

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

King Abdulaziz University  
Engineering College  
Deprt. of Prod. Eng. and Mech. Sys. Design

Mechanical Vibrations  
MENG 470  
Spring 1425 H

1<sup>st</sup> Homework Assignment  
Due Saturday: 1/1/1425 H

A reciprocating engine is mounted on a foundation as shown in Fig. 1. The unbalanced forces and moments developed in the engine are transmitted to the frame and the foundation. An elastic pad is placed between the engine and the foundation block to reduce the transmission of vibration. Develop two mathematical models of the system using a gradual refinement of the modeling process.

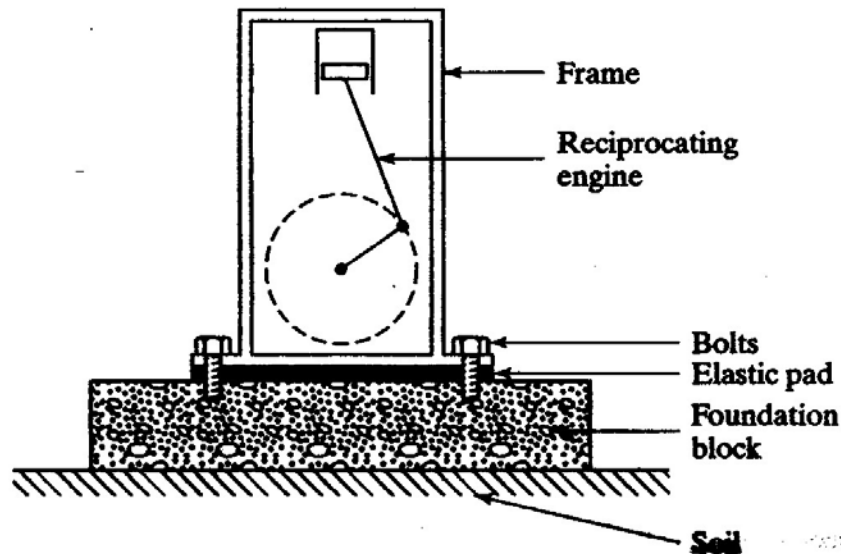
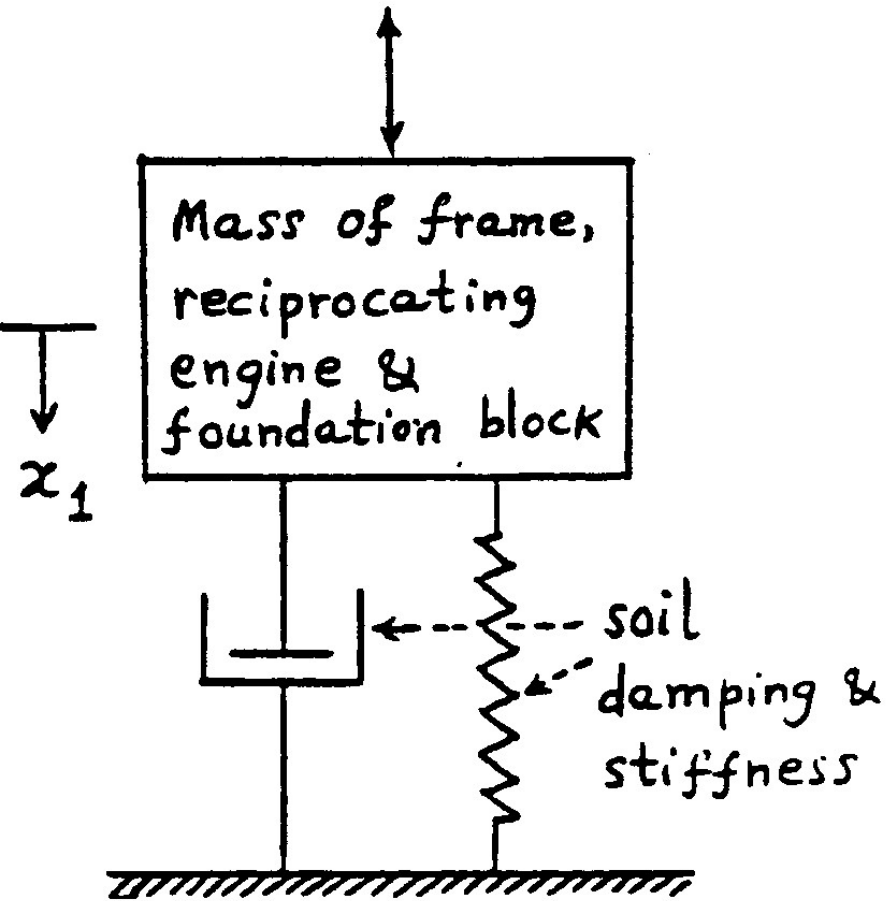


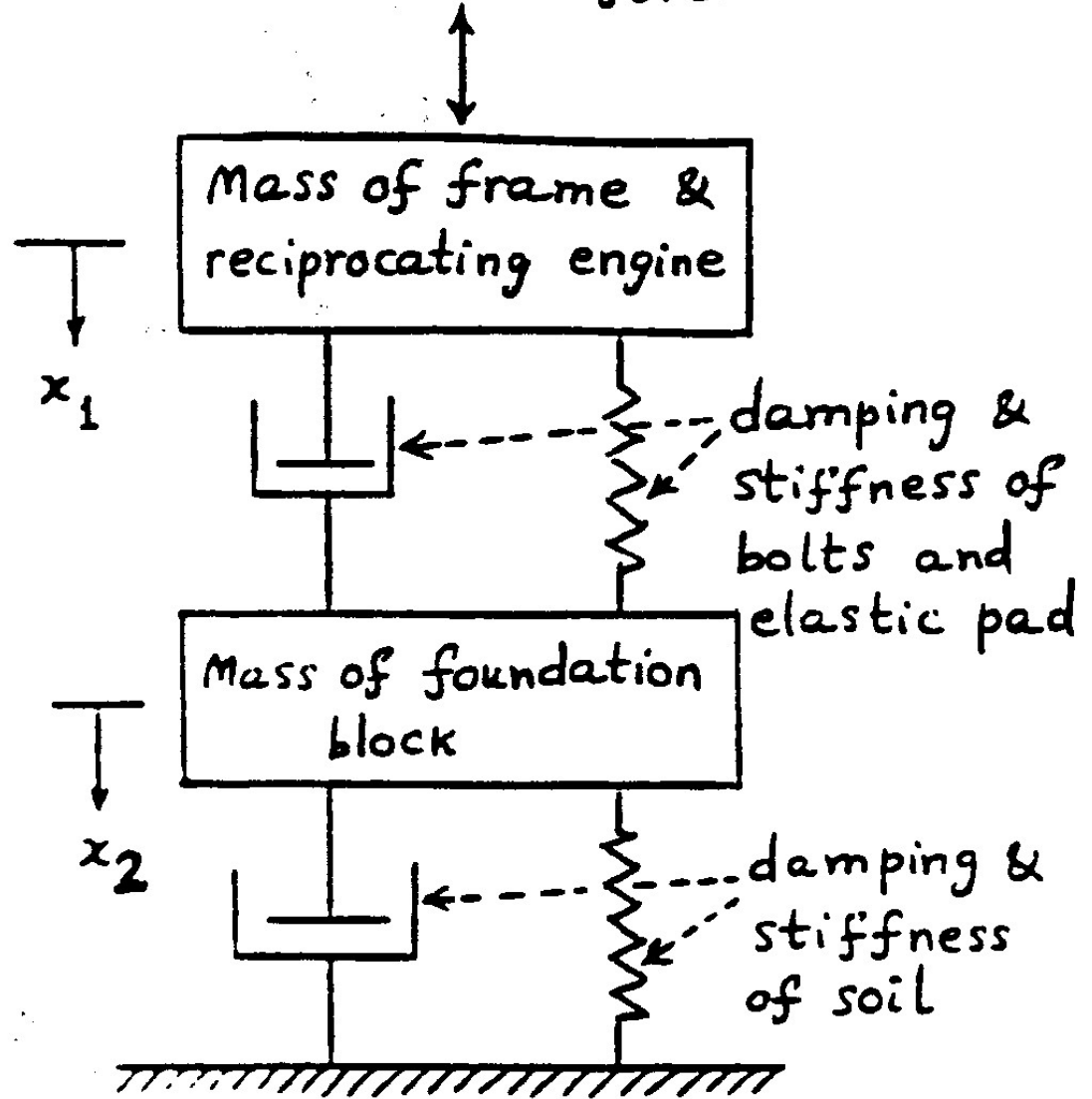
Figure. 1 A reciprocating engine on a foundation.

unbalanced forces



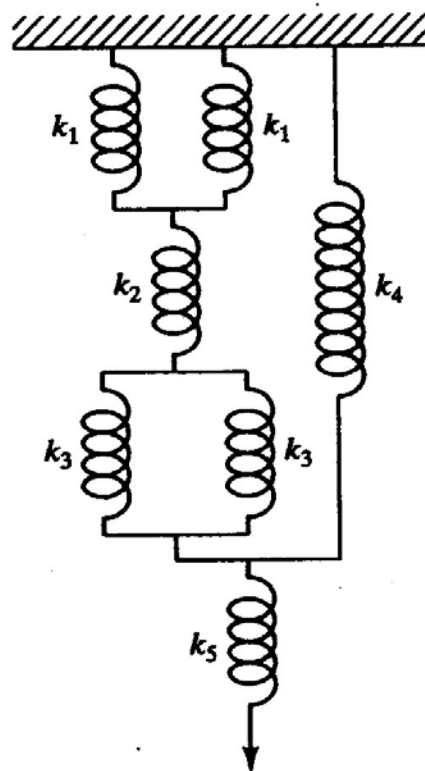
(a) one degree of freedom model

unbalanced forces



(b) Two degree of freedom model

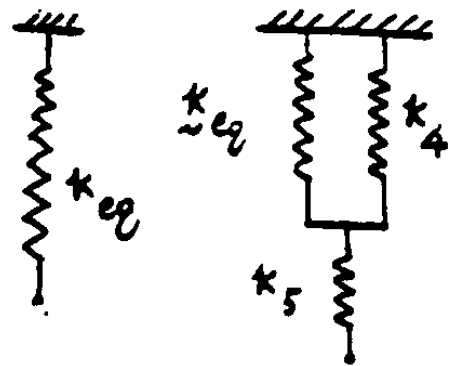
Determine the equivalent spring constant of the system shown in Fig. 2 .



**FIGURE. 2** Springs in series—parallel.

$$\frac{1}{k_{eq}} = \frac{1}{2k_1} + \frac{1}{k_2} + \frac{1}{2k_3} ; \quad k_{eq} = \left( \frac{2k_1 k_2 k_3}{k_2 k_3 + 2k_1 k_3 + k_1 k_2} \right)$$

$$\frac{1}{k_{eq}} = \frac{1}{k_{eq} + k_4} + \frac{1}{k_5}$$



$$k_{eq} = \frac{k_5 (k_{eq} + k_4)}{k_5 + k_4 + k_{eq}} = \frac{k_2 k_3 k_4 k_5 + 2k_1 k_3 k_4 k_5 + k_1 k_2 k_4 k_5 + 2k_1 k_2 k_3 k_5}{k_2 k_3 k_4 + k_2 k_3 k_5 + 2k_1 k_3 k_4 + 2k_1 k_3 k_5 + k_1 k_2 k_4 + k_1 k_2 k_5 + 2k_1 k_2 k_3}$$

Figure. 3 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 the restraints for a vibration analysis of the system.

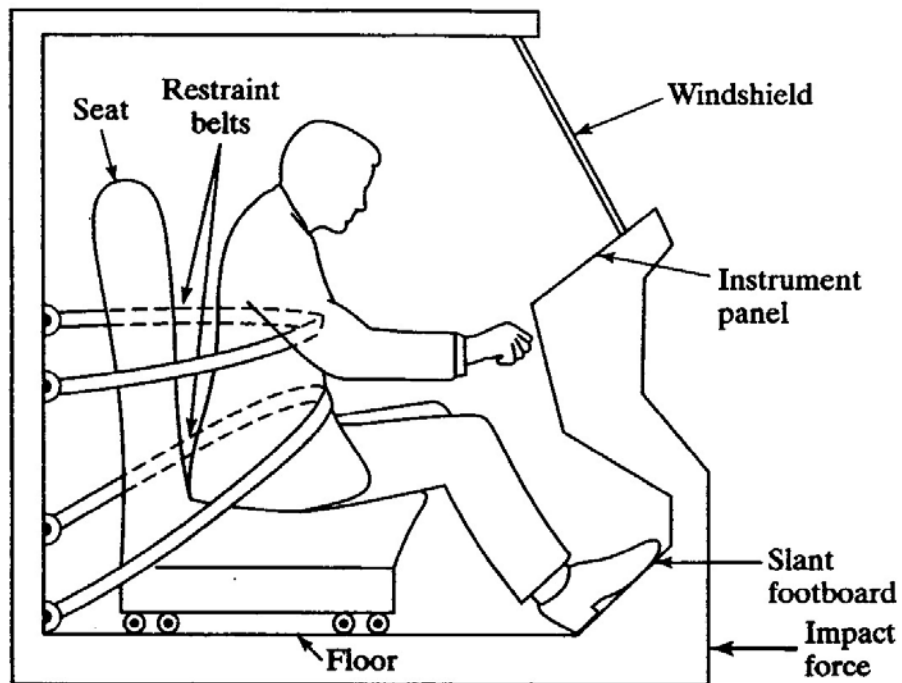
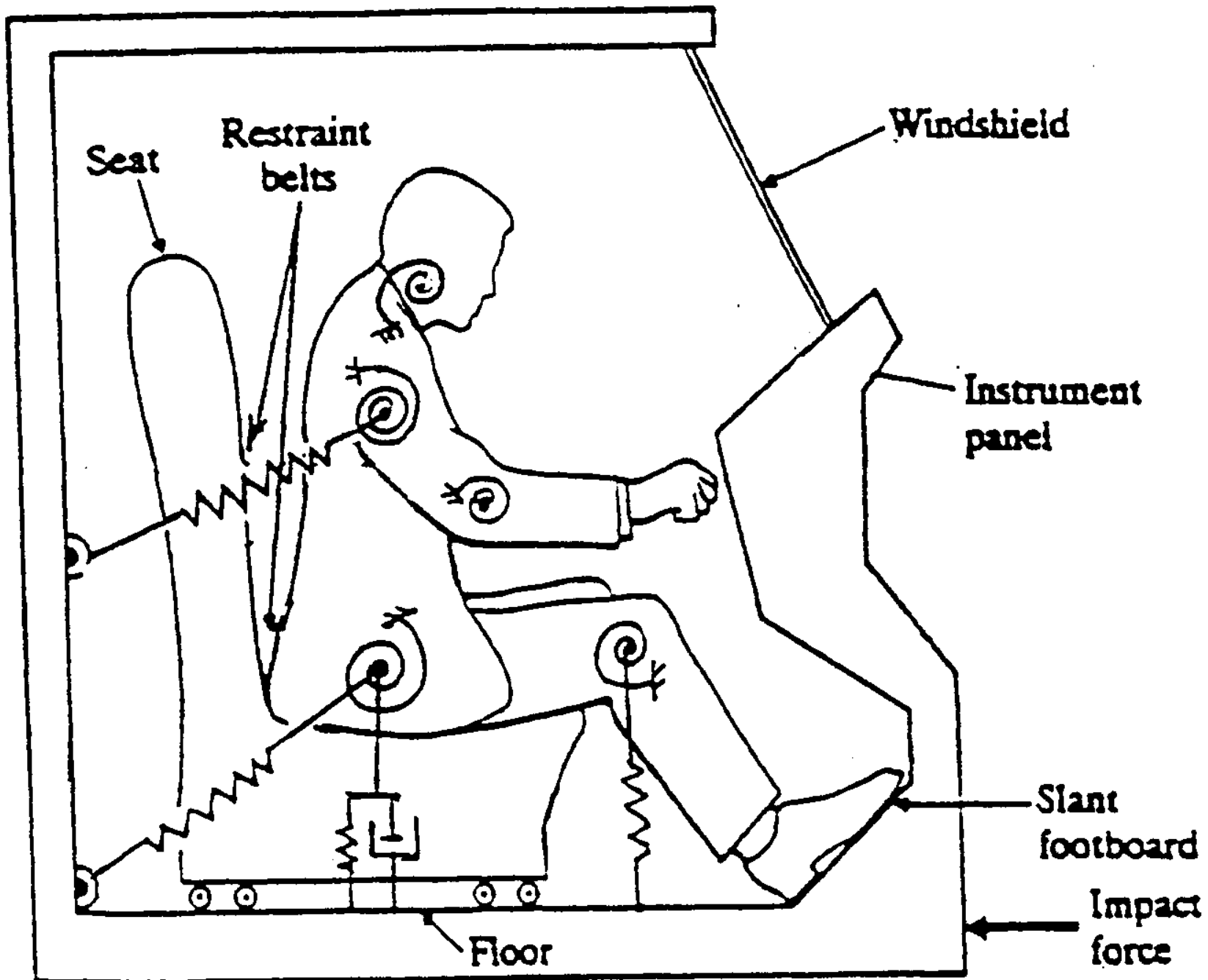
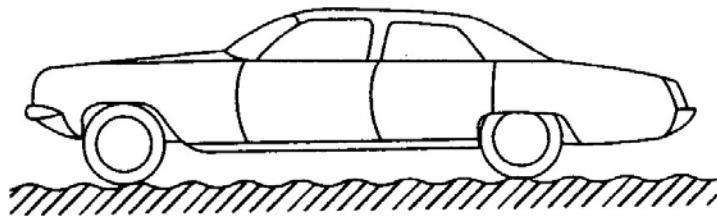


FIGURE. 3 A human body and a restraint system.



An automobile moving over a rough road (Fig. 4 ) can be modeled considering (a) weight of the car body, passengers, seats, front wheels, and rear wheels; (b) elasticity of tires (suspension), main springs, and seats; and (c) damping of the seats, shock absorbers, and tires. Develop three mathematical models of the system using a gradual refinement in the modeling process.



**FIGURE. 4** An automobile moving on a rough road.

