MA 203 | NUMERICAL METHODS

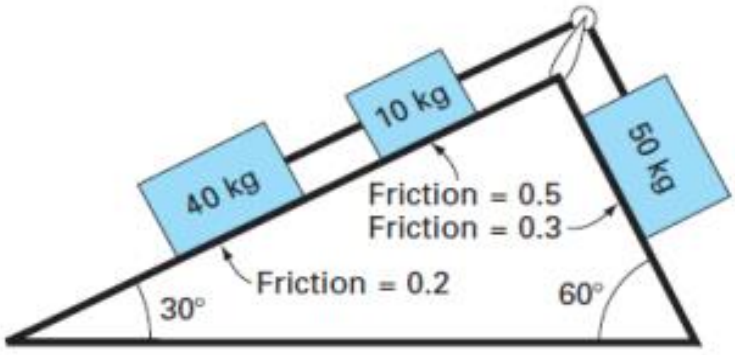
PROBLEM SET 3

INSTRUCTIONS

- Problems marked with an asterisk (*) are tutorial problems and solutions must be submitted by the students in Google classroom by the end of the tutorial session (**6:30 pm**). Note that if the submission is not made by the end of the tutorial session or if the submission does not reflect reasonable effort and work, the student may be marked absent for the tutorial session. Late submissions will not be accepted.
- In addition, you will need to do Problem 5 and any one of the remaining problems as a homework assignment (excluding the tutorial problem). You will need to use the Tridiagonal Matrix Algorithm (TDMA) for Problem 5 and the Gauss-Seidel method for the other problem. You must submit the assignment by **10 pm on August 31, 2023** in Google classroom.
- You should write a computer program to solve the problems. You may use Matlab or any other programming language of your choice.
- The report must entail a description of the problem, the procedure used to solve it (see assignment format in the course plan for details), and results/solutions and discussions. The report must be in **PDF format**. Please upload the report and program files separately (that is, please do NOT submit all of them together as a single ZIP file) in Google classroom. **Solutions to each problem should be submitted as a separate file**. Name each file as: problemnumber_Rollnumber.***. For example, if your roll number is 22110110 and for problem A1, name your report file as A1_22110110.pdf and program file as A1_22110110.m (if you are using MATLAB).

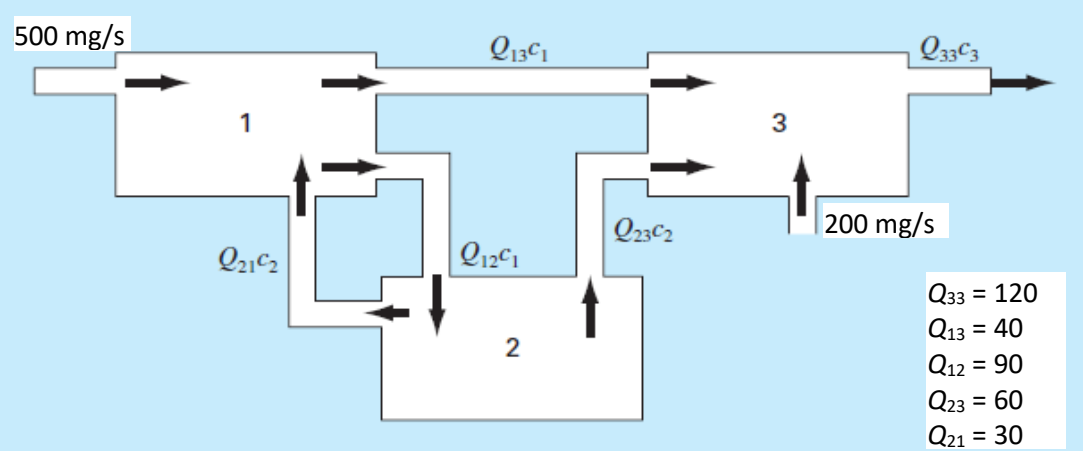
Problem 1* (Tutorial problem)

Three blocks on an inclined plane are connected by a weightless cord, as shown below. Using free body diagrams, derive a set of equations describing the motion of each block. Write a computer program and solve the resulting set of equations numerically using the Gauss elimination method and determine the acceleration of each block and the tensions in the cords connecting them.



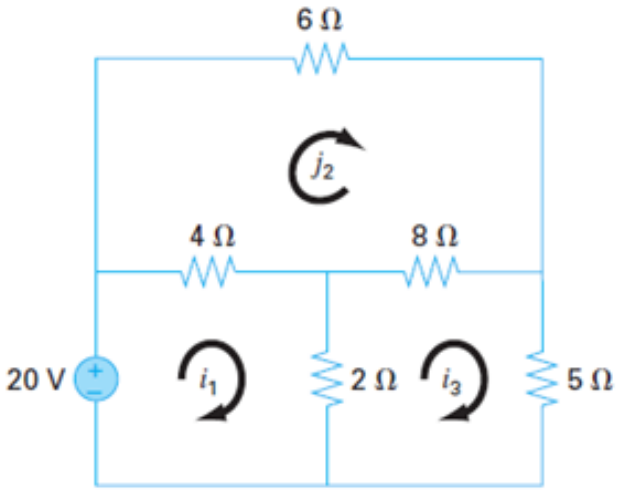
Problem 2

Figure below shows three reactors linked by pipes. As indicated, the rate of transfer of chemicals through each pipe is equal to a flow rate (Q with units of cubic meters per second) multiplied by the concentration of the reactor from which the flow originates (c, with units of milligrams per cubic meter). If the system is at a steady state, the transfer into each reactor will balance the transfer out. Develop mass balance equations for the reactors and solve the three simultaneous linear algebraic equations for their concentrations.



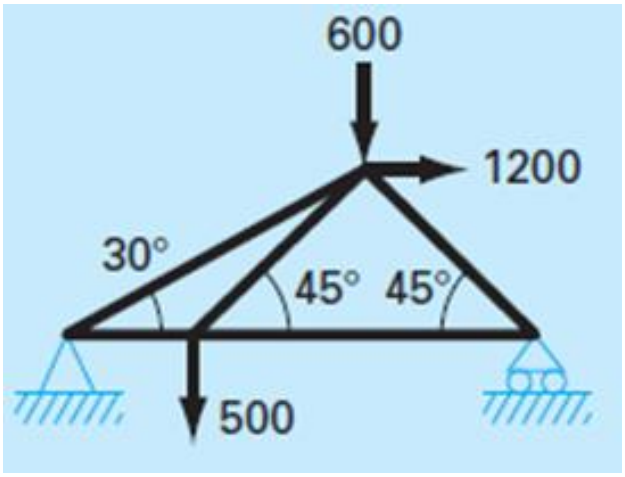
Problem 3

Using Kirchhoff's voltage law to derive set of equations for calculating currents for the circuit shown below. Solve the resulting system of equations numerically.



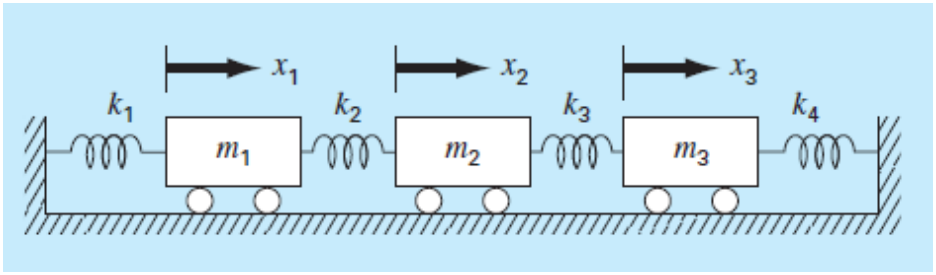
Problem 4

Draw free-body diagrams to obtain the system of equations to find the forces and reactions associated with the statically determinant truss system shown below. Solve the system of equations numerically.



Problem 5

Consider the three mass- four spring system shown below. Determine the equations of motion from $\sum F_x = ma$ for each mass using its free-body diagram.



where $k_1 = k_4 = 10\ \text{N/m}$, $k_2 = k_3 = 30\ \text{N/m}$ and $m_1 = m_2 = m_3 = 2\ \text{kg}$. Write the three equations in matrix form:

0= [Acceleration vector] + [*k*/*m* matrix] [displacement vector *x*]

At a specific time when $x_1 = 0.05\ \text{m}$, $x_2 = 0.04\ \text{m}$ and $x_3 = 0.03\ \text{m}$, this forms a tridiagonal matrix. Solve for the acceleration of each mass using the Tridiagonal Matrix Algorithm (TDMA).