MME 9621: Computational Methods in Mechanical Engineering

Assignment 4

(**Due date: 29 March 2024**, **Friday**. *Submit through owl*)

Note:

(i) For all of the problems, comment on accuracy and cost of computing.
(ii) Please submit your computer programs with necessary outputs.
(iii) Mark distribution: Problem 1 (60), Problem 2 (40).

1. A large flat plate at temperature T = 925K is placed in front of a second large flat plate. The heated plate emits radiation to the second plate and the second plate reflects some radiation back to the heated plate. The emissivity as a function of wavelength of the heated plate is given by equation (1) where the wavelength λ is measured in micrometers.

$$\epsilon(\lambda) = \begin{Bmatrix} 0.850\left(1-\dfrac{\lambda}{10.5}\right) & 0 \le \lambda \le 10.5 \\ 0 & \text{otherwise} \end{Bmatrix} \tag{1}$$

The reflectivity of the second plate as a function of wavelength λ is given by equation (2),

$$\rho(\lambda) = \begin{Bmatrix} 0.35 & \text{for } 0 \le \lambda \le 4.5 \\ 0.82 & \text{for } \lambda > 4.5 \end{Bmatrix} \tag{2}$$

The energy flux of radiation being absorbed by the first plate is given by equation (3),

$$Q_{\text{abs}} = \rho(\lambda)\int_0^\infty \epsilon^2(\lambda)E(\lambda,T)\,d\lambda \tag{3}$$

$$\text{where,} \qquad E(\lambda,T) = \frac{2\pi C_1}{\lambda^5\left(e^{\frac{C_2}{\lambda T}}-1\right)}$$

$$\text{with} \qquad C_1 = hc_0^2\ , \qquad C_2 = \frac{hc_o}{k_B} \tag{4}$$

Considering $c_0 = 2.9979 * 10^8$ m/s, $h = 6.626 * 10^{-34}$ Js and $k_B = 1.3806 * 10^{-23}$ J/K,

calculate the energy flux absorbed by the first plate.

Use (a) MATLAB function and (b) Simpson's 1/3 rule.

2. An automobile is modeled as shown in Figure 1 with mass M, mass moment of inertia J_G, suspension system springs of k_1, k_2 and k_3 with weights m_1 and m_2. Four degrees of freedom are defined for the system as x_1, x_2, x_3 and θ. The governing equations for the free harmonic oscillations with variables $x_r = X_r e^{i\omega t}$ (r =1,2,3) and $\theta = \Theta e^{i\omega t}$ are as follows:

$$-m_1\omega^2 X_1 + (k_1 + k_2)X_1 - k_2 X_3 + k_2 l_1 \Theta = 0$$
$$-m_2\omega^2 X_2 + (k_1 + k_3)X_2 - k_3 X_3 - k_3 l_2 \Theta = 0$$
$$-M\omega^2 X_3 - k_2 X_1 - k_3 X_2 + (k_2 + k_3)X_3 + (k_3 l_2 - k_2 l_1)\Theta = 0$$
$$-J_G\omega^2 \Theta + k_2 l_1 X_1 - k_3 l_2 X_2 + (k_3 l_2 - k_2 l_1)X_3 + (k_2 l_1^2 + k_3 l_2^2)\Theta = 0$$

If k_1 =18,000 N/m, k_2 =20,000 N/m, k_3 =20,000 N/m, l_1 =1.0 m, l_2 =1.5 m, M =1000 kg, m_1 = 100 kg, m_2 = 200 kg, radius of gyration r =0.9 m and J_G =Mr^2,

find the natural frequencies of the system.

Use (a) Q-R factorization, (b) MATLAB ‘eig’ function.

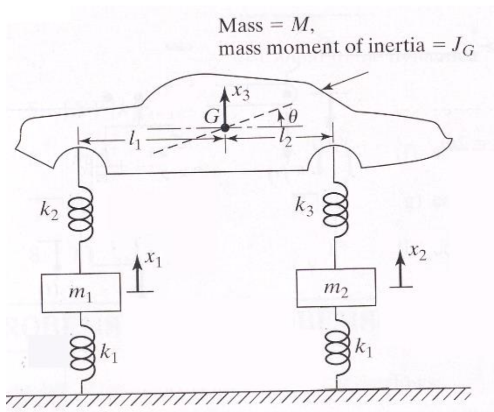

Figure 1.
