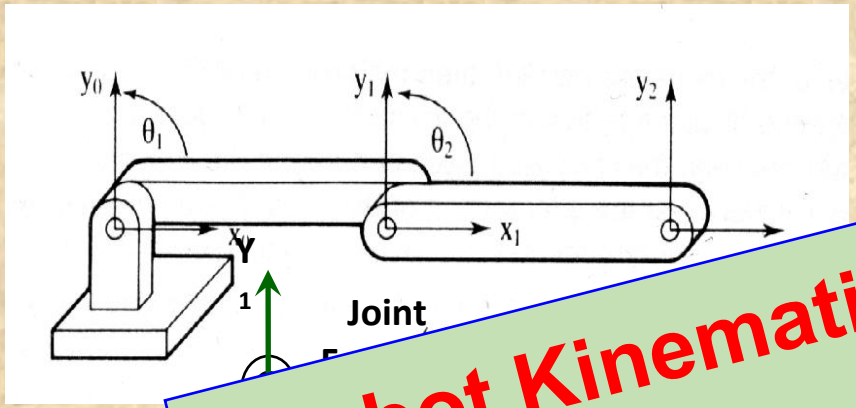
Vishwakarma Institute of Technology

FY - Department of Engineering, Sciences and Humanities

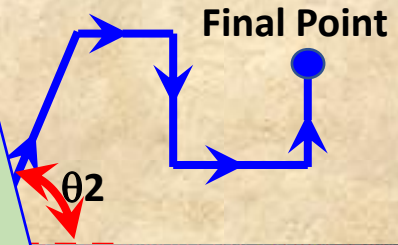


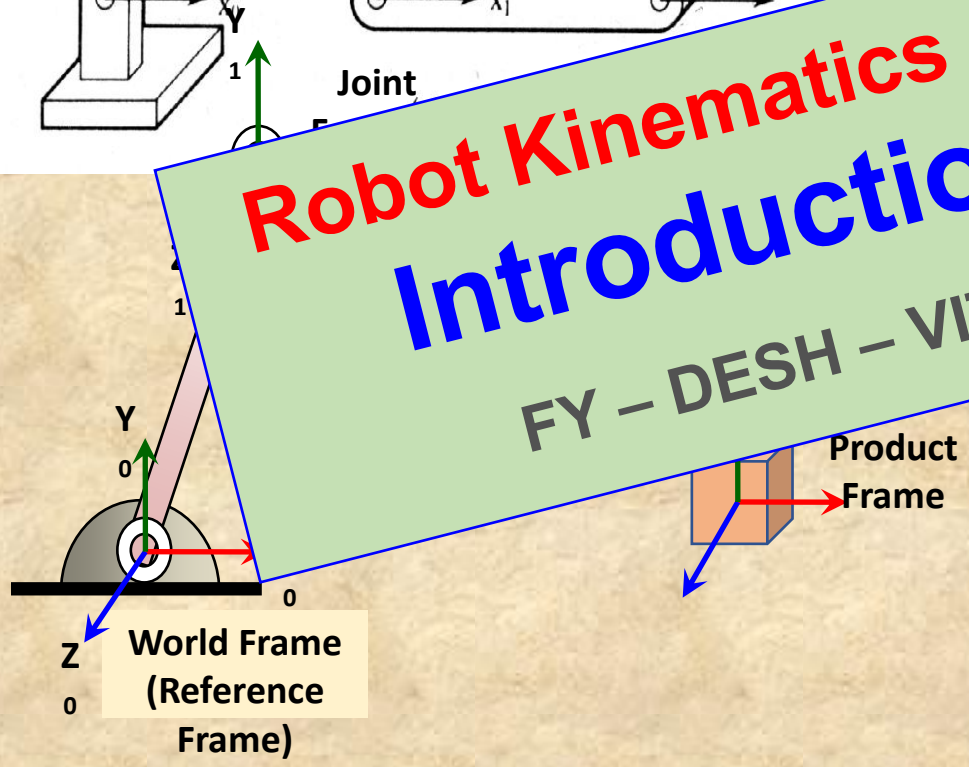
Robot Kinematics – 2.1

Introduction

FY – DESH – VIT

Forward Kinematics -





An Introduction to Robot Kinematics

A Robot is …..

- ✓ a re-programmable
- ✓ multi-functional manipulator
- ✓ designed to move ….. material, parts, tools or specialized devices
- ✓ through variable programmed motions
- ✓ for the performance of a variety of tasks.

Robot in Packaging Industry

Robot Functions –

- Generate angles of rotation of joints
- Integrate tooling and sensors
- Decide most suitable Path
- Repetitive moves
- Remember everything

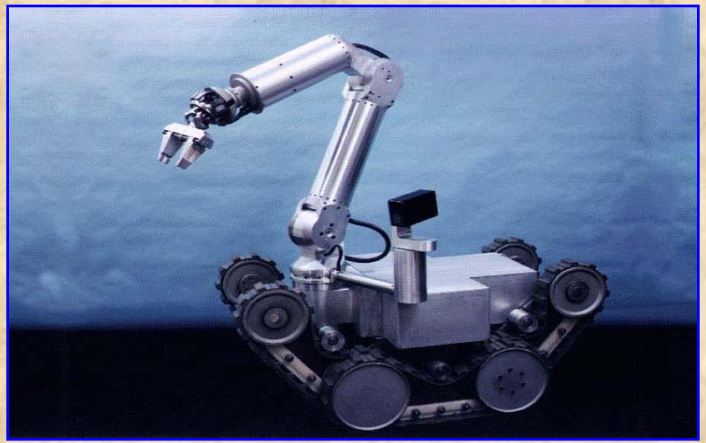
…. and many more …. this is endless ….

Robot's 3 main Functions – Summary

Sense – sensors, limit switches

Think – computer, micro controller, PLC

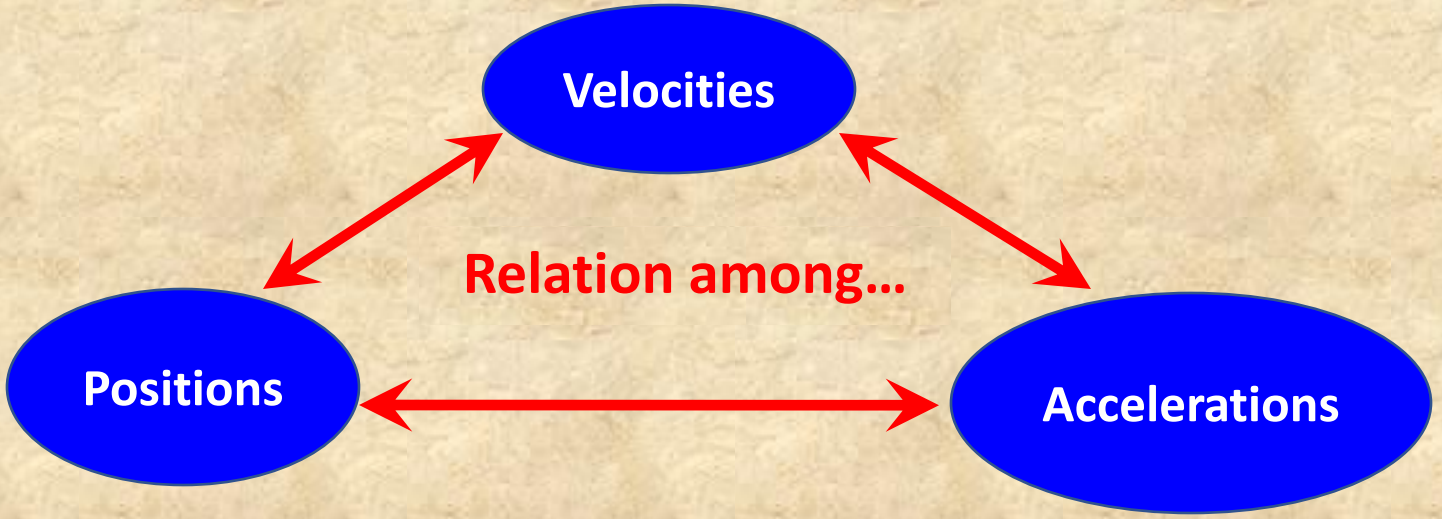
Act – arm, links, end effectors etc.



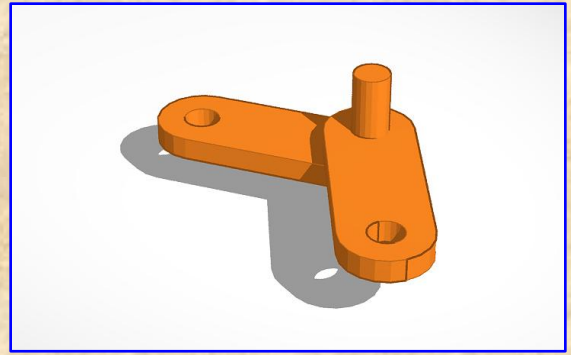
Robot Kinematics –

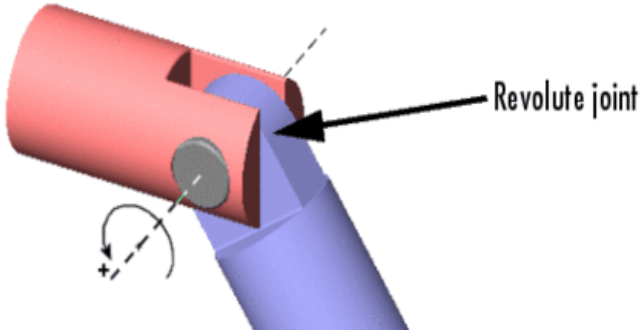
What is Kinematics of Robots ?

- Kinematics is the science of motion of Robot.
- Links and joints can have positions, velocities and accelerations.

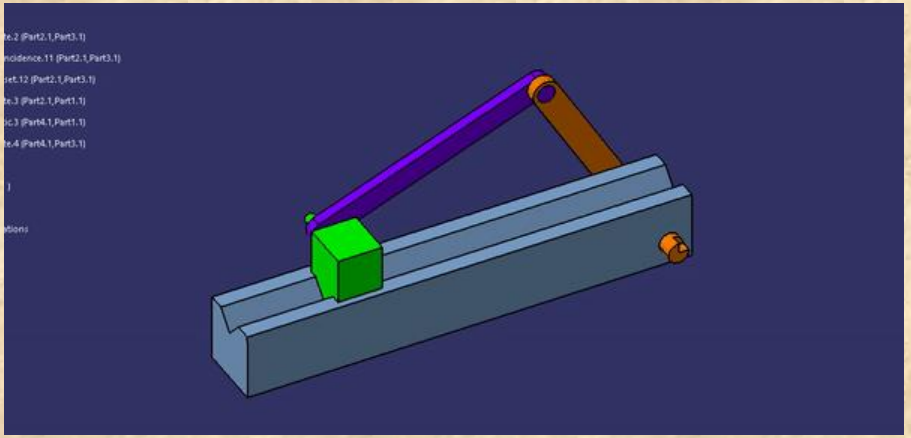


Basic Joints in a Robot –





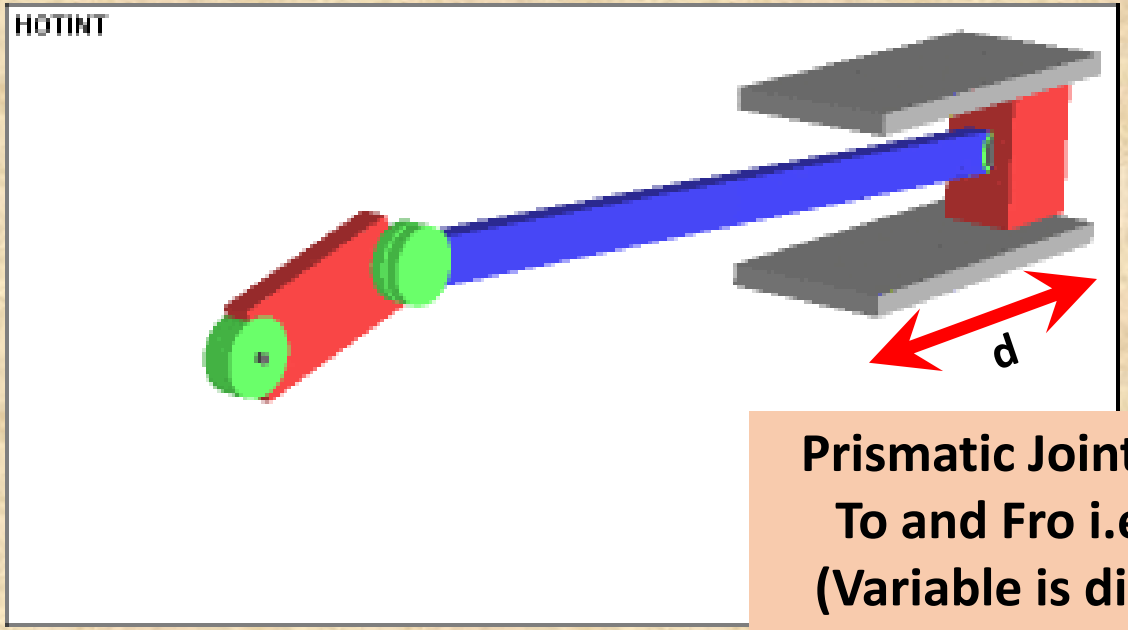
Revolute Joint of 1 DOF
(Variable is angle θ)



How many Revolute Joints are here ?

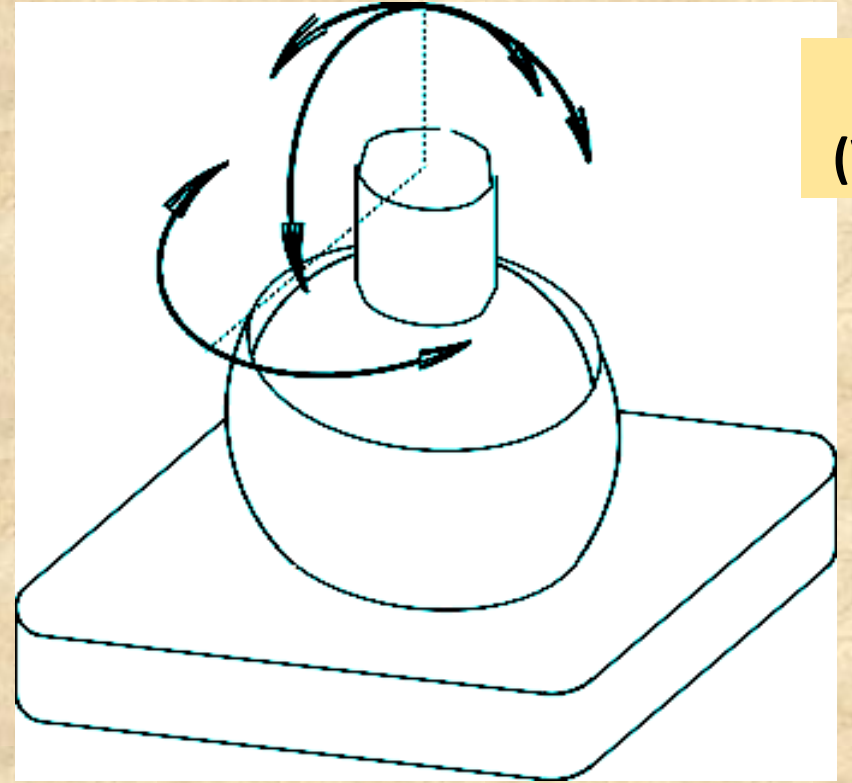
Any other Joint ?

Basic Joints in a Robot – Prismatic Joint



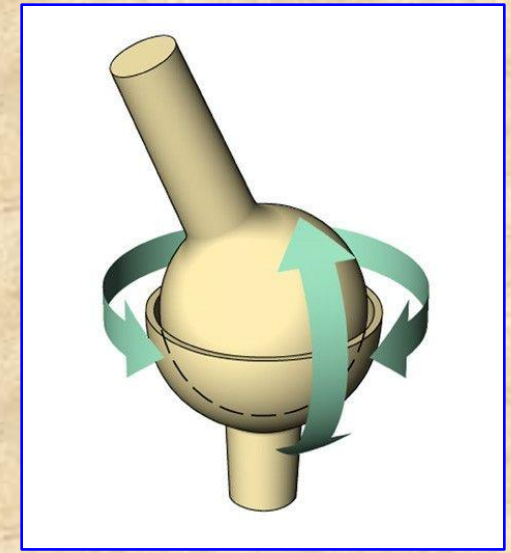
Prismatic Joint of 1 DOF
To and Fro i.e. linear.
(Variable is distance d)

Basic Joints in a Robot –

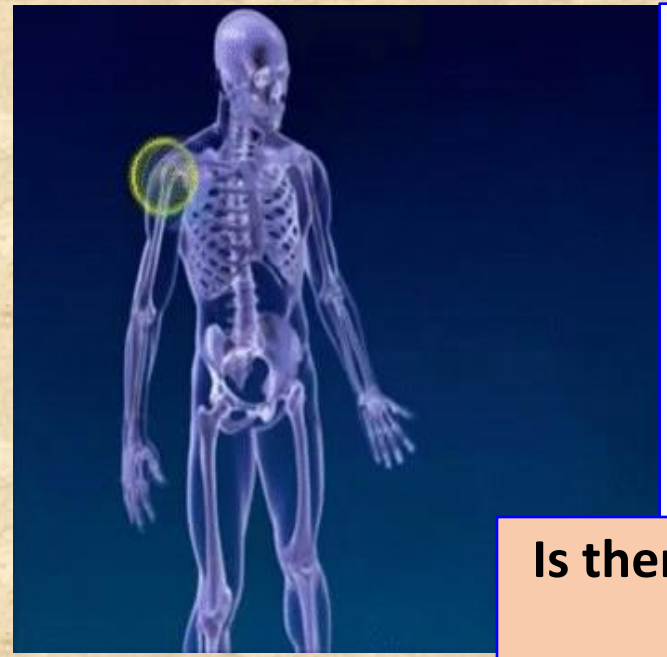


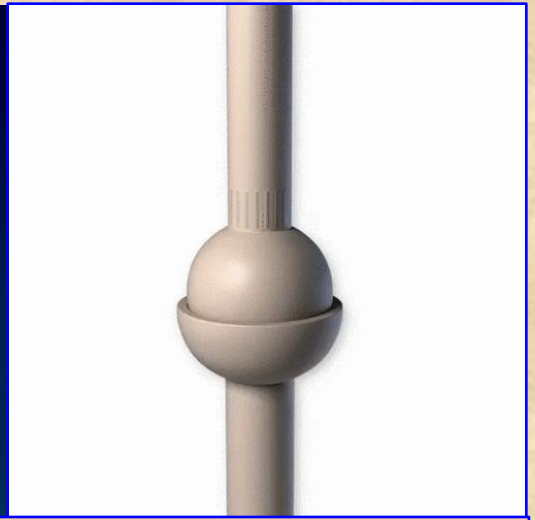
Spherical Joint of 3 DOF
(Variable is angle - θ_1, θ_2 and θ_3)

Basic Joints in a Robot –



Spherical Joint of 3 DOF
(Variable is angle - θ_1, θ_2 and θ_3)

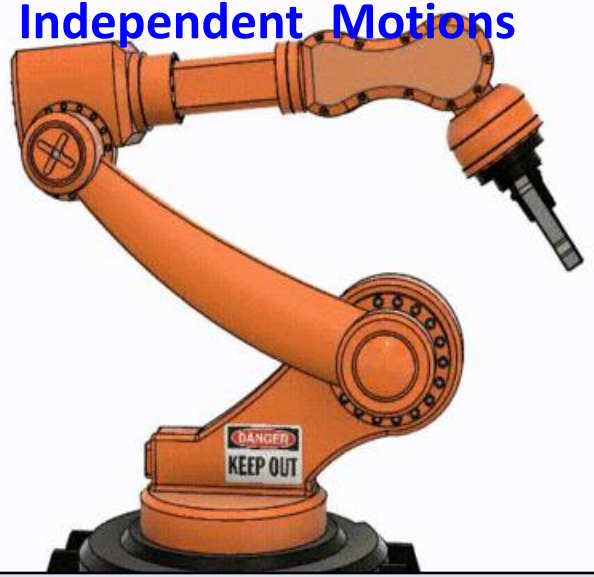




Is there a Revolute Joint in Human Body ?

Concept of Degrees Of Freedom (DOF)

Independent Motions

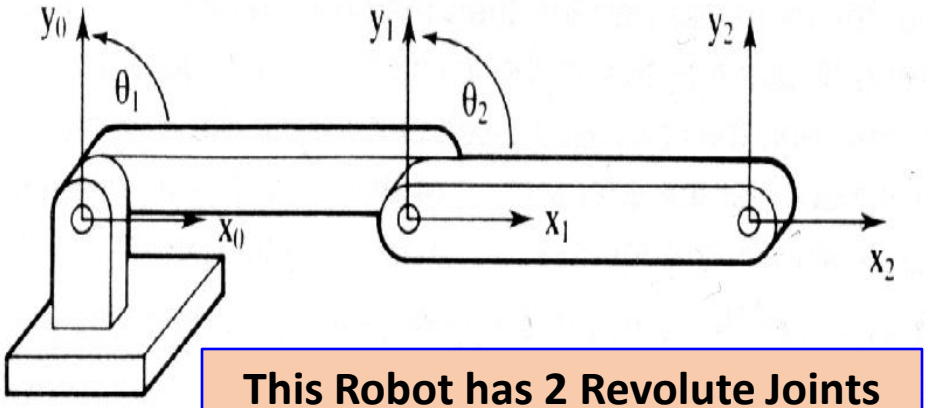


Robot with SIX revolute joints.

ONE revolute joint = ONE degree of freedom (1 DOF)

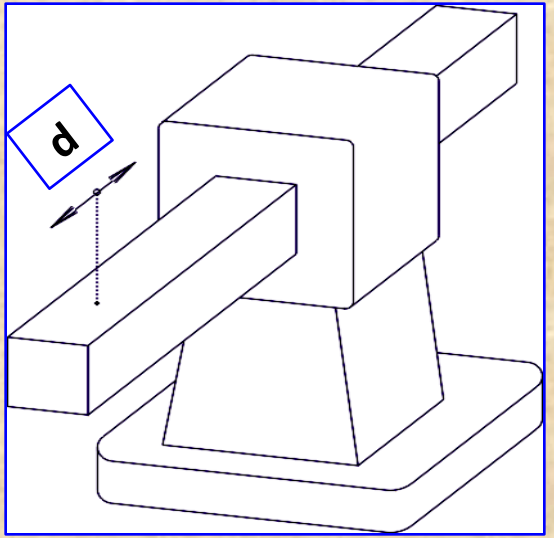
DOF means how many independent motions can be done ?

Basic Joints in a Robot and Degrees of Freedom DOF –



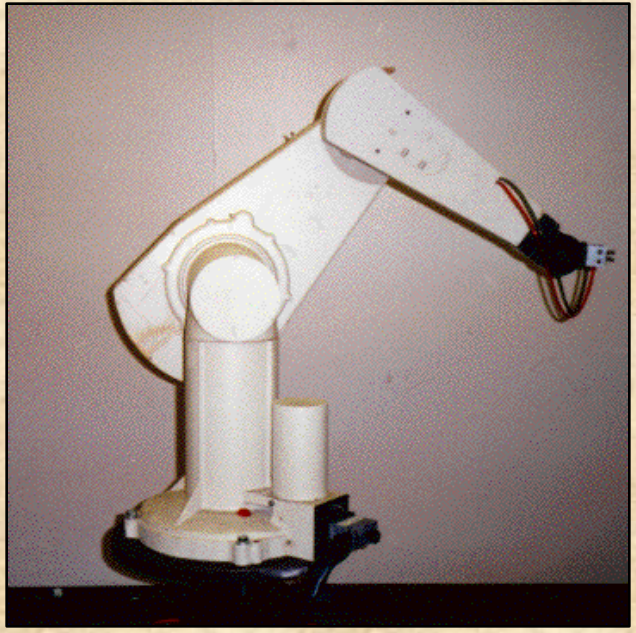
This Robot has 2 Revolute Joints

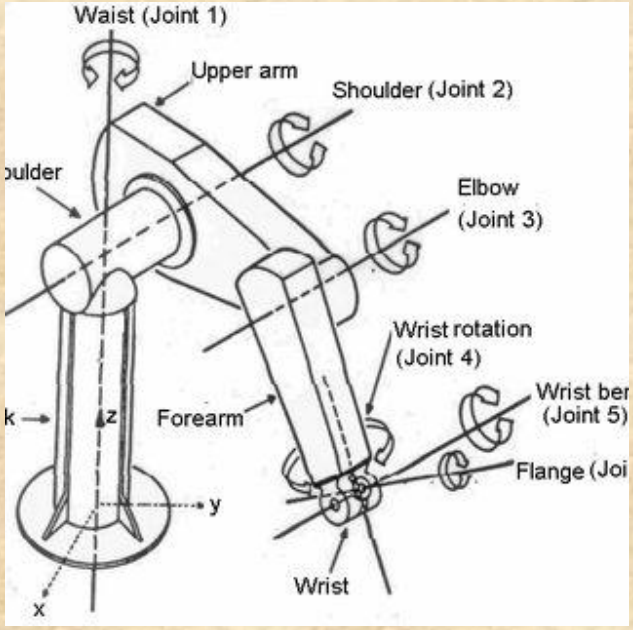
Revolute Joints of 1 DOF each.
Total DOF = 2
(Variable is angle θ)



Prismatic Joint of 1 DOF
To and Fro i.e. linear.
(Variable is distance d)

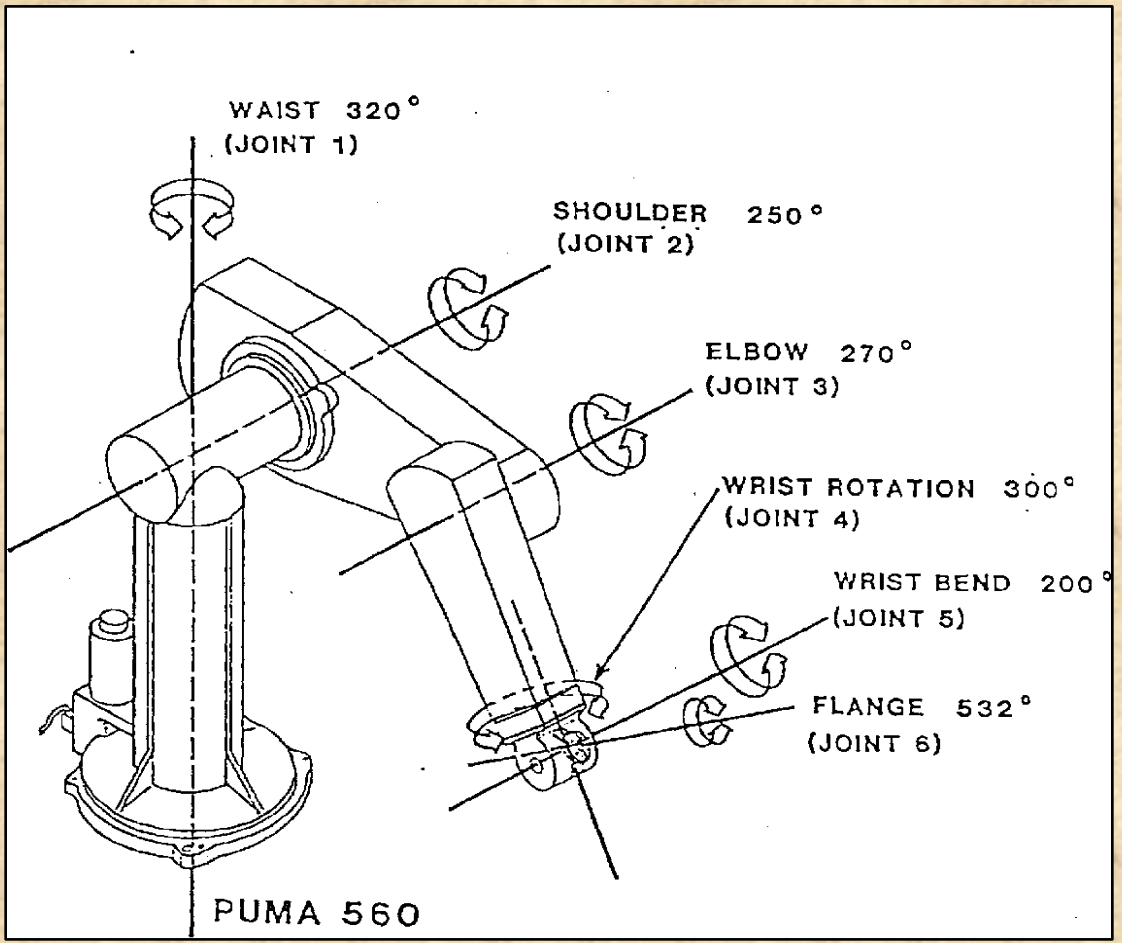
PUMA 560 Robot





The PUMA 560 has SIX revolute joints = 6 DOF
ONE revolute joint = ONE degree of freedom (1 DOF)

PUMA 560 Robot



Kinematics in Robotics –

Forward Kinematics (angles to position)

- ✓ What you are given : The length of each link
  The angle of each joint
- ✓ What you can find : The Position where Robot will reach…
  (i.e. its coordinates)

Forward Kinematics (angles to position)

- ✓ What you are given : The Path
- ✓ What you can find : Destination

Reaching an unknown house if the correct road map is given.

Kinematics in Robotics –

Inverse Kinematics (position to angles)

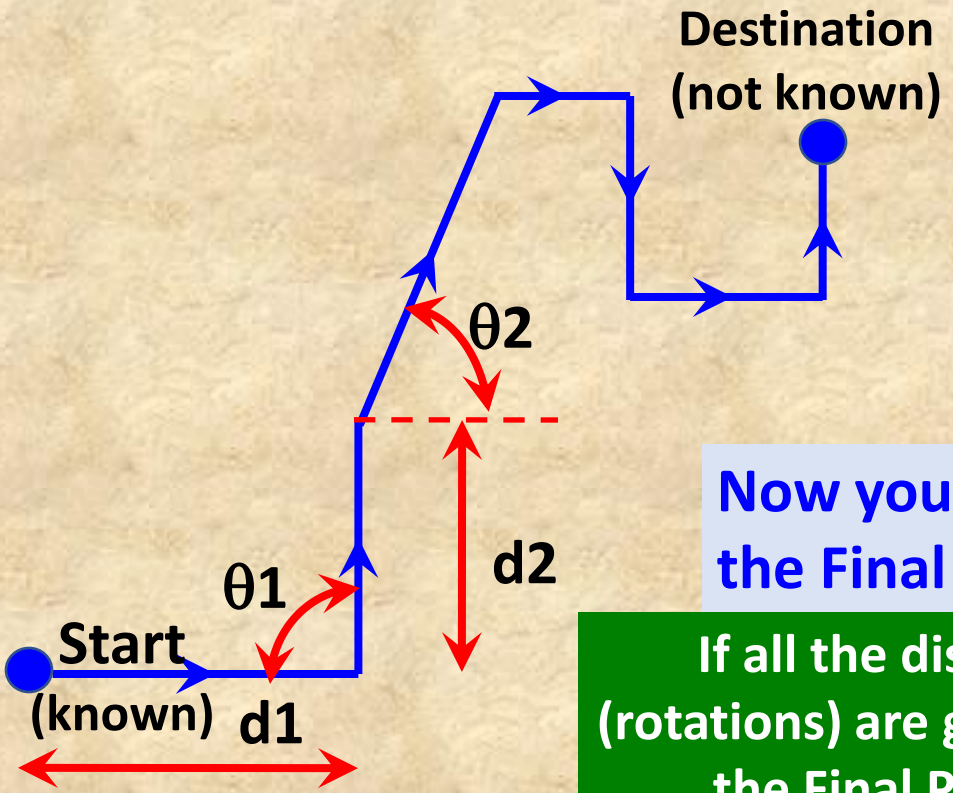
- ✓ What you are given : The length of each link
  The position of destination point on the Robot
- ✓ What you can find : The angles of each joint needed to reach at the destination

Inverse Kinematics (position to angles)

- ✓ What you are given : Destination
- ✓ What you can find : The Path

To reach a known house, there can be many paths to travel.

Forward Kinematics -



How to find co-ordinates of Final Point ?

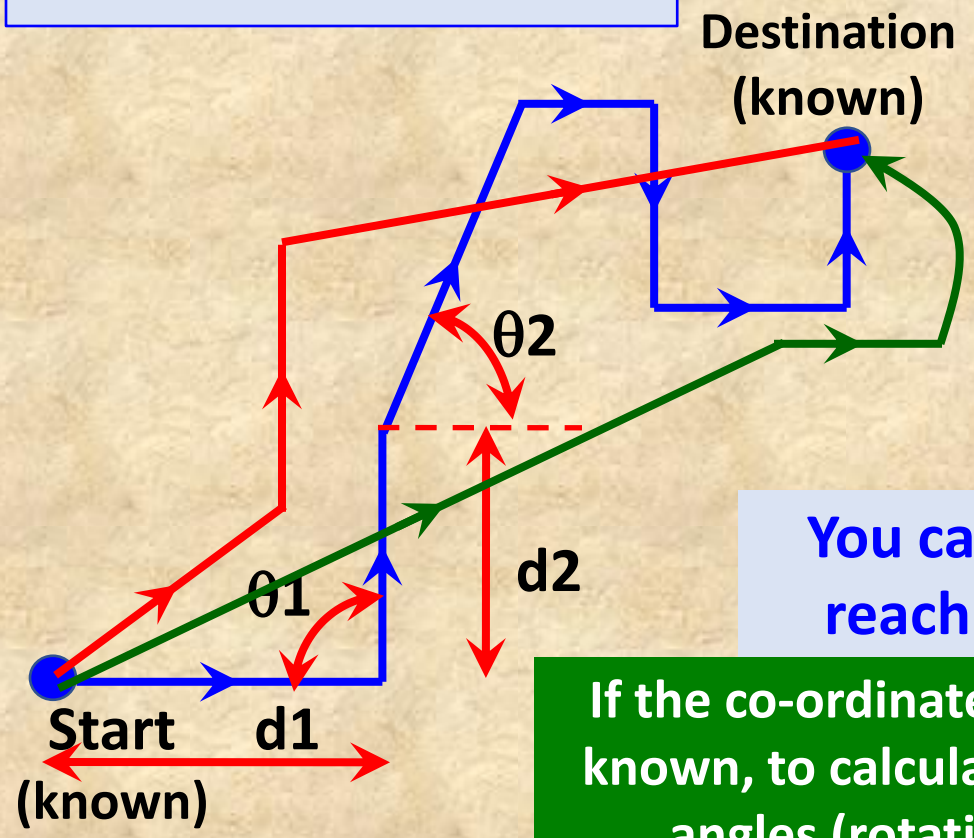
If all distances d1, d2, d3, …dn are given.
Is this enough ?

We need corresponding angles like - θ1, θ2, θ3, …θn.

Now you can find the coordinates of the Final Point (Destination).

If all the distances (links) and all angles (rotations) are given, to find the co-ordinates of the Final Point is Forward Kinematics.

Inverse Kinematics -



How to reach to the Destination Point ?

What you should calculate ?

1) the distances and
2) corresponding angles

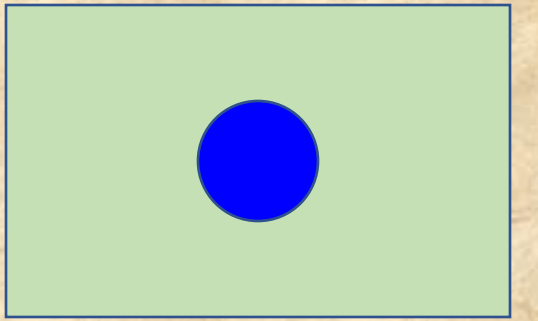
There can be multiple ways of doing this !

…and all answers are correct!

You can finalise the best path to reach to the Destination Point.

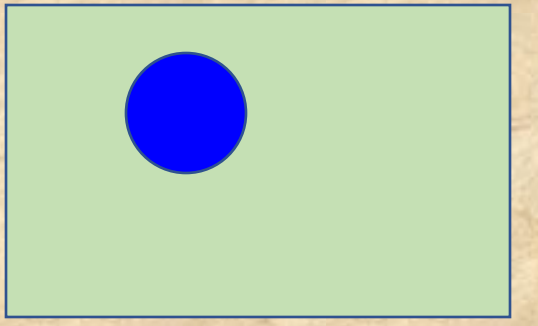
If the co-ordinates of the Destination Point are known, to calculate the distances (links) and all angles (rotations) is Inverse Kinematics.

Why reference frames are important ?



Where is the blue circle in the green rectangle ?

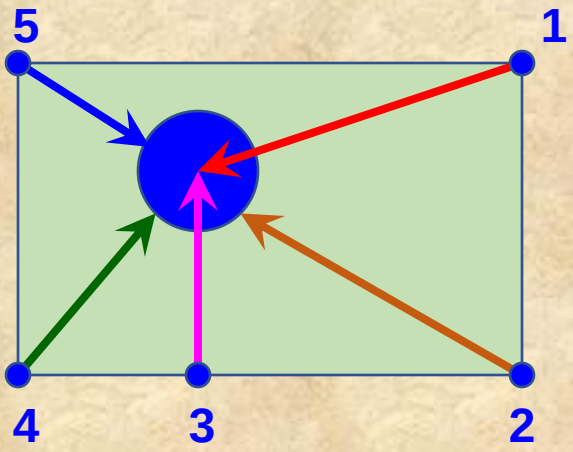
At the center … Right ?



Where is the blue circle in the green rectangle now ?

Thousands of answers…
Right ? Why ?

Why reference frames are important ?



Which distance of the circle from the rectangle is correct ???

All answers are correct !

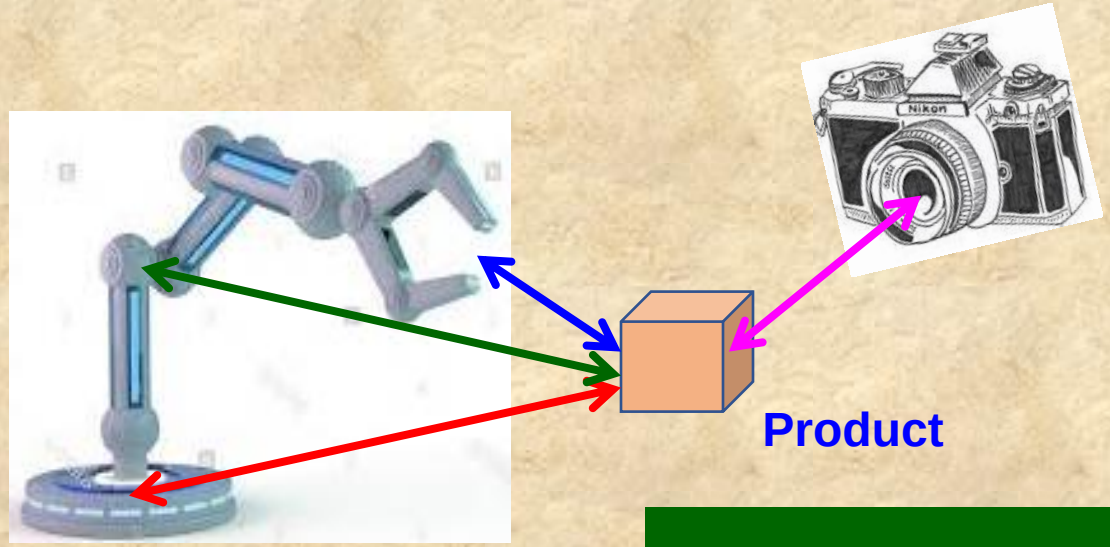
Why there are so many answers ?

Just because every distance is measured from a different Reference Point !

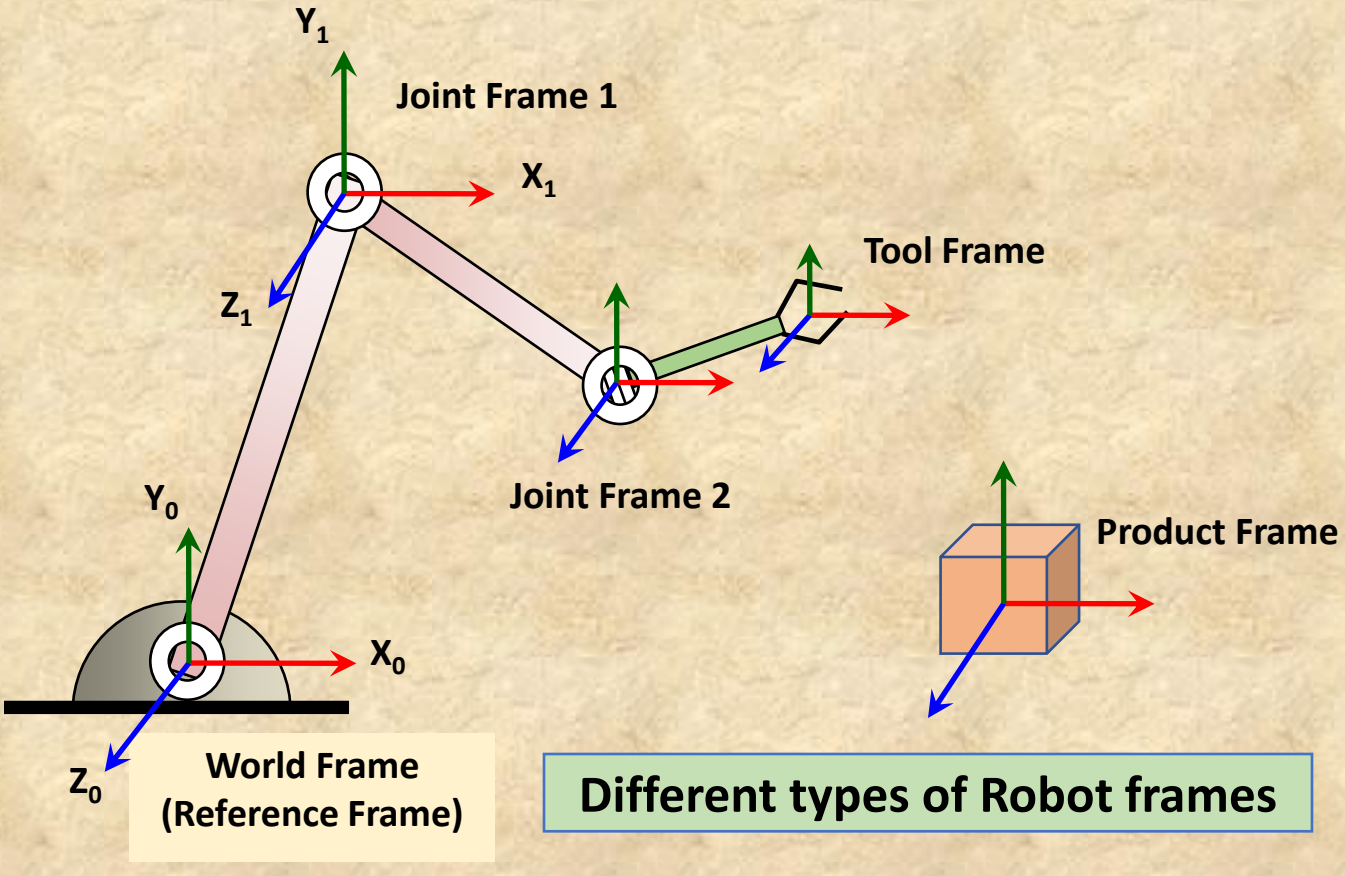
If we select a specific Reference Point, there will be just ONE single answer !

This is nothing but a Reference Frame !

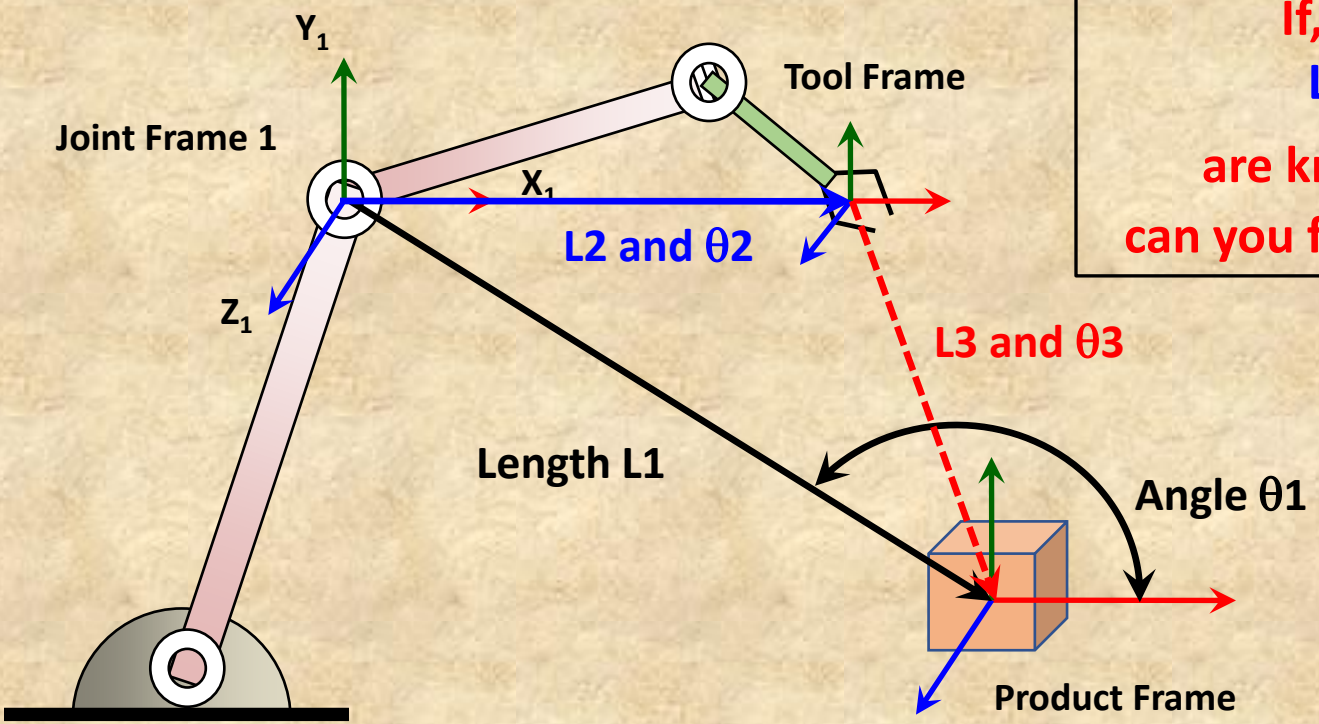
Why reference frames are important ?



The base, the joint, the gripper… all are at different distance from the product. But to hold the same, movement of all joints is required !



Different types of Robot frames



If, L1 and θ1
L 2 and θ 2
are known, ...
can you find L3 and θ3 ???

This means... if coordinates of ....
Joint frame 1 and Tool frame are known .....
We should learn how ....
the Gripper will reach to the Product ..... !

This is a 2D or 3D ?

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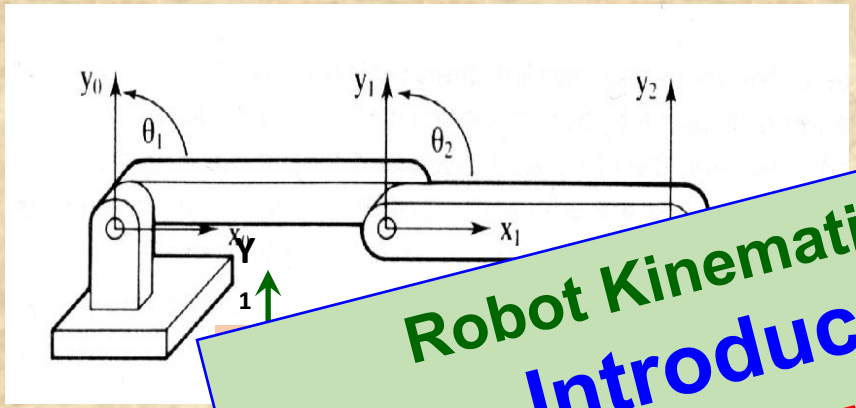

Forward Kinematics -

Robot Kinematics – 4.1

Introduction

Thanks !

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