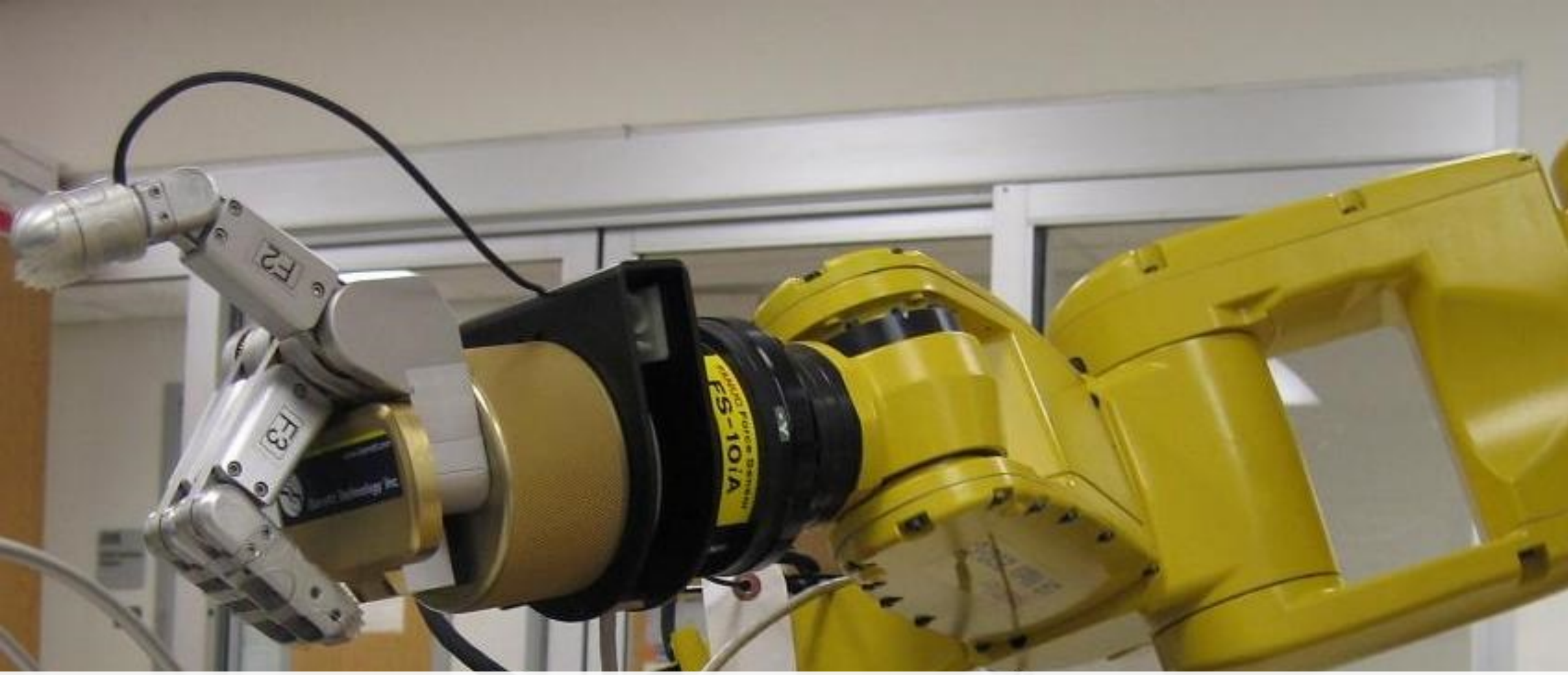
Intro to Robotics

Lecture 1

Outline

- Syllabus
  - Textbook and content
  - Office hours
  - TA and TA hours
  - Grades and grading policy
- Attendance
- Robots
- Robot geometric representation
- Robot kinematics

Syllabus

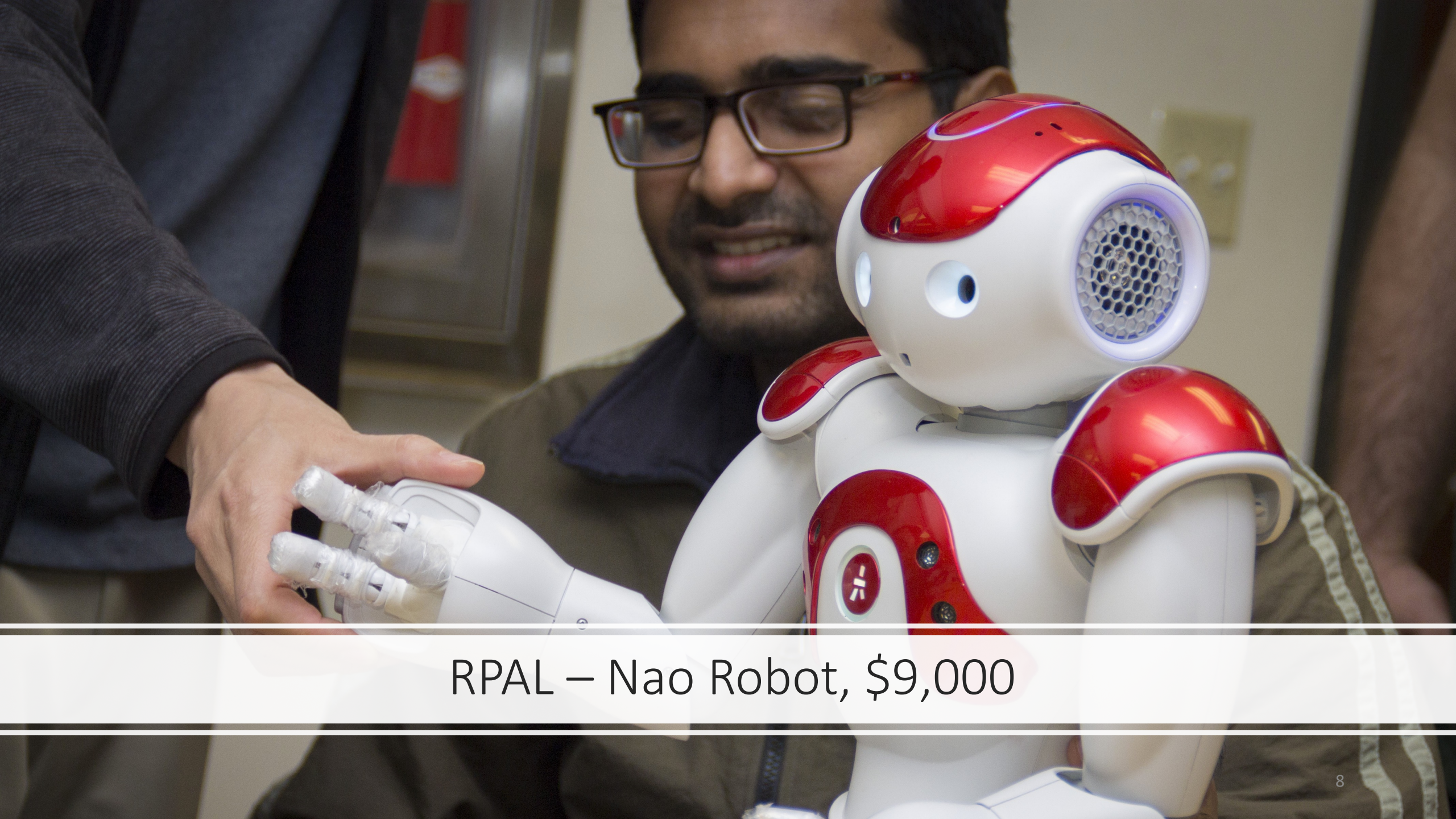


Robots in RPAL – FANUC 6-axis arm, $35,000

RPAL – UR5e 6-axis arm, $35,000

RPAL – Barrett Hand, $30,000

RobotiQ 2F-85 Gripper $5,000



RPAL – Nao Robot, $9,000

RPAL – DJI UAV, $4,000

RPAL – Mobile Robot

Robot Types Not in RPAL

Tesla Bot

WORLD BUILT BY HUMANS,
FOR HUMANS

FRIENDLY

ELIMINATES DANGEROUS,
REPETITIVE, BORING TASKS

HEIGHT	CARRY CAPACITY
5’8”	45 LBS
WEIGHT	DEADLIFT
125 LBS	150 LBS
SPEED	ARM EXTEND LIFT
5 MPH	10 LBS

Technical Details

5'8" | 125 LBS

AUTOPILOT CAMERAS

SCREEN FOR USEFUL INFORMATION

FSD COMPUTER

LIGHTWEIGHT MATERIALS

HUMAN-LEVEL HANDS

2 AXIS FEET FOR BALANCING

MULTI-CAM VIDEO

NEURAL NETWORKS

NEURAL NET PLANNING

40 ELECTROMECHANICAL ACTUATORS

ARMS 12	NECK 2
TORSO 2	HANDS 12
LEGS 12	

AUTO-LABELING

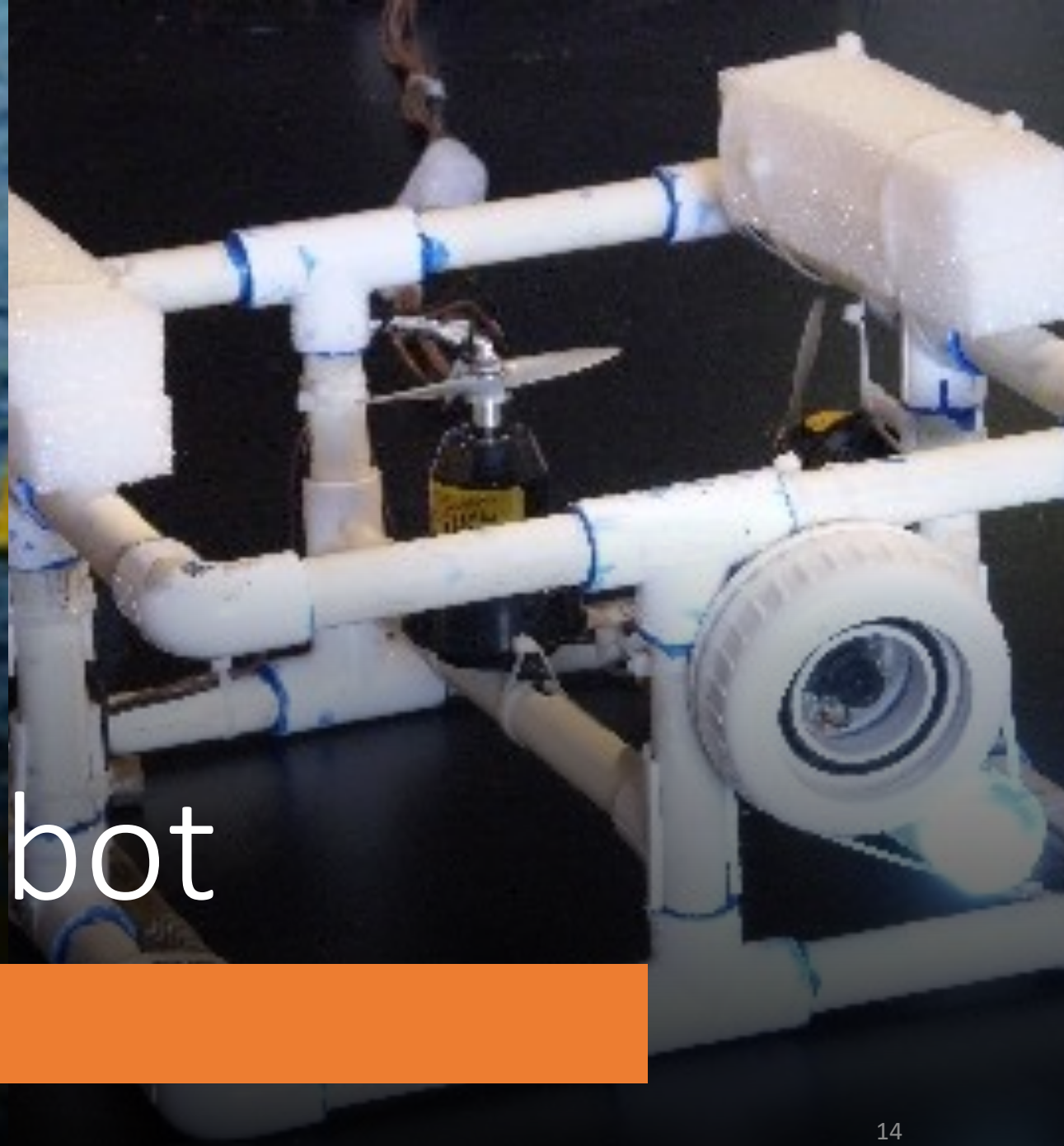
SIMULATION TOOLS

FSD HARDWARE

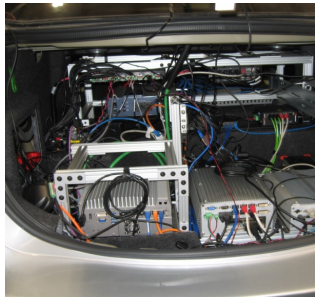
DOJO TRAINING

FORCE FEEDBACK SENSING

TESLA LIVE



Underwater Robot

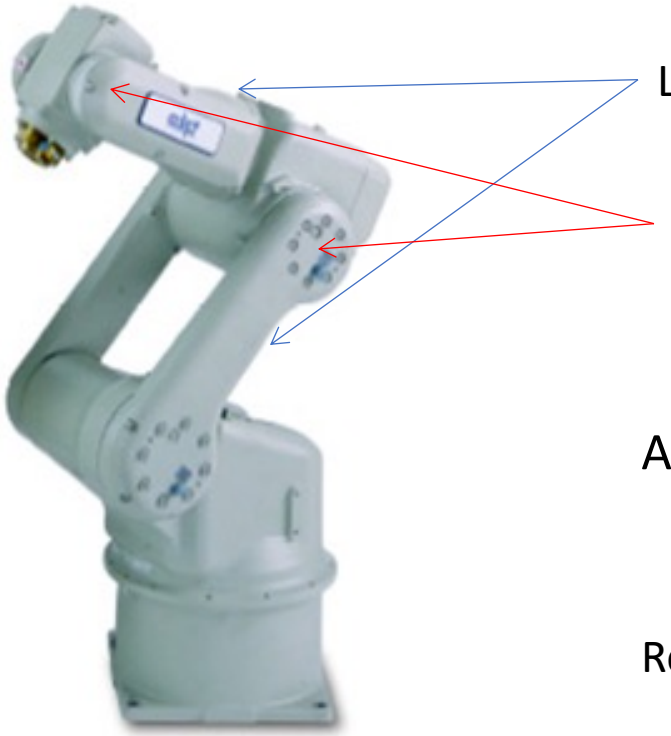


Autonomous Car

Medical Robot

Modeling

- Represent basic geometric aspects of robotic manipulation



Links

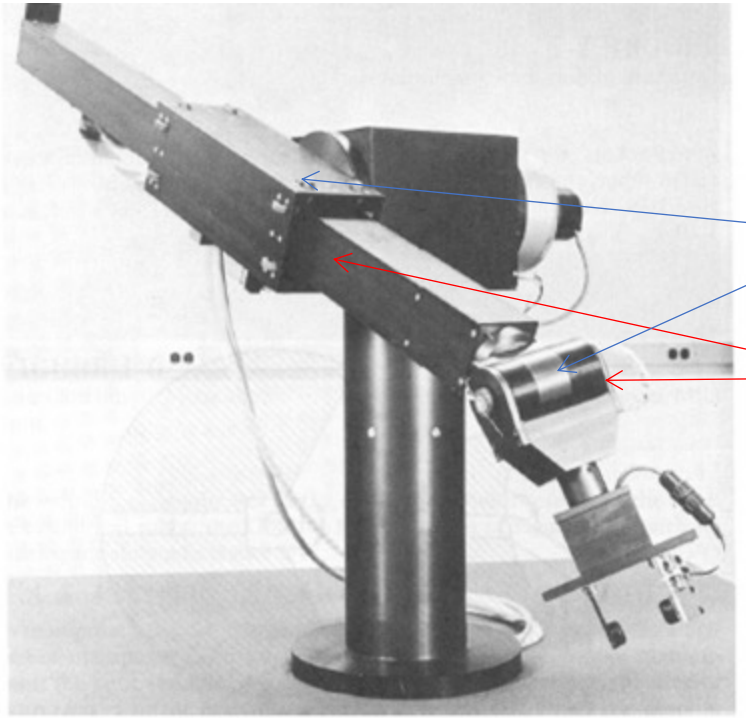
Joints

Kinematic chain

Any other joints?

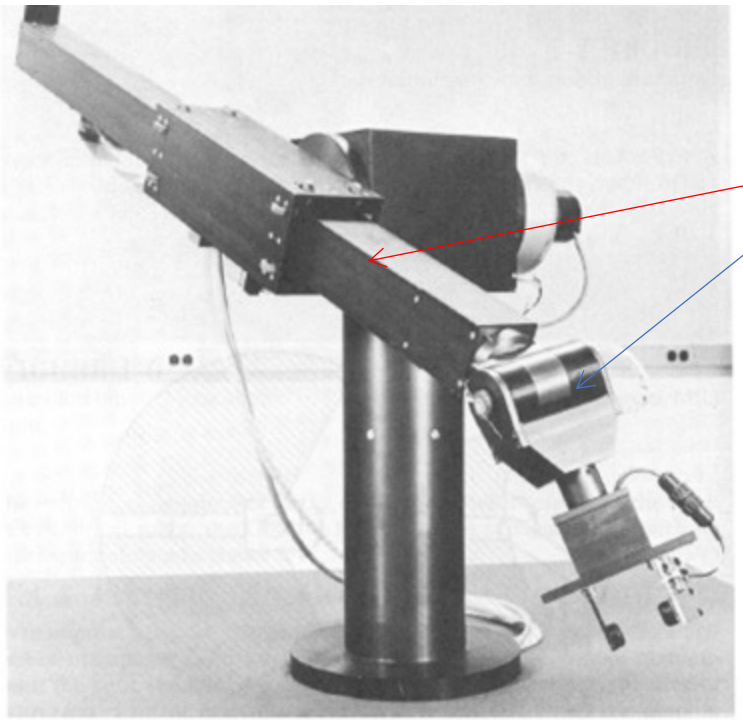
Revolute joint

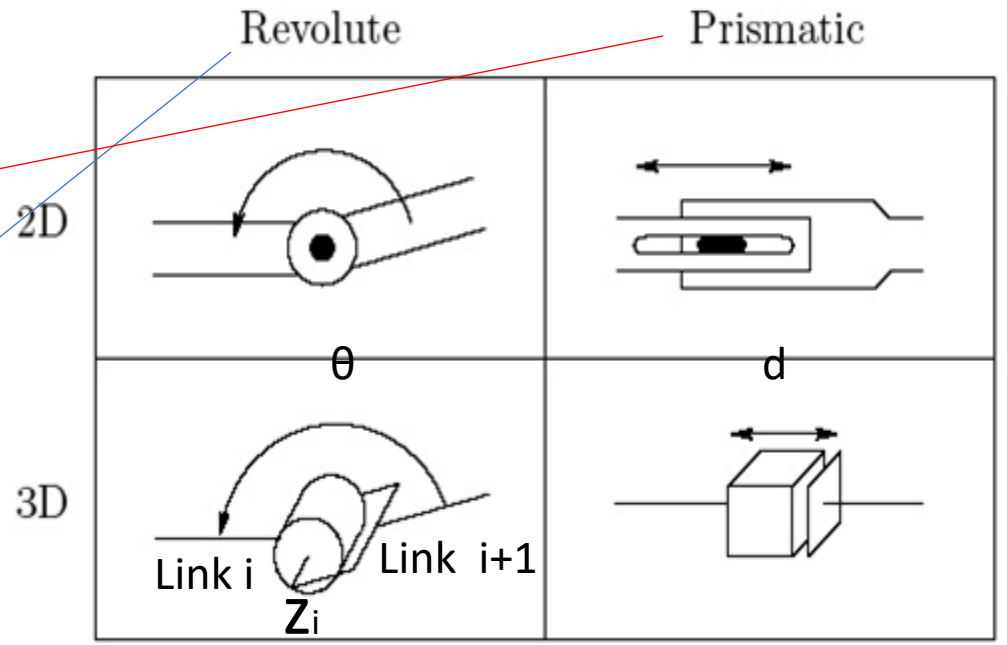
Modeling



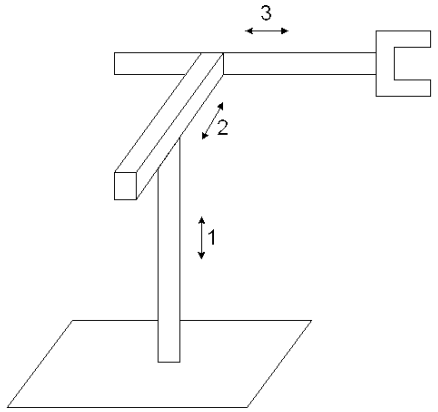
Prismatic joint

Joints

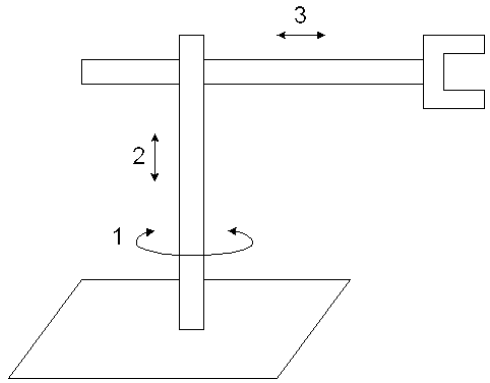




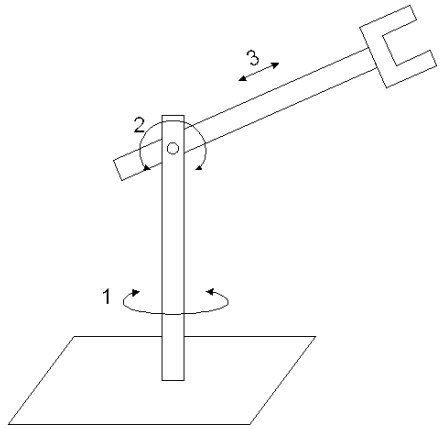
Geometric Types



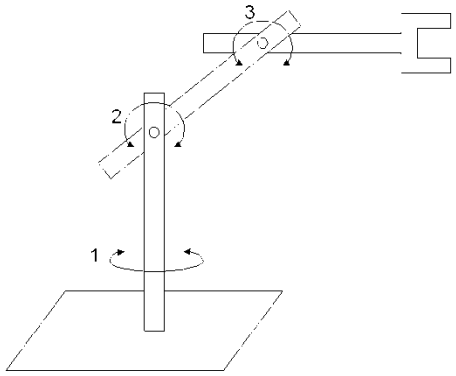
Cartesian: PPP



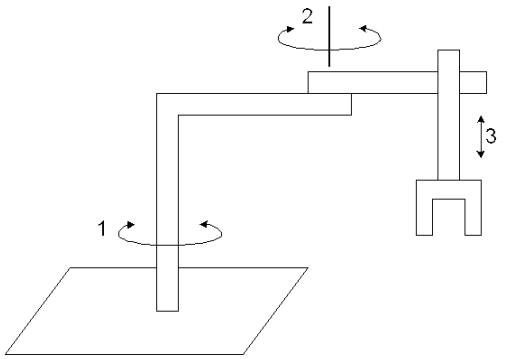
Cylindrical: RPP



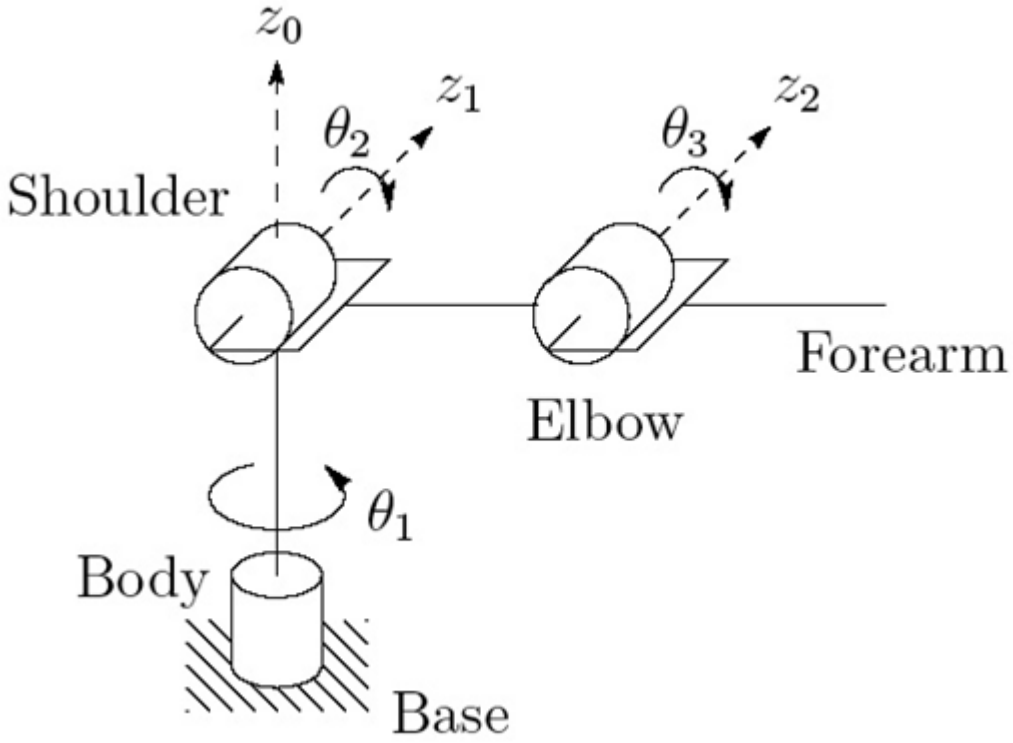
Spherical: RRP



Articulated: RRR



SCARA RRP



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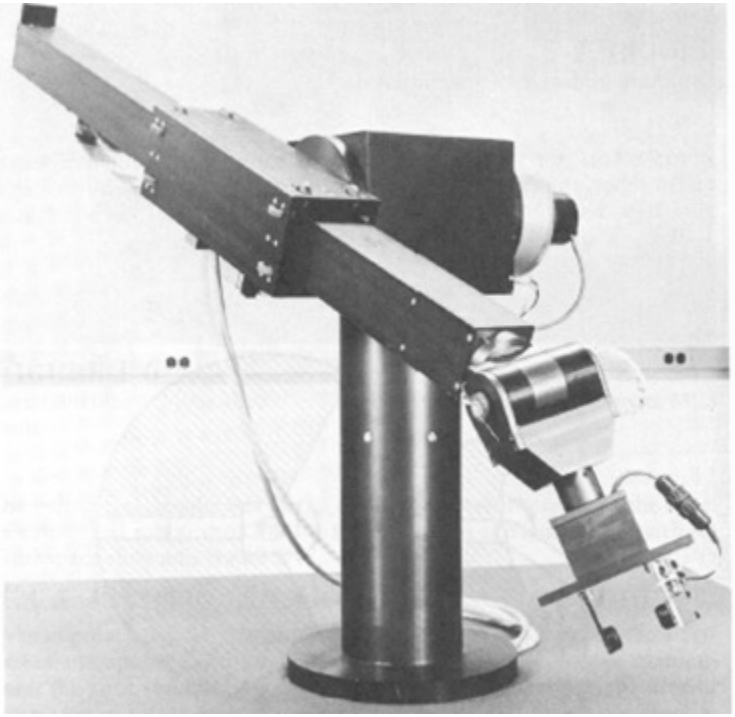
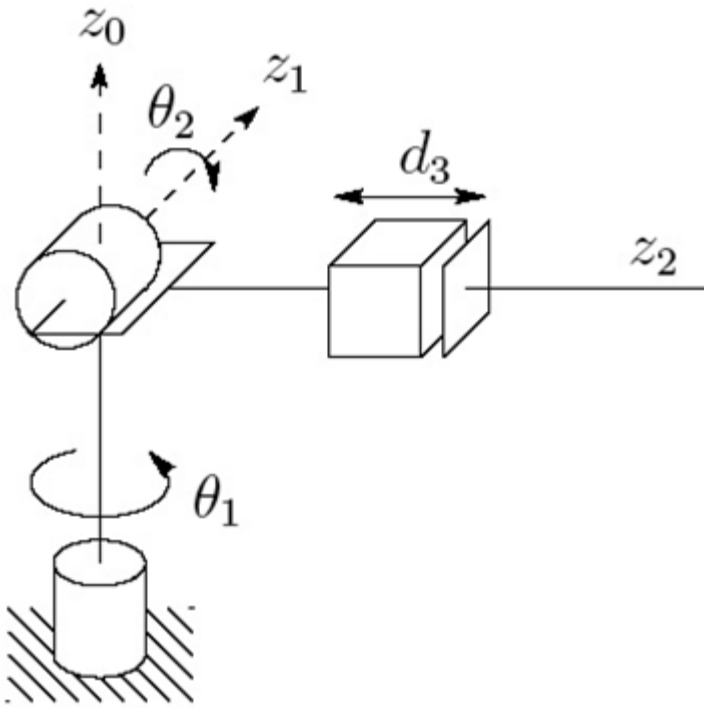
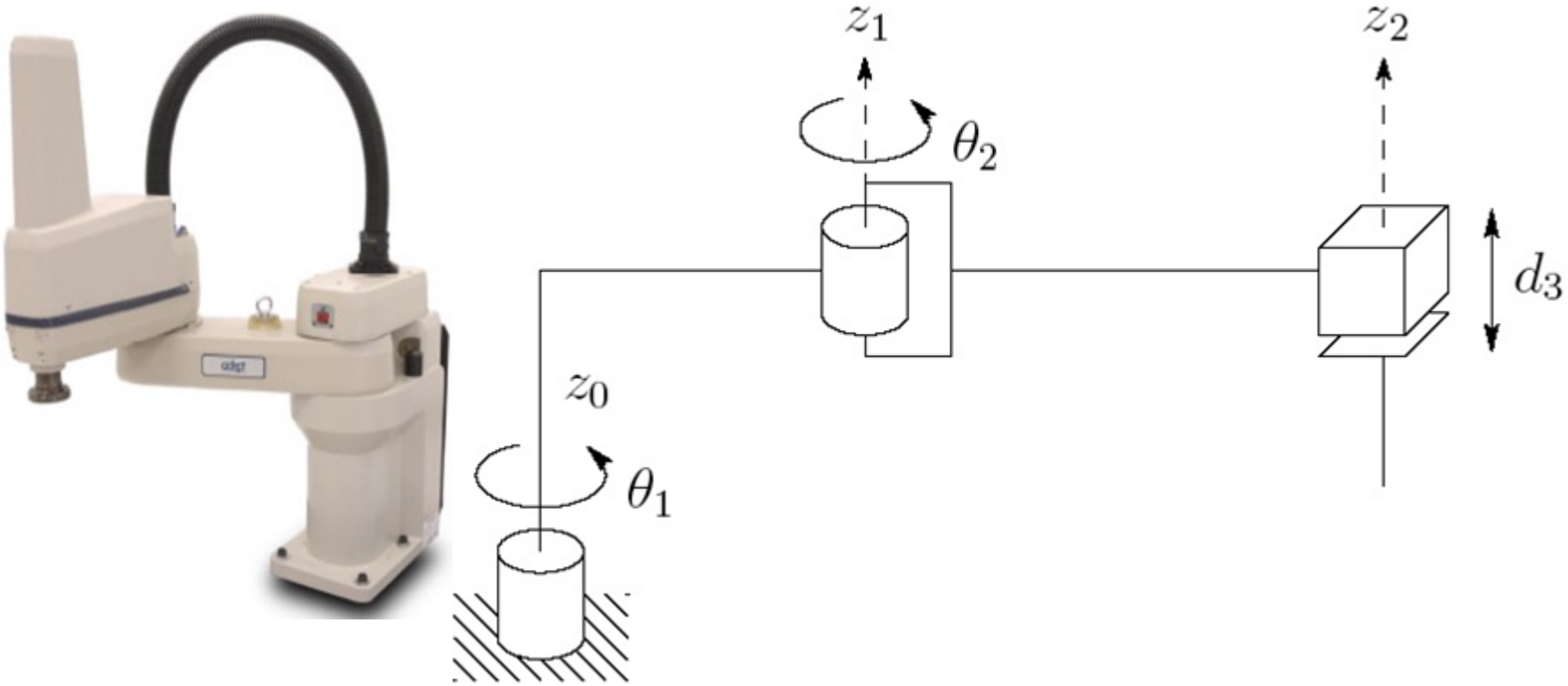
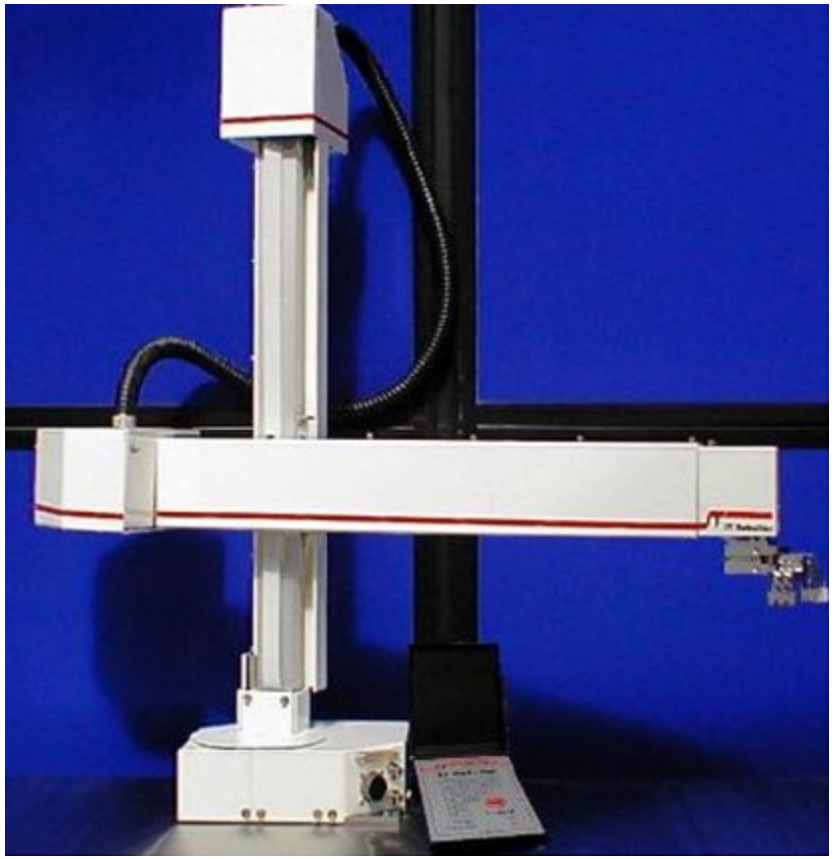


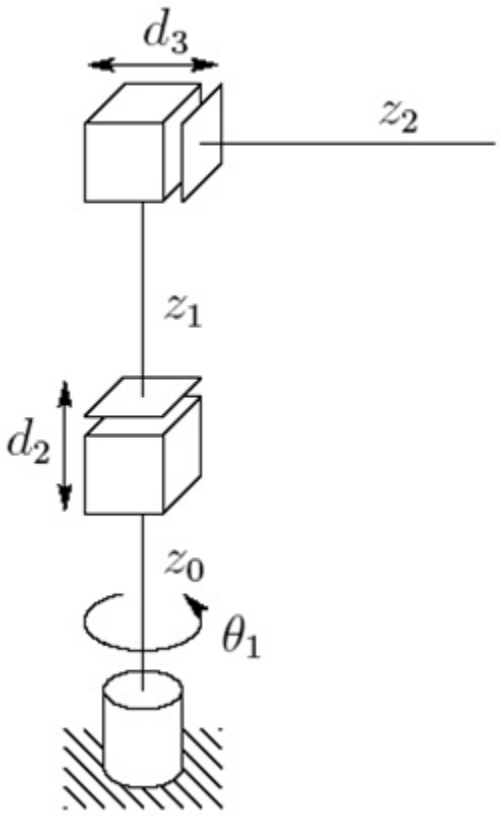


Spherical: RRP

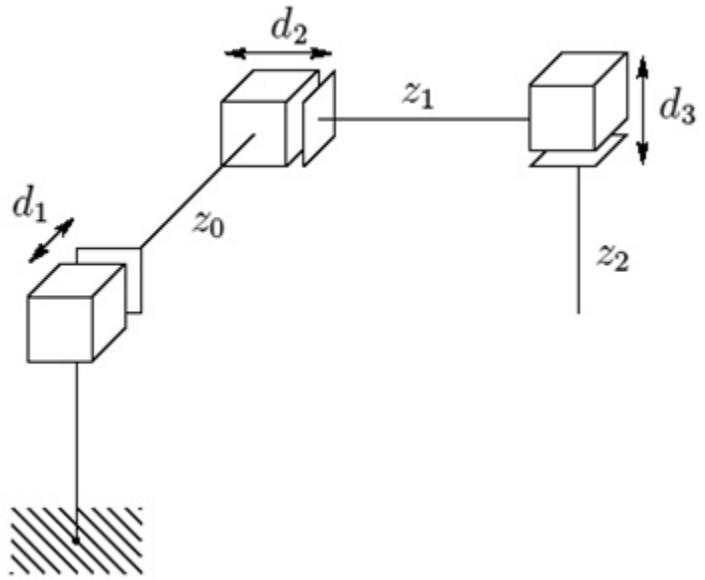


SCARA RRP



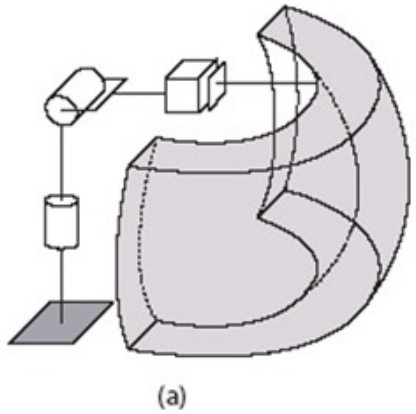


Cylindrical: RPP

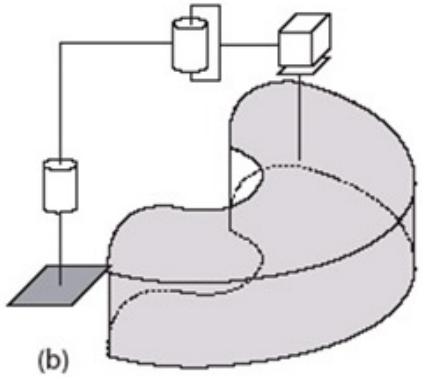


Cartesian: PPP

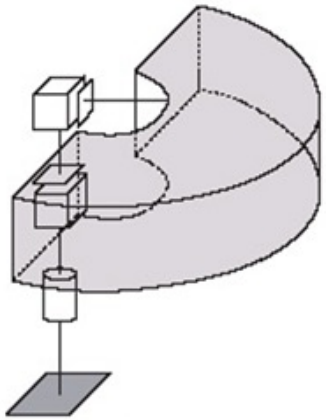
Workspaces



(a)



(b)



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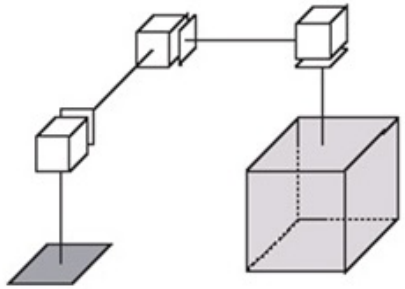

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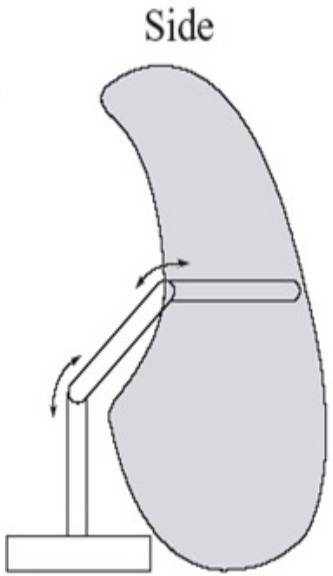
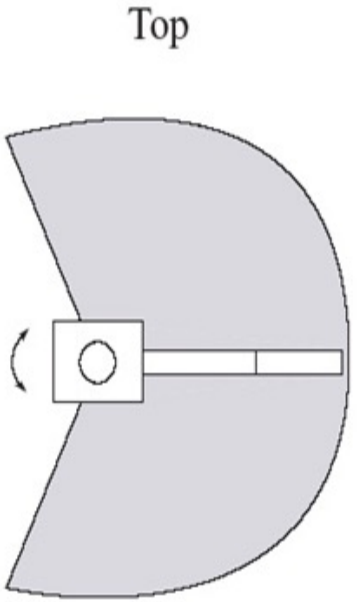
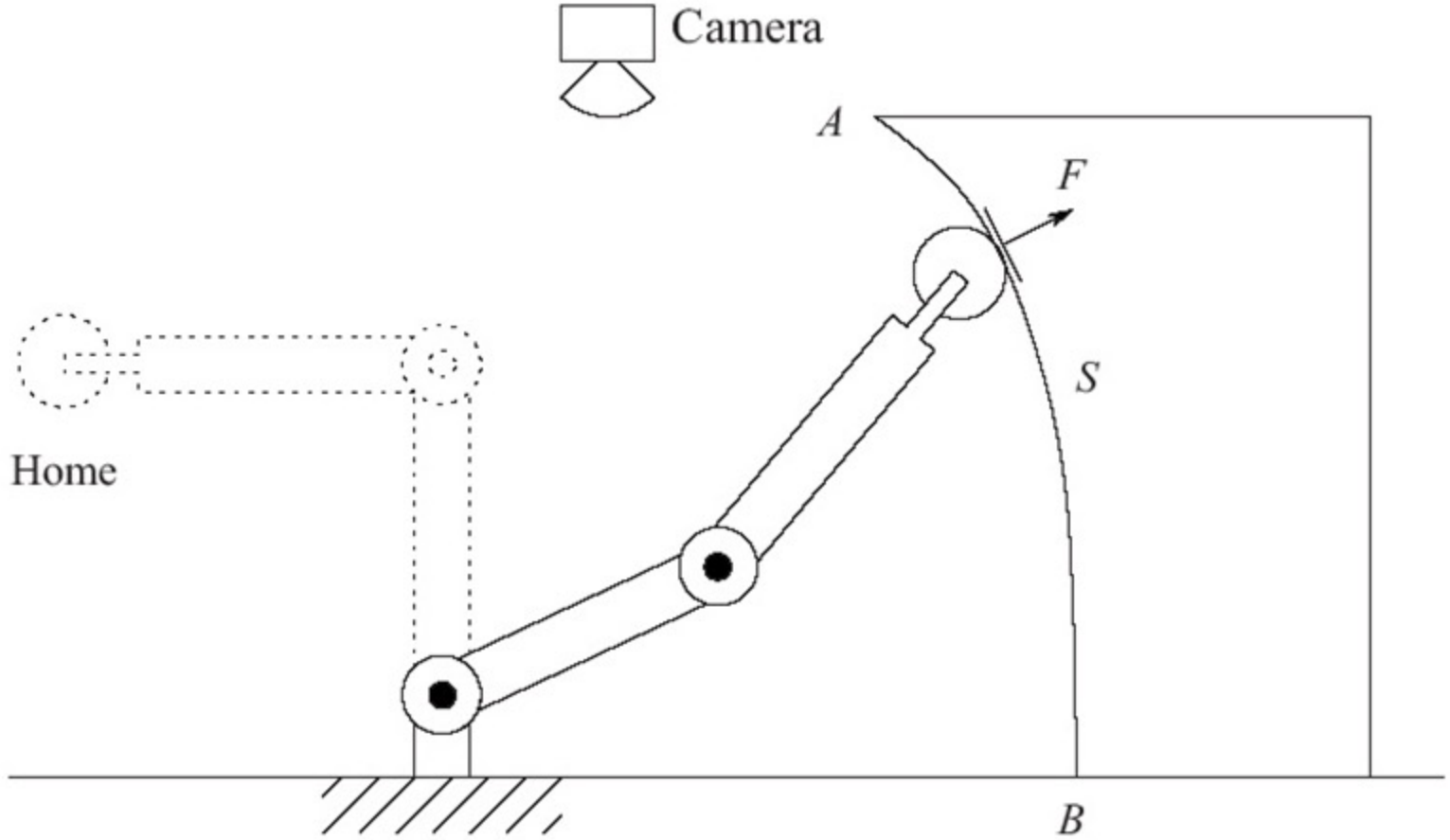
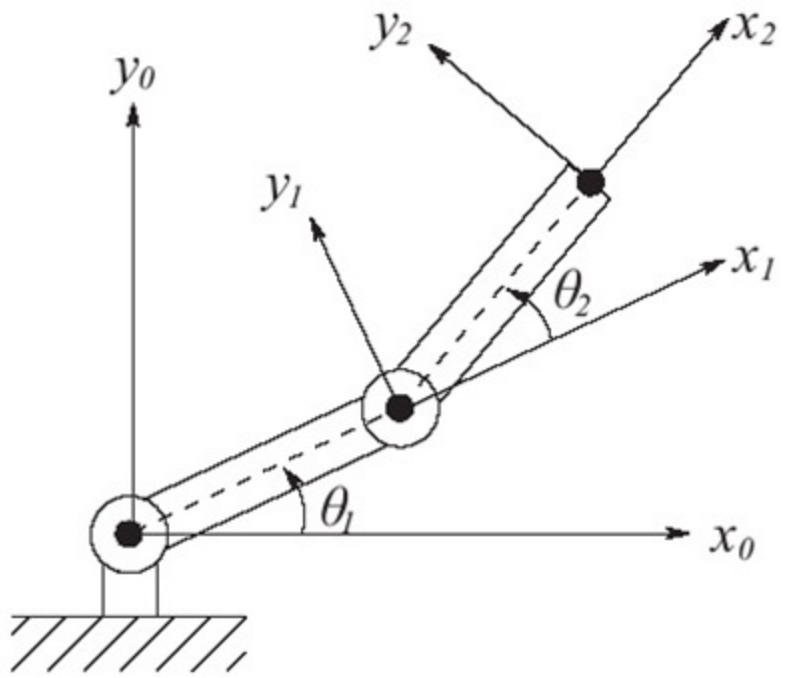




Robot System

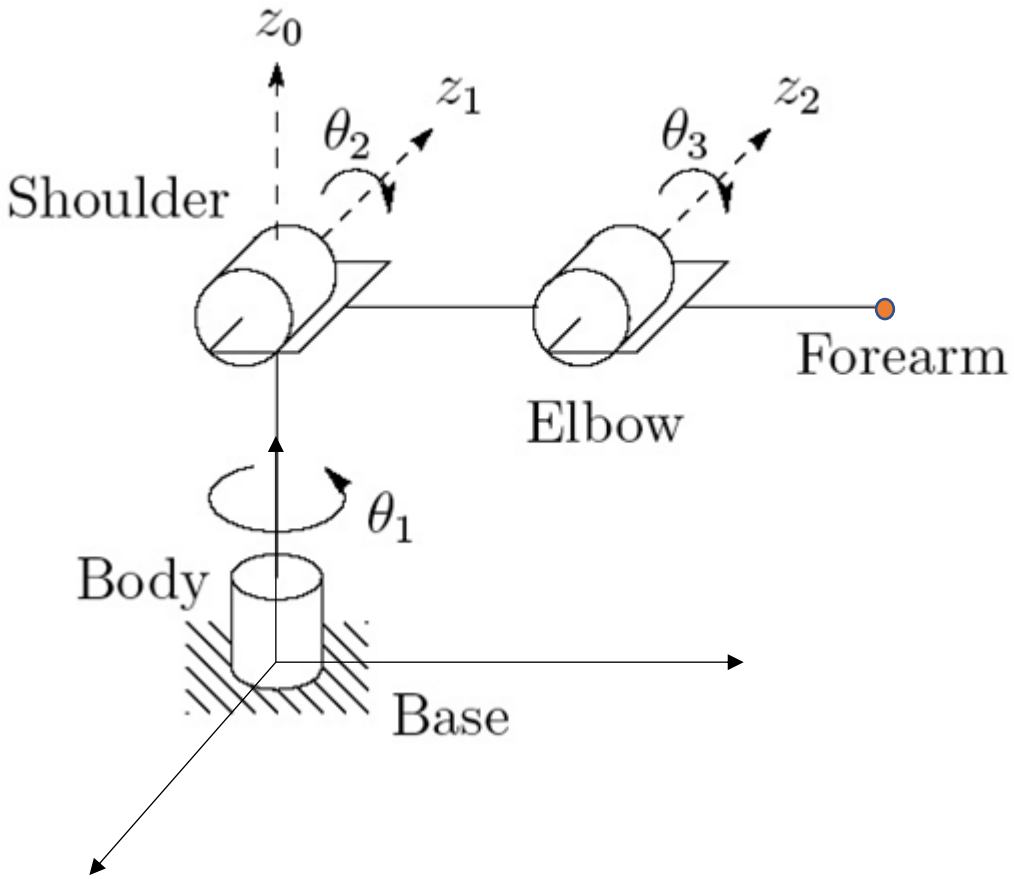


Forward Kinematics



Sensor reading of joint angles
$\Rightarrow$what is the position and orientation of the end effector?

Robotic Arm Modeling



Linear Algebra -- Vectors

- Transpose

$$\begin{pmatrix} x_1 \\ \vdots \\ x_n \end{pmatrix}^T = [x_1, \ldots, x_n]$$

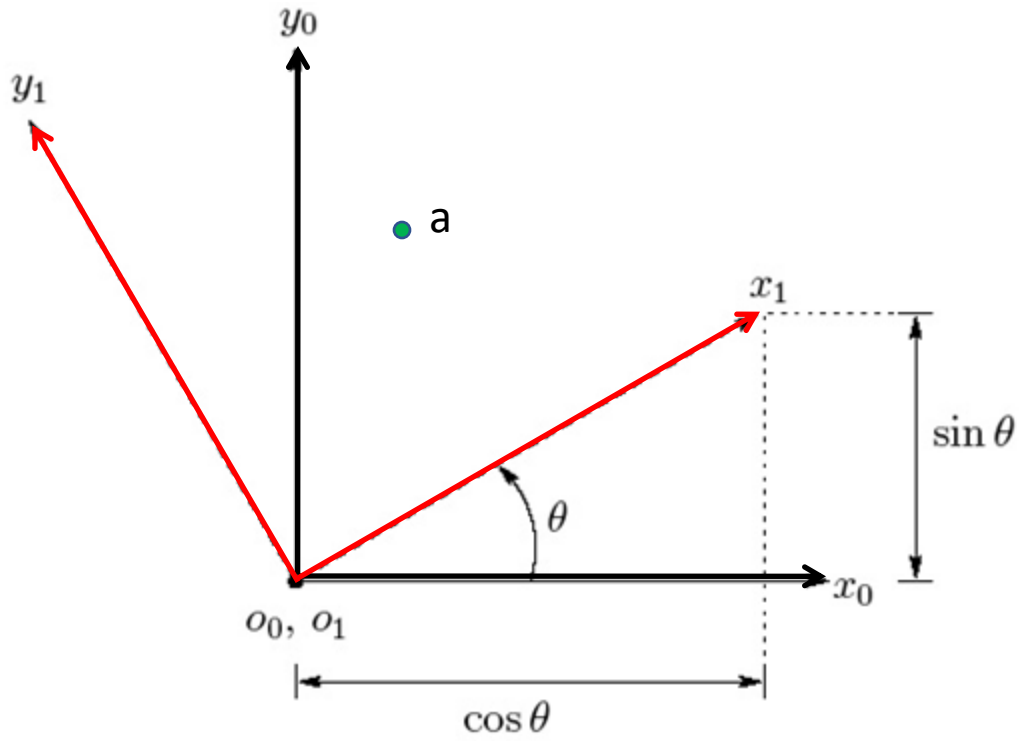
- Dot product (scalar product, inner product)

$$\langle x, y \rangle = x \cdot y = x^T y = [x_1, \ldots, x_n] \begin{pmatrix} y_1 \\ \vdots \\ y_n \end{pmatrix}$$

- Norm

$$|| x || = \langle x, x \rangle^{1/2}$$

Transformation

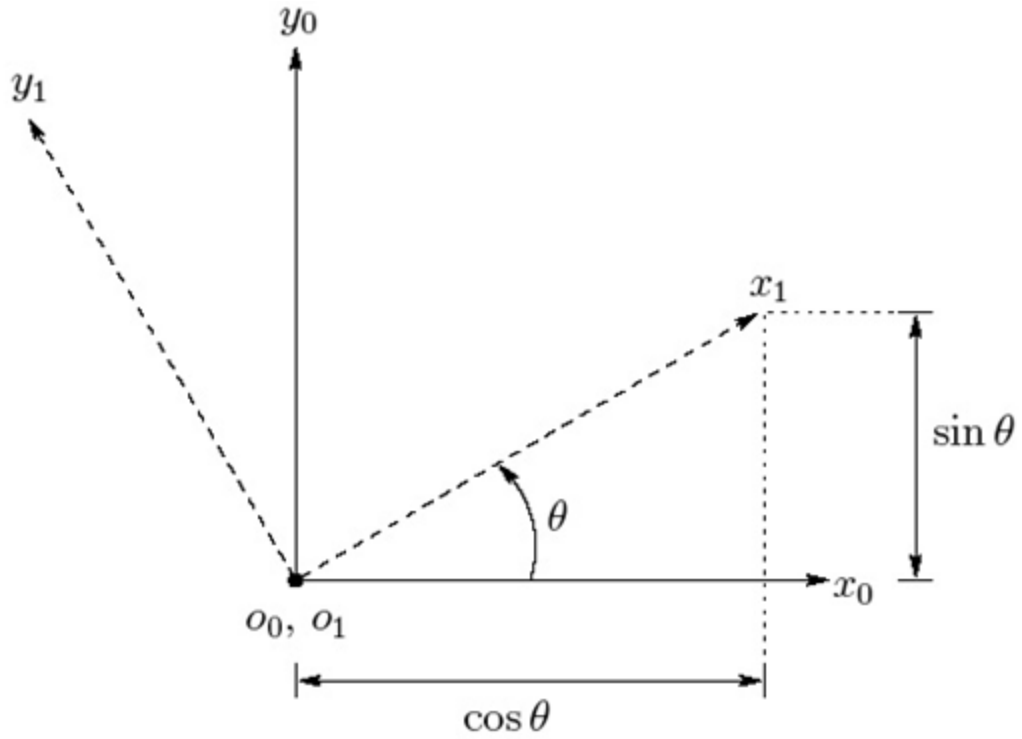


$$x_1^0 \quad y_1^0 \quad ?$$

$$a_0^1 = \begin{pmatrix} a_{x1}, & a_{y1} \end{pmatrix}$$

$$a_0^0 \quad ?$$

Coordination Rotation in 2D



$$x_1^0 = \begin{bmatrix} \cos\theta \\ \sin\theta \end{bmatrix}$$

$$y_1^0 = \begin{bmatrix} -\sin\theta \\ \cos\theta \end{bmatrix}$$

$$R_1^0 = \begin{bmatrix} \cos\theta & -\sin\theta \\ \sin\theta & \cos\theta \end{bmatrix}$$