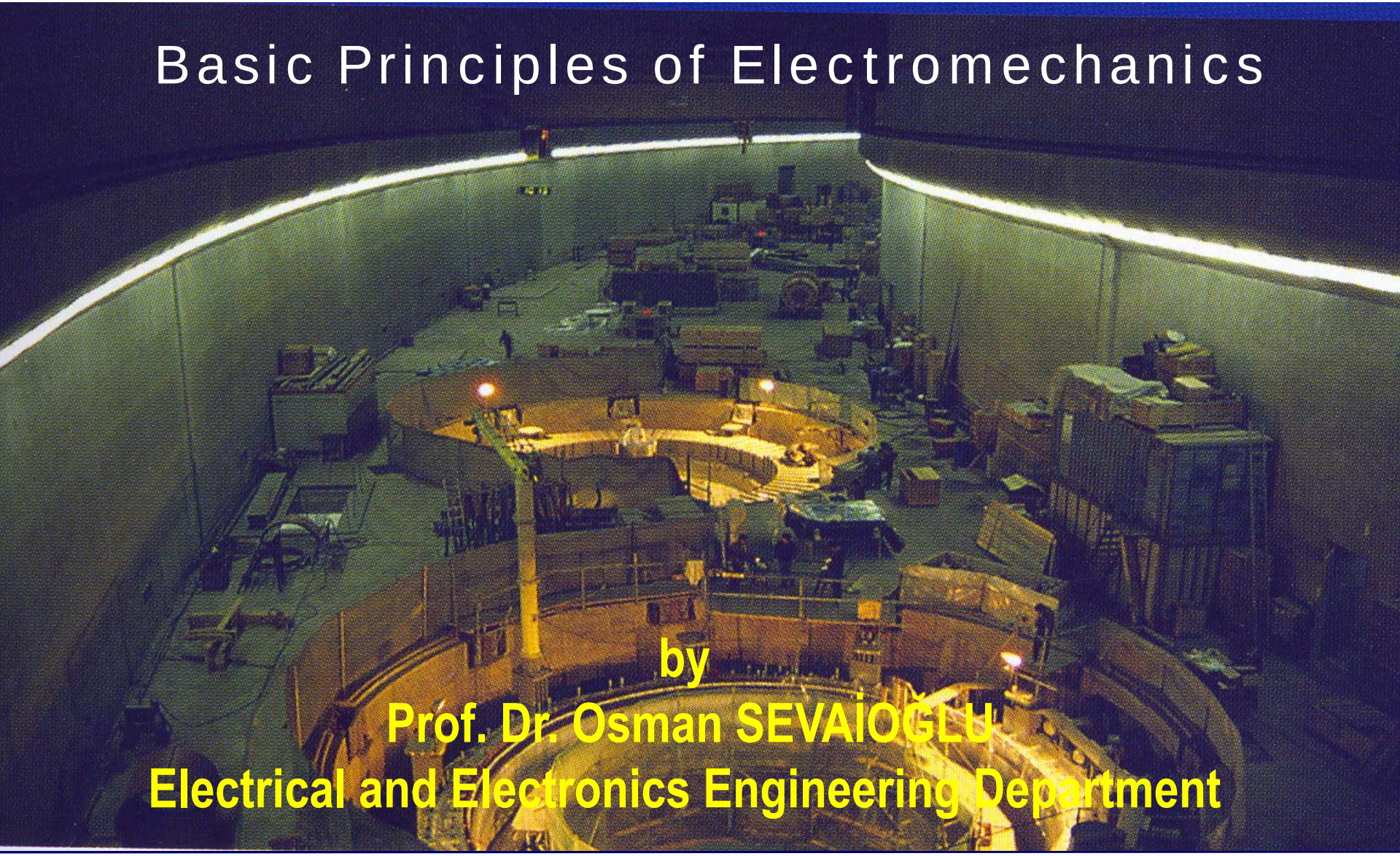
Basic Principles of Electromechanics



by
Prof. Dr. Osman SEVAİOĞLU
Electrical and Electronics Engineering Department

Basic Principles of Electromechanics

Left Hand Rule - Principle of Electric Motors

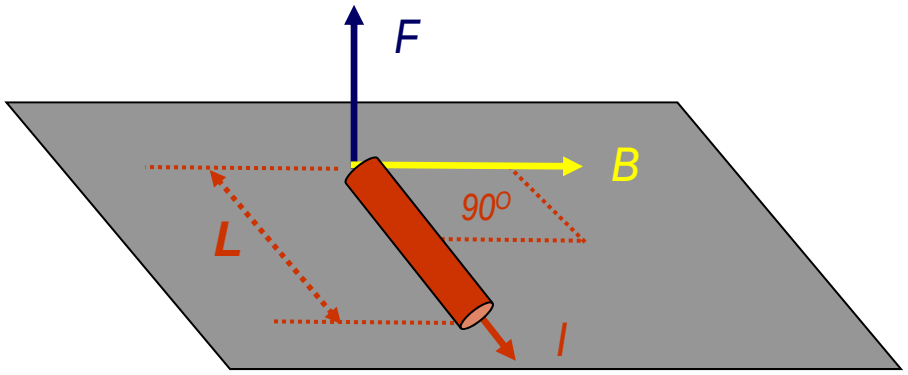
Left Hand Rule

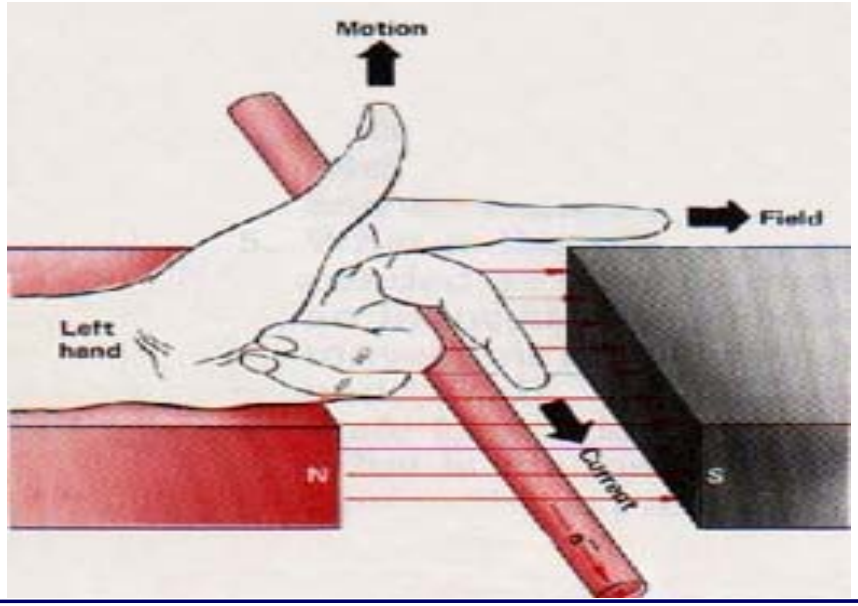
A force is created in the vertical direction shown, in a conductor carrying a current I in a magnetic field as shown in the figure on the RHS

$$F = (I L) \times B$$

This principle is best explained by Left Hand Rule

- *Thumb finger of the left hand points the direction of the force generated,*
- *Index finger points the direction of magnetic field,*
- *Middle finger points the direction of current applied,*





Basic Principles of Electromechanics

Left Hand Rule - Principle of Electric Motors

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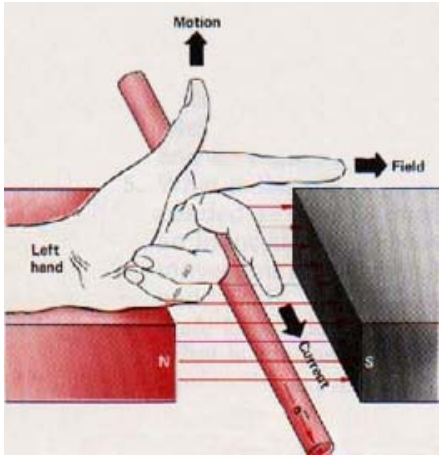
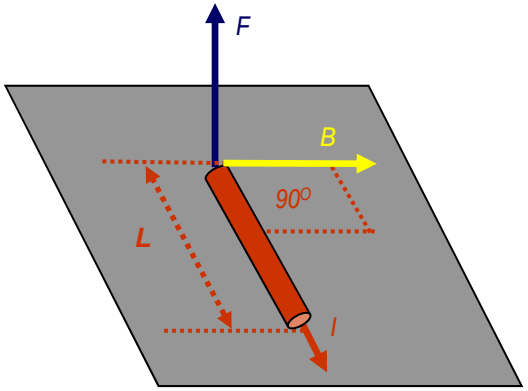
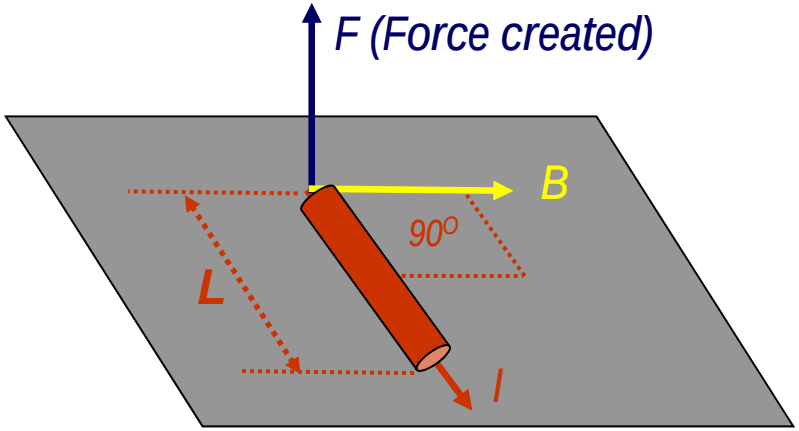
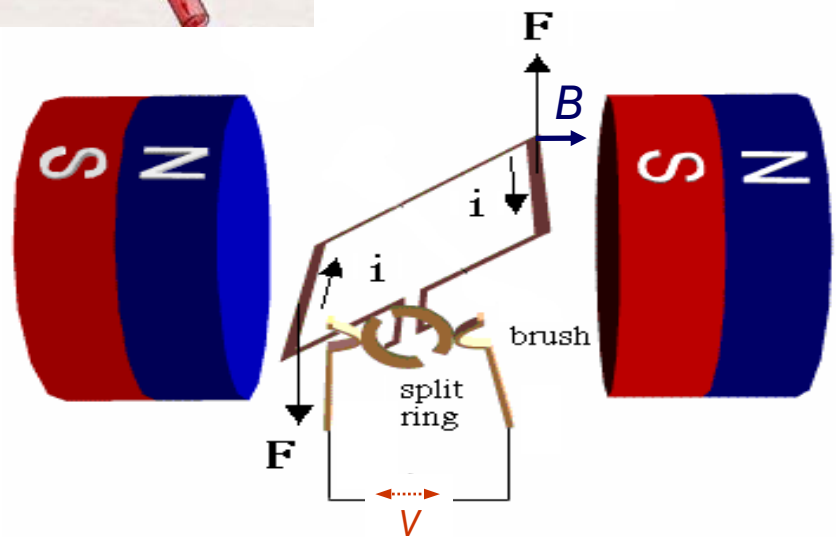






$$F = (I L) \times B$$



Basic Principles of Electromechanics

Right Hand Rule - Principle of Electric Generators

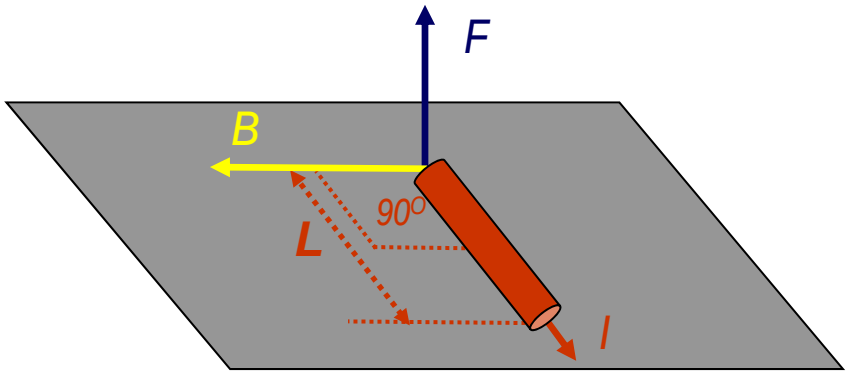
Right Hand Rule

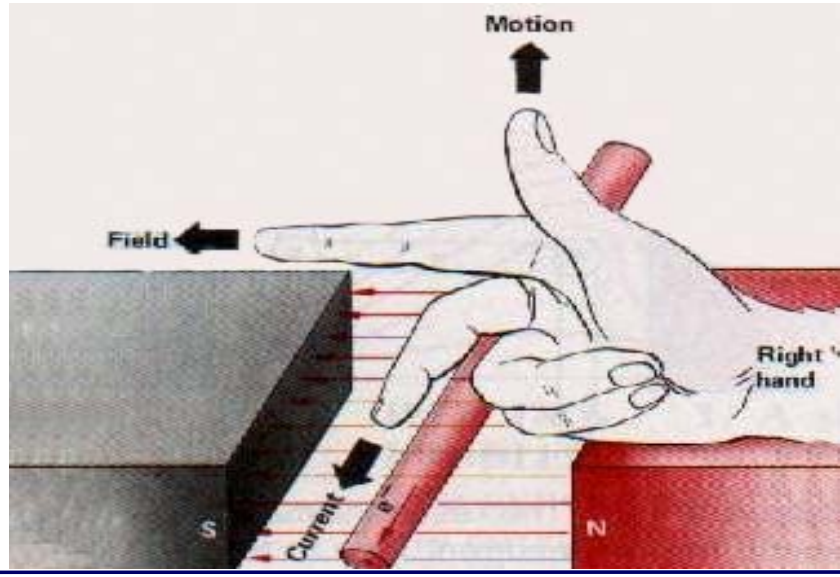
A current is induced (generated) in the direction shown, on a conductor moving vertically in a magnetic field as shown in the following figure

$$F = -(I L) \times B$$

This principle is best explained by Right Hand Rule

- *Thumb finger points the right hand points the direction of the force applied,*
- *Index finger points the direction of magnetic field,*
- *Middle finger points the direction of current generated,*



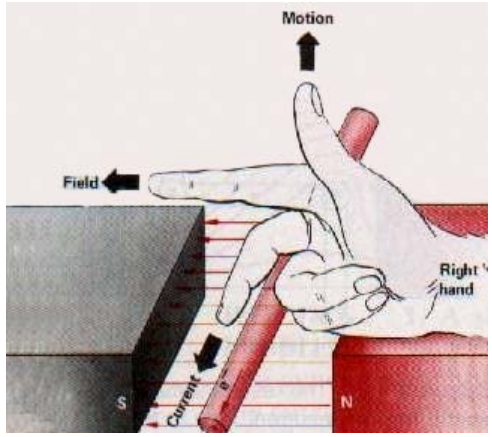


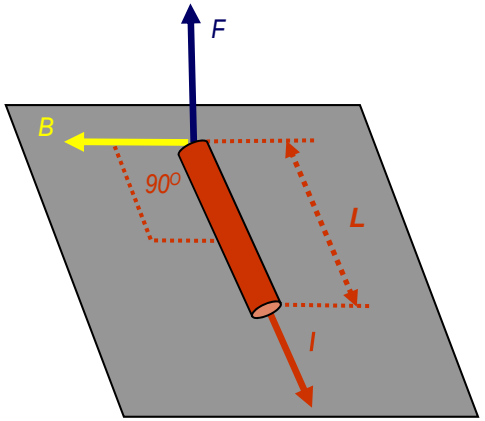
Basic Principles of Electromechanics

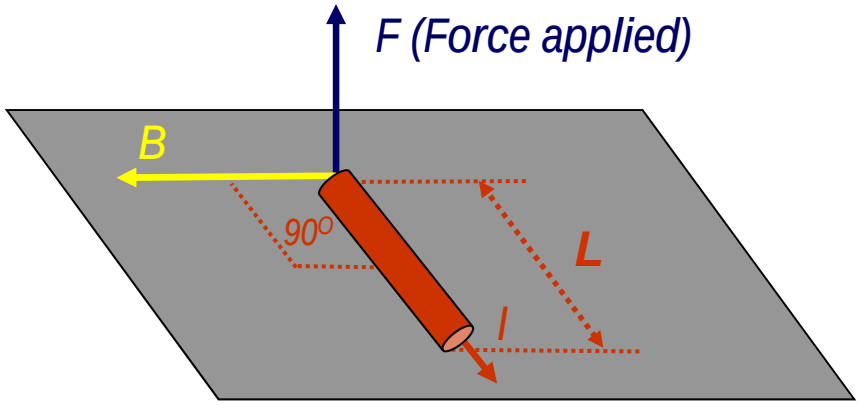
Right Hand Rule - Principle of Electric Generators

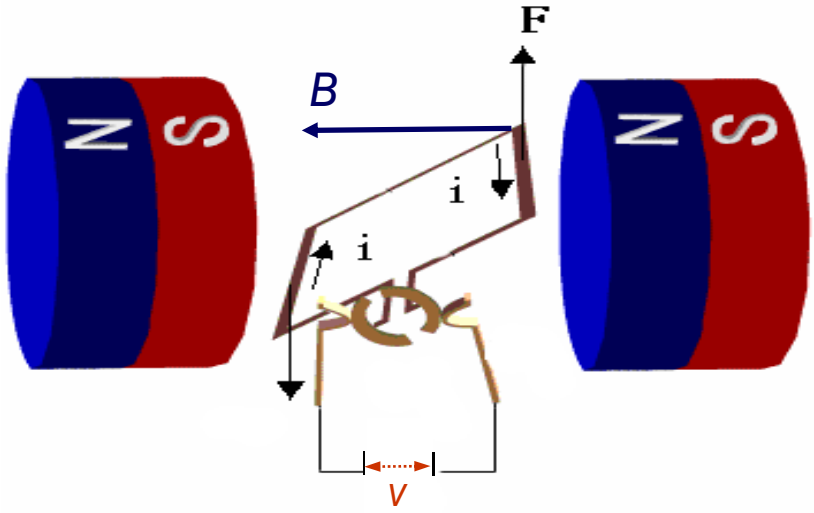
Right Hand Rule

A current is induced (generated) in the direction shown, on a conductor moving vertically in a magnetic field as shown in the following figure







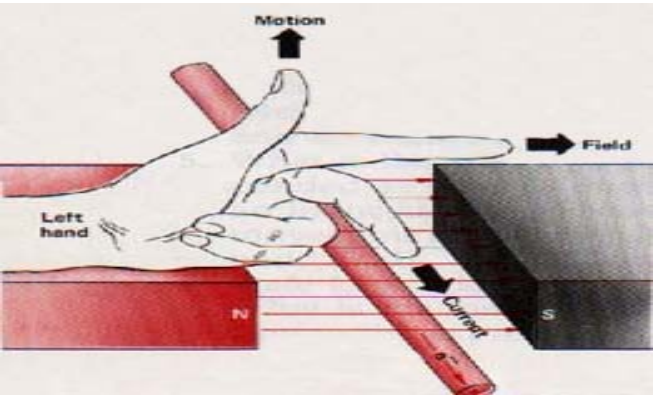


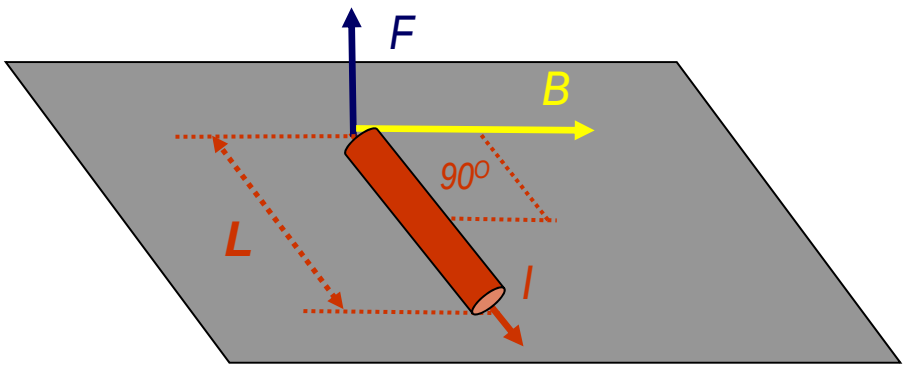
$$F = -(I L) \times B$$

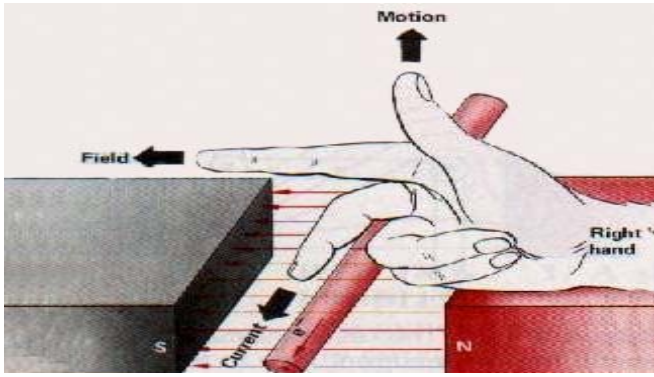
Basic Principles of Electromechanics

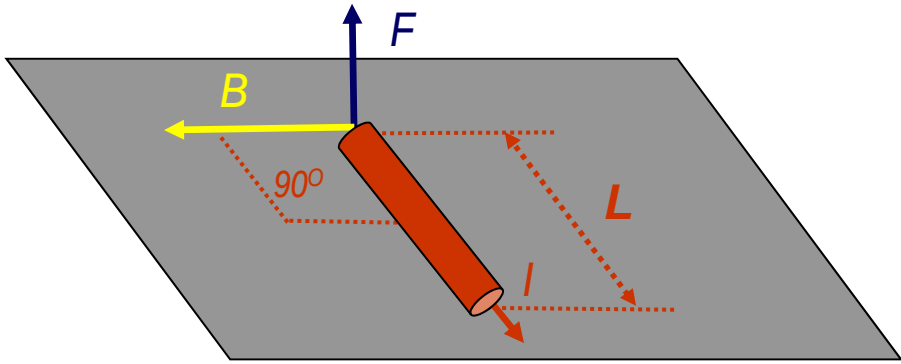
Please do not Confuse

Left Hand Rule-Electric Motor	Right-Hand Rule-Electric Generator
$F = (I L) \times B$	$F = -(I L) \times B$





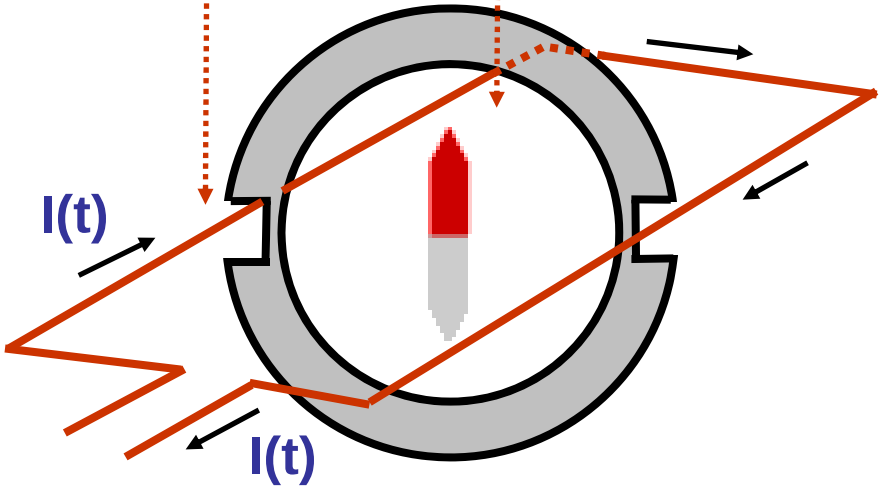


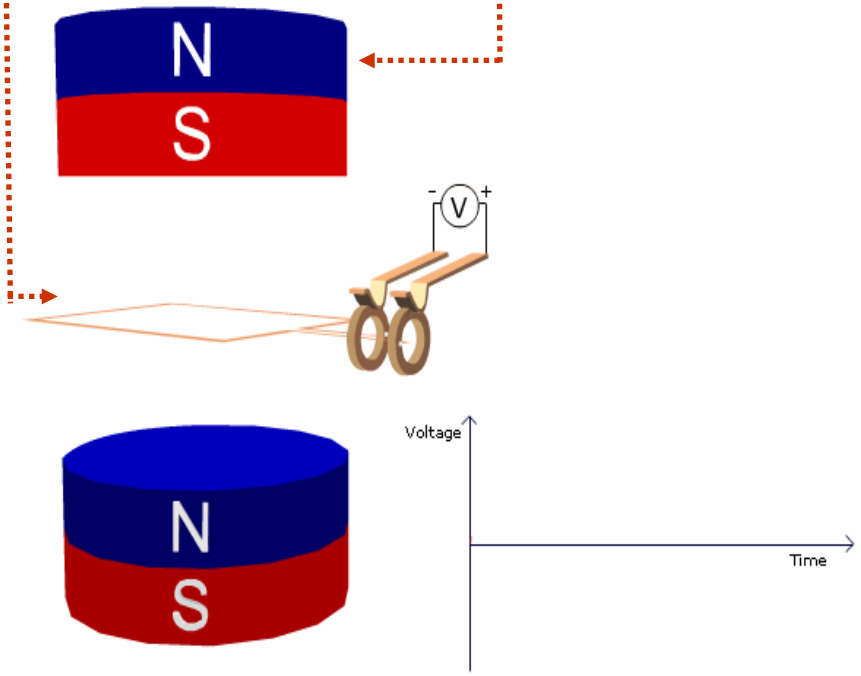


Basic Principles of Electromechanics

Generation of AC Voltage

Fixed Stator Coils, Rotating Poles		Fixed Poles, Rotating Coils	
Fixed Stator Coil	*Rotating Poles*	*AC Rotating Rotor Coil*	*Fixed Stator Poles*



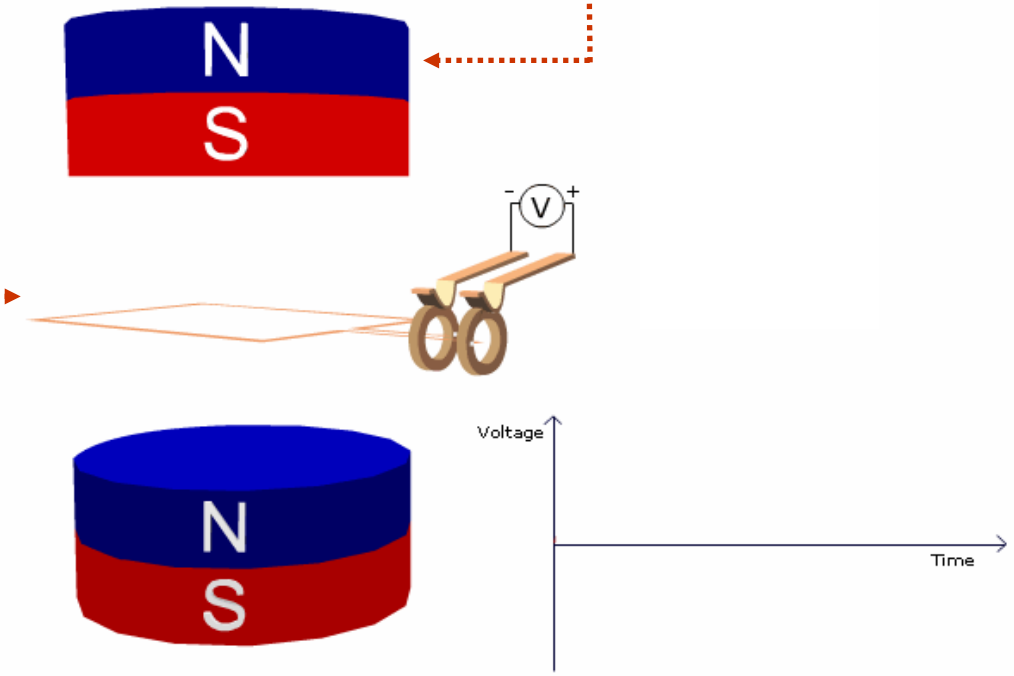


Basic Principles of Electromechanics

Generation of AC Voltage

Fixed Poles, Rotating Coils

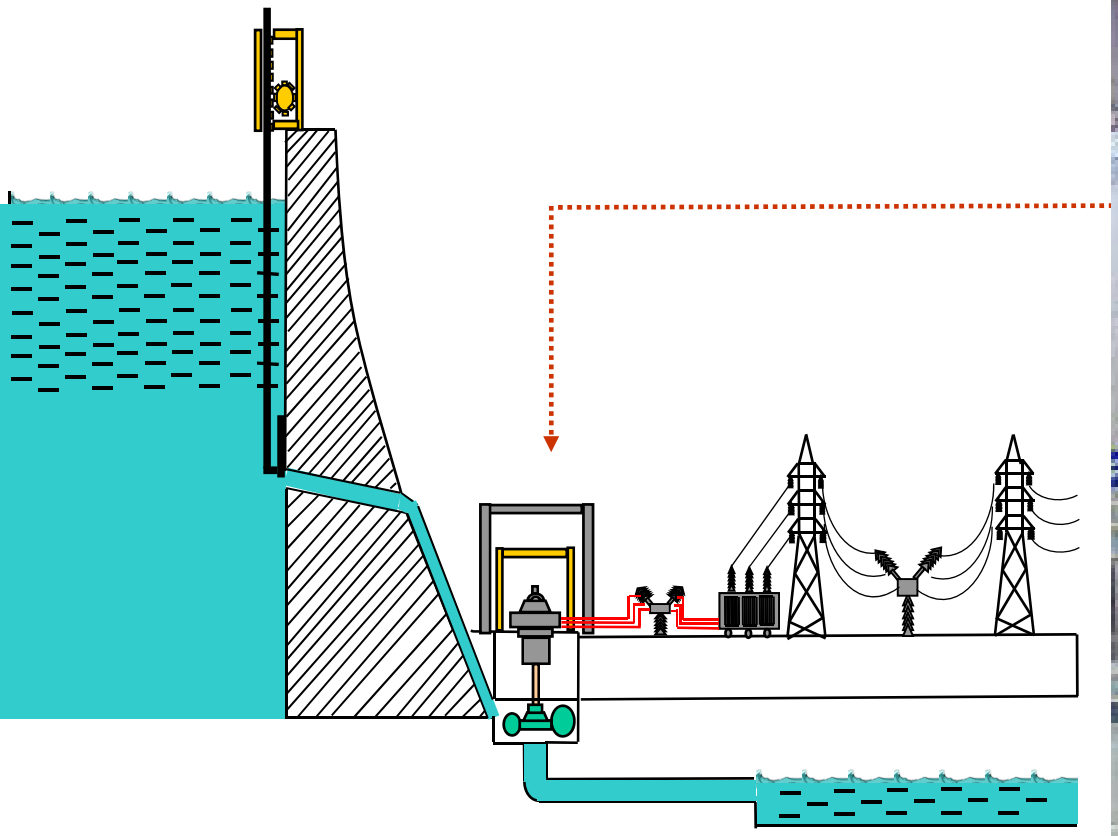
AC Rotating Rotor Coil	*Fixed Stator Poles*



Basic Principles of Electromechanics

Generation of AC Voltage - Synchronous Generator

Hydroelectric Dam

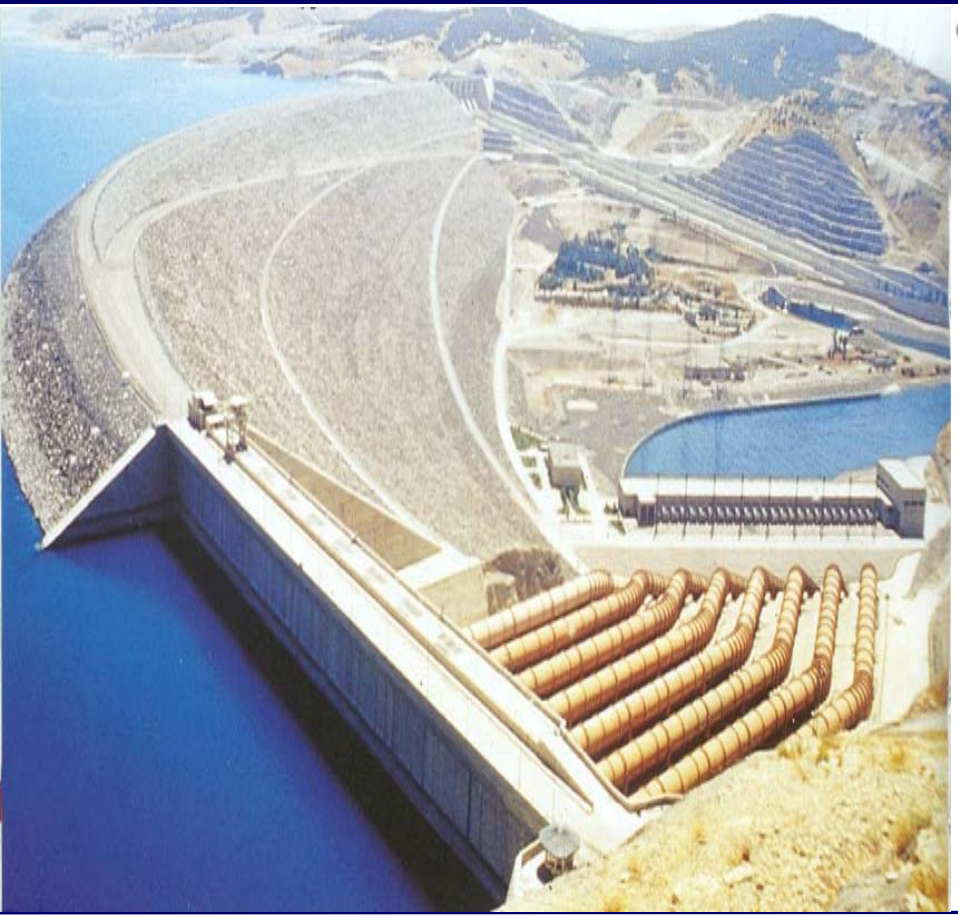


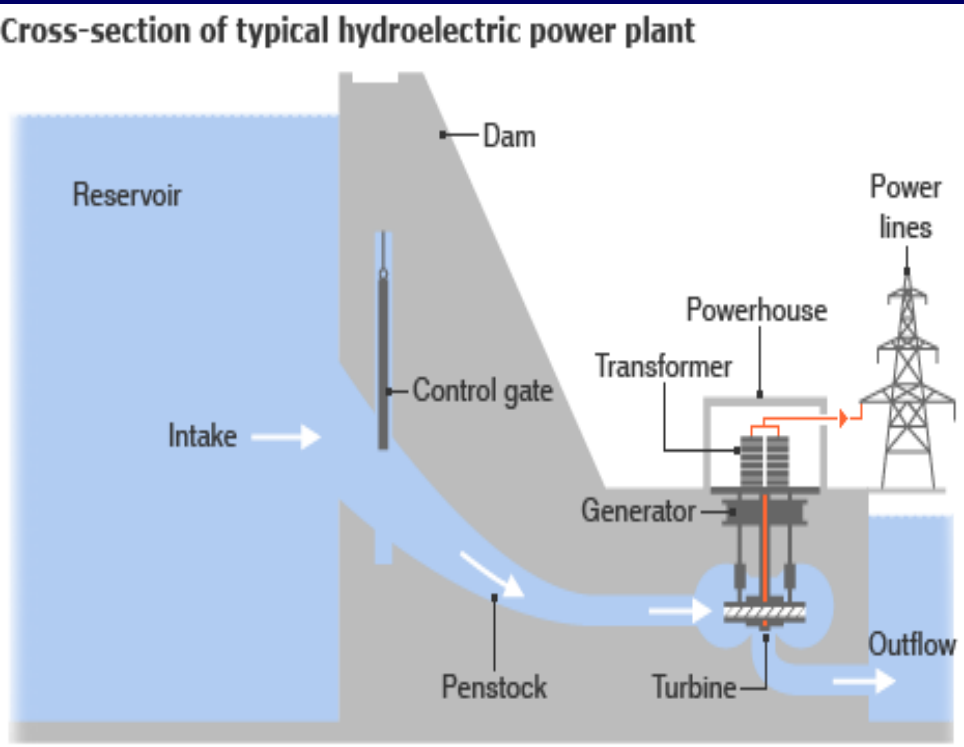
Generating Units

Basic Principles of Electromechanics

Generation of AC Voltage - Synchronous Generator

Atatürk Hydroelectric Dam (2400 MW)

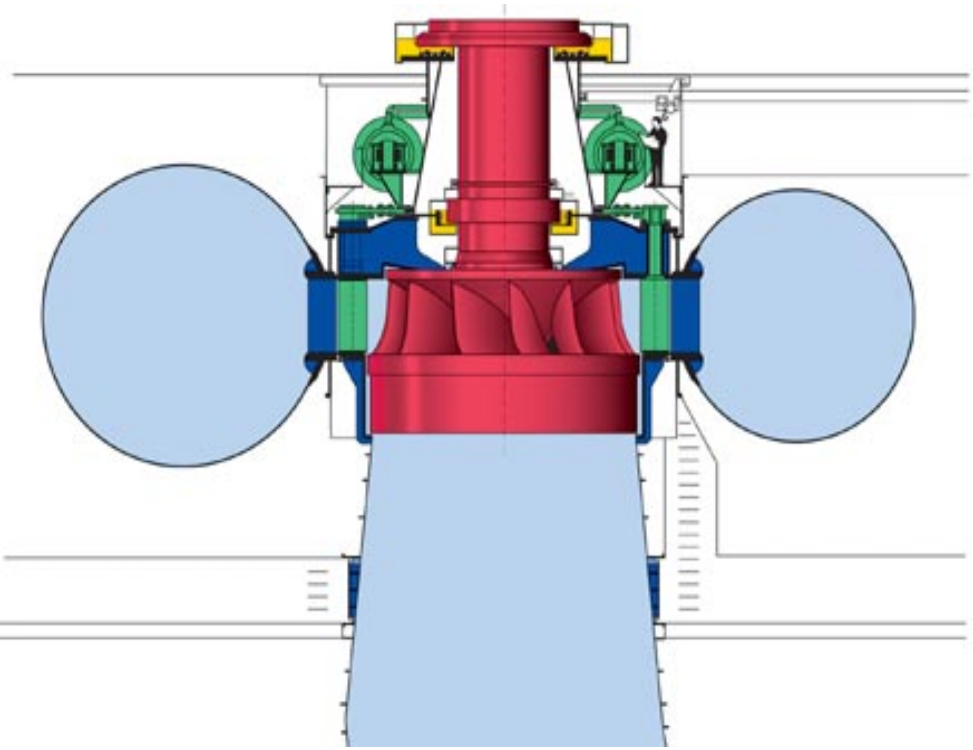


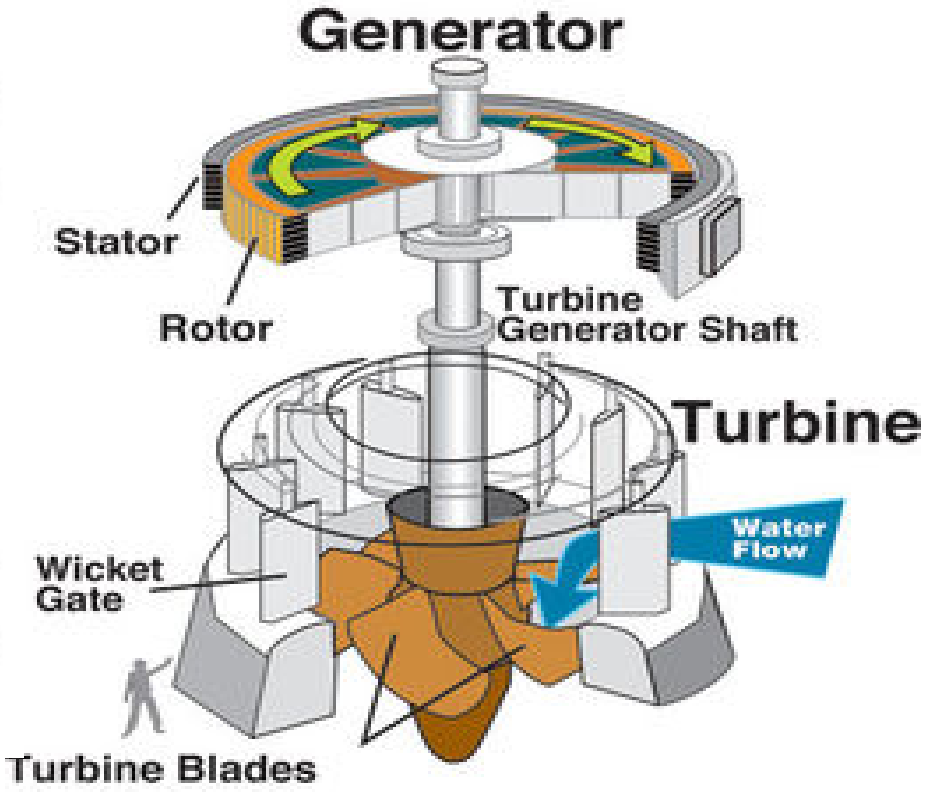


Basic Principles of Electromechanics

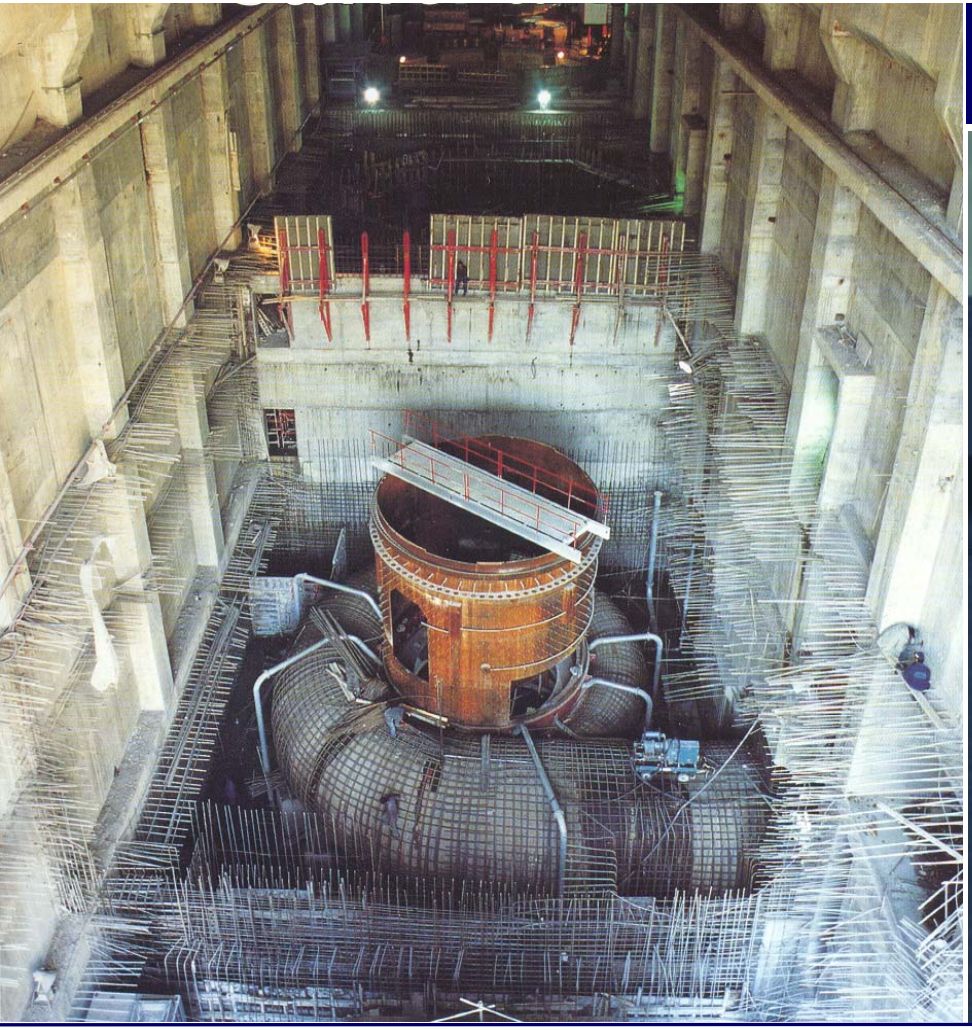
Francis Turbine Generator Set

Cross Section	View

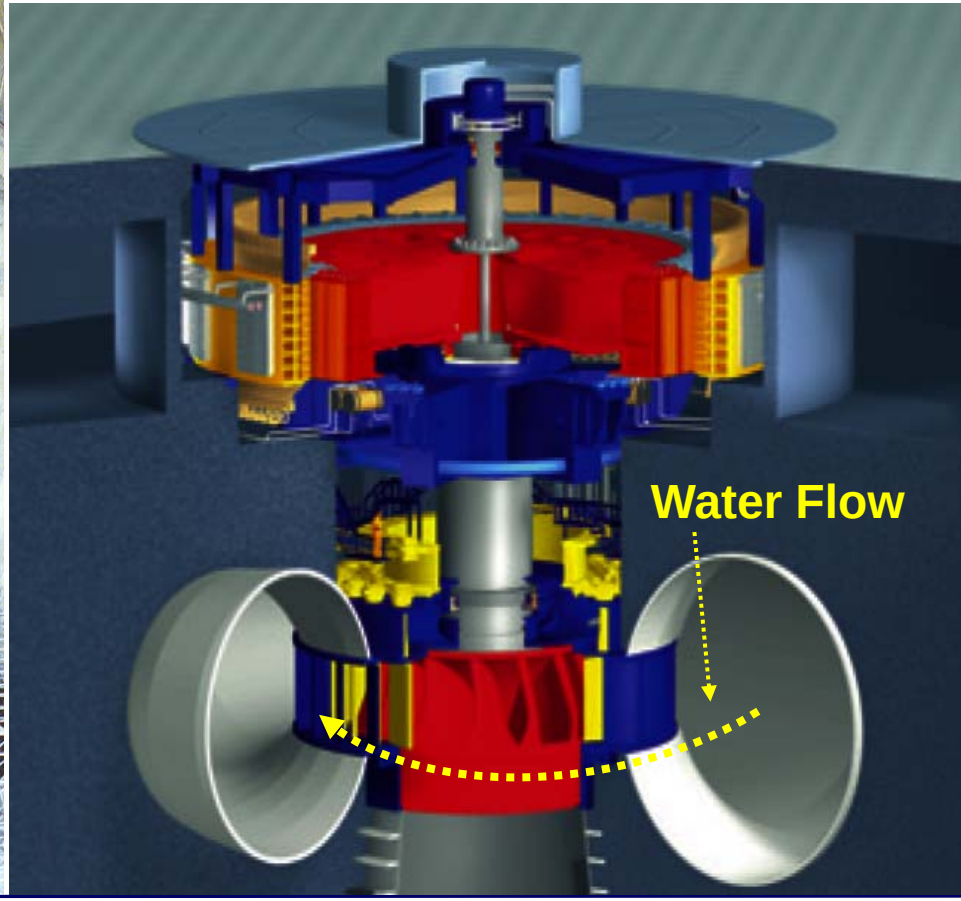




Generation of AC Voltage - Synchronous Generator

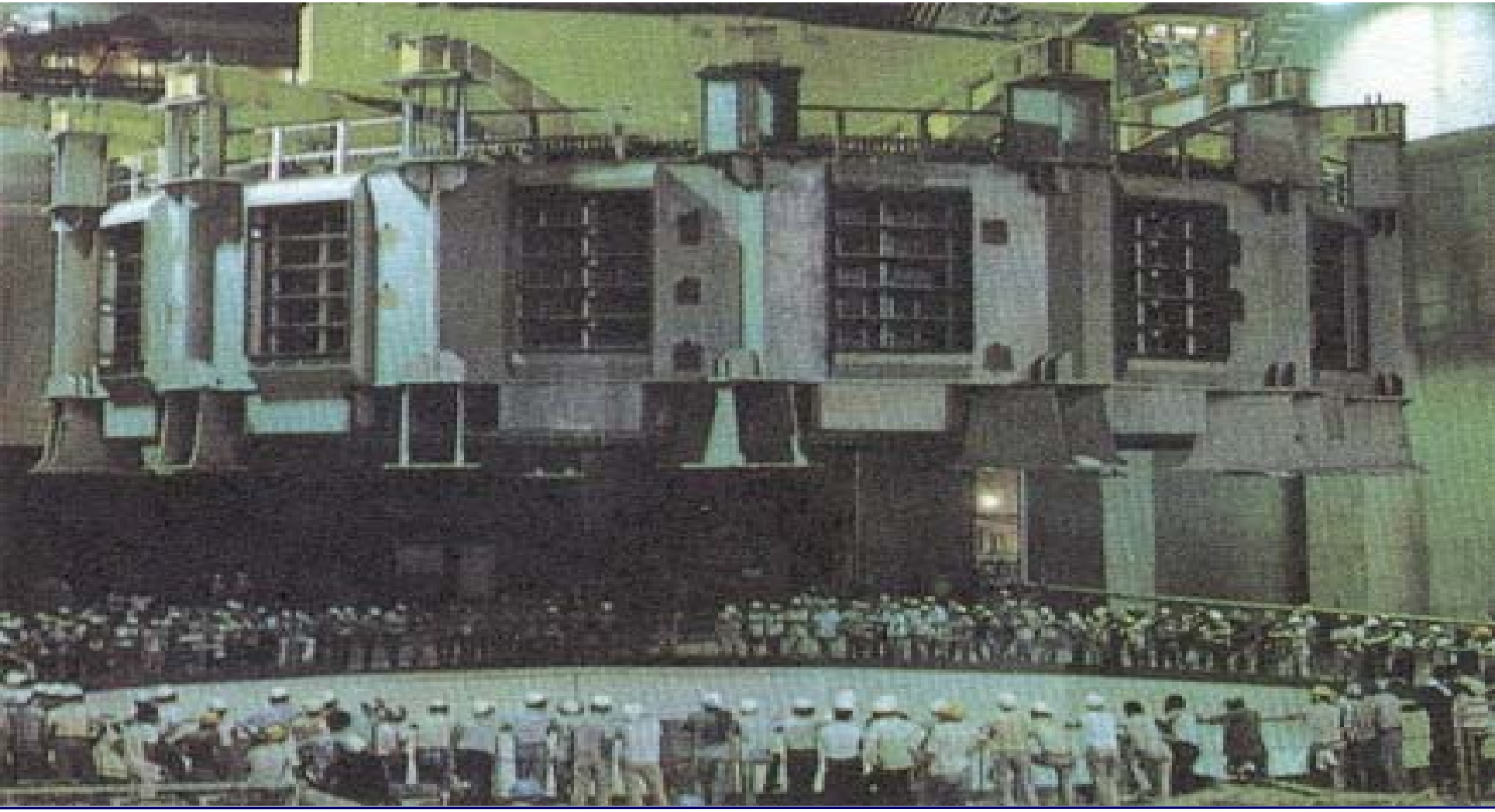


Francis Turbine - Generator



Basic Principles of Electromechanics

Itaipu Generating Unit - Stator



Basic Principles of Electromechanics

Generation of DC Voltage

Fixed Poles, Rotating Coils

Split Ring Rotating Rotor Coil

Fixed Stator Poles

DC Windings

Split Rings

Basic Principles of Electromechanics

Generation of DC Voltage

Fixed Poles, Rotating Coils | *Split Rings* | V_{DC}

Rotating Rotor Coil | *Fixed Stator Poles*

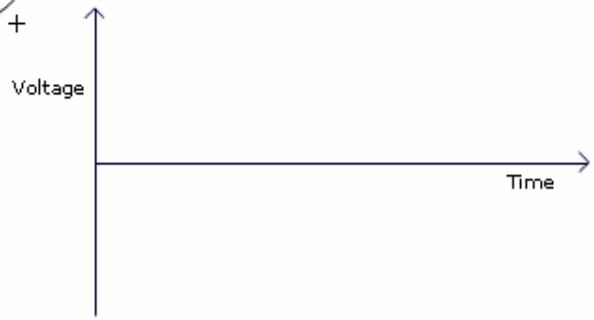
DC Windings

Basic Principles of Electromechanics

Generation of DC Voltage

Fixed Poles, Rotating Coils

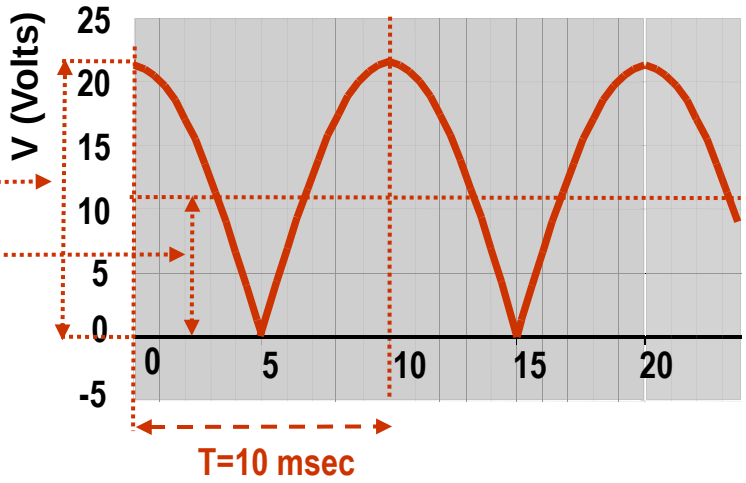
Split Ring Rotating Rotor Coil | *Fixed Stator Poles*



Average Voltage

$V_{peak} = 22\ V$

$V_{average} = V_{DC}$



$$V_{average} = (1/T) \int_0^{10} V(t)\, d/dt$$

$$= (1/5) \int_0^{5} V_{peak} \cos wt\, dt$$

$$= (2/\pi)\, V_{peak} = 0.63\, V_{peak}$$

Basic Principles of Electromechanics

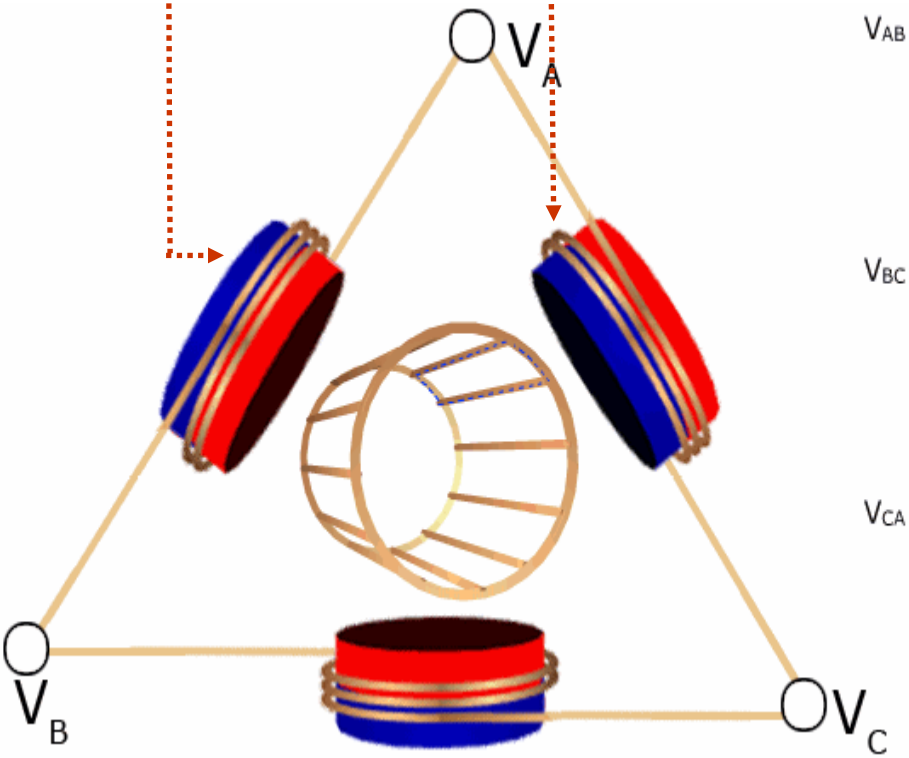
Squirrel Cage AC (Induction) Motors

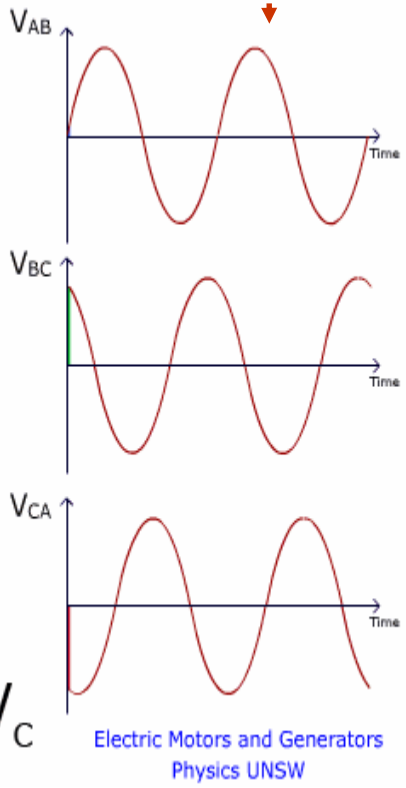
Fixed Poles, Rotating Coils

Fixed Stator Poles

Rotor Coils (Fixed Bars)

Line Voltages Applied





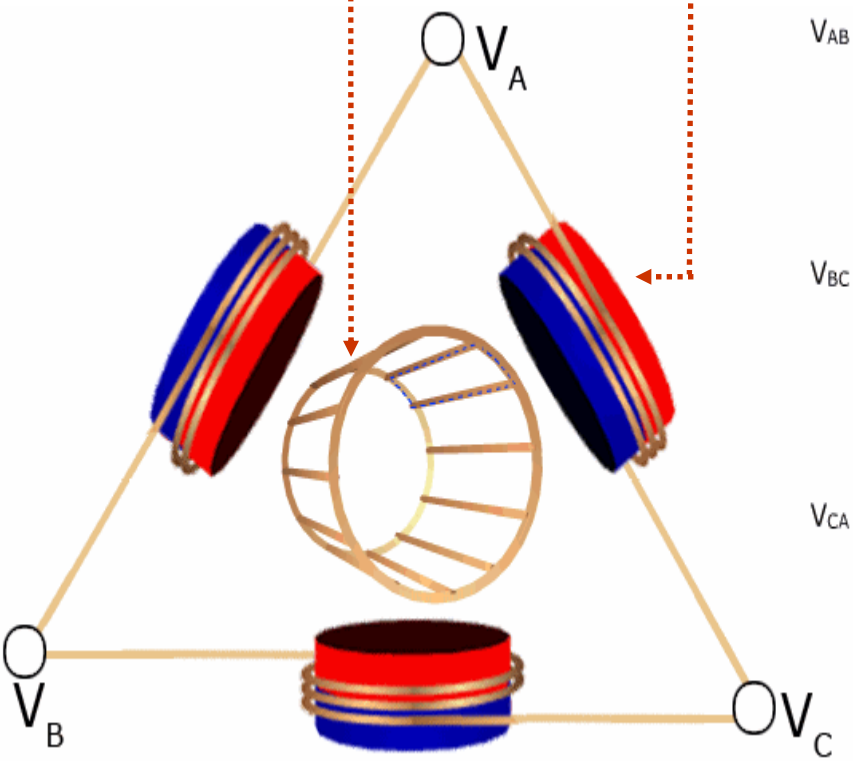
Electric Motors and Generators
Physics UNSW

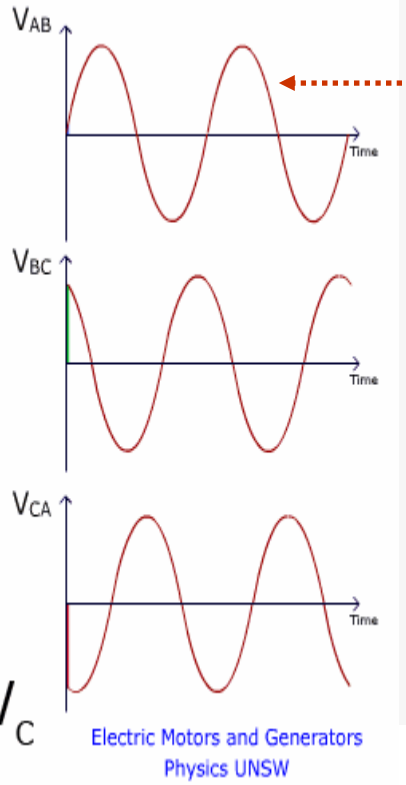
Basic Principles of Electromechanics

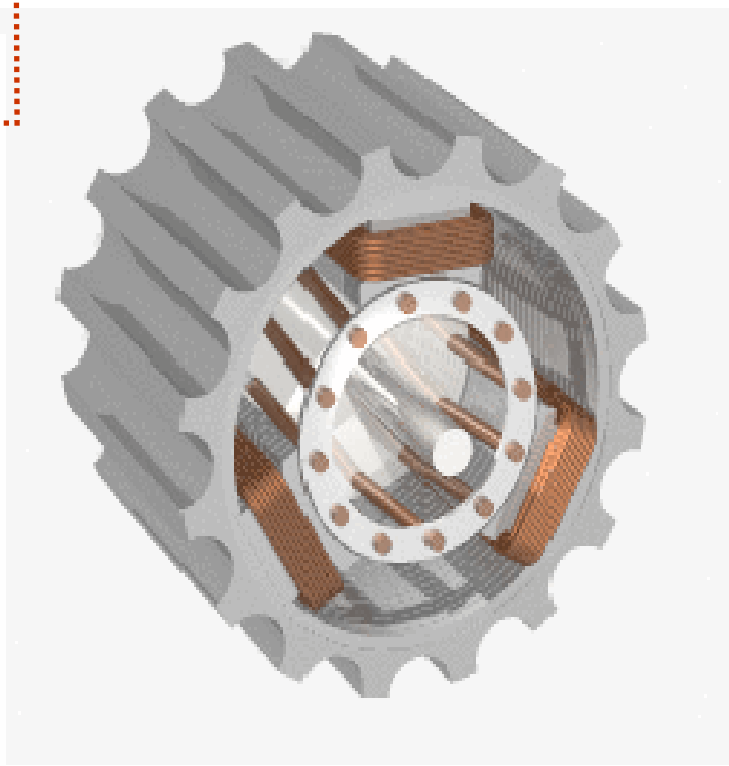
Squirrel Cage AC (Induction) Motors

Fixed Poles, Rotating Coils | **Line Voltages Applied**

Rotor Coils (Fixed Bars) | *Fixed Stator Poles*







Basic Principles of Electromechanics

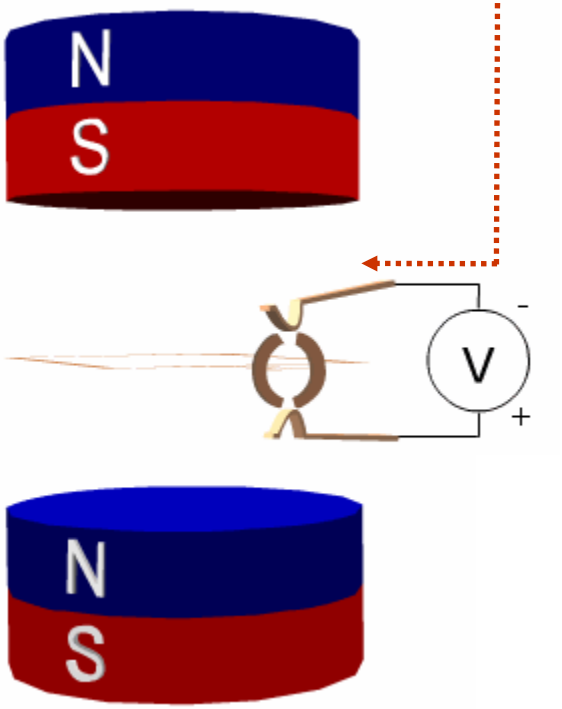
DC Motors

Fixed Poles, Rotating Coils

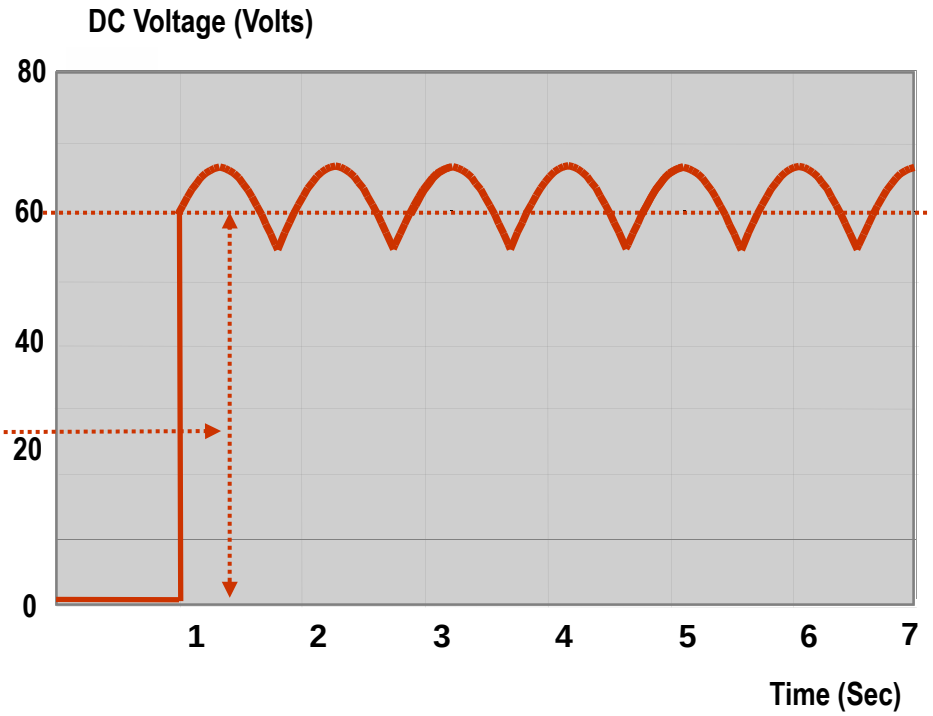
DC Voltage Applied

Fixed Stator Poles

Split Ring Rotor Coils



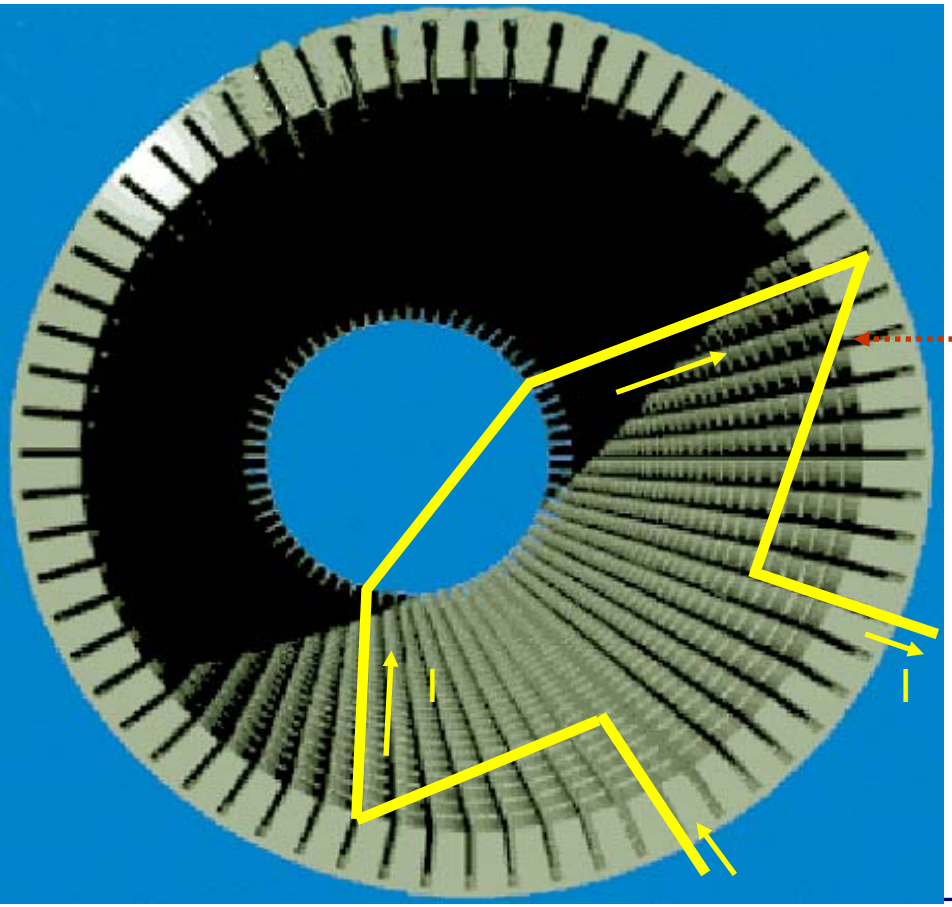
DC (mean) Voltage



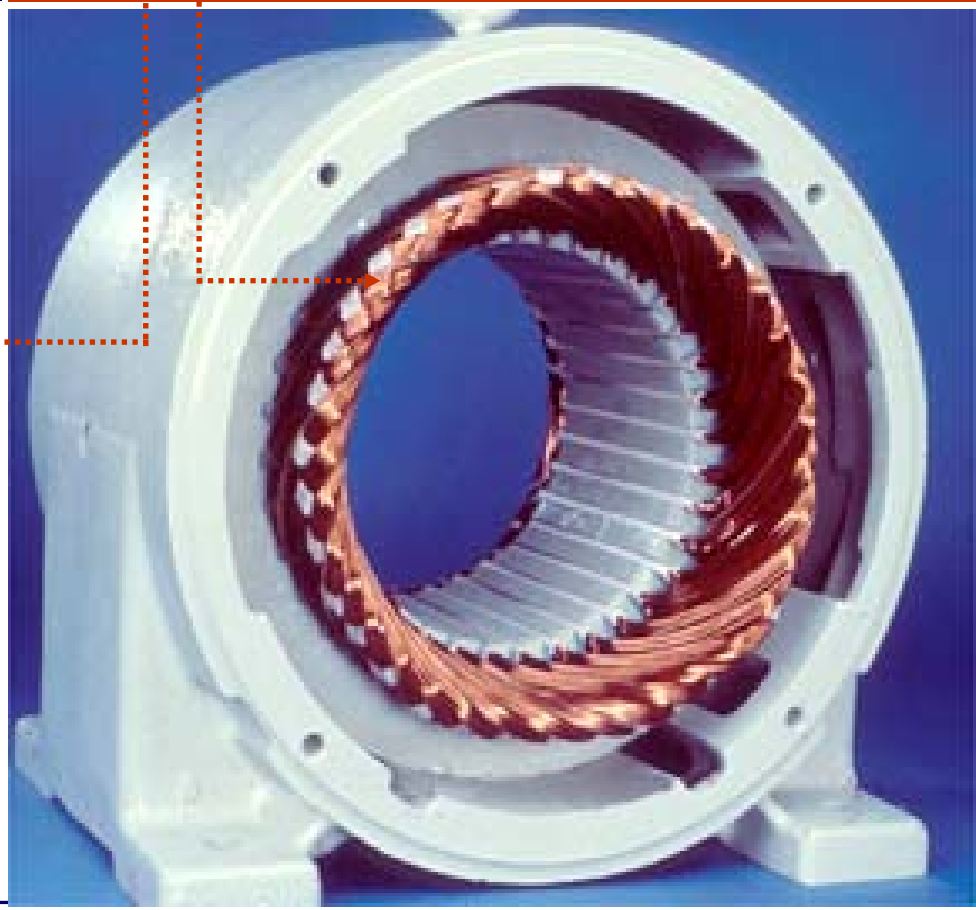
Basic Principles of Electromechanics

Arrangement of Windings

Stator Shell



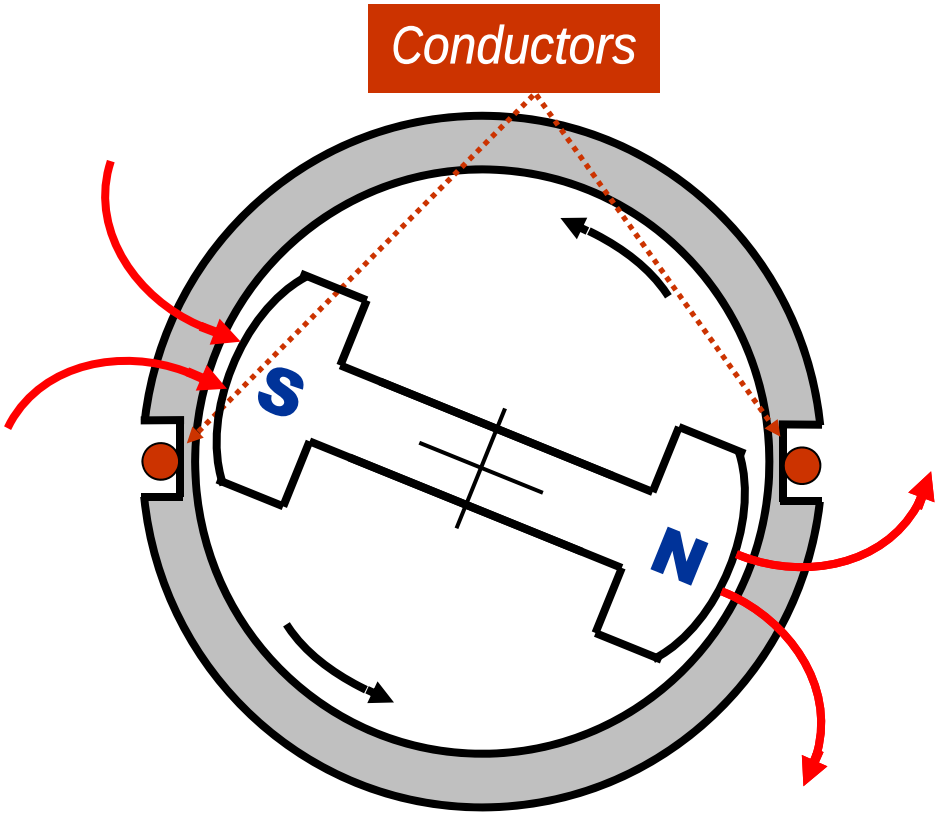
Conductors in Stator Coil



Generation of AC Voltage
Synchronous Generator

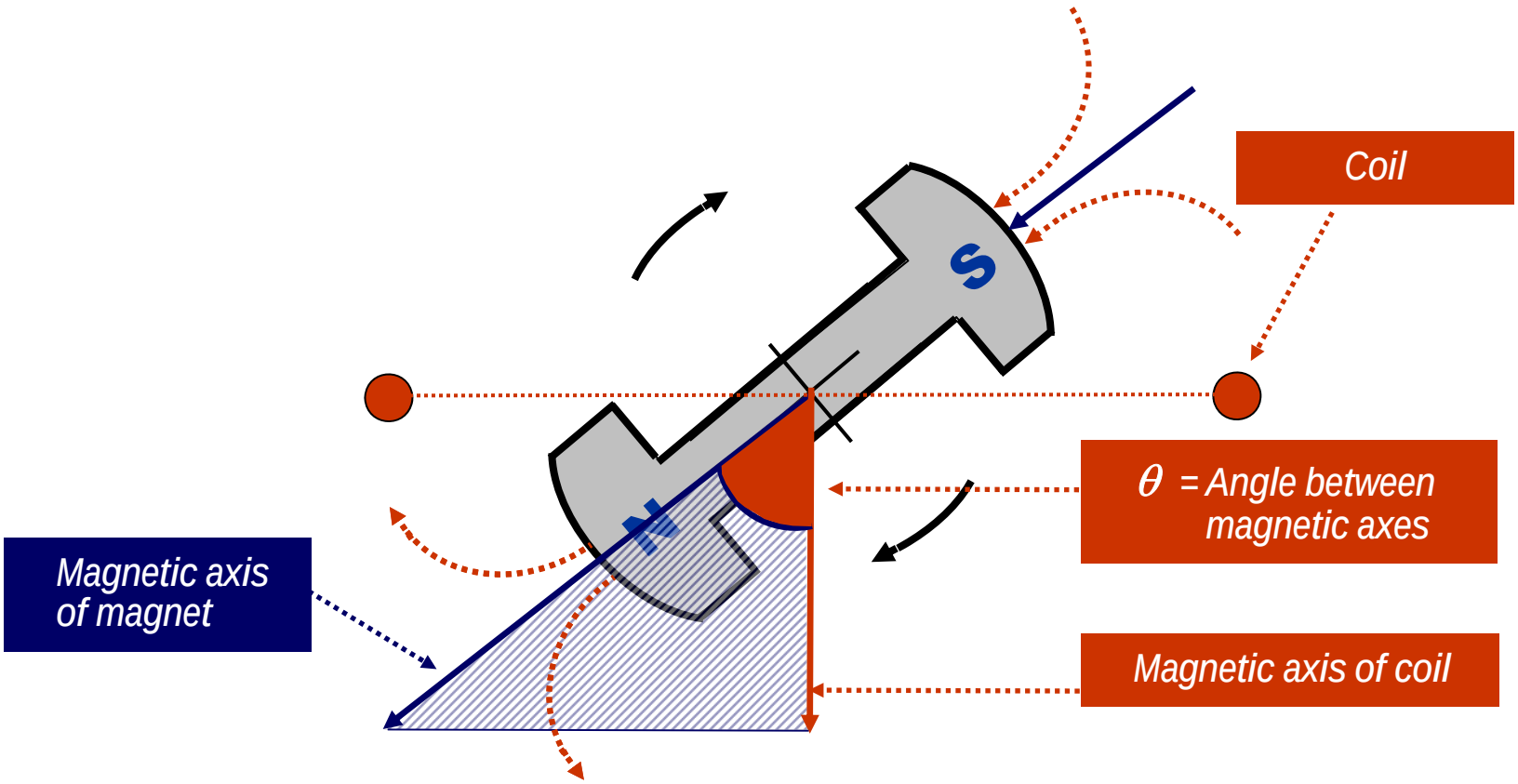
Stator Coils

Configuration



Generation of AC Voltage

Basic Principles of Synchronous Generator



Basic Principles of Electromechanics

Generation of AC Voltage

Basic Relation

$\phi_{coil} = \phi_{max} \times \cos\theta$

$\theta = wt$

$\phi_{coil}(t) = \phi_{max} \times \cos wt$

Lenz Law

$V(t) = - N \, d/dt \, \phi_{coil}(t)$

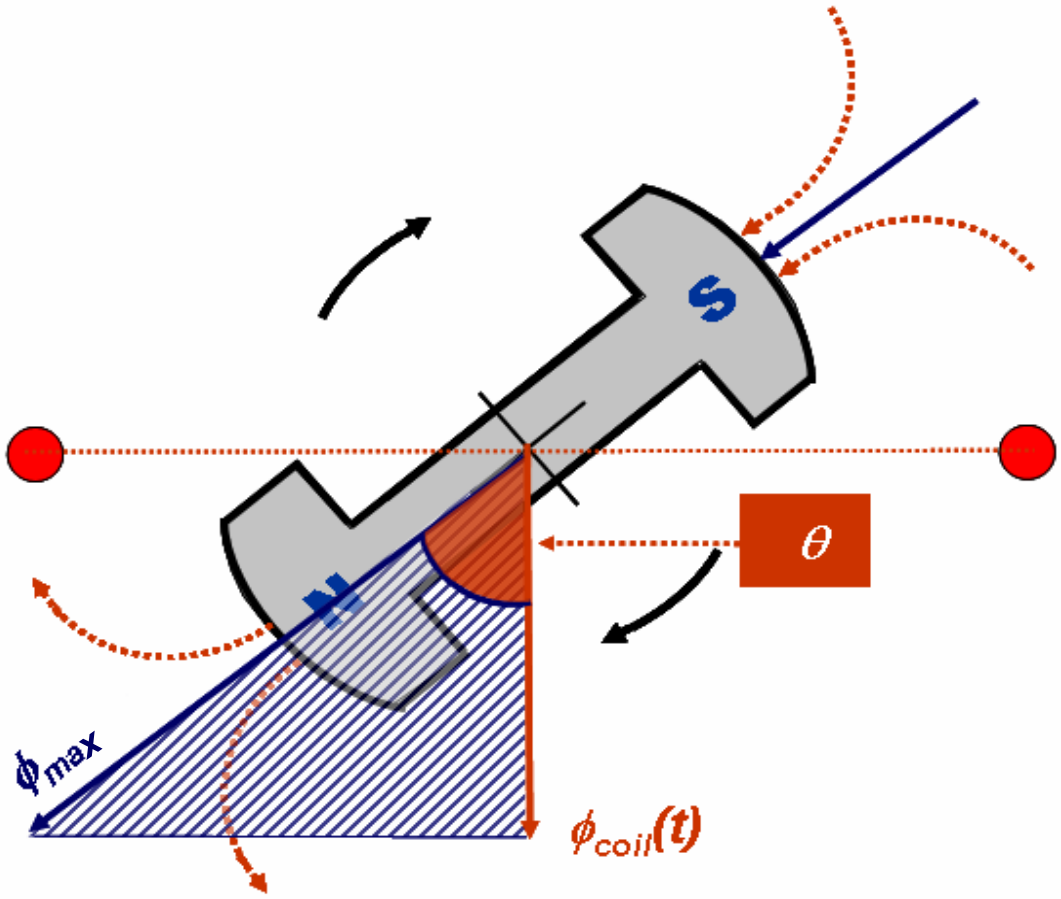
$= - N \, d/dt \, \phi_{max} \times \cos wt$

$= N w \phi_{max} \sin wt$

$= V_{max} \sin wt$

Sinusoidal voltage is generated

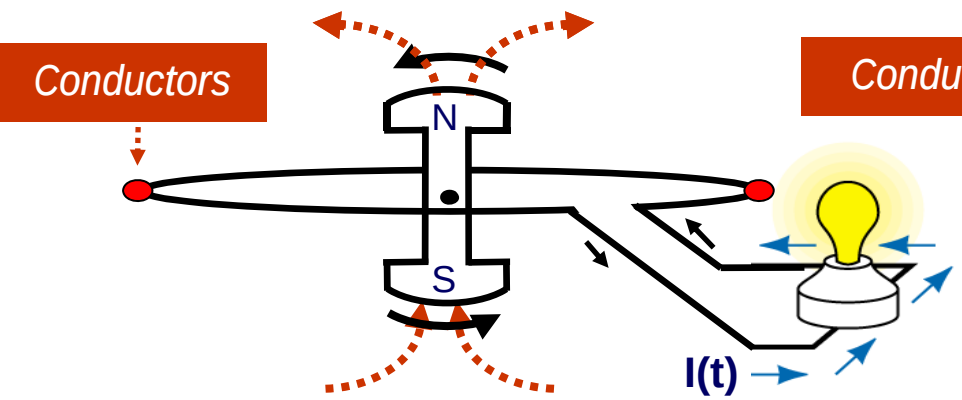
Synchronous Generator

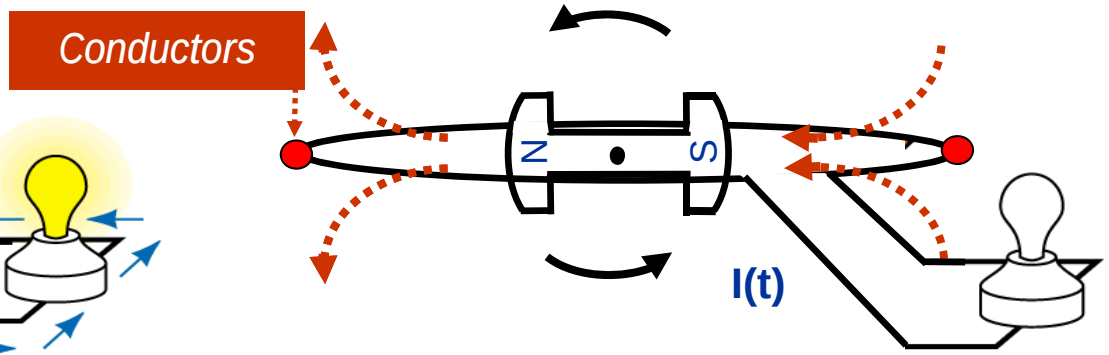


Basic Principles of Electromechanics

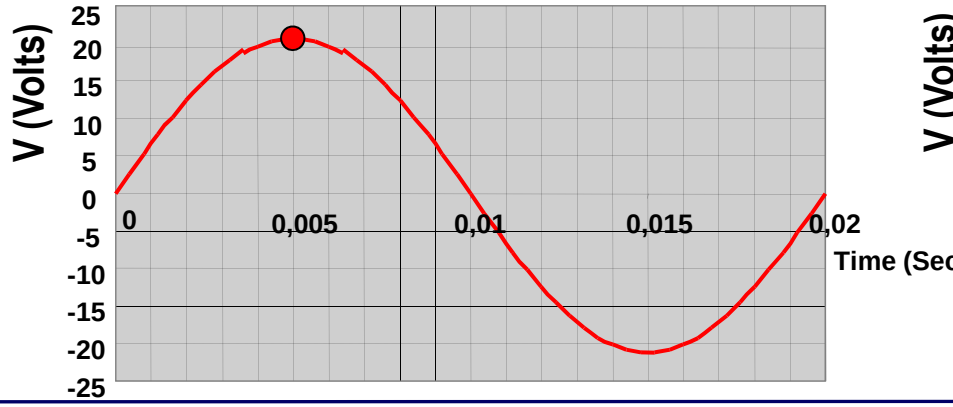
Generation of AC Voltage

Basic Principles of Synchronous Generator

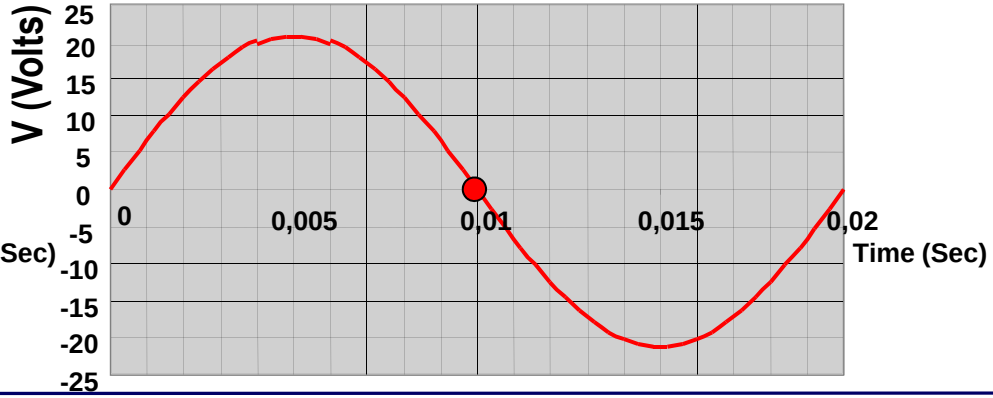




$\phi_{coil}(t) = \phi_{max} \times \cos wt = \phi_{max}$



$\phi_{coil}(t) = \phi_{max} \times \cos wt = 0$



Basic Principles of Electromechanics