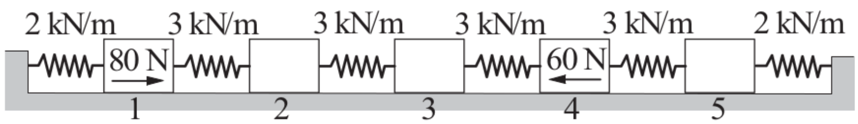
Homework I due May 6/2021

Part I (Chapter 2)

Problem Set 2.3

20. ■



The equilibrium equations of the blocks in the spring-block system are

$$3(x_2 - x_1) - 2x_1 = -80$$

$$3(x_3 - x_2) - 3(x_2 - x_1) = 0$$

$$3(x_4 - x_3) - 3(x_3 - x_2) = 0$$

$$3(x_5 - x_4) - 3(x_4 - x_3) = 60$$

$$-2x_5 - 3(x_5 - x_4) = 0$$

where x_i are the horizontal displacements of the blocks measured in mm. (a) Write a program that solves these equations by the Gauss-Seidel method without relaxation. Start with $\mathbf{x} = \mathbf{0}$ and iterate until four-figure accuracy after the decimal point is achieved. Also print the number of iterations required. (b) Solve the equations using the function `gaussSeidel` using the same convergence criterion as in part (a). Compare the number of iterations in parts (a) and (b).

21. ■ Solve the equations in Prob. 20 with the conjugate gradient method using the function `conjGrad`. Start with $\mathbf{x} = \mathbf{0}$ and iterate until four-figure accuracy after the decimal point is achieved.

Part II (Chapter 3)

Problem Set 3.1

20. ■ The table shows how the relative density ρ of air varies with altitude h. Determine the relative density of air at 10.5 km.

h (km)	0	1.525	3.050	4.575	6.10	7.625	9.150
ρ	1	0.8617	0.7385	0.6292	0.5328	0.4481	0.3741

Problem Set 3.2

7. ■ The relative density ρ of air was measured at various altitudes h. The results were

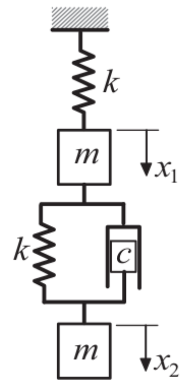
h (km)	0	1.525	3.050	4.575	6.10	7.625	9.150
ρ	1	0.8617	0.7385	0.6292	0.5328	0.4481	0.3741

Use a quadratic least-squares fit to determine the relative air density at $h = 10.5$ km. (This problem was solved by interpolation in Prob. 20, Problem Set 3.1.)

Part III (Chapter 4)

Problem Set 4.2

16. ■



The two blocks of mass m each are connected by springs and a dashpot. The stiffness of each spring is k, and c is the coefficient of damping of the dashpot. When the system is displaced and released, the displacement of each block during the ensuing motion has the form

$$x_k(t) = A_k e^{\omega_r t} \cos(\omega_i t + \phi_k),\ k = 1, 2$$

where A_k and ϕ_k are constants, and $\omega = \omega_r \pm i\omega_i$ are the roots of

$$\omega^4 + 2\frac{c}{m}\omega^3 + 3\frac{k}{m}\omega^2 + \frac{c}{m}\frac{k}{m}\omega + \left(\frac{k}{m}\right)^2 = 0$$

Determine the two possible combinations of ω_r and ω_i if $c/m = 12\ \mathrm{s}^{-1}$ and $k/m = 1\,500\ \mathrm{s}^{-2}$.