Vibration Mechanics Hw #1

(Fundamental of Vibration)

10 Points /each, total 70 points

Issued: Tue. Feb. 14, 2023 Due: Fri. Mar. 03, 2023(18:00)

1. Rao. P 1.2 Vibration problems formulation

The following figure shows a human body and a restraint system at the time of an automobile collision. Suggest a simple mathematical model by considering the elasticity, mass, and damping of the seat, human body, and restraints for a vibration analysis of the system. (直接將該圖變成 mass-spring-damper 圖)

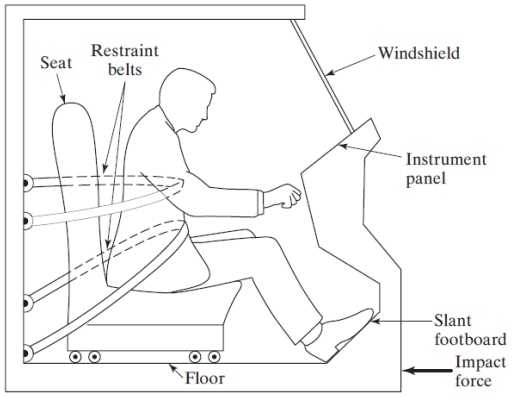

FIGURE 1.62 A human body and a restraint system.

2. Rao. P 1.9 Spring combinations

In Fig. 1.69, find the equivalent spring constant of the system in the direction of θ.

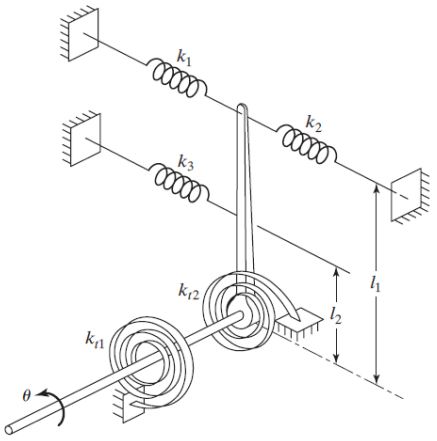

FIGURE 1.69

3. Rao. P 1.10 Spring combinations

Find the equivalent torsional spring constant of the system shown in Fig. 1.70.

Assume that k_1, k_2, k_3, and k_4 are torsional and k_5 and k_6 are linear spring constants.

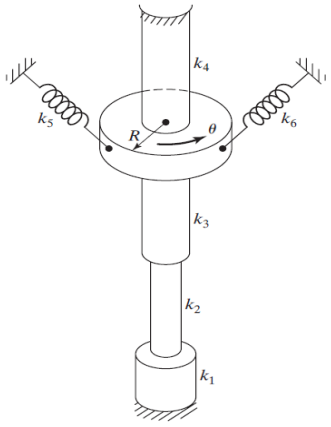

FIGURE 1.70

4. Rao. P. 1.31 Equivalent stiffness

Derive the expression for the equivalent spring constant that relates the applied force F to the resulting displacement x of the system shown in Fig. 1.86. Assume the displacement of the link to be small.

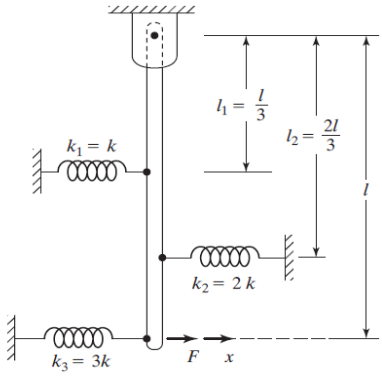

FIGURE 1.86 Rigid bar connected by springs.

5. Rao. P 1.52 Equivalent mass

A simplified model of a petroleum pump is shown in Fig. 1.99, where the rotary motion of the crank is converted to the reciprocating motion of the piston. Find the equivalent mass, m_{eq}, of the system at location A.

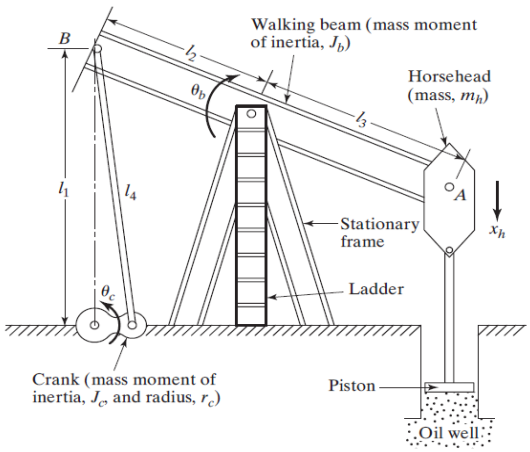

FIGURE 1.99

6. Rao. P.1.55 Equivalent damping

Find a single equivalent damping constant for the following cases:

a. When three dampers are parallel.

b. When three dampers are in series.

c. When three dampers are connected to a rigid bar (Fig. 1.102) and the equivalent damper is at site c_1.

d. When three torsional dampers are located on geared shafts (Fig. 1.103) and the equivalent damper is at location c_{t1}.

Hint: The energy dissipated by a viscous damper in a cycle during harmonic motion is given by $\pi c \omega X^2$, where c is the damping constant,ω is the frequency, and X is the amplitude of oscillation.

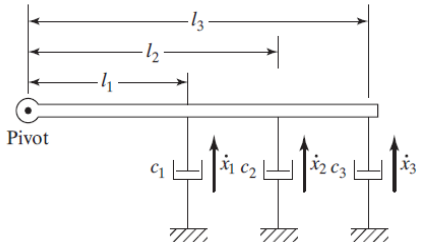

FIGURE 1.102 Dampers connected to a rigid bar.

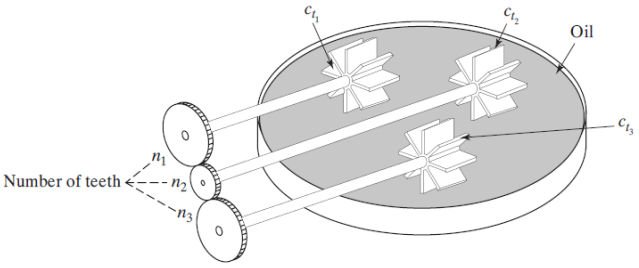

FIGURE 1.103 Dampers located on geared shafts.

7. Rao. P.1.74 Equivalent damping

Find an expression for the equivalent translational damping constant of the system shown in Fig. 1.110 so that the force F can be expressed as $F=c_{eq}v$, where v is the velocity of the rigid bar A.

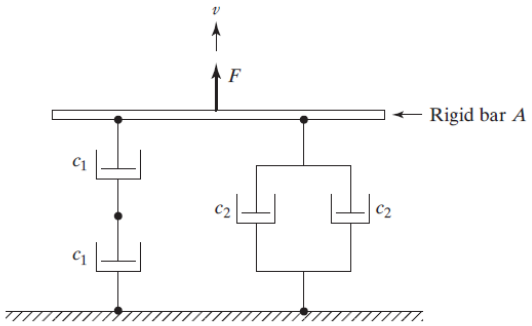

FIGURE 1.110 Dampers connected in series-parallel.