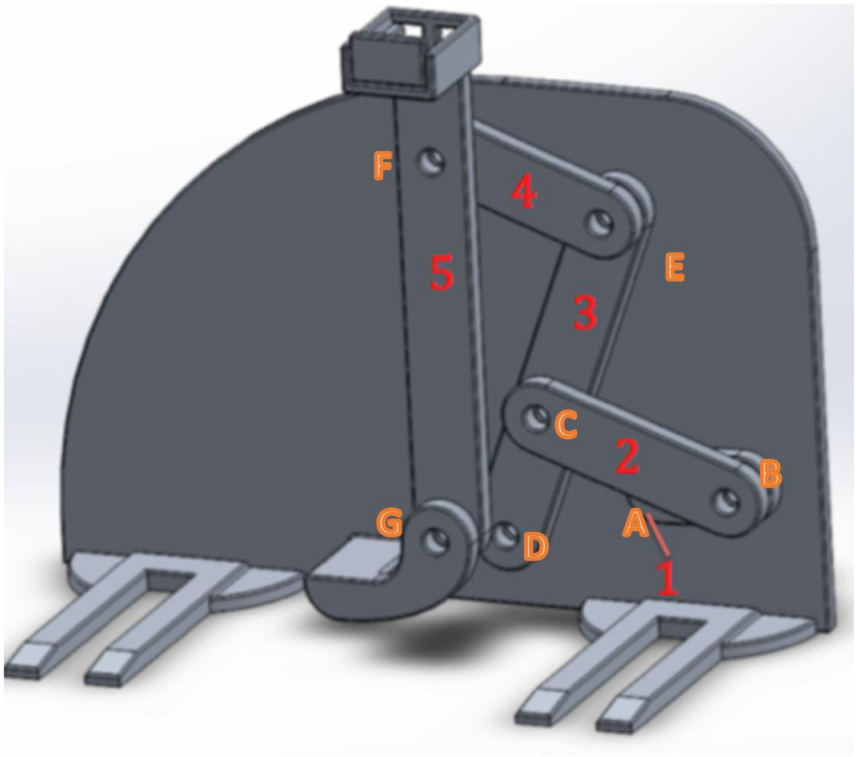
ME/RBE 4322 MODELING AND ANALYSIS OF MECHATRONIC SYSTEMS

Spring 2025 – Term C **Homework #1** **Due: 02/03/2025, 11.59 pm**

Objective: Linkage Statics, Kinematics and Kinetics; vector-based techniques; MATLAB

Details about the Linkage:

The linkage below (a six-bar linkage with three grounded joints and all revolute joints) is used to pick an artifact from a moving conveyor, rotate it by 90° and place it on a different conveyor. This is used in an industrial setting (part of an engine assembly unit) and uses a metal alloy with an appropriately high fatigue life. Motor is at A and the grounded joints are A, D and G.



The dimensions of various links are given in the table below. These lengths are measured between joint centers.

Link	Length (m)
Link 1 (AB)	0.5726
Link 2 (BC)	1.4157
Link 3 (DE)	2.4866
Link 4 (EF)	1.1754
Link 5 (GF)	2.5841

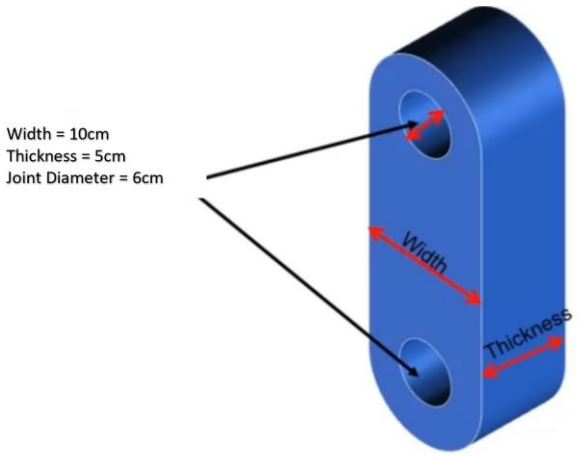
The joint coordinates are given below:

Joint	X (m)	Y (m)
A	1.4	0.485
B	1.67	0.99
C	0.255	1.035

Joint	X (m)	Y (m)
D	0.285	0.055
E	0.195	2.54
F	-0.98	2.57
G	0.05	0.2

Consider the gripper to be placed at a distance of 1.843m from the joint F. You can consider this to be the location for the load transported by the mechanism.

Tentative cross-sectional information is given below. You are free to modify these dimensions.



Methodology:

a. You will do analysis for all positions of the linkage (that is, 360deg rotation of the input link).
b. You will draw a kinematic outline of the linkage with joint coordinates for the first position.
c. Determine the joint forces and the input torque required using static equilibrium and Newton's second law for each position. In the process, you will also determine the position, velocity and acceleration kinematics of the linkage (joint and link kinematics). You will also draw FBDs of the links (for one position).
d. You will be using MATLAB to solve the various position, velocity, acceleration kinematics and the statics/dynamics equations. It would be easier to use for-loop, cross-products and symbolic toolbox within MATLAB to obtain the required quantities for all positions. You will however be required to write representative equations for one position as part of the report associated with this homework.
e. You will also use PMKS+ (https://pmksplus.mech.website) to verify your kinematics values (velocity and acceleration of joints and links) and joint forces/input torque in static equilibrium.
f. Assume the weight of the artifact supported by the linkage to be 200N.

Keep in mind that you are also required to determine appropriate input characteristics (such as the input angular velocity required) such that the linkage can transport 7450 parts in seven hours. The associated assumptions related to the gripping, releasing of the artifact, etc. need to be specified. The weight of the imaginary gripper can be ignored.

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Additional Pointers: https://wpi0-my.sharepoint.com/:w:/g/personal/pradhakrishnan_wpi_edu/Ef83LaZkWlNDlnP_4f_cFk0Ban35jbt0jRzBCUFnL9LmPQ?e=YMFZiA

Deliverables/Requirements (Total Points: 550):

Ensure that the homework solution addresses the following:

a. Assumptions (10 Points)
b. Free-body diagrams (20 Points)
c. Statics and Dynamics Equations (50 Points)
    1. Force, Moment equations (Static Equilibrium and Newton's Second Law)
    2. Mass Calculations
    3. Mass moment of inertia calculations
    4. Kinematics Equations (Position, Velocity and Acceleration)
    5. Accelerations at mass centers
d. Results (320 Points)
    1. First Position (70 Points)
        1. Joint Forces and Torque (Static Equilibrium and Newton's Second Law)
        2. Position, velocity, acceleration (Linear and Angular terms)
        3. Masses and Mass moment of inertia
    2. Plots/Graphs of Various Quantities (150 Points)
        1. Include Plots/Graphs showing the variation (static force,static torque, dynamic force, dynamic torque, velocity of joints, angular velocity of links, angular accelerations of links, accelerations of joints, positions of joints)
    3. Comparison of Kinematics and Static Forces/Torque between PMKS+ and MATLAB implementations (100 Points)
e. Submission of a working MATLAB program that produces results. (130 Points)
f. Discussion – the insights you acquired in terms of static and dynamic force/torque values, highlight the max/min values for forces at joints and motor torque, you can talk about how such prototypes could be constructed for industrial operation, indicate the type of motor you would choose for the purpose and the related specifications, etc. (15 Points)
g. References (5 Points): indicate all information sources.

Please include all the above details in a Google Document or Word Online (Office 365) document and share that link (with permissions to add comments) on Slack. Please share your work in the homework channel created for each team. Along with this link, you will be required to share the MATLAB file too. Please do not upload any pdfs to the slack channel as part of this homework submission.

Feel free to use the public homework channel or your private help-report channel to ask questions.