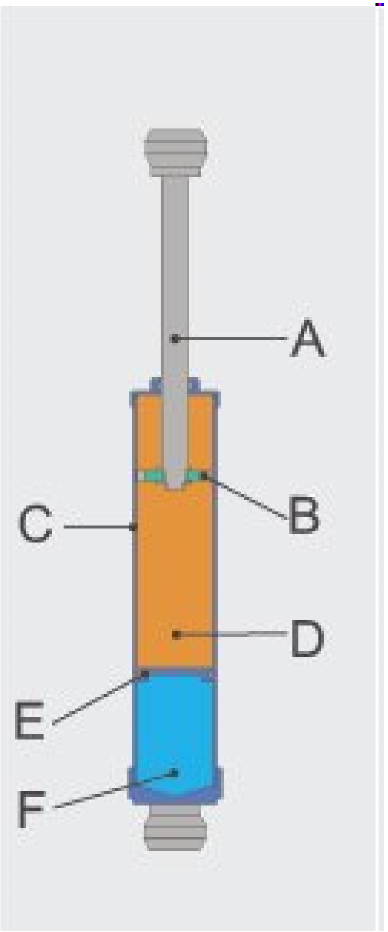
AE 230 - **Modeling and Simulation Laboratory**

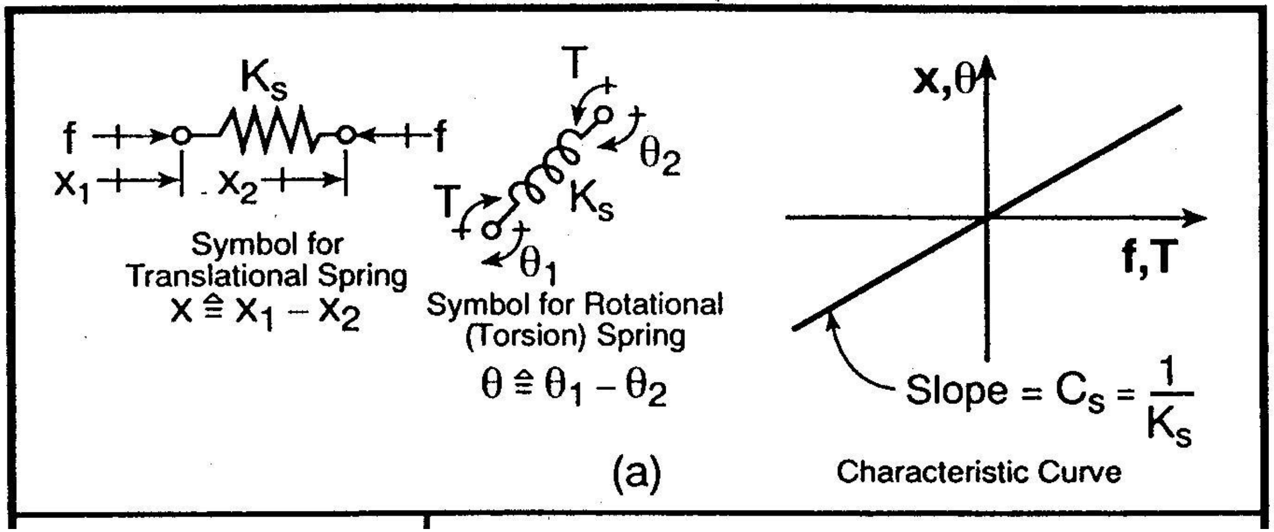


Shock absorber with internal reservoir. The components are:

A - rod,
B - the piston with seals,
C - the cylinder,
D - oil reservoir,
E - floating piston,
F - air chamber.

http://en.wikipedia.org/wiki/Shock_absorber

Mechanical systems



Force acting on the ends of spring $$f = K_s(x_1 - x_2) = K_s x$$

Torque acting on the ends of the spring $$T = K_s(\theta_1 - \theta_2) = K_s \theta$$

Mechanical systems

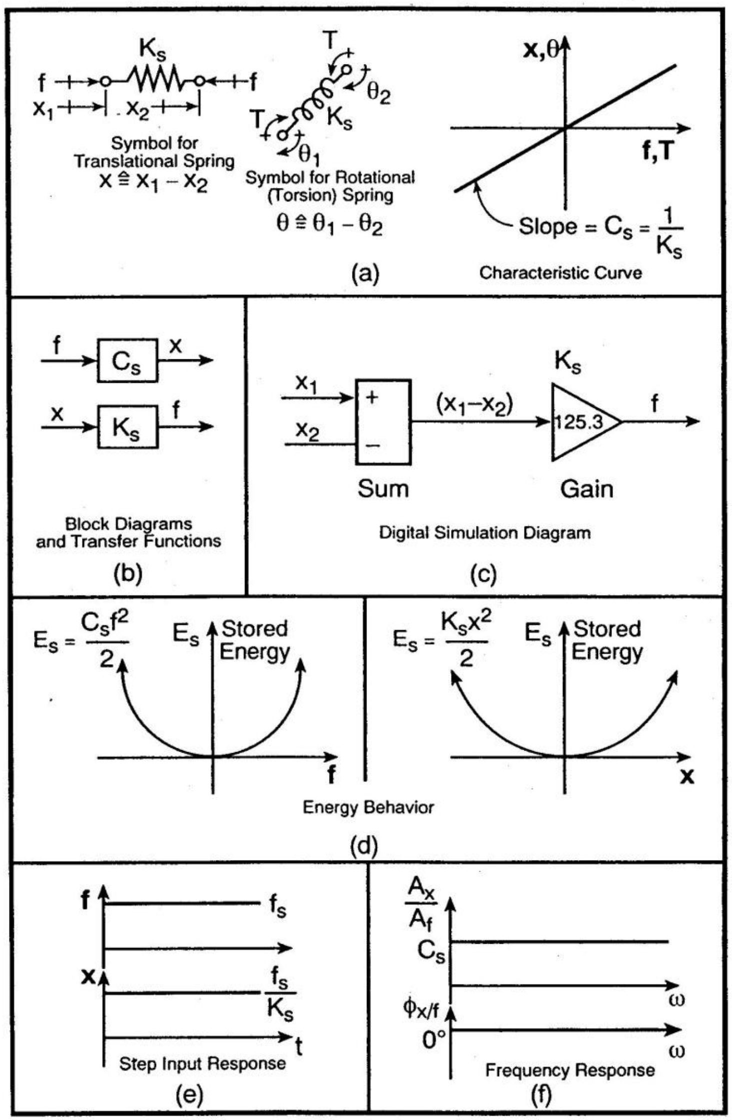
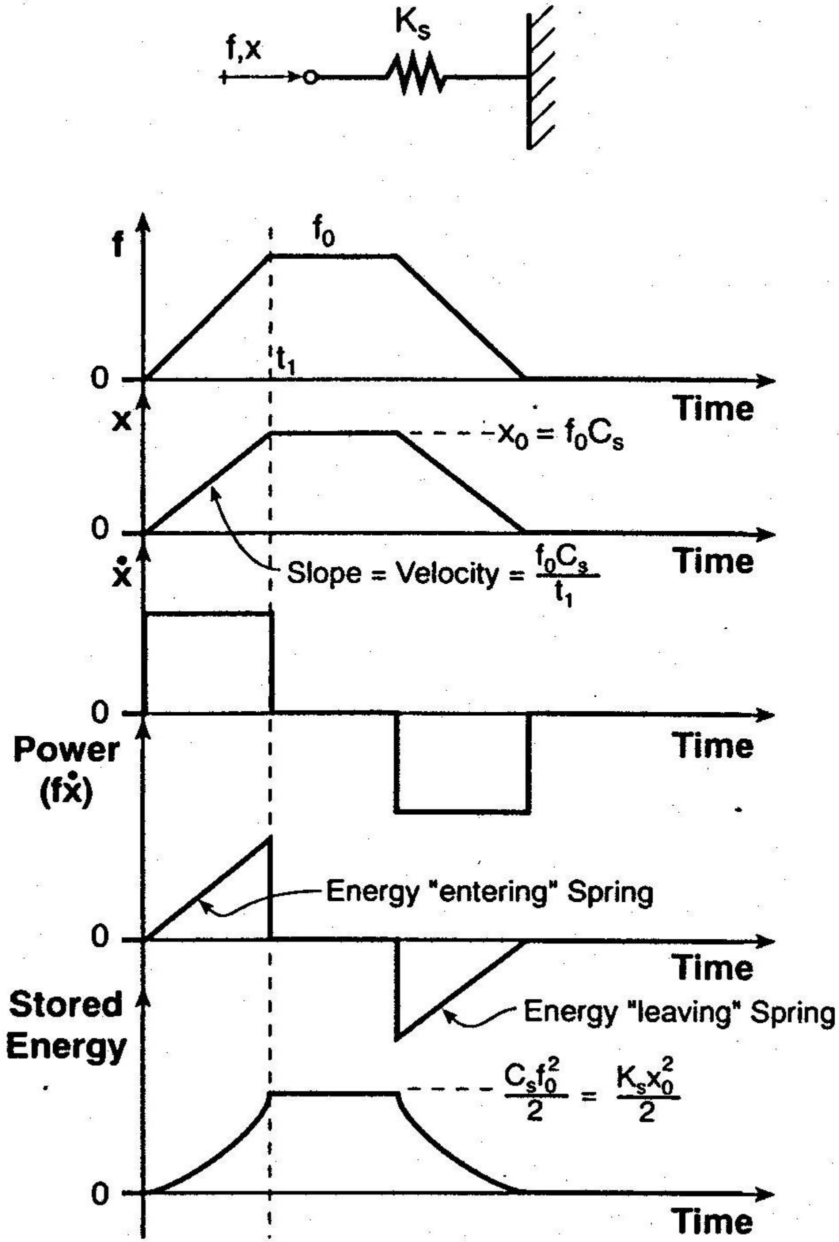


Figure 2-1 The spring element.

Energy stored in the spring

$$E_s = K_s \frac{x_0^2}{2}$$

Mechanical systems



Mechanical systems

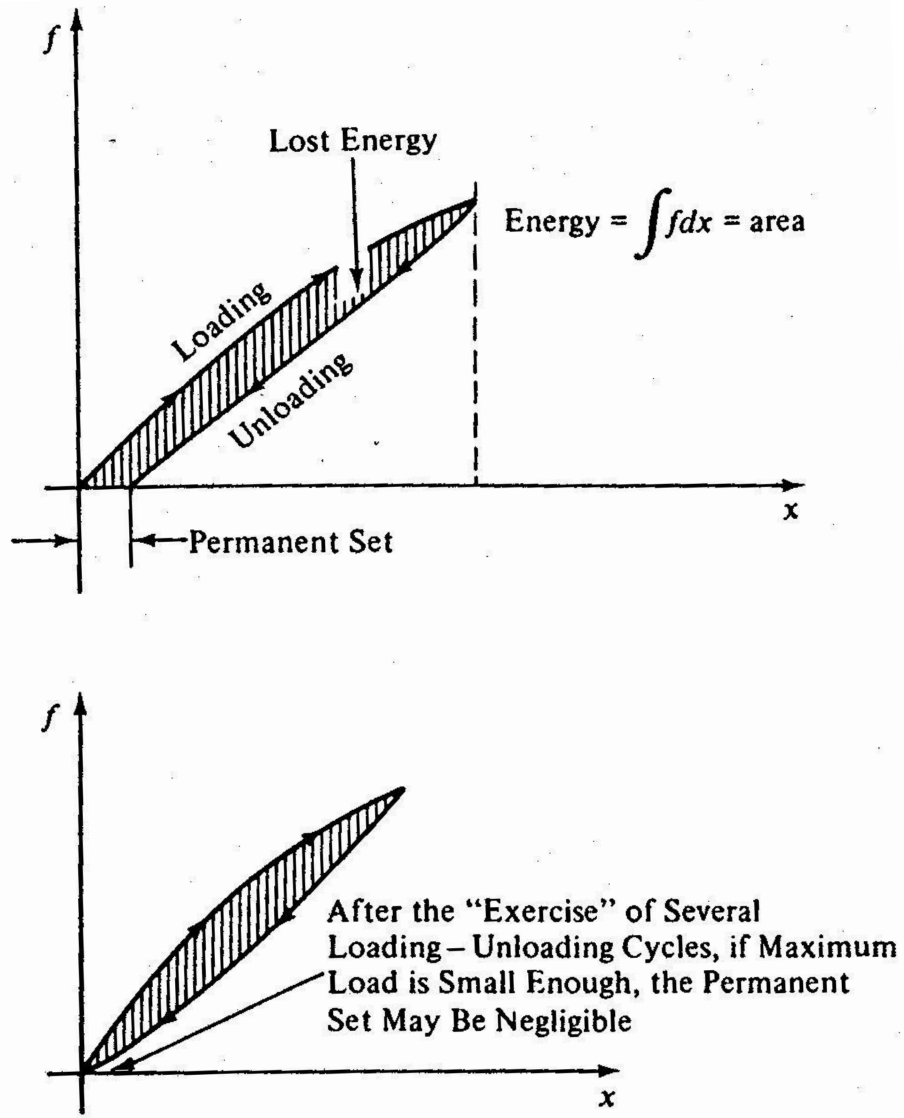
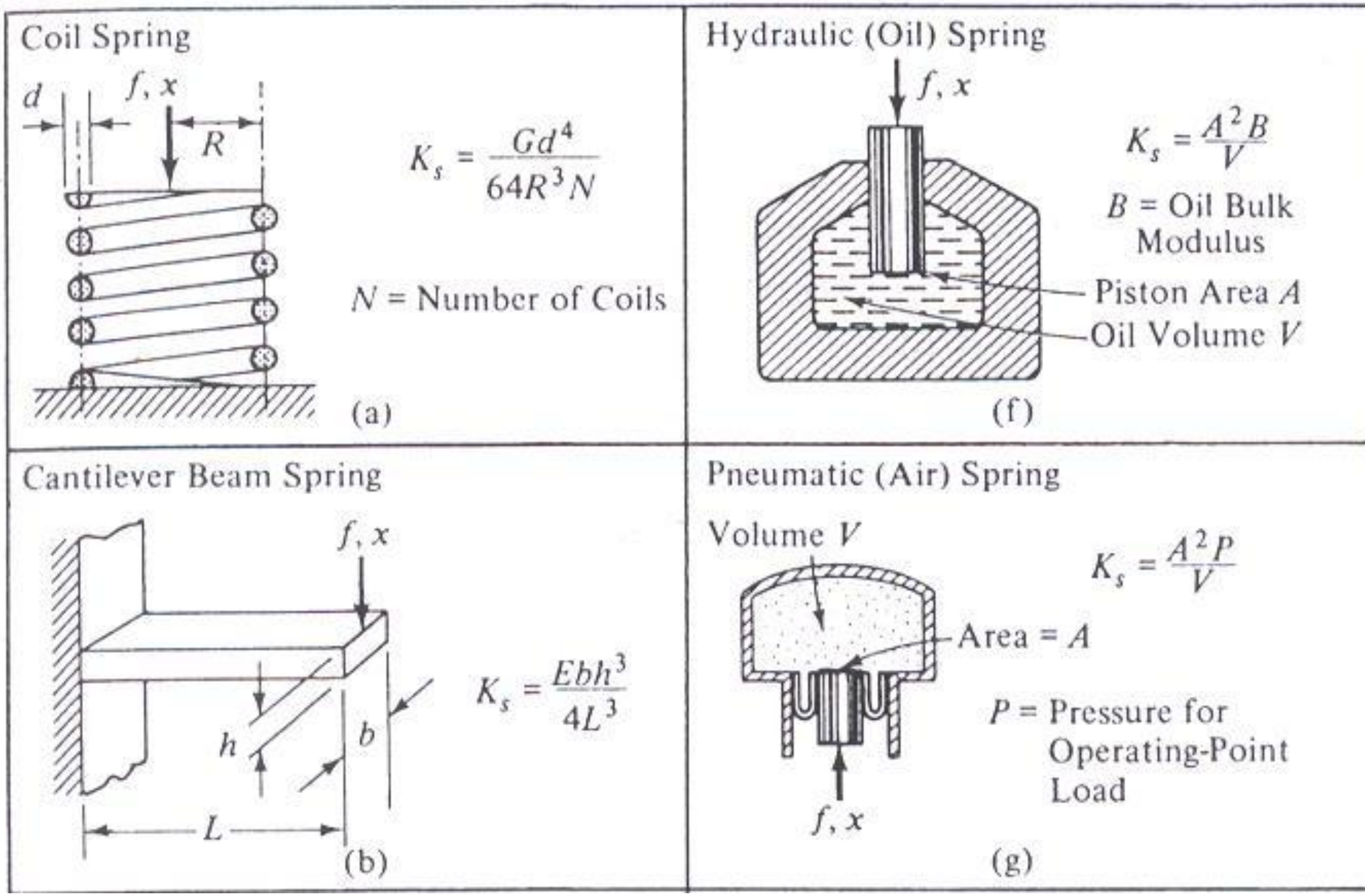
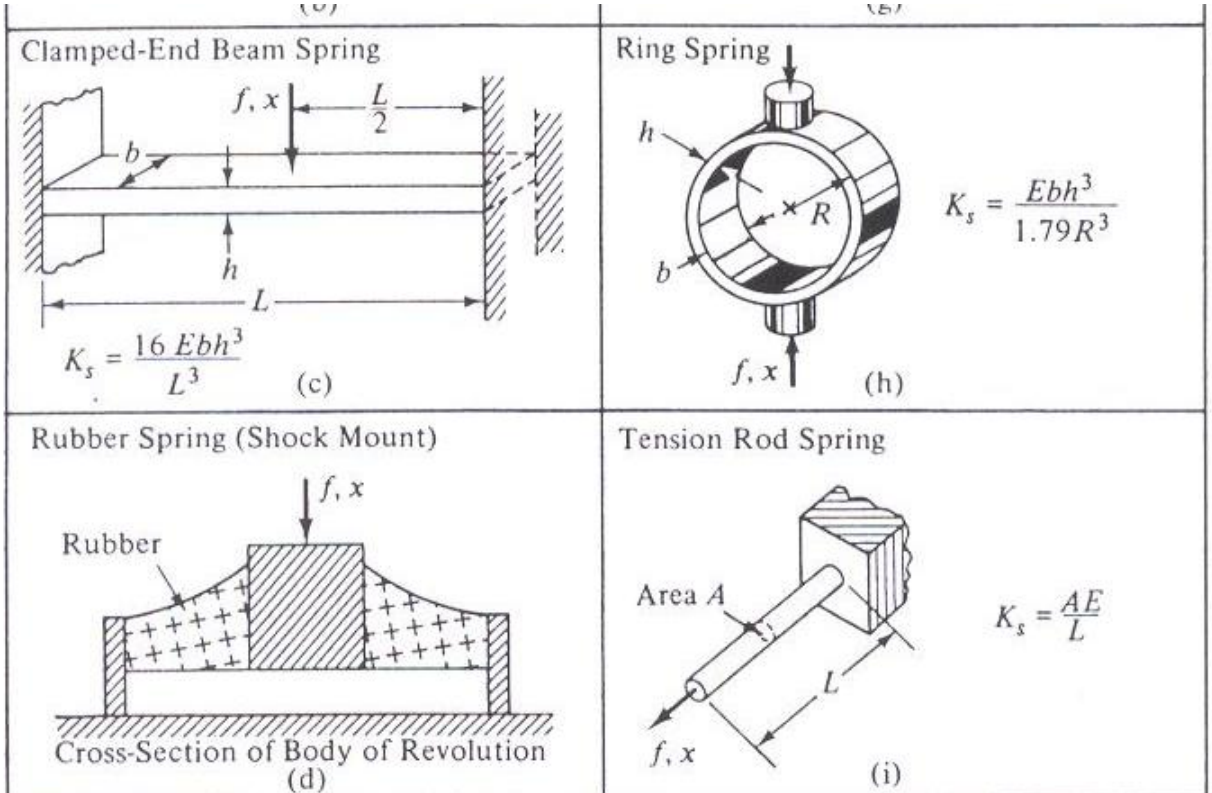


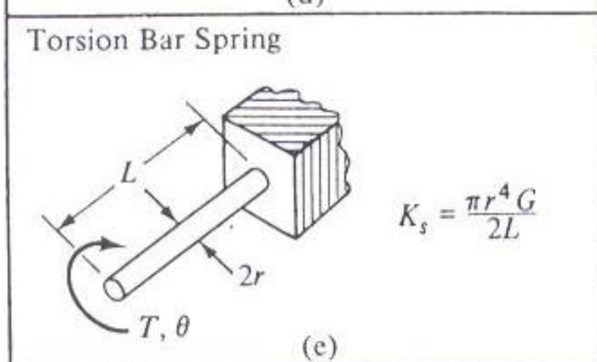
Figure Energy losses in real springs.

Mechanical systems



Mechanical systems



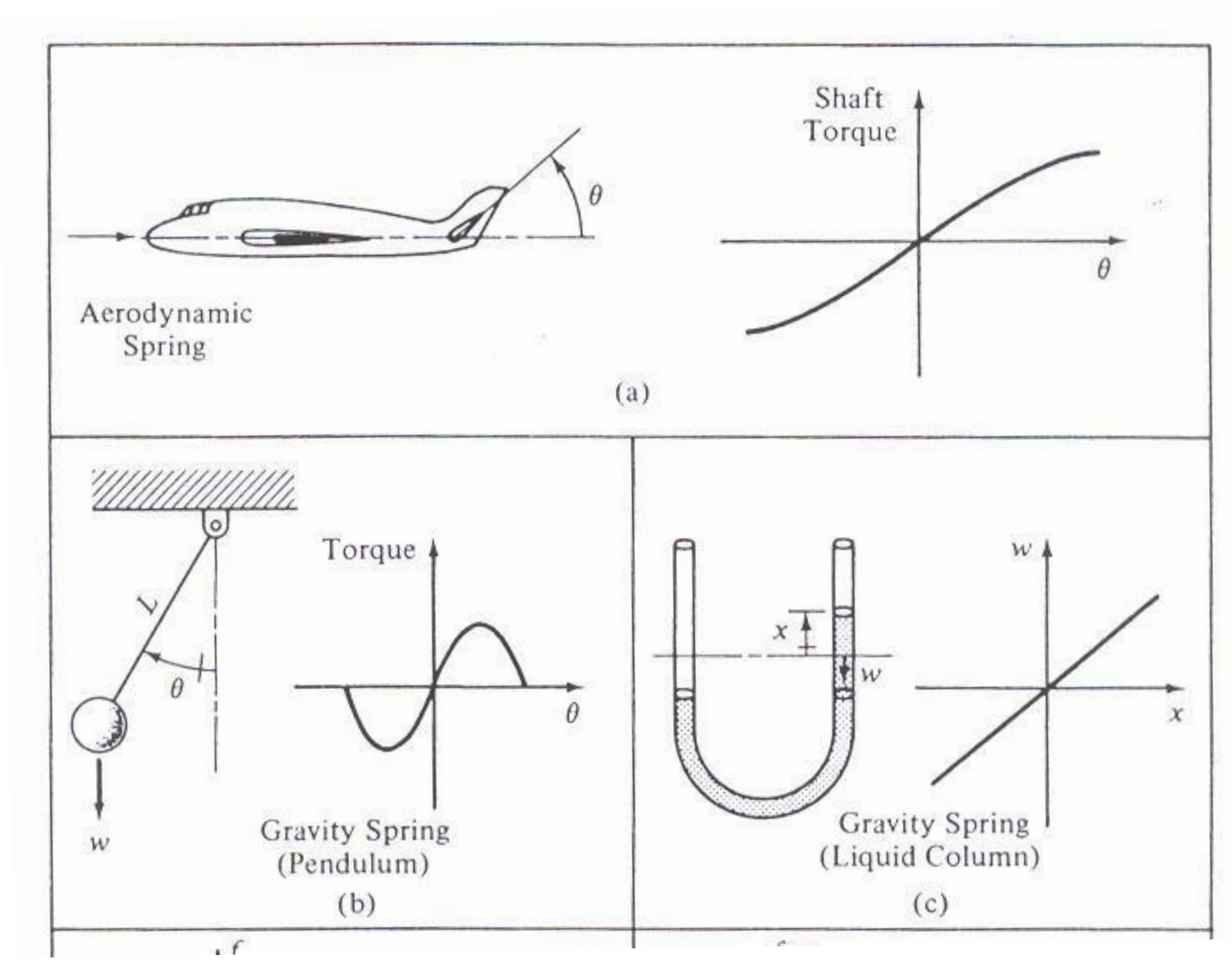


Spring Material Properties

Material	E, Modulus of Elasticity $lb_f/inch^2$	G, Modulus of Rigidity $lb_f/inch^2$
Steel	3×10^7	1.2×10^7
Aluminum	1×10^7	0.4×10^7
Brass	1.3×10^7	0.5×10^7
Iso-Elastic	2.6×10^7	0.92×10^7

Figure Several types of practical springs.

Mechanical systems



Mechanical systems

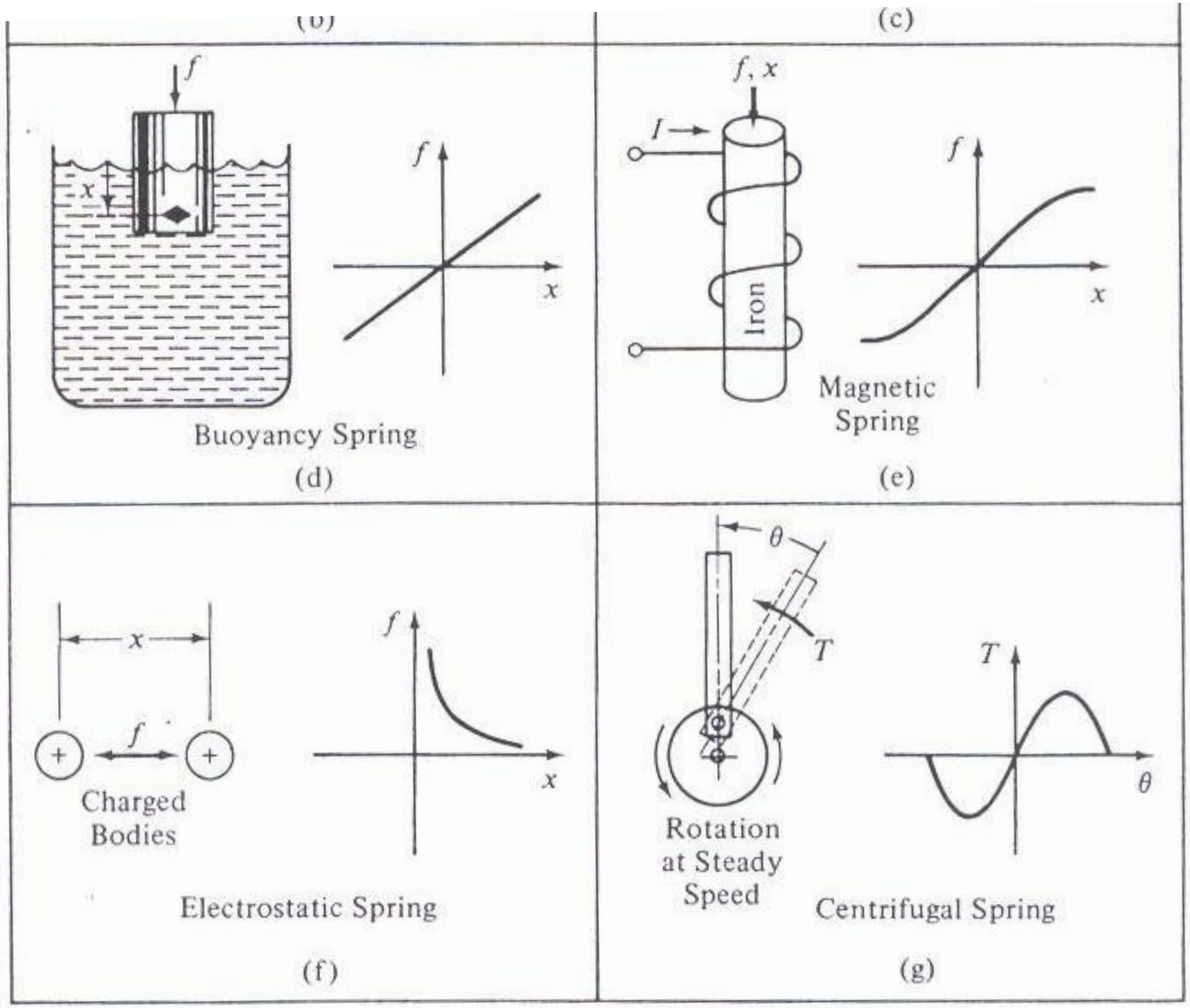
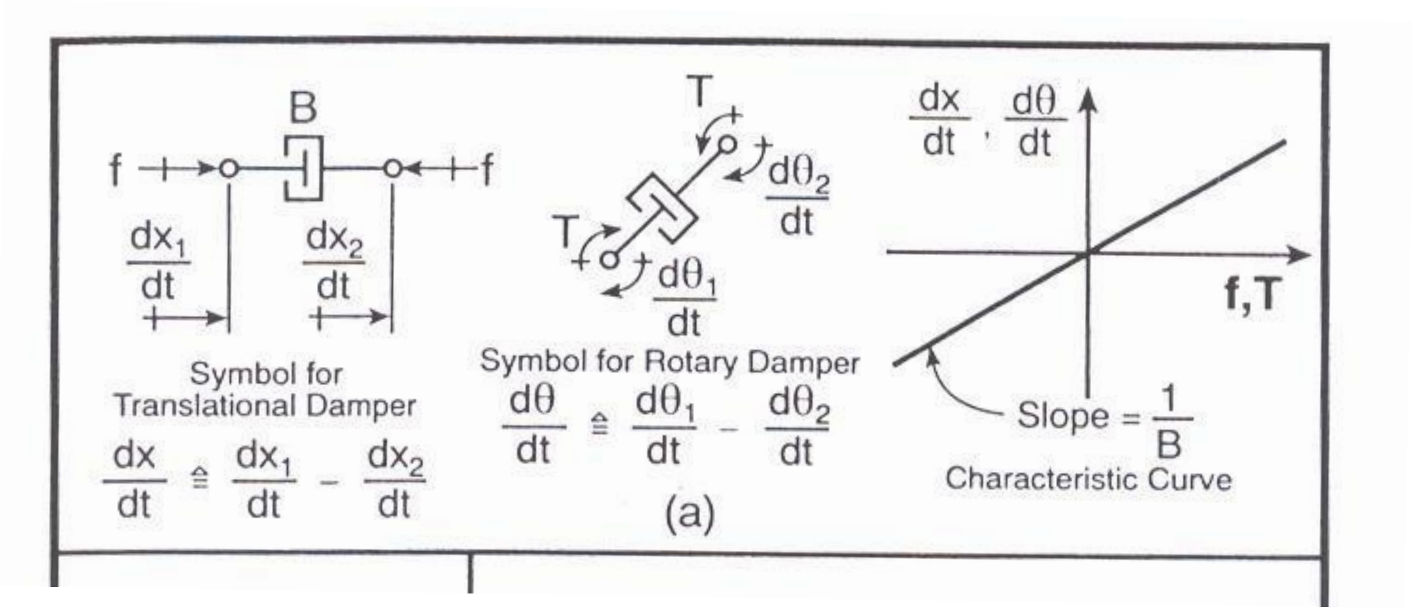


Figure Some springlike effects in unfamiliar forms.

Mechanical systems



Force applied to ends of damper $$f = B\left(\frac{dx_1}{dt} - \frac{dx_2}{dt}\right) = B\frac{dx}{dt}$$

Torque applied to ends of damper $$T = B\left(\frac{d\theta_1}{dt} - \frac{d\theta_2}{dt}\right) = B\frac{d\theta}{dt}$$

Mechanical systems

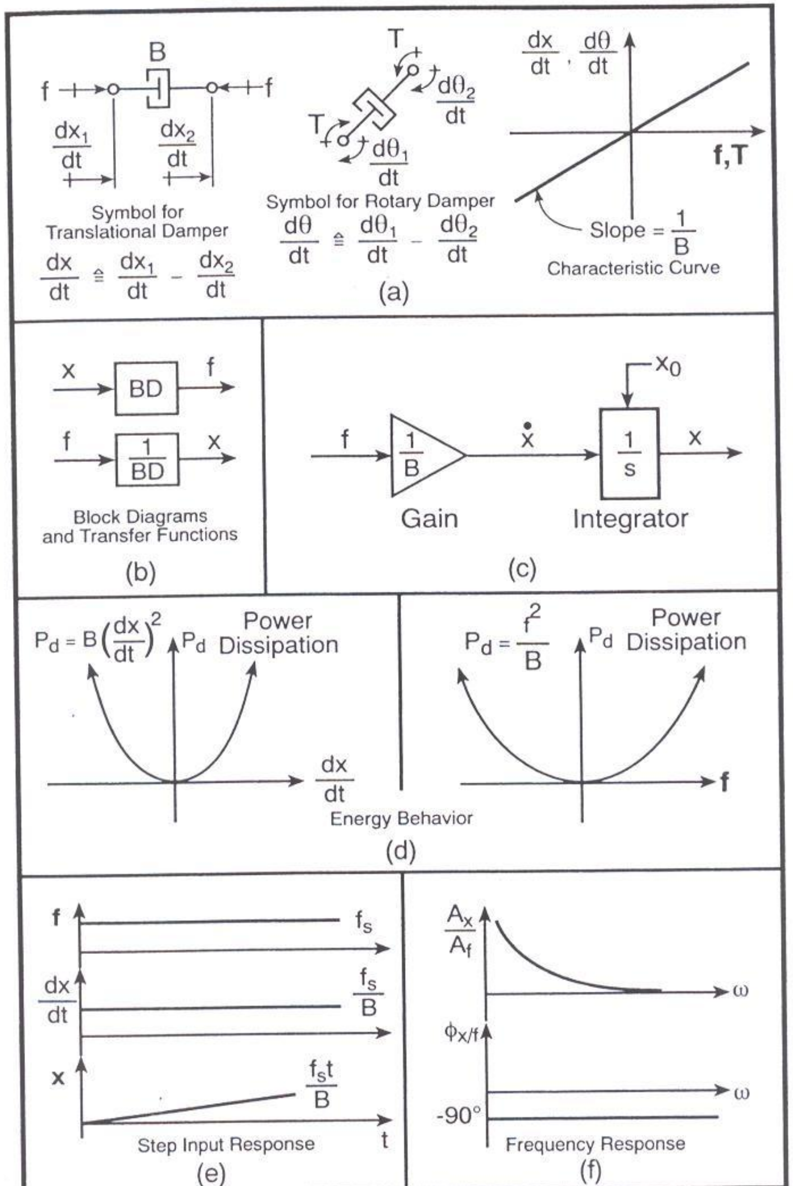


Figure The damper element.

Mechanical systems

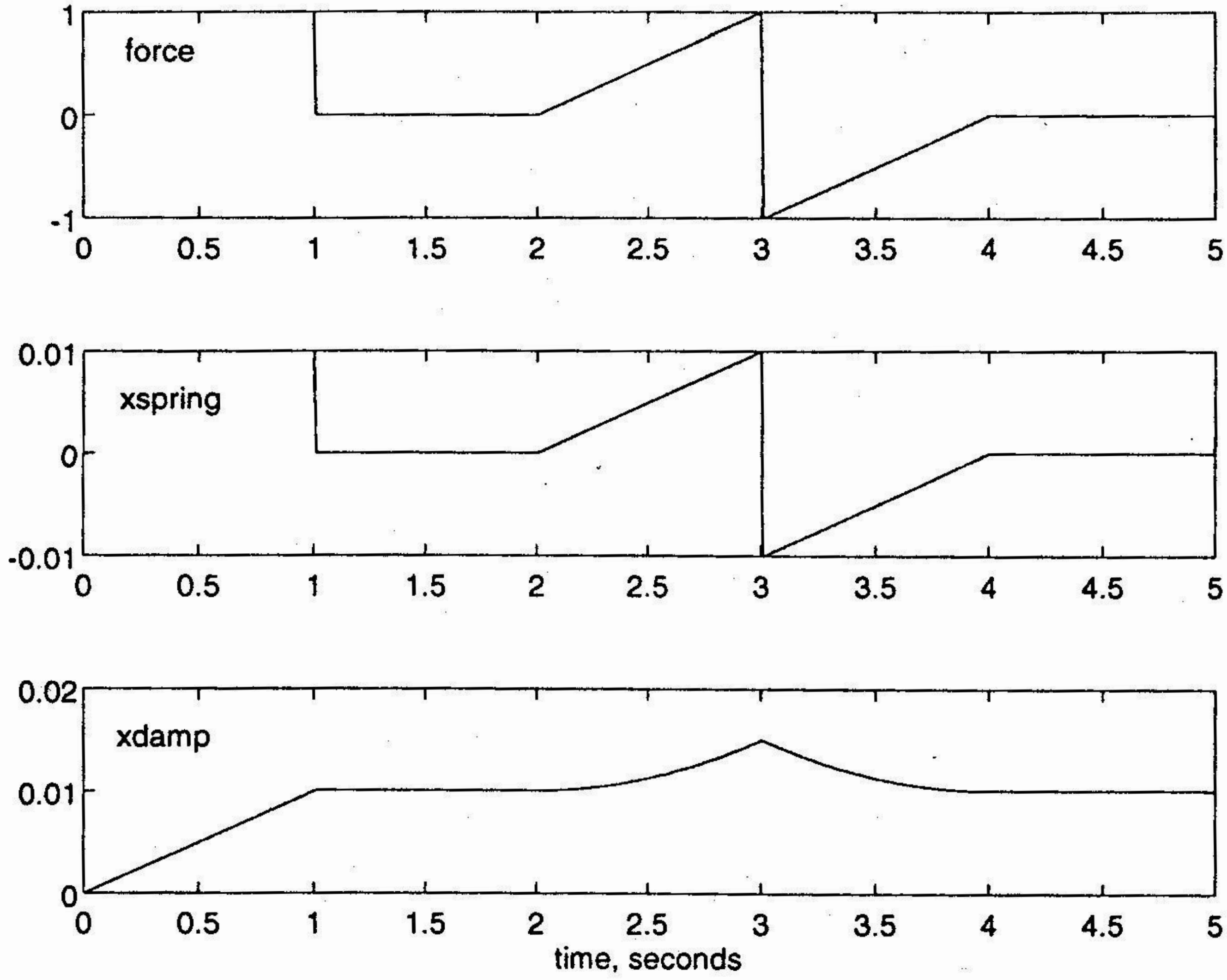
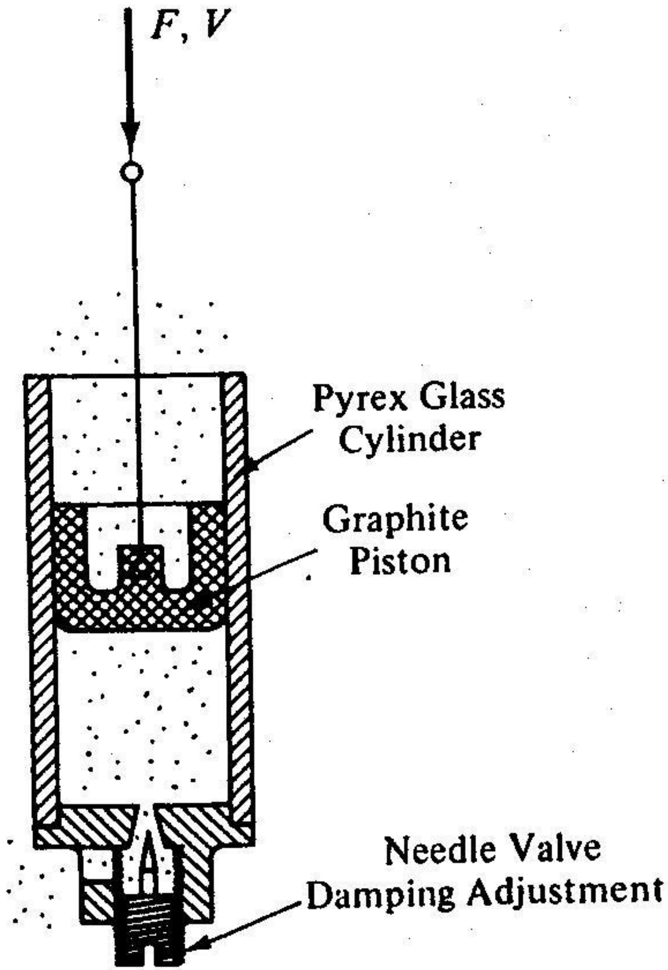


Figure Comparison of spring and damper behavior for same force input.

Mechanical systems



F lb_f	V inch/sec
0.0130	0.0104
0.0632	0.0526
0.1086	0.0935
0.1582	0.1389
0.2040	0.1755
0.2560	0.2170

Figure A commercial air damper.

Mechanical systems

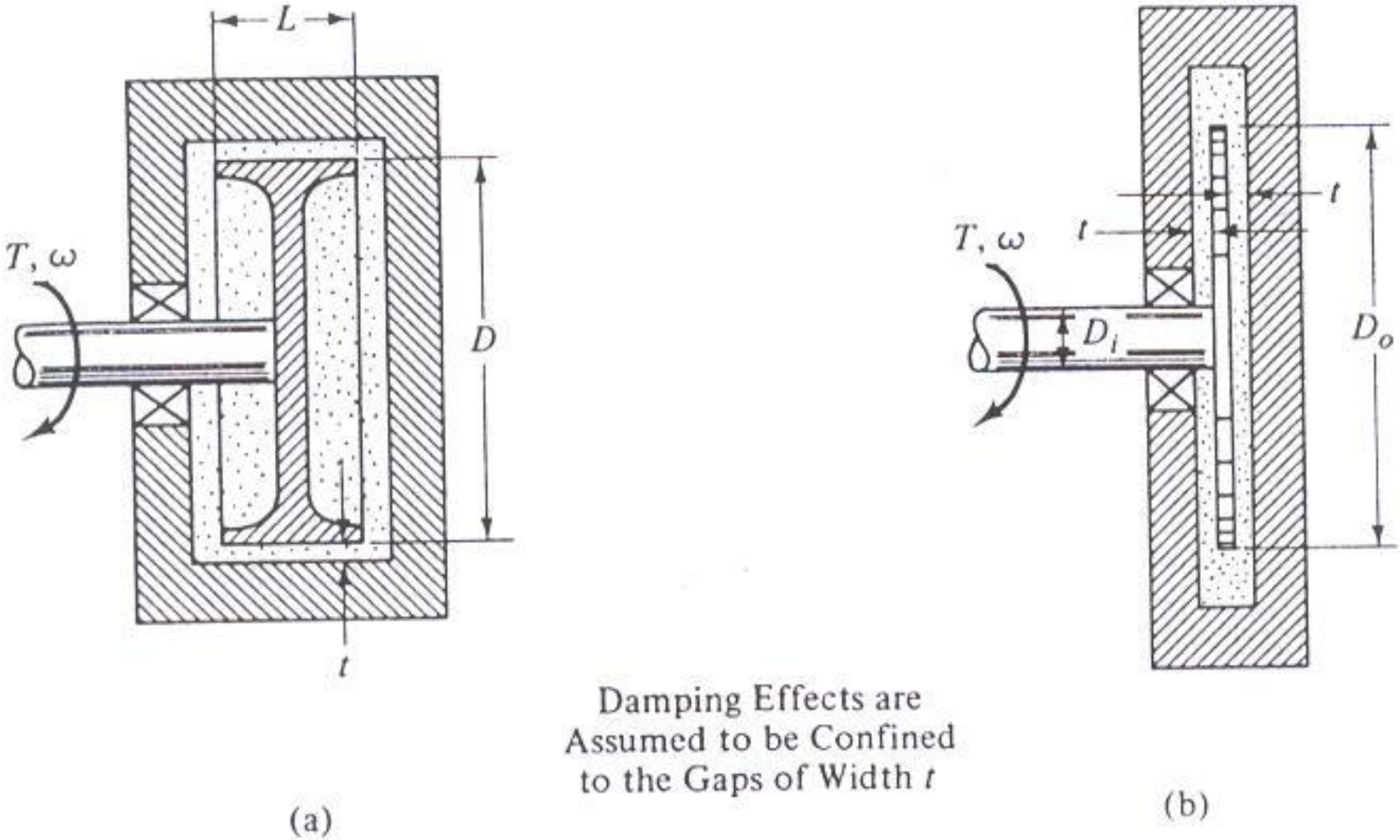


Figure Two types of rotary damper.

Mechanical systems

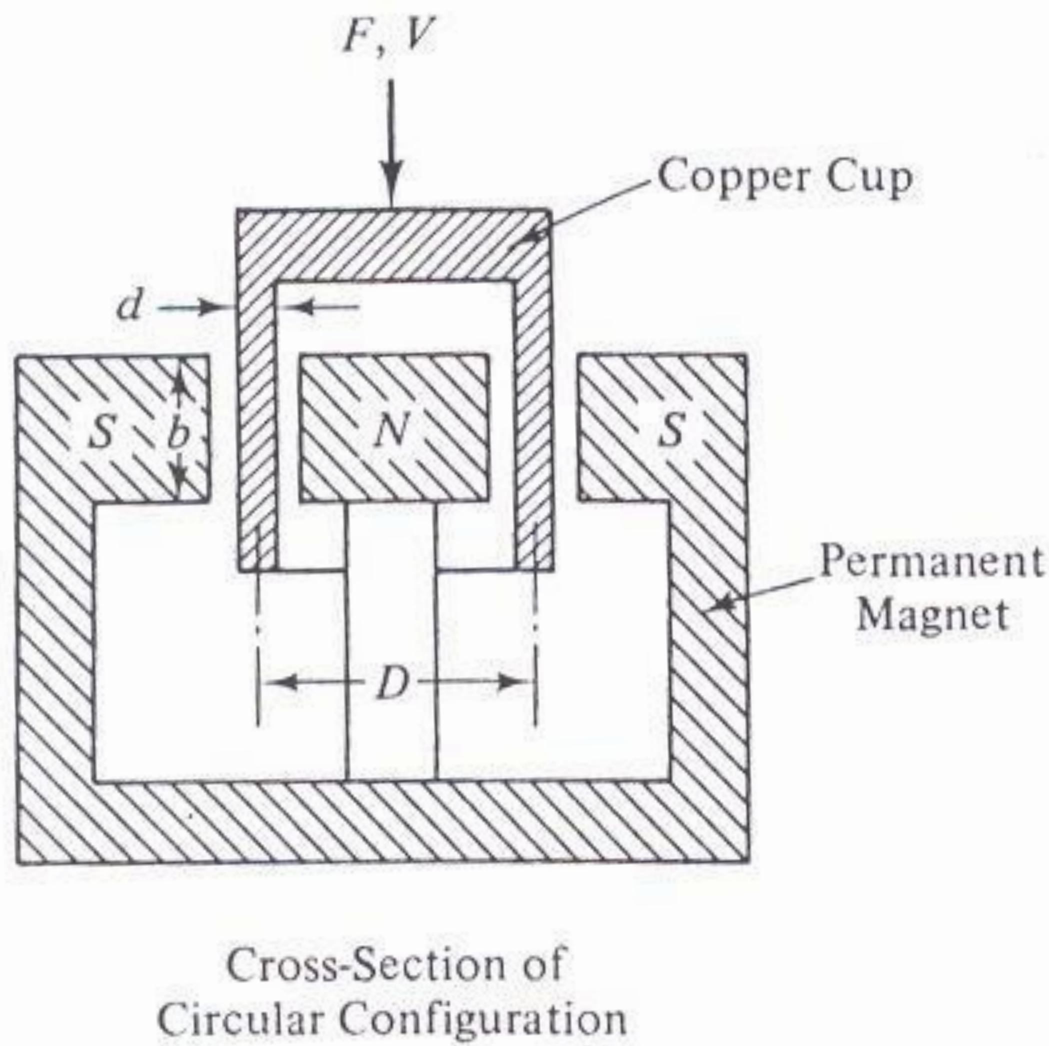
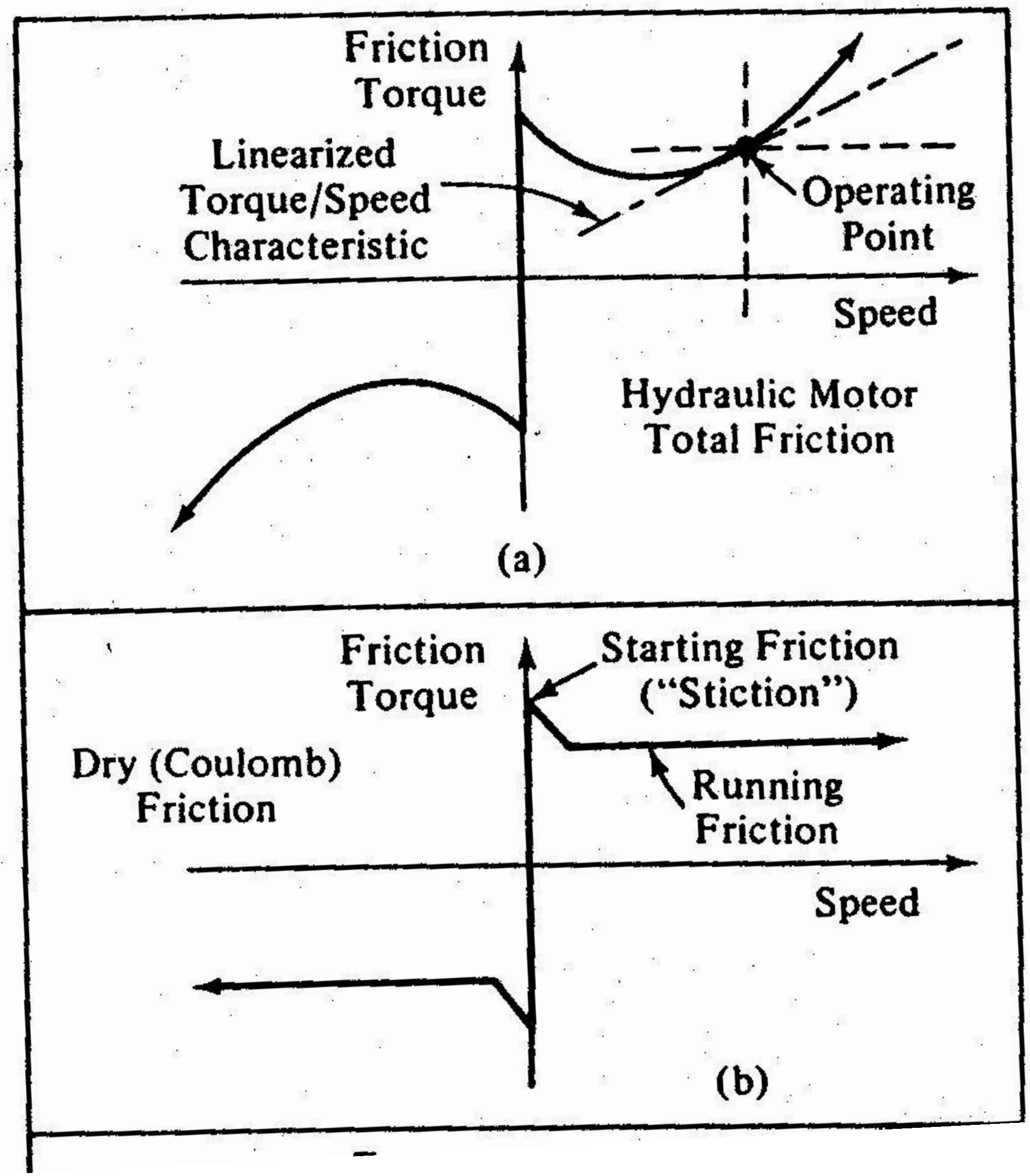


Figure Eddy-current damper.

Mechanical systems



Mechanical systems

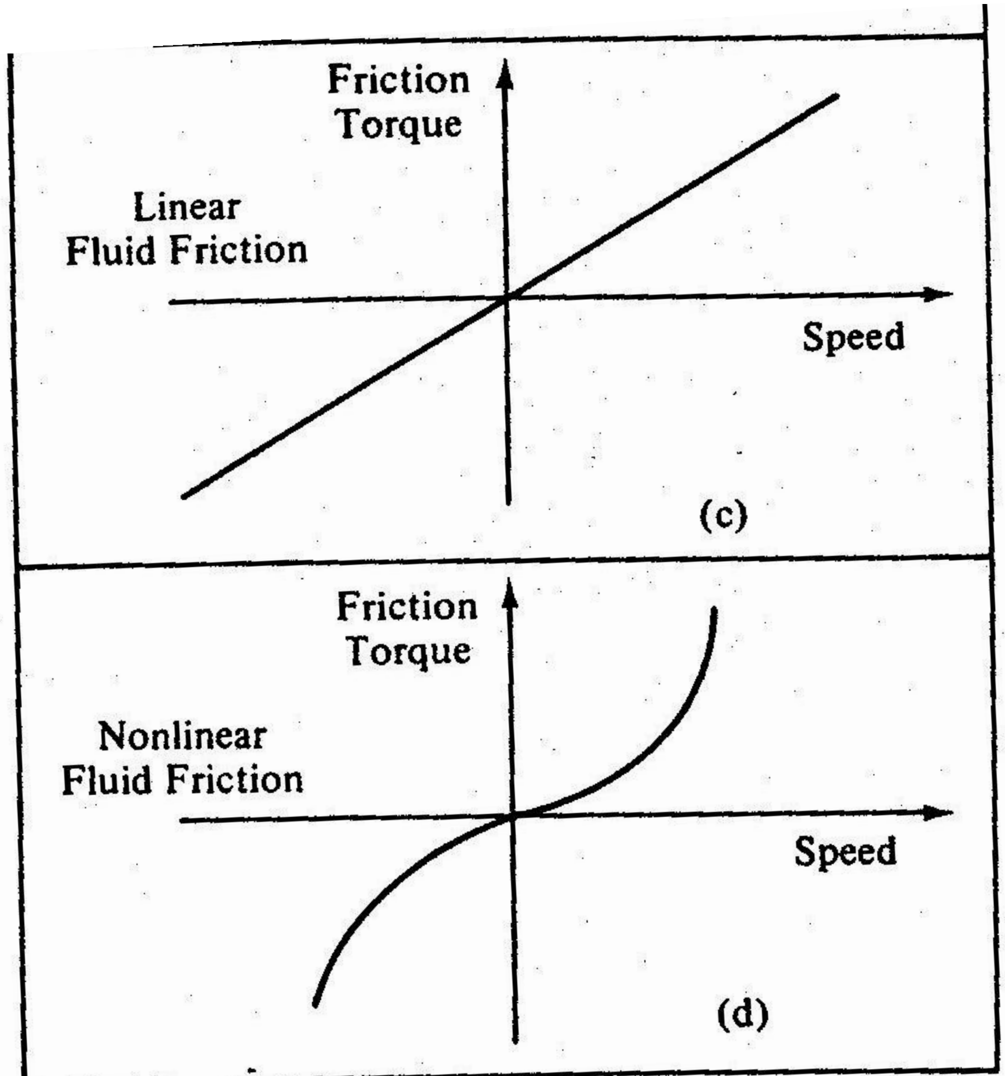


Figure Hydraulic motor friction and its components.

Home work

Use Matlab to simulate spring and damper behavior for the force history given in slide 13

a) Individual elements b) when both are connected in series.

Spring constant = 0.01N/m and damping coefficient = 0.01 N/(m/sec)

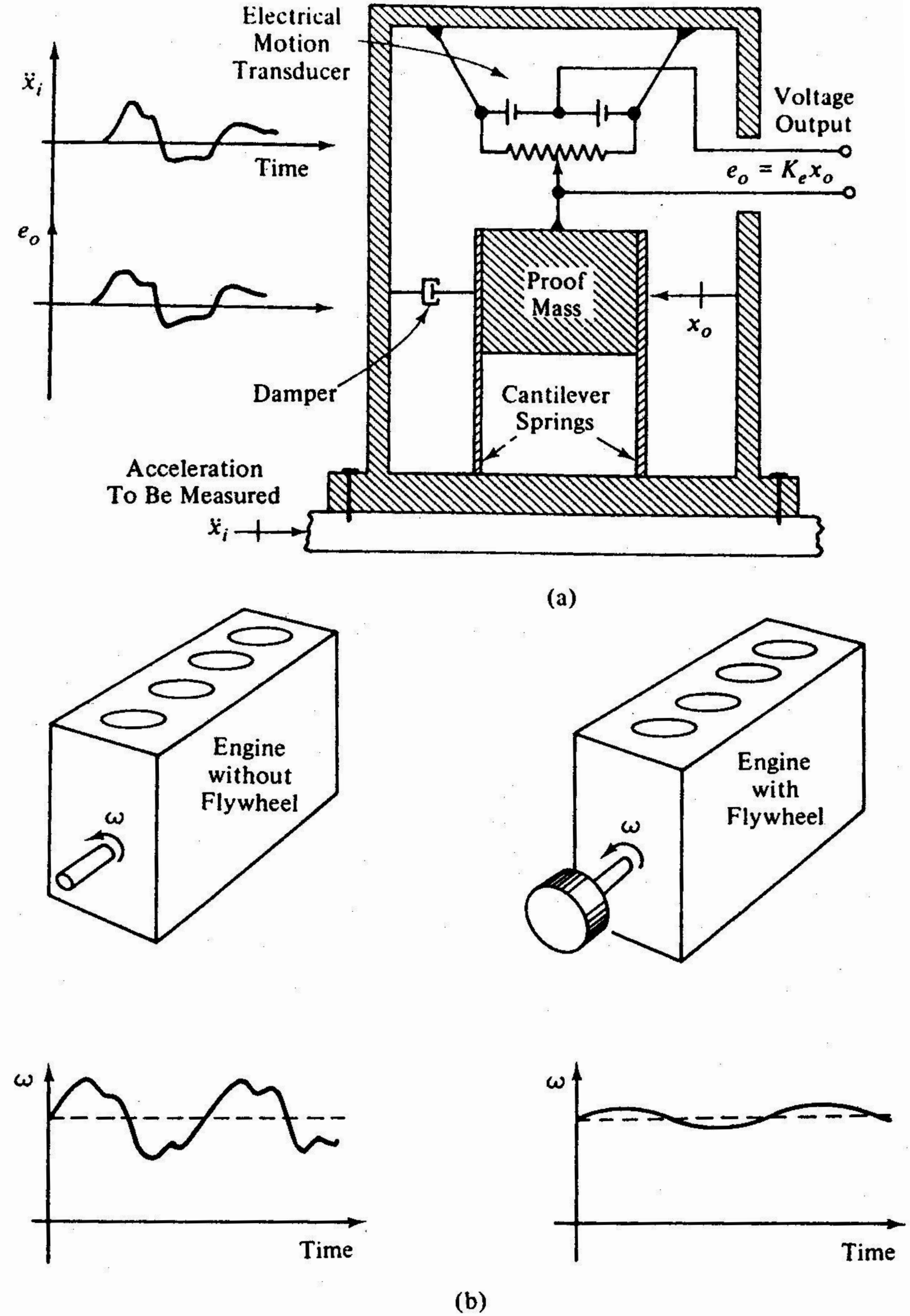


Figure Useful applications of inertia.

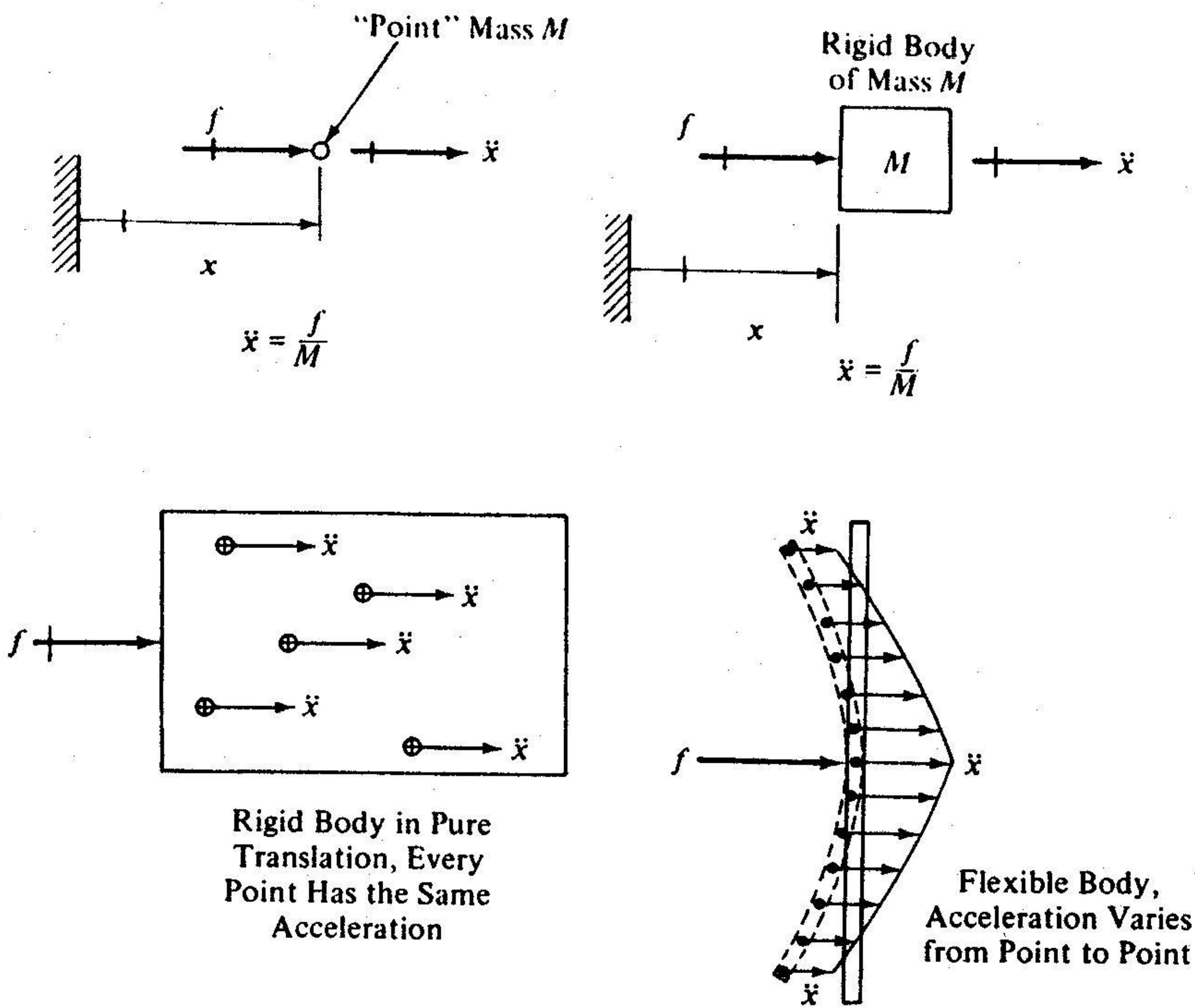
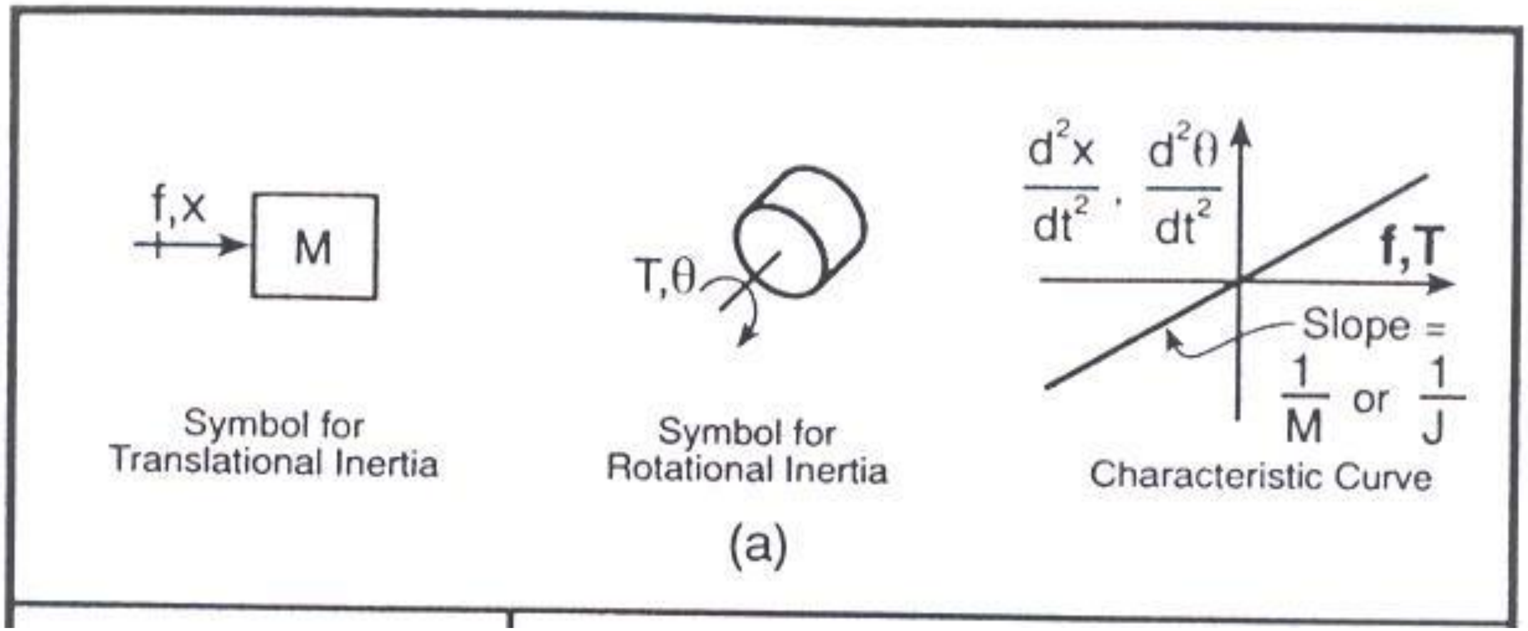


Figure Rigid and flexible bodies: definitions and behavior.

Mechanical inertia



Newton's Law $\sum Forces = (mass)(acceleration)$

Assumption: rigid point mass (valid for many practical situations). Internal elastic deformation is very small compared to gross motion

Mechanical inertia

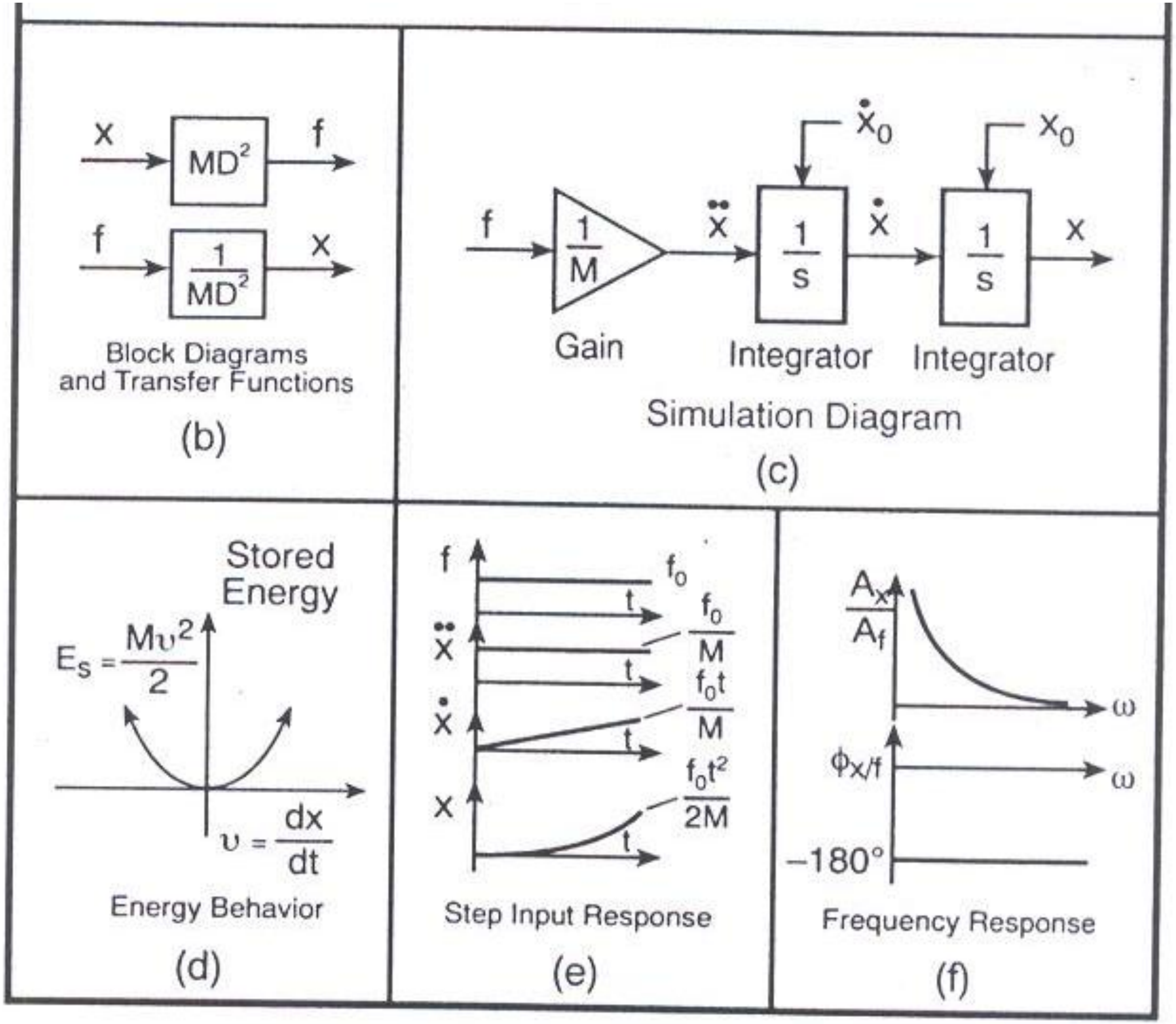
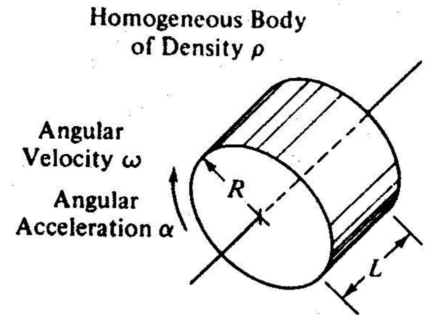


Figure The inertia element.

Mechanical inertia



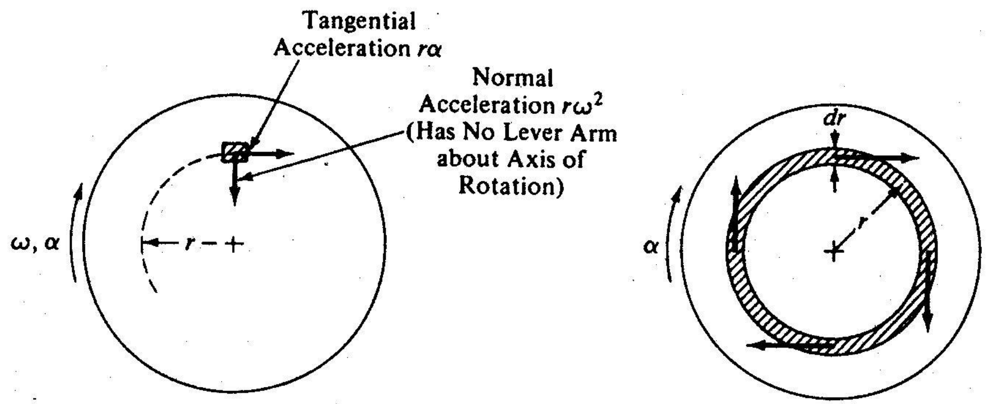
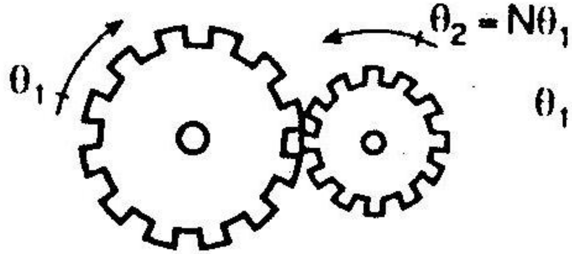


Figure Rotational inertia.

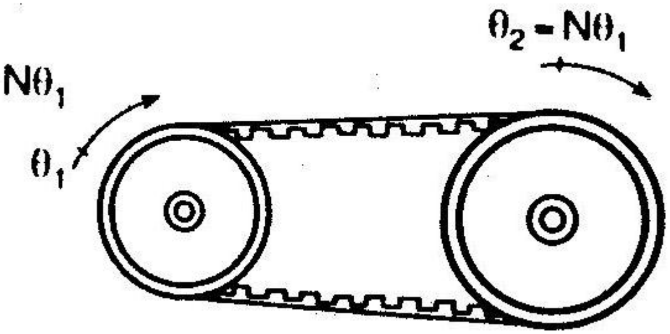
Newton's Law $\sum Torques = (moment\ of\ inetria)(angular\ acceleration)$

Assumption: rigid body assumption (mass distribution is constant)

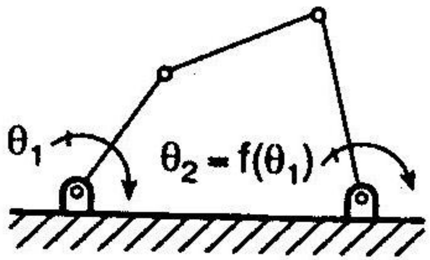
Motion transfer elements



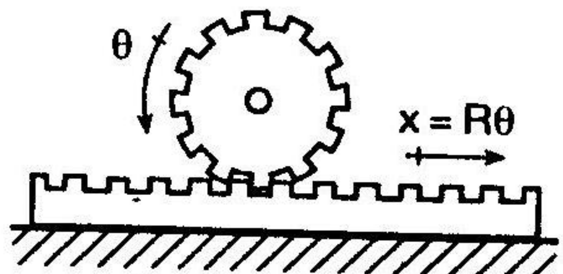
Gears



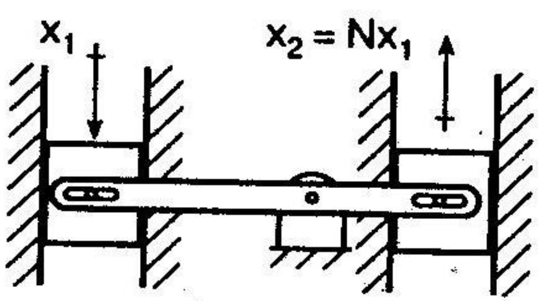
Belts, Chains



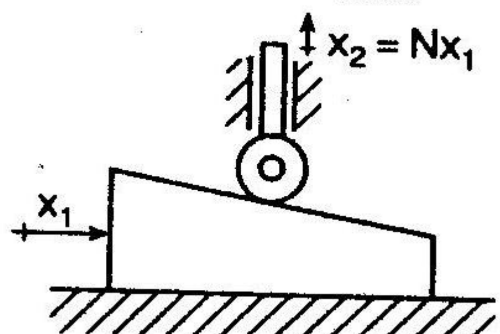
Linkage



Rack and Pinion



Lever



Cam

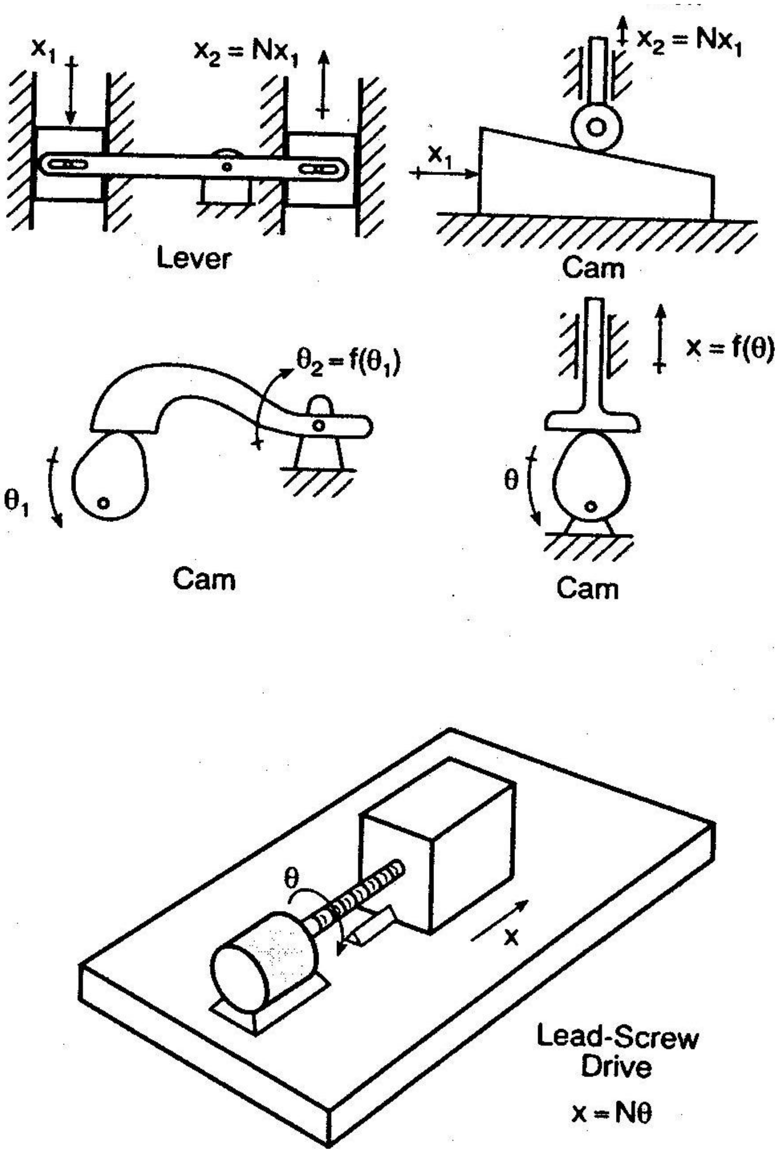


Figure Motion transformers.

Only kinematic relations
Transformation of motion of an input member into kinematically related motion of output member.
Complex mechanism can be represented by simple algebraic equation