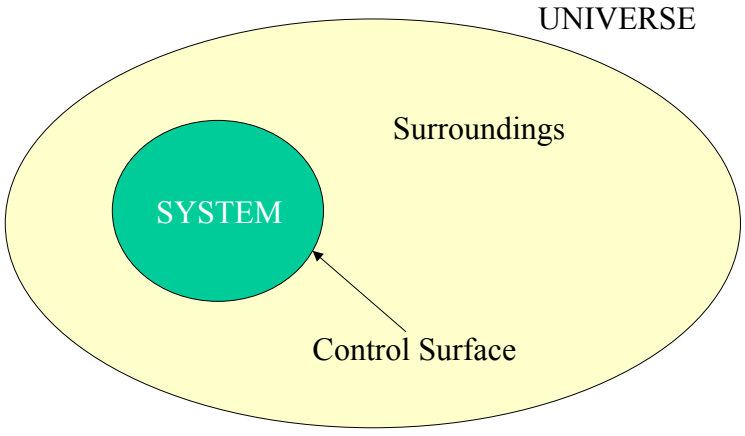
ME242 – MECHANICAL ENGINEERING SYSTEMS

LECTURE 2

- System Reticulation 2.1
- Source-Load Synthesis 2.1
- Generalized Forces and Velocities 2.2

System Reticulation



Reticulate means to make into or like a net

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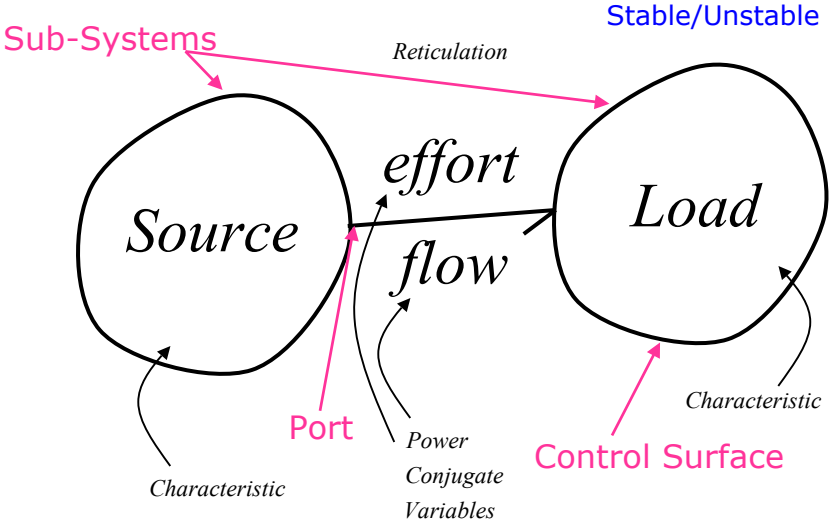
System = Subsystems + meshpoints or bonds of the net

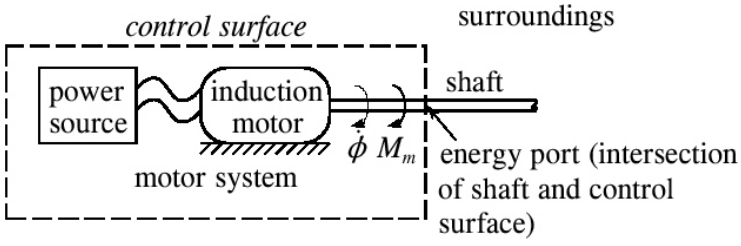
Source-Load Synthesis

Systems → Steady State/Equilibrium → Single/Multiple
Stable/Unstable



Source Subsystem

Induction Motor

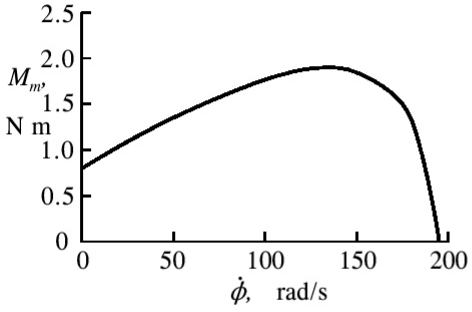


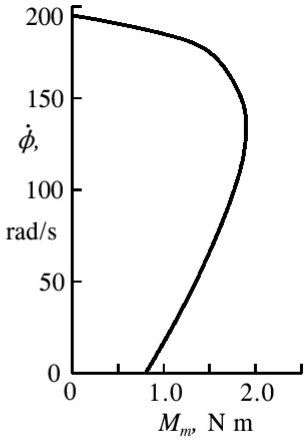
Induction Motor $\frac{M_m}{\dot{\phi}}$

$$P = M_m \dot{\phi}$$

Source Subsystem

Induction Motor - Characteristic

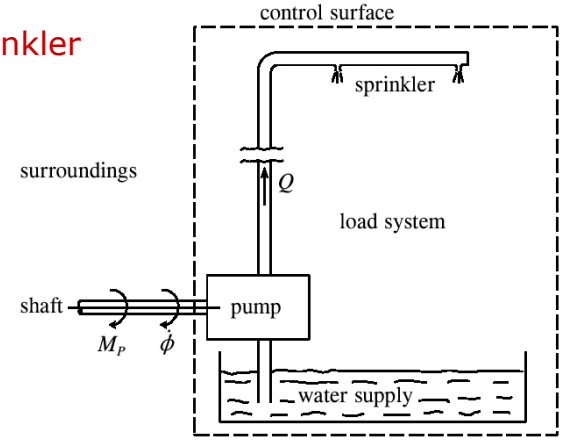




$$M_m = M_m(\dot{\phi}) \qquad \dot{\phi} = \dot{\phi}(M_m)$$

Load Subsystem

Water Sprinkler

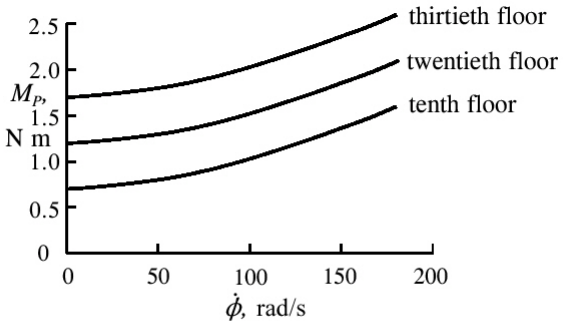


$$\frac{M_p}{\dot{\phi}}$$ Load System

$$\mathrm{P} = M_p \dot{\phi}$$

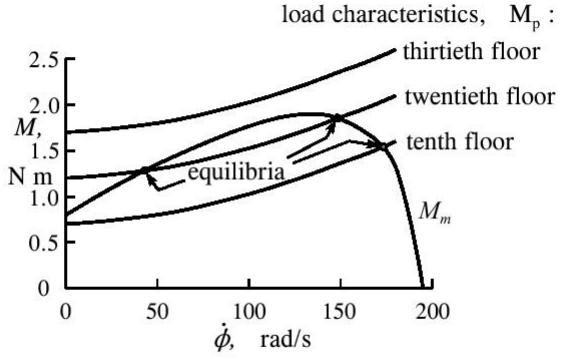
Load Subsystem

Water Sprinkler - Characteristic

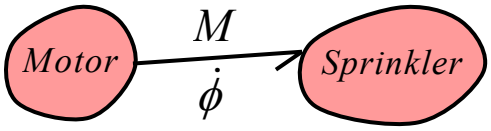


Source-Load Synthesis

Induction Motor ↔ Water Sprinkler



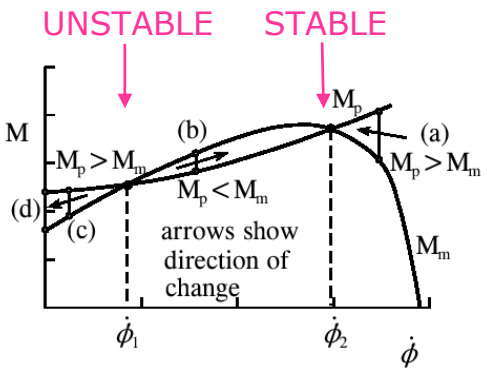
Equilibrium ⇔ Both conjugate variables have common values



Induction Motor $\frac{M}{\dot{\phi}}$ Load System

Source-Load Synthesis: Stability of Equilibrium

Induction Motor ↔ Water Sprinkler



Generalized Forces and Velocities

Power is the product of two conjugate variables

Power = effort (generalized force) × flow (generalized velocity)

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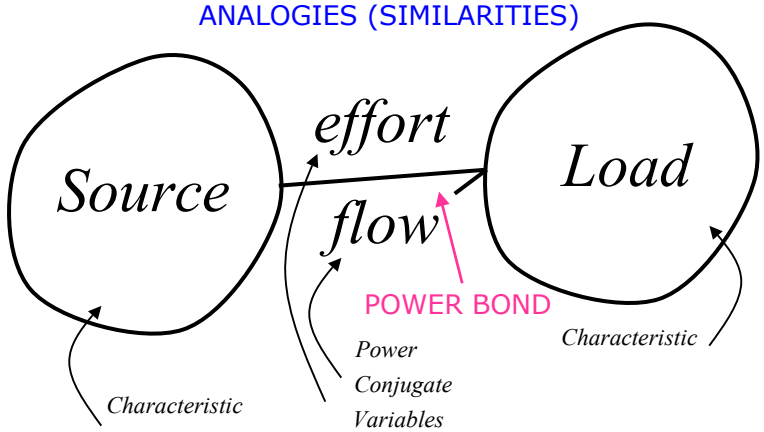
ANALOGIES (SIMILARITIES)



Conjugate Power Variables

effort or generalized force

----labeled as "e" or "ṗ"

flow or generalized velocity

---labeled as either "f" or "q̇"

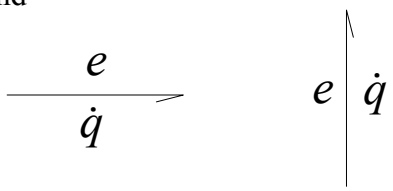
Power = effort × flow

$$\mathrm{P} = e\dot{q}$$

Generalized Forces and Velocities

Convention:

- Effort variable written above a horizontal bond or to the left of a vertical bond
- Flow variable written below a horizontal bond or to the right of a vertical bond



- The half arrow on the bonds indicate the direction that power when $P>0$
- The half arrow should be placed on the flow side of the bond

Generalized Forces and Velocities

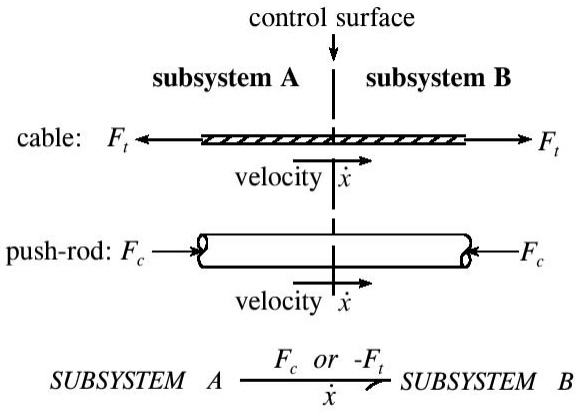
Effort vs. Flow:

examine the variables action onto the system
and the reaction on its environment

if the action/reaction symmetric than scaler
---like forces and voltages, i.e. efforts

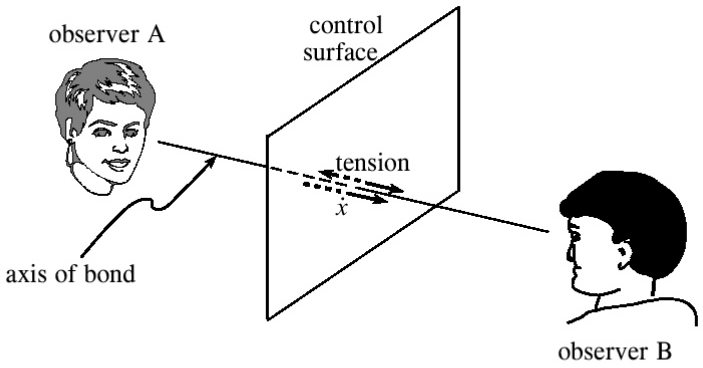
if the action/reaction antisymmetric than vector
---like velocities and currents, i.e. flows

Longitudinal Mechanical Motion



$$\mathrm{P} = -F_t\dot{x}, \text{ or } \mathrm{P} = F_c\dot{x}$$

Generalized Forces and Velocities



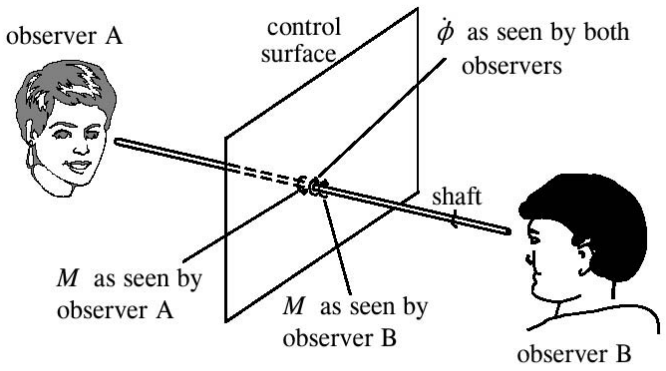
Tension, Compression → Symmetry → Effort
Velocity → Anti-Symmetry → Flow

Rotational Motion

Induction Motor $\xrightarrow[\dot{\phi}]{M_m}$

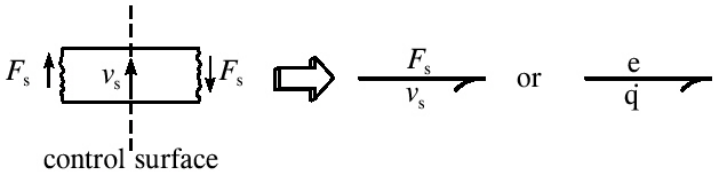
$$\boxed{P = M_m \dot{\phi}}$$

Rotational Motion



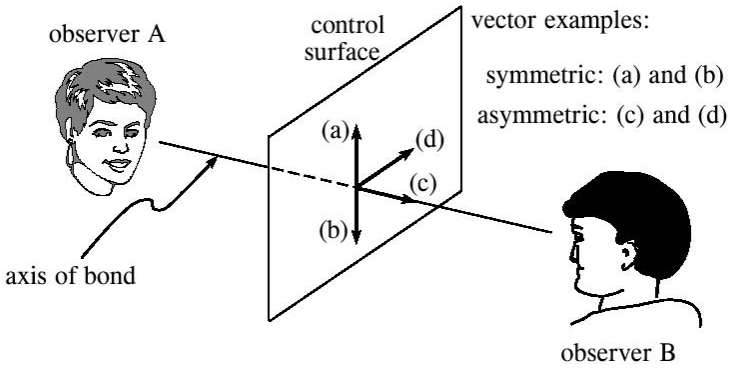
Moment → Symmetry → Effort
Angular Velocity → Anti-Symmetry → Flow

Lateral Motion



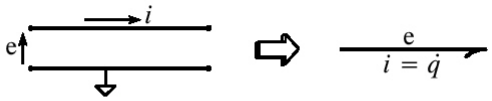
$$P = F_s v_s$$

Lateral Motion



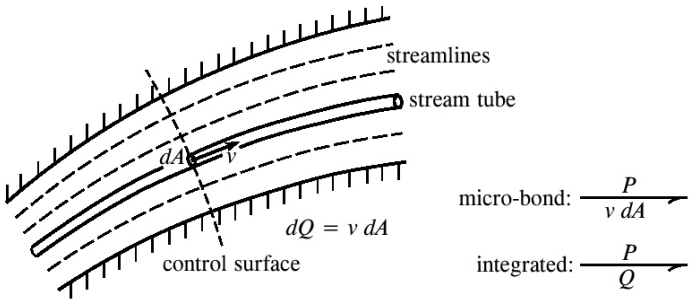
Force → Symmetry → Effort
Angular Velocity → Anti-Symmetry → Flow

Electric Conductor



$$\boxed{P = ei}$$

Incompressible Fluid Flow



$$\mathrm{P} = PQ$$

Generalized Forces and Velocities

	Generalized Force or Effort, e	Generalized Velocity or Flow, $\dot{q}$
Mechanical Longitudinal	F_c	$v = \dot{x}$
Mechanical Transverse: Rotation Translation (Shear)	 M F_s	 $\dot{\phi}$ v_s
Electric Conductor	e	i
Incompressible Fluid	P	$Q = \dot{V}$

Mechanical Systems ↔ ANALOGY ↔ Electrical Systems