ME242 – MECHANICAL ENGINEERING SYSTEMS

LECTURE 3:

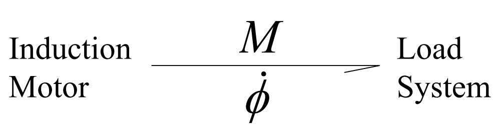
- Generalized Sources, Sinks and Resistances 2.3

HOMEWORK 1: Due on 1/28/05

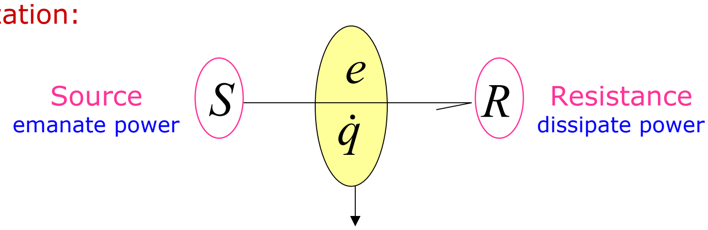
- Read Section 1.6 (basic but fundamental)
- Problem 1.2
- Problem 1.3
- Problem 2.3
- Problem 2.4
- Problem 2.6
- Problem 2.15
- Problem 2.16
- Problem 2.17

GENERALIZED SOURCES, SINKS, RESISTANCES

Case study of last class:



Generalization:



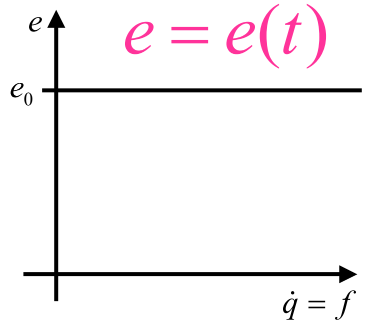
Any energy type:
-Mechanical (rotational, lateral, longitudinal)
-Fluid
-Electrical

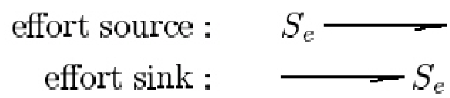
INDEPENDENT EFFORT SOURCES AND SINKS

EFFORT:

An independent-effort source (usually called simply an effort source), and a independent-effort sink (usually called simply an effort sink), are defined to have efforts that are independent of their flows.

$$e = e(t)$$



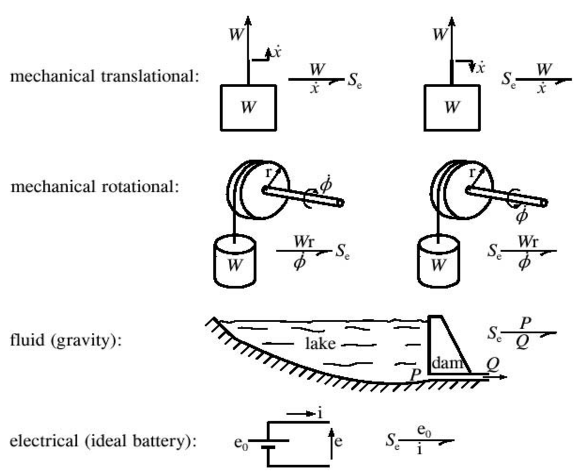


They are the SAME!!!

Effort SINK = Effort SOURCE with $P<0$

INDEPENDENT EFFORT SOURCES AND SINKS

Examples:

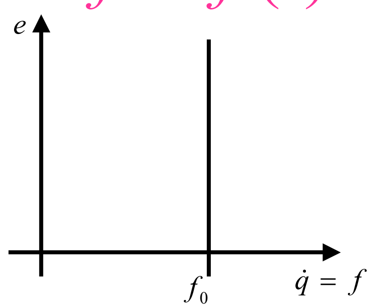


INDEPENDENT FLOWS SOURCES AND SINKS

FLOW:

An independent-flow source (usually called simply a flow source), and a independent-flow sink (usually called simply a flow sink), are defined to have efforts that are independent of their flows.

$$f = f(t)$$



flow source : S_f ——⇀

flow sink : ——⇀ S_f

They are the SAME!!!

Flow SINK = Flow SOURCE with $P<0$

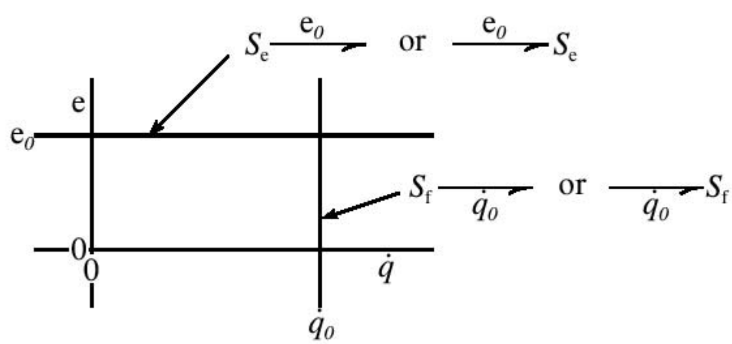
INDEPENDENT FLOW SOURCES AND SINKS

Examples:

- Synchronous motor turning at constant speed (determined by AC voltage)
- Constant current source
- Constant velocity source
- Fluid flow source such as a stream

In all these cases the flow does not depend on the effort!

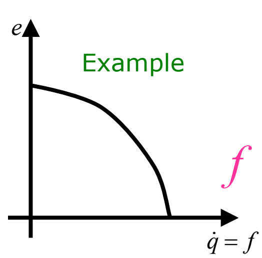
INDEPENDENT SOURCES AND SINKS



GENERAL SOURCES AND SINKS (RESISTANCE)

A GENERAL SOURCE can represent any prescribed (static) relationship between its effort and its flow

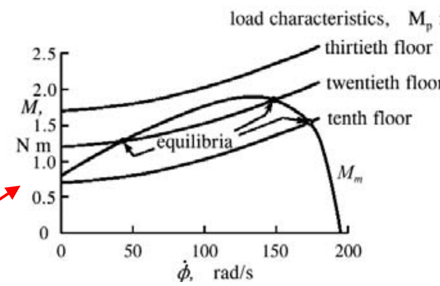
A GENERAL SINK (RESISTANCE) can represent any prescribed (static) relationship between its effort and its flow



$$f = f(e), e = e(f)$$

GENERAL SOURCES

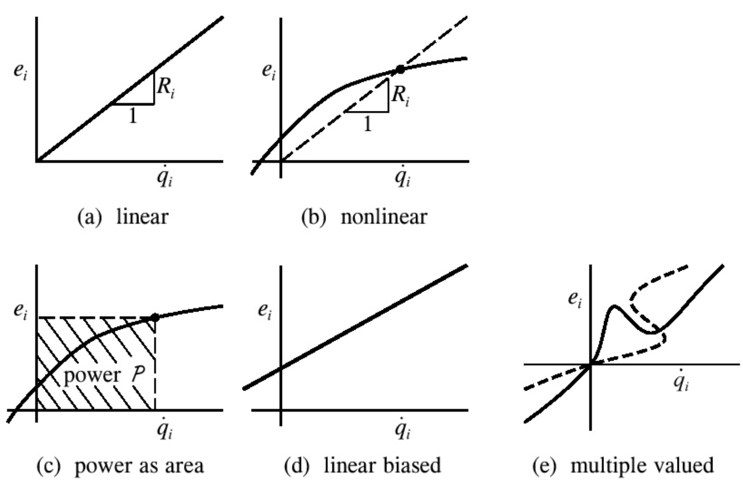
Examples:



- Induction motor
- Battery with voltage dependent on current draw
- Velocity dependent force in a mechanical system
- Pressure source dependent on fluid flow

(GENERALIZED SINKS) RESISTANCES

Examples:

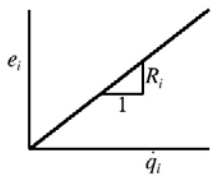


Types of Resistances

LINEAR RESISTANCES

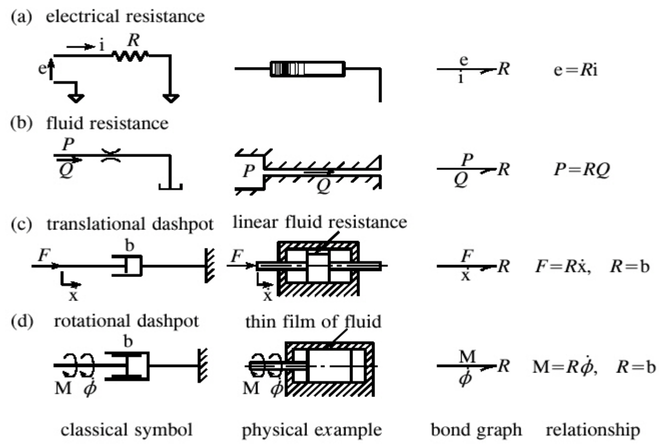
Examples:

$$\frac{e}{\dot{q}} \rightharpoondown R$$



(a) linear

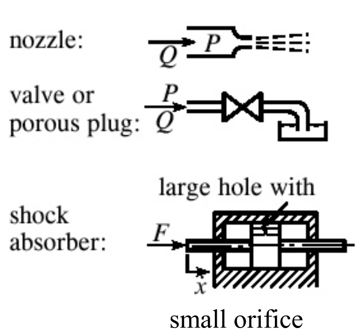
$$e = R\dot{q}$$



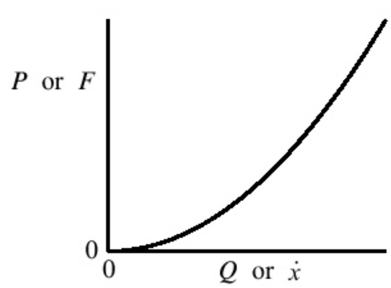
Algebra is never included within a bond graph!
The algebraic relationship is written separately

NONLINEAR RESISTANCES

Examples:



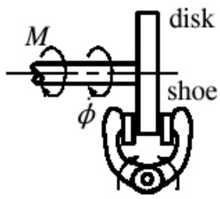
$$\frac{e}{\dot{q}} \rightharpoondown R$$

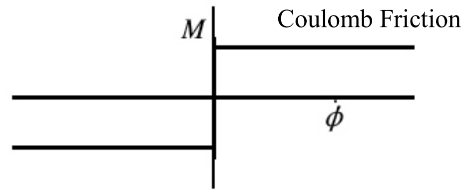


$$e = e(\dot{q})$$

NONLINEAR RESISTANCES

Examples:





Mechanical brake

CORDAL RESISTANCE

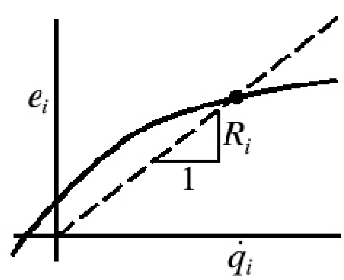
Modulus of resistance, R, is defined as the slope of the chord from the origin to point of interest.

The **chordal resistance** is not constant, it is a function of e or f.

$$e = R(\dot{q})\dot{q}$$

or

$$\dot{q} = e / R(e)$$



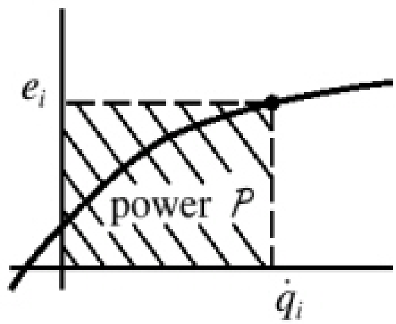
POWER

Power is the product of effort and flow and thus power dissipated by resistance, linear or nonlinear, equals the area of the rectangle shown.

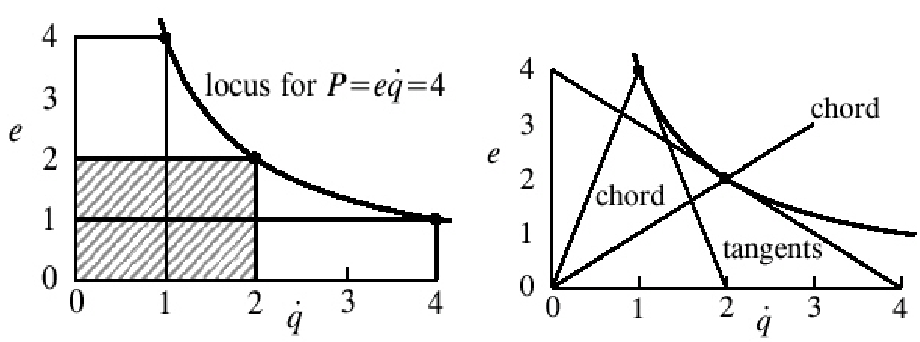
$$Power = R(\dot{q})\dot{q}^2$$

or

$$Power = e^2 / R(e)$$



POWER

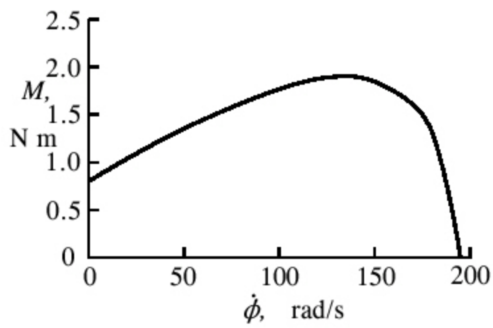


(a) rectangles (b) chords and tangents

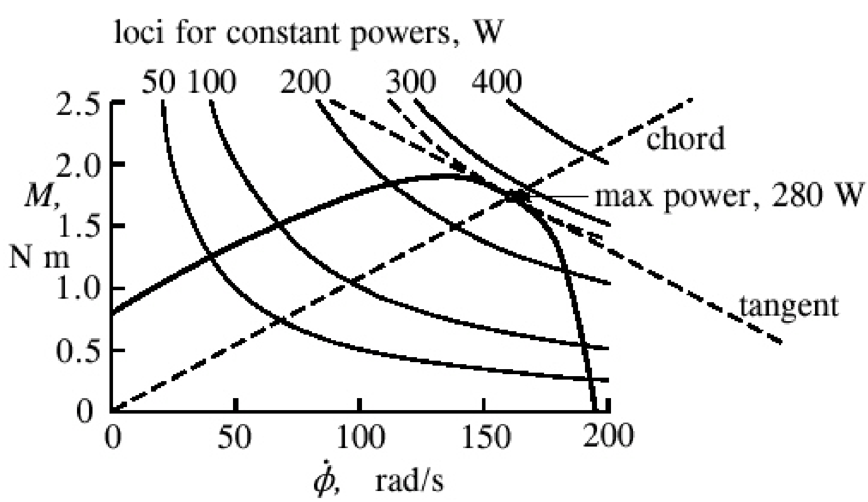
"The slope of a chord drawn from the origin to any point on a locus of constant power equals the magnitude of the slope of the tangent to the locus drawn at the same point"

POWER

Example: Locate the point of maximum power on the torque-speed characteristic of the induction motor as plotted below



POWER



POWER

Example: Find the load impedance that maximizes the power transfer