Washington University in St. Louis
ESE447
Robotics Laboratory

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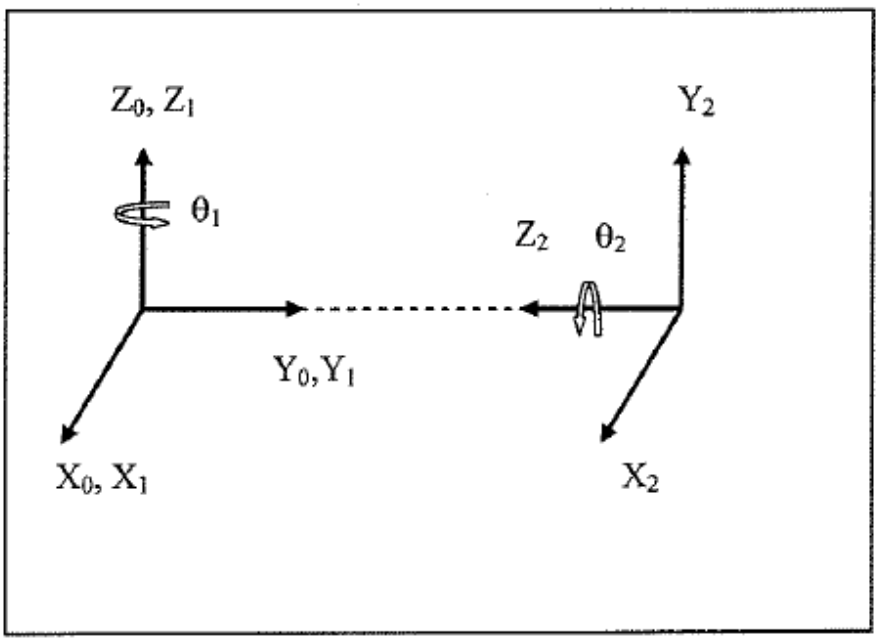
LAB ASSIGNMENT – Two axis robot simulation
TOOLS: MATLab embedded function, Simulink, and Quanser Pendulum



$$ {}^{0}_{1}T = \begin{bmatrix} Cos(\theta_1) & -Sin(\theta_1) & 0 & 0 \\ Sin(\theta_1) & Cos(\theta_1) & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} \quad {}^{1}_{2}T = \begin{bmatrix} Cos(\theta_2) & -Sin(\theta_2) & 0 & 0 \\ 0 & 0 & -1 & (l_1 + l_2) \\ Sin(\theta_2) & Cos(\theta_2) & 0 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} $$

TASK OBJECTIVE: In this lab we will use MATLab to create a 2-axis robot simulation model, find the robot's work envelope, and use the Quanser Pendulum to test our simulation.

TASK-1: Use 'plot3' command in MATLab to draw base of robot in FRAME-O (this is the stationary frame). A line with markers is a simple representation.

TASK-2: Draw first link of robot with the following points in FRAME-1: (0,0,0), (0,0,-1), (0,6,-1), (0,6,0) and (0,8,0).

TASK-3: Write a function in MATLab (TRANS0_1) to convert the points representing the first link. The homogeneous transformation matrix is given above. This transformation will introduce the variable 'theta1' which is the rotation about the Z-axis of FRAME-1. Your program should accept input values for 'theta1' and plot the results to the figure in Task #1. Loop program in order to create animation effect.

- What FRAME is your graph representing?
- What is the shape of the work envelope of this one-link robot?

TASK-4: Draw second link of robot with the following points in FRAME-2: (0,0,0) and (0,12,0). These points represent the link as would be viewed from FRAME-2.

TASK-5: Write a function in MATLab (TRANS1_2) to convert the points representing the second link. The homogeneous transformation matrix is given above. This transformation will introduce the variable 'theta2' which is the rotation about the Z-axis of FRAME-2. Your program should accept input values for 'theta2' and plot the results to the figure in Task #1.

- Input both angles into program and animate robot.
- What is the shape of the work envelope of this two-link robot?

TASK-6: Write a separate function representing the work envelope of the two-link robot. Impose this figure on previous graph. Does animated robot follow envelope?

TASK-7: Using Simulink, Quanser Pendubot, and your MATLab program, move pendubot **"by hand**" to check simulation. The encoders are serving as the 'theta1' and 'theta2' inputs to your program. *NOTE: This is a two part process. The first step is to use a Simulink program to collect data for the real hardware. The second step is to use another Simulink program to playback this data.

6.0 SYSTEM PARAMETERS

Parameter	Symbol	Value	Units
Motor Torque constant (and back emf constant in SI units)	Km	0.00767	Nm/Amp V/ rad sec $^{-1}$
Motor Armature Resistance	Rm	2.6	Ω
Internal gearbox ratio	N/A	14.1	N/A
External gearbox ratio(high gear ratio)	N/A	5	N/A
Total gear ratio	Kg	60.5	N/A
Motor pinion # teeth	NA	24	teeth
Total inertia after gearbox including arm	J_b	0.0044	Kg m^2
Pendulum true length	Lp	0.43	m
Pendulum mass	mp	0.14	Kg
Servo position potentiometer sensitivity	N/A	35	Deg/Volt
Pendulum angle encoder resolution	N/A	1024 * 4	count/rev
Pendulum angle calibration constant	N/A	.08789	deg/count