EE/ME 4290/5290 Mechanics & Control of Robotic Manipulators

Dr. Bob, Fall 2025

Robotics Laboratory Mini-Projects (LMP 1 – 7)

Laboratory Exercises: The laboratory exercises are to be done in teams of two (or one) outside of class time. Each lab report must be submitted at the start of class according to the schedule shown in the EE/ME 4290/5290 Syllabus. Each laboratory requires a single written technical report, for the team, with a **Memo**. Each LMP report is worth 10 points, except for **LMP 6**, which is worth 5 points.

Each lab should be completed with the same partner all semester, if possible (or solo all semester is fine). If you have a partner, both partners must work and write equally for each LMP report submission (absolutely no alternating assignments with your partner!). Turn in one report with both names for all lab submissions. Normally both partners will earn the same grade.

NO LATE ASSIGNMENTS WILL BE ACCEPTED! NO LMP GRADE WILL BE DROPPED!! Your laboratory reports for all submissions must include plenty of graphics – sketches, photographs, etc., to support your results. Be sure to properly reference any graphics obtained from an outside source.

Safety: Even though these activities are more virtual than physical, for any hardware interaction, ***safety*** is of **PARAMOUNT IMPORTANCE**!! You must have at least one other person in the laboratory with you at all times; use common sense.

Laboratory Mini-Projects Summary

1. Planar and spatial robot mobility (number of degrees-of-freedom, dof)
2. Robot reachable workspaces
3. Adept SCARA Industrial Robot sketches, modeling, DH parameters, joint limits, workspace
4. Industrial parallel robot report
5. Detailed report on student video day (5 pts max – individual only, no lab teams)
6. Detailed report for journal article presentation

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Laboratory Reports Format

Each submitted lab report must be formal and of technical report quality. They needn't be long but they must be complete. The MUST include plenty of graphics: sketches, diagrams, and digital photos. If a figure comes from another source, you MUST reference that source. Here is the required report format for each EE/ME 4290/5290 lab report:

1. The cover sheet must be the memo, serving as the Executive Summary: abstract and mini-results, mini-discussion, and mini-conclusion.
2. Problem statement
3. Results
4. Discussion
5. Conclusion
6. References
7. Appendices (if necessary)

Laboratory Mini-Project Assignments

LMP 1. Mobility

Calculation of mobility (number of degrees-of-freedom) for various planar and spatial serial and parallel robots

Use the appropriate mobility equation (planar or spatial) to calculate the number of degrees-of-freedom for each of the following robots:

- The six planar robots and one mechanism on the next page.
- The eight spatial robots on the ensuing two pages.

For **all** cases, ignore the gripper or other end-effector dof (e.g. ignore the fingers in the human arm).

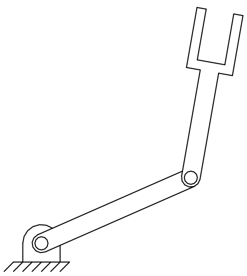
You **must** fill in the tables below:

name	N	J_1	J_2	M
2R serial robot				
3R serial robot				
4R serial robot				
RRPR serial robot				
5-bar RRRRR parallel robot				
3-RRR parallel robot				
Parallel jaw gripper				

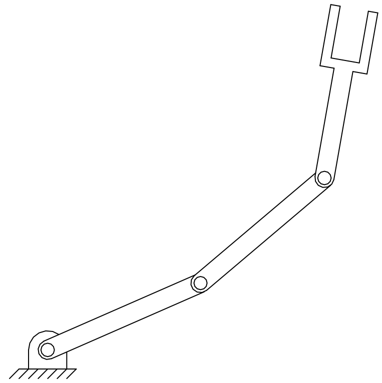
name	N	J_1	J_2	J_3	M
RRPR SCARA serial robot					
5R Mitsubishi serial robot					
6R PUMA serial robot					
7R FTS serial robot					
SRRU Human arm					
8R ARMII serial robot					
6-UPS Stewart platform					
3-RUU Delta parallel robot					

Make your own sketches for each of these devices. Clearly indicate the rotation and other active motion axes. You must also provide discussion for all of your planar and spatial mobility results.

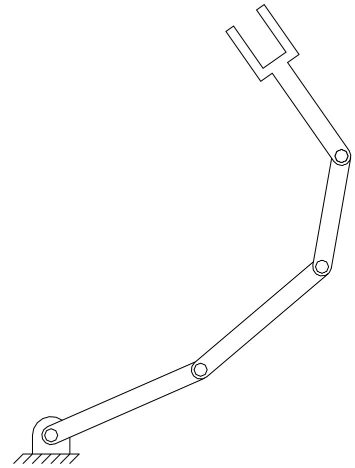
Planar robots:



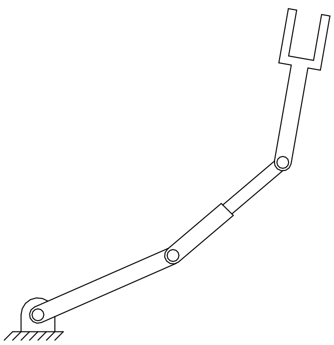
2R serial robot



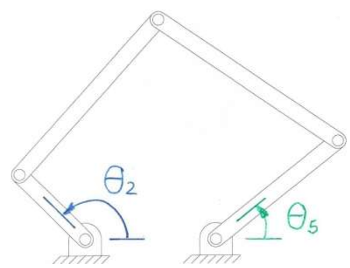
3R serial robot



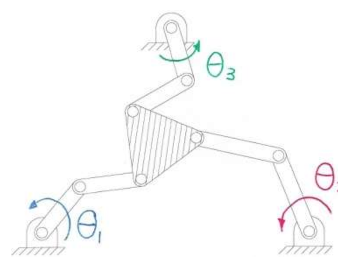
4R serial robot



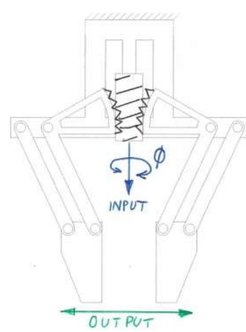
RRPR serial robot



5-bar RRRRR parallel robot

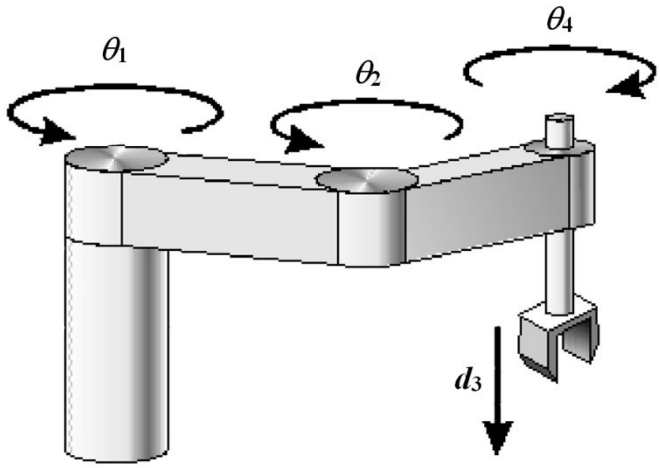


3-RRR parallel robot

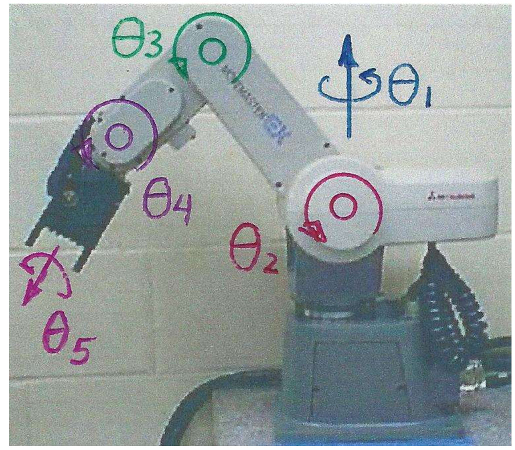


Parallel jaw gripper mechanism

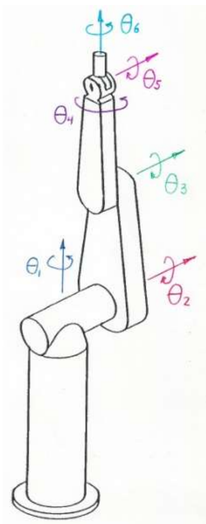
Spatial robots:



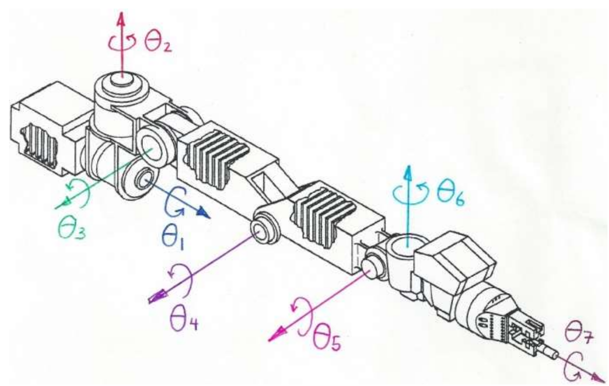
RRPR SCARA serial robot



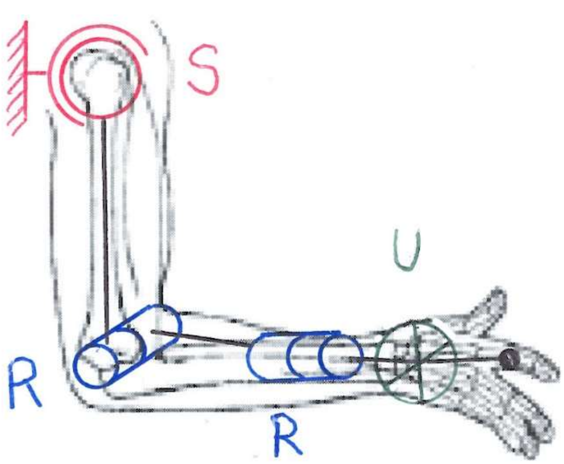
5R Mitsubishi serial robot



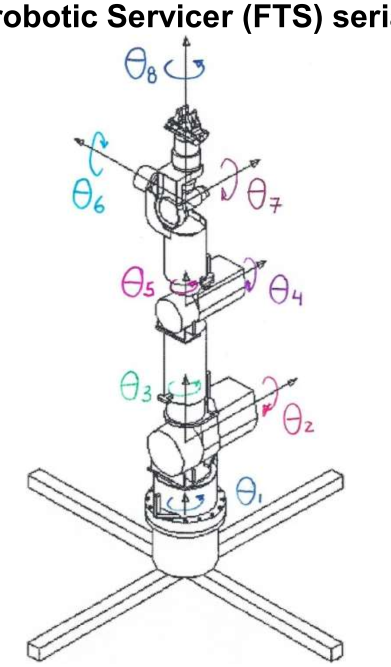
6R PUMA serial robot



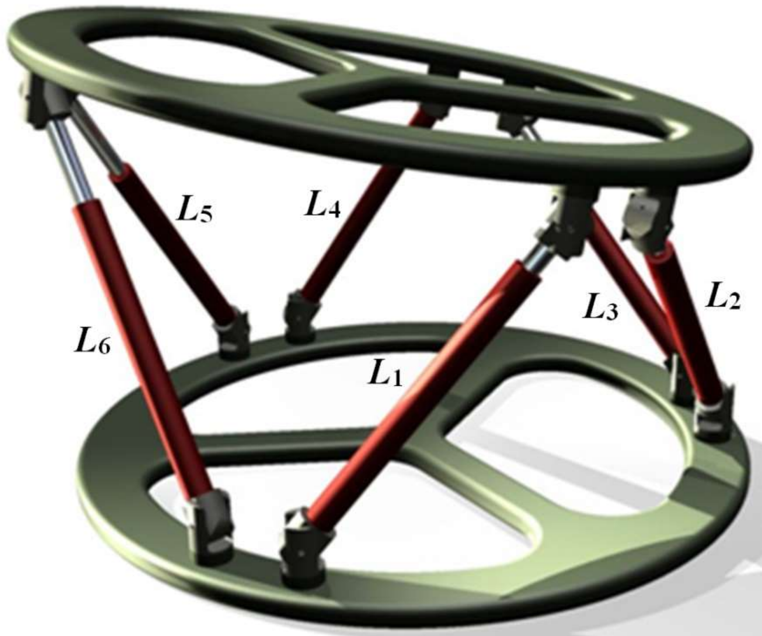
7R Flight Telerobotic Servicer (FTS) serial robot



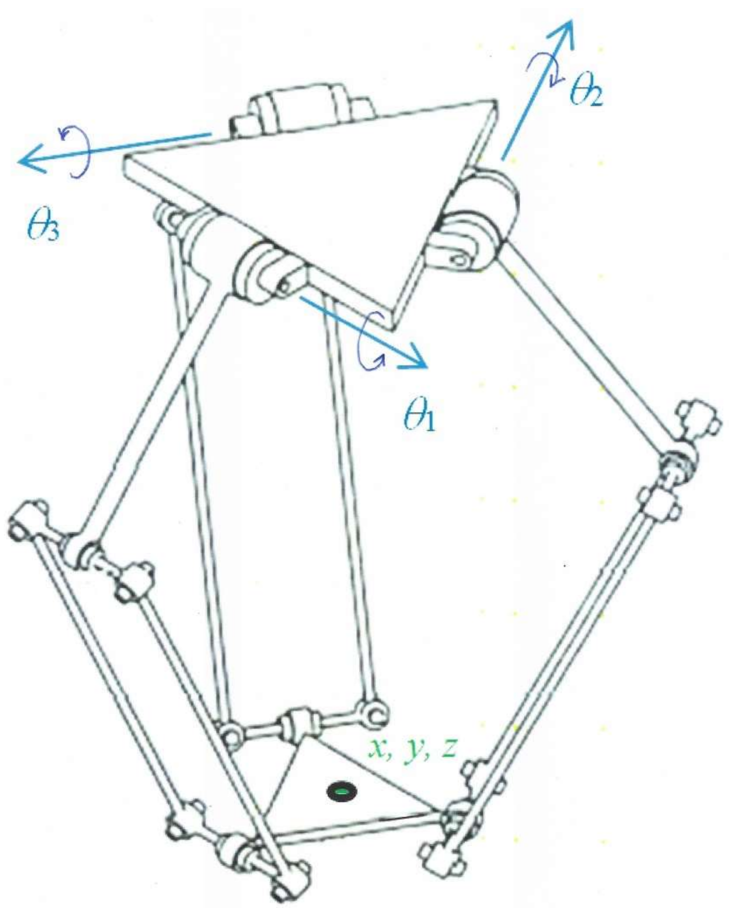
SRRU Human arm (ignore hand freedoms)



8R NASA ARMII serial robot



6-U<u>P</u>S Stewart platform parallel robot



3-<u>R</u>UU translational-only Delta parallel robot

LMP 2. Robot Workspaces

Reachable workspace of various common robot architectures

With your partner, draw the reachable (translational) workspaces of the following spatial robot designs, assuming realistic joint limits for each case.

- 3-dof 3P Cartesian serial robot
- 3-dof PRP Cylindrical serial robot
- 3-dof RRP Spherical serial robot
- 3-dof 3-RUU translational-only Delta parallel robot
- 4-dof RRPR SCARA serial robot
- 4-dof 4R Articulated serial robot
- 6-dof 6-UPS Stewart Platform parallel robot
- 8-dof Cartesian Contour Crafting Cable-Suspended parallel robot

Discuss the advantages and disadvantages of the reachable workspaces of each of the above cases, relative to each other, assuming similar sizes.

As usual, include plenty of graphics to demonstrate your discussions.

LMP 3. ADEPT 550 SCARA Robot

Adept SCARA Industrial Robot sketches, modeling, DH parameters, joint limits, and workspace

For the ADEPT 550 SCARA table-top industrial robot:

- What does SCARA stand for?
- Identify all active joints of the Adept 550 SCARA robot; include joint variable names for each.
- Measure all important dimensions for the Adept 550 SCARA robot (units: m and deg)
- Identify the robot power source, actuators, and transmissions.
- Identify the power source and actuation of the gripper.
- Sketch the kinematic diagram
- Attach the coordinate frames
- Derive the Denavit-Hartenberg Parameters
- Determine the joint limits – report in a clear table, using deg units (mm for the prismatic joint)
- Sketch the approximate translational workspace of this robot

This activity requires the Adept 550 manual (found on Dr. Bob's 4290/5290 website, see below). You are also free to use any valid Internet resources to answer each part – be sure to reference your sources in a professional manner.

Adept 550 SCARA Robot

As with all lab reports, include plenty of sketches, diagrams, and photographs for all important items in this assignment.

For your convenience, here is the Adept 550 User Manual:

people.ohio.edu/williams/html/PDF/Adept550Manual.pdf

LMP 4. Industrial Parallel Robot

In-depth study and report on a specific industrial parallel robot of your choosing

A parallel robot has multiple mechanical linkages connecting the ground link to the end-effector. This is in contrast with standard serial robots that have one cantilevered mechanical path from the ground link to the end-effector.

With your partner, choose one specific industrial parallel robot, preferably one for which a lot of images and technical data are available on the Internet.

- Include a clear photograph
- Sketch the kinematic diagram – show one if that is available but also make your own sketch.
- Demonstrate the motion of each joint.
- Sketch the approximate translational workspace.
- Discuss the range of applications this robot is used for.
- Discuss the power supply and transmission.
- What sensors are used?
- What control method(s) are used?
- Enumerate the technical data: manufacturer, cost, weight, payload-to-weight ratio, repeatability, accuracy, maximum speed and acceleration, etc.
- Discuss the advantages and disadvantages of your chosen parallel robot compared to a similar non-parallel serial robot.

As usual, include plenty of graphics to demonstrate your discussions.

LMP 5. Industrial Kinematically-Redundant Robot

In-depth study and report on a specific serial industrial kinematically-redundant robot of your choosing

A kinematically-redundant robot (KRR) is one that has more active joints (*n*-dof) than the required Cartesian motions (*m*-dof). For example, our 3D world requires 6 Cartesian dof (x, y, z, roll, pitch, yaw) and so any serial robot with 7 joints or higher is kinematically-redundant. There are many other real-world scenarios (i.e. other *m* and *n* values) that lead to kinematic redundancy.

With your partner, choose one specific industrial kinematically-redundant robot, preferably one for which a lot of images and technical data are available on the Internet.

- Include a clear photograph
- Sketch the kinematic diagram – show one if that is available but also make your own sketch.
- Demonstrate the motion of each joint.
- Sketch the approximate translational workspace.
- Discuss the range of applications this robot is used for.
- Discuss the power supply and transmission.
- What sensors are used?
- What control method(s) are used?
- Enumerate the technical data: manufacturer, cost, weight, payload-to-weight ratio, repeatability, accuracy, maximum speed and acceleration, etc.
- Discuss the advantages and disadvantages of your chosen serial kinematically-redundant robot compared to a similar non-kinematically-redundant serial robot.

As usual, include plenty of graphics to demonstrate your discussions.

LMP 6. Robotics Video Day

Report on the robot video you presented as an individual in class on Student Robotics Video Day

This report is worth 5 points, instead of the usual 10.

Unlike the rest of the labs, this one is to be done strictly individually.

Cover sheet: memo

Screen shots of crucial points in the video

What did you learn?

Discussion / Results / Conclusion

Reference information – video link and any other references used

For LMP 5 only, you must do this individually (without your lab partner).

LMP 7. Journal Article Presentation

Report on the journal article your lab team presented (individual for graduate students) in class

For the report requirements, see:

people.ohio.edu/williams/html/PDF/ResPapePres4290.pdf