Modelling and control summaries

by Anthony Rossiter

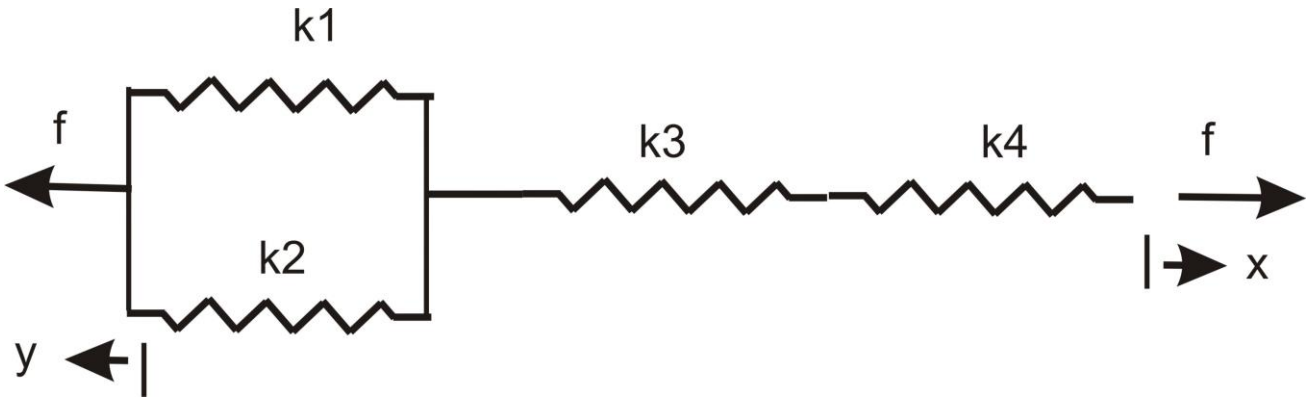
Modelling principles and analogies:

Tutorial sheet on mechanical, fluid and heating systems

M1. What force applied to a spring with spring constant 0.8 N/m will produce a displacement of 0.5m ?

M2. What velocity is produced when 0.04 kg_f is applied to a damper with viscous friction constant 8 Ns/m? (Note: 1 N = 0.10197 kg_f)

M3. Calculate the combined stiffness for the following spring arrangement, where k_1 = 1 N/m, k_2 = 2 N/m, k_3 = 3 N/m and k_4 = 4 N/m.



Questions: Thermal and Fluid Systems

TF1. When is a system said to be in *equilibrium* ? Give an example using a liquid level system with an inlet and outlet flow to illustrate your answer.

TF2. Assuming that a thermal system can be represented by a *lumped-parameter model*, write the physical equations defining the conduction heat transfer along a component of constant cross-sectional area. Define all the terms used. (A *lumped-parameter model* assumes that substances that are characterized by resistance to heat flow have negligible heat capacitance, and that substances that are characterized by heat capacitance have negligible resistance to heat flow (Ogata. K., *System Dynamics*, 1992.)

TF3. Which of the following equations correctly describe the relationship between flow Q and pressure drop ΔP across an orifice (assuming laminar flow and fluid body forces can be ignored such that a proportionality relationship can be assumed between flow and pressure drop):

(a) $Q = R/(\Delta P)$ (b) $Q = R\,\Delta P$

(c) $R=\Delta P/Q$ (d) $\Delta P = 1/(R\,Q)$

TF4. The values of the pressure drop ΔP are measured when different fluid flows Q are applied to a pipe. Determine the resistance to flow in each case and report whether the assumption that the resistance is constant is valid and give a reason for your answer.

Q volume flow rate (m^3)	0.1	0.5	0.8
ΔP pressure drop (N/m^2)	0.03	0.16	0.4

CONCISE ANSWERS

M1. 0.4N M2. 0.05 m/s M3. 12/11 N/m

TF1. A system is said to be in *equilibrium* when its behaviour is steady i.e its output and inputs are unchanging. For the liquid level system with an inlet and outlet flow, this corresponds to the inlet and outlet flows being the same.

TF3. The relationship is proportional between pressure drop and Q, thus all bar (b,c) would work for suitable R.

TF4. The flow cannot be assumed to be laminar as the proportionality constant is not linear as the flow increases through the pipe i.e.

$1/R$ resistance ($Pa.s/m^3$)	3	3	2