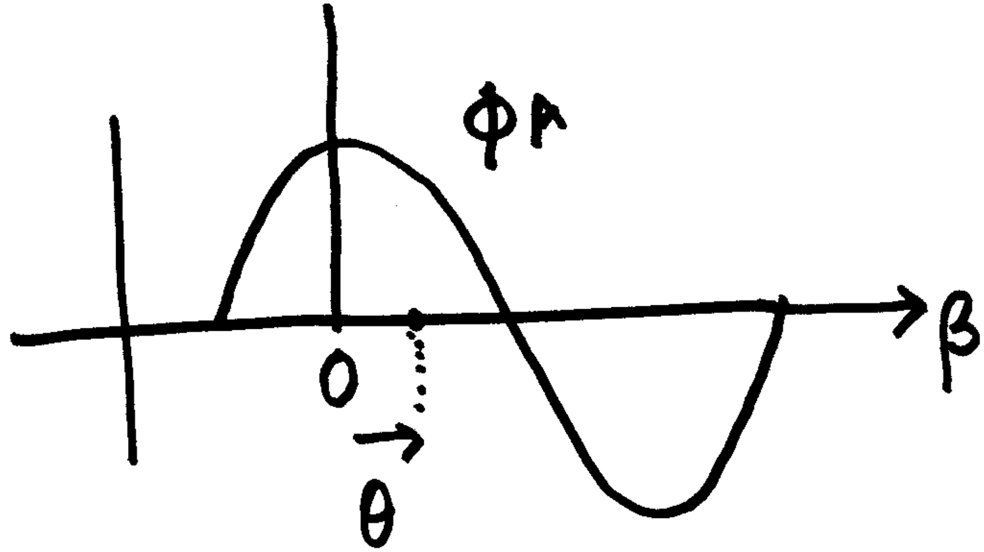
↓

$f$

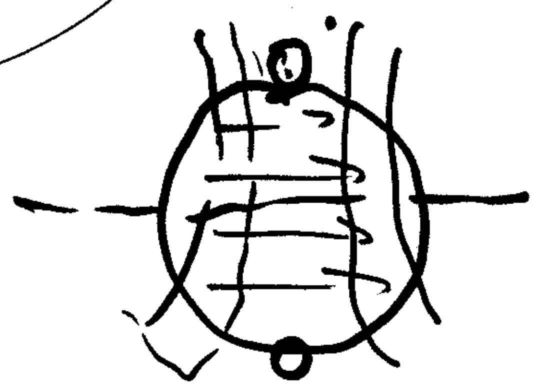


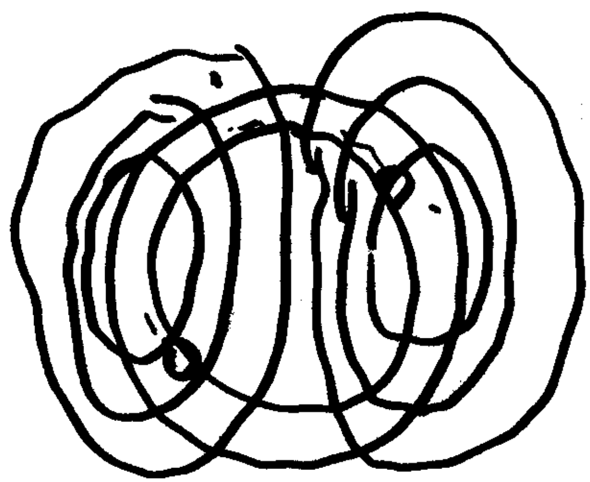

β
S
θ
a
A
B
0
90
180
β
ΦA



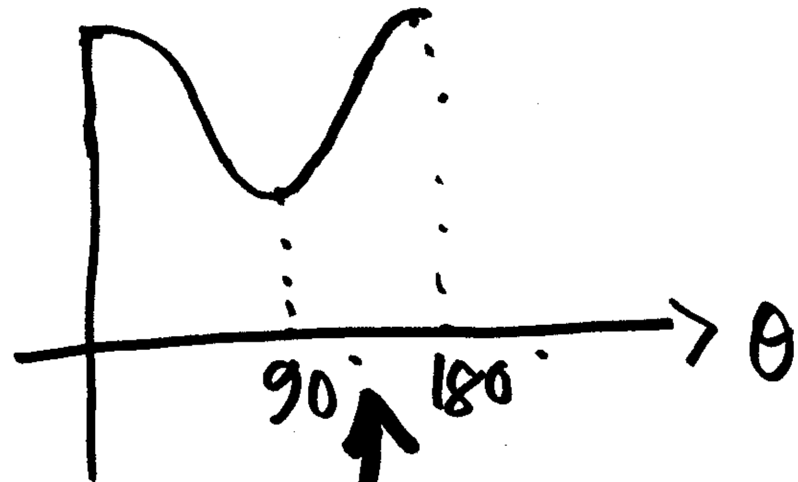

mutual → $M_{af} \cos\theta$

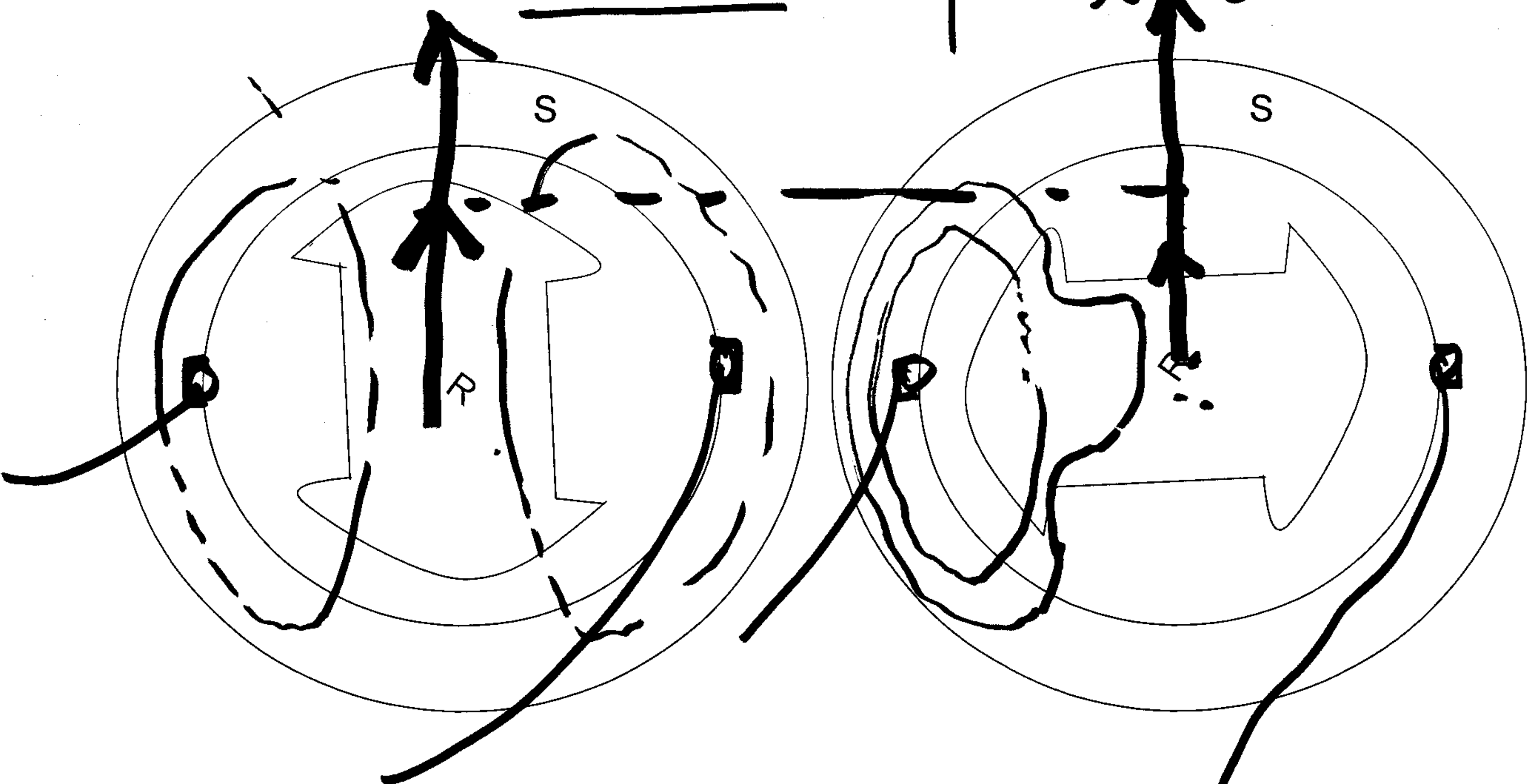


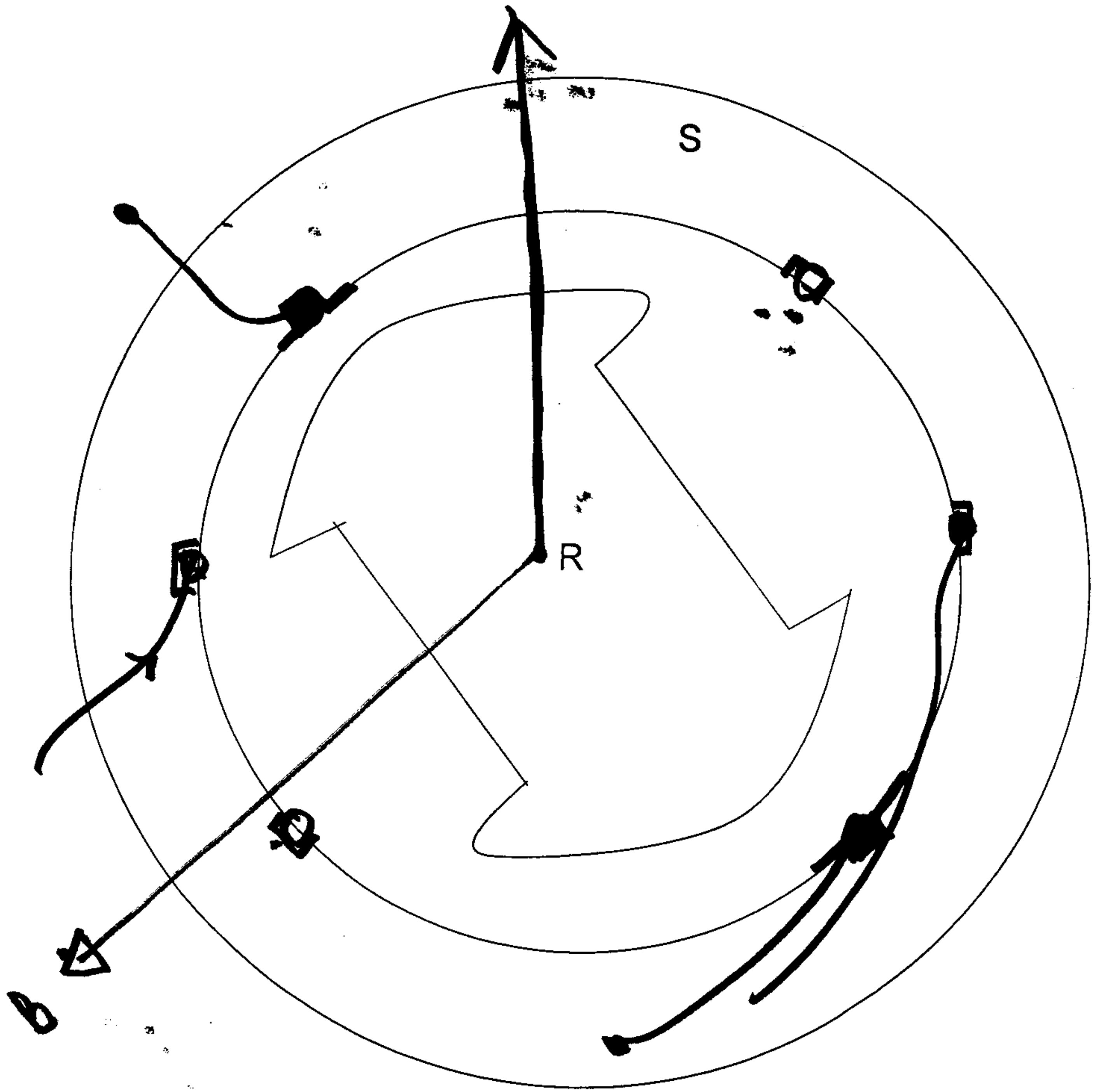


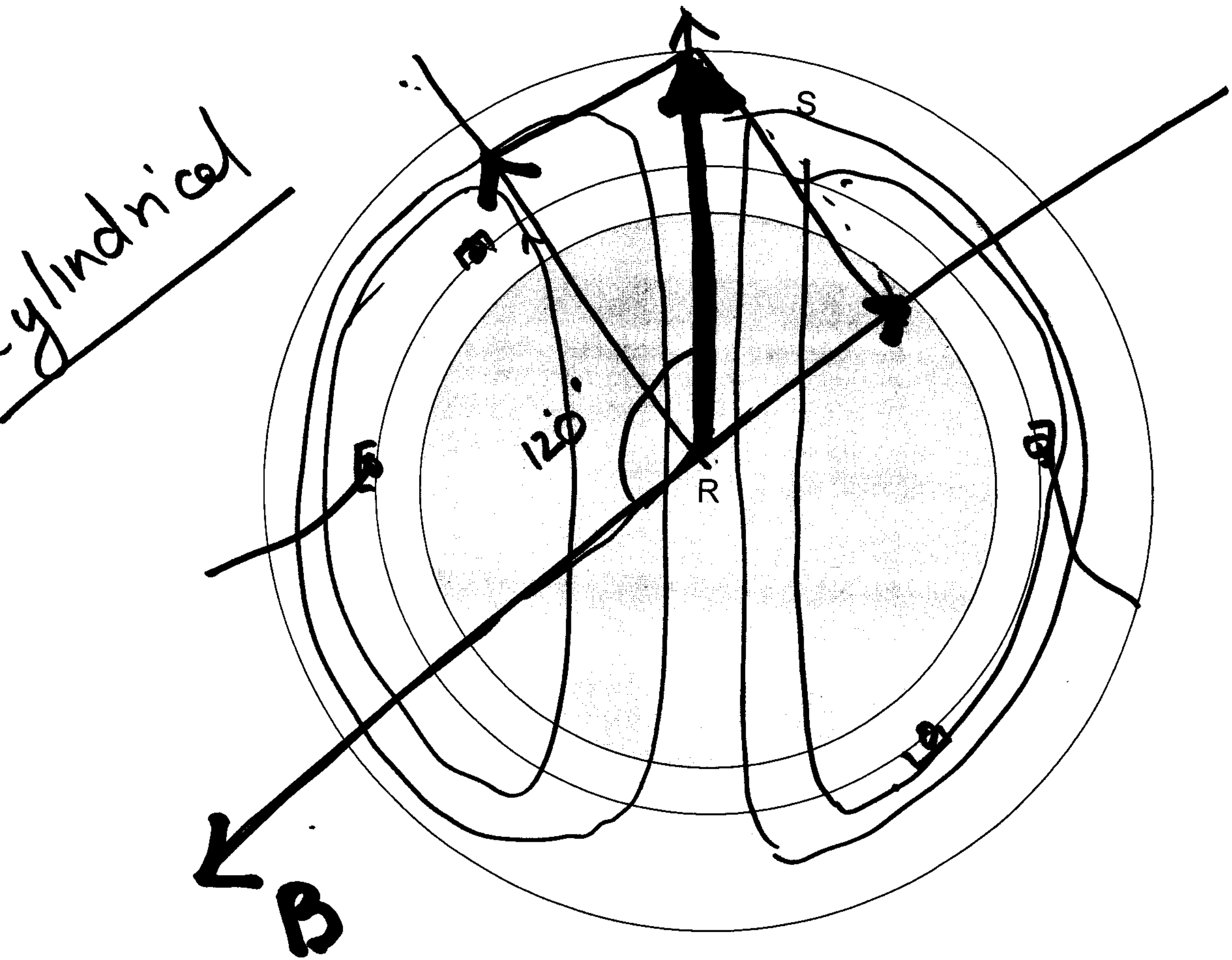
$$l_{aa} = L_{aa0} + L_{aa2} \times \cos 2\theta$$

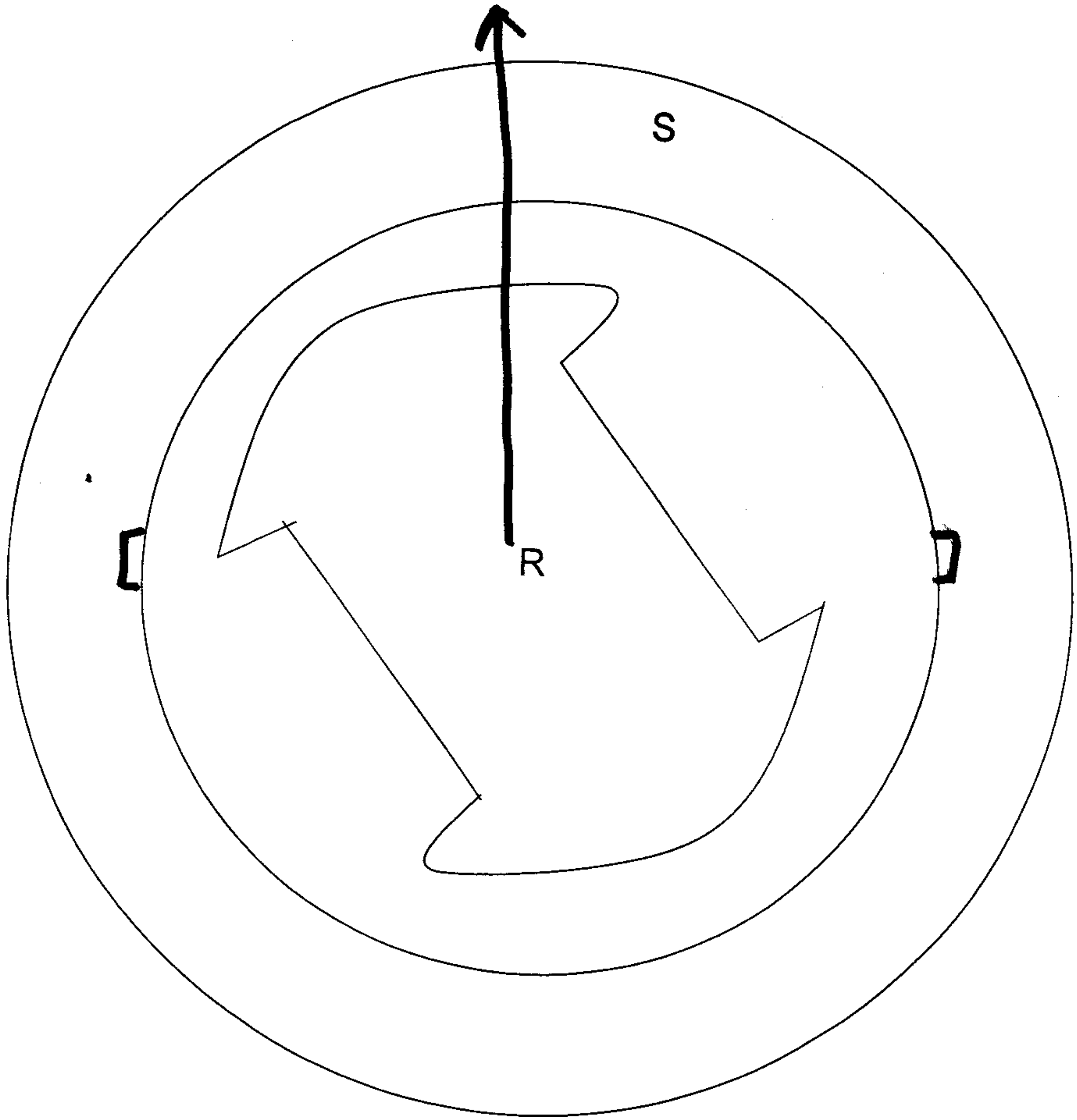
salient




S
R
B


cylindrical
S
R
120
B


S
R