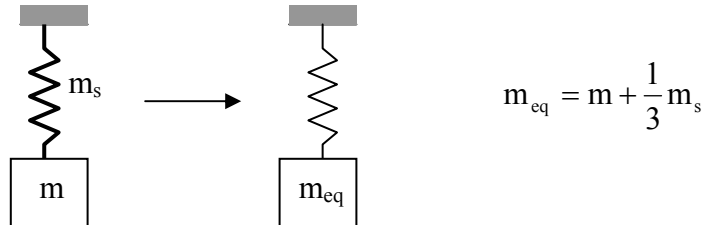


Modeling of System Elements

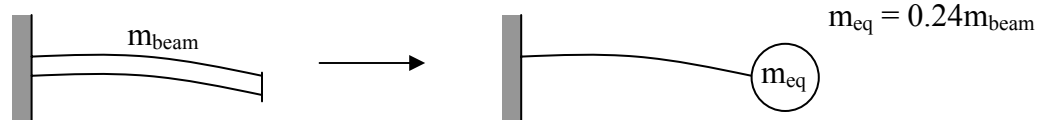
Many additional equations can be found in *Modeling and Analysis of Dynamic Systems* by Cochin and Plass.

Lumped Mass Equivalent Systems:

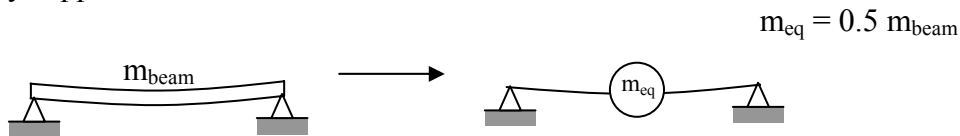
Helical Spring or Rod



Cantilever Beam



Simply supported beam



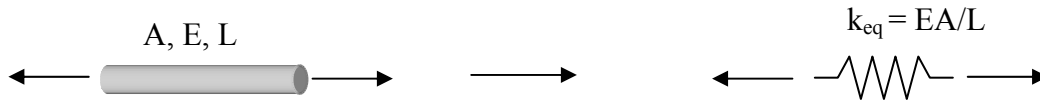
Shaft in Torsion



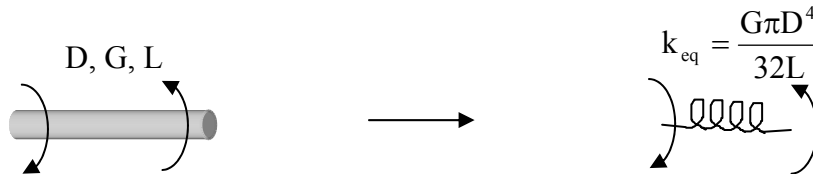
Others in Cochin and Plass: Bellows, clock springs, fluid masses, etc.

Lumped Stiffness Equivalent Systems:

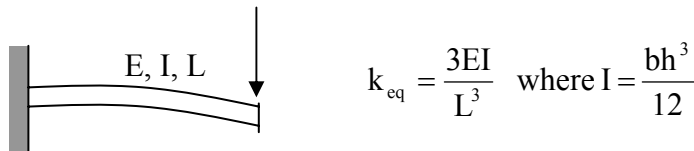
Rod in tension/compression (A=area, E = Young's Modulus, L = length)



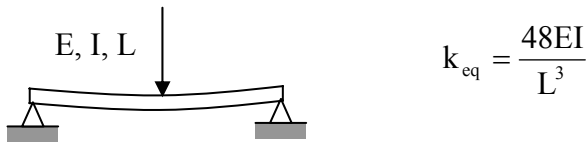
Rod in Torsion (D = diameter, G = shear modulus, L = length)



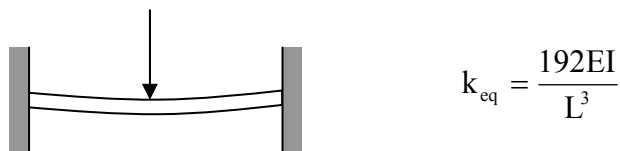
Cantilevered beam (E = Young's modulus, I = area moment of inertia, L = length, b = beam width, h = beam thickness)



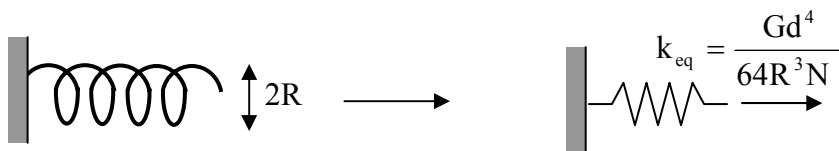
Simply supported beam



Double clamped beam



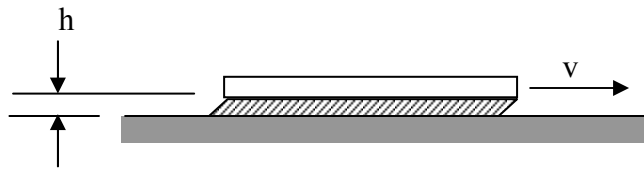
Helical wire coil in translation (round wire) (G = shear modulus, d = wire diameter, R = coil radius, N = number of coils)



Others in Cochran and Plass: rubber in compression, disk springs, other beams with different boundary conditions, coiled spring in torsion, clock springs, fluid springs, etc.

Lumped Damping Equivalent Systems

Translating Surface (sliding viscous friction)



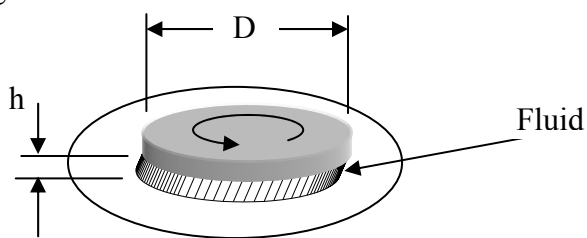
$$D_{eq} = \frac{\mu A}{h}$$

where

A = wetted surface area

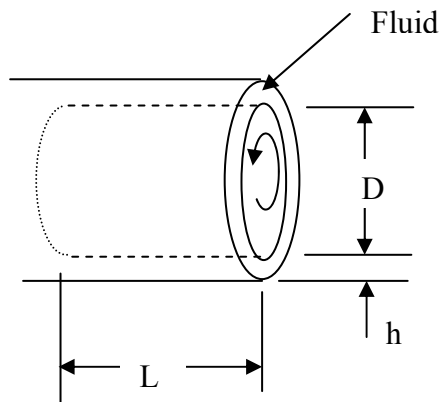
μ = coefficient of viscosity (absolute)

Rotating disk



$$D_{eq} = \frac{\pi \mu D^4}{32h}$$

Rotating cylinder (journal bearing)



$$D_{eq} = \frac{\pi \mu D^3 L}{4h}$$

Others in Cochin and Plass: Translating cylinder, damping due to flow restriction (dashpots), damping due to drag, mechanical dampers, structural damping, rubber pads, etc.