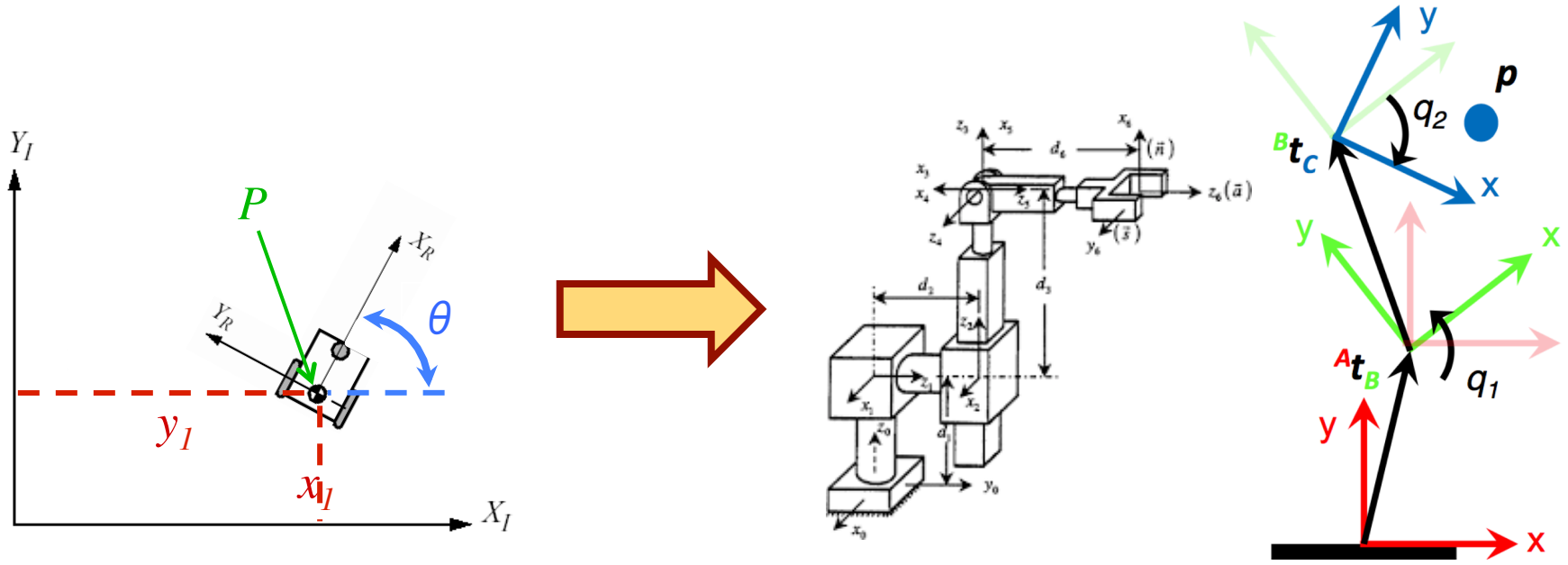
Kinematics

Manipulator Kinematics



Bookkeeping

- Team meetings status
- Assignment 2
- Thursday:
  - Quiz 3 (*will be easier than 1 and 2*)
    - Manipulation concepts, Grasping, Kinematics concepts
    - Closes 11:59pm Nov 4
  - Homework 2 (*homeworks are always easy*)
    - Resolution, Kinematics & IK, Course Progress
- Nov 5
  - Assignment 3 (due Nov 13)

Bookkeeping

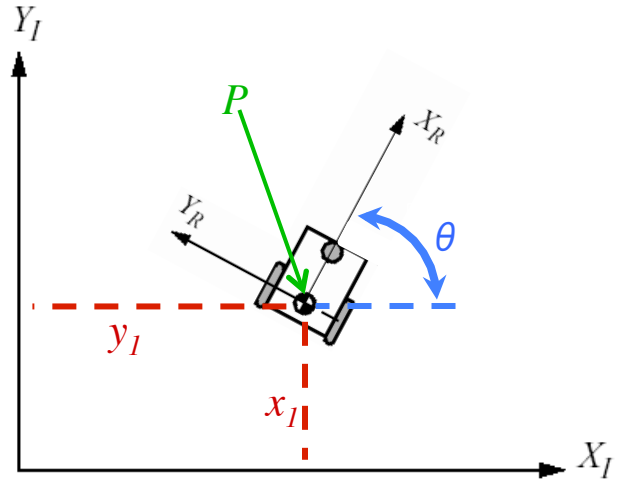
- Today:
- General notes on project progress
  - Schedule wiki
  - Signout sheet
  - Meetings
- A final note on mobile kinematics
- Manipulator kinematics
- Reading: CB 2.1 & 2.2–2.2.2

Project Progress

- Checkout sheet: http://tiny.cc/iral-checkout-sheet
- Schedule wiki: http://tiny.cc/robotics-team-schedules
  - Look for your team in left-hand nav column
- Milestones: How is *each component* going?
  - Contain:
    - Writeups – what am I seeing?
    - Demos, images, code, videos, …
- Is everyone fully involved?

(A final note on) Mobile Kinematics

- Given this setup:

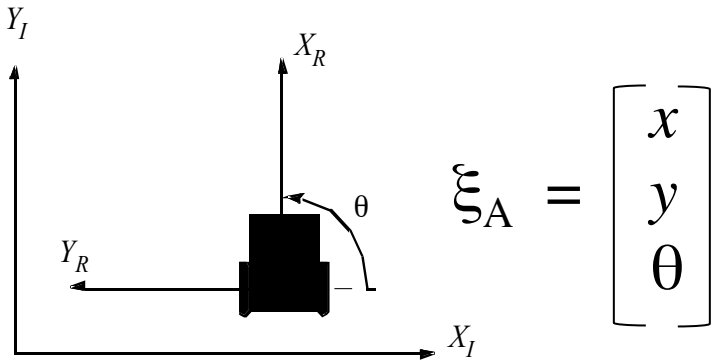


$$\xi_I = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix}$$

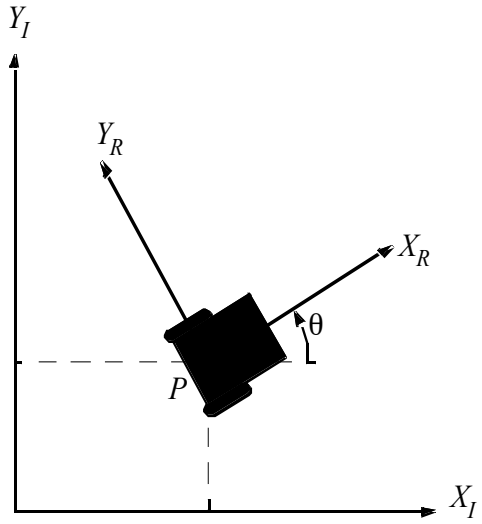
- We can map $\{X_I, Y_I\}$ (global) ←→ $\{X_R, Y_R\}$ (robot)
  - Use rotation matrices and velocity vector in x, y, θ
- Why do we care so much?

(A final note on) Mobile Kinematics

- Goal: take robot from $\mathbf{A_I}$ to $\mathbf{B_I}$
  - We know where we want it in the *global* setting
  - What do we actually control? (In what frame of reference?)



$$\xi_A = \begin{bmatrix} x \\ y \\ \theta \end{bmatrix}$$



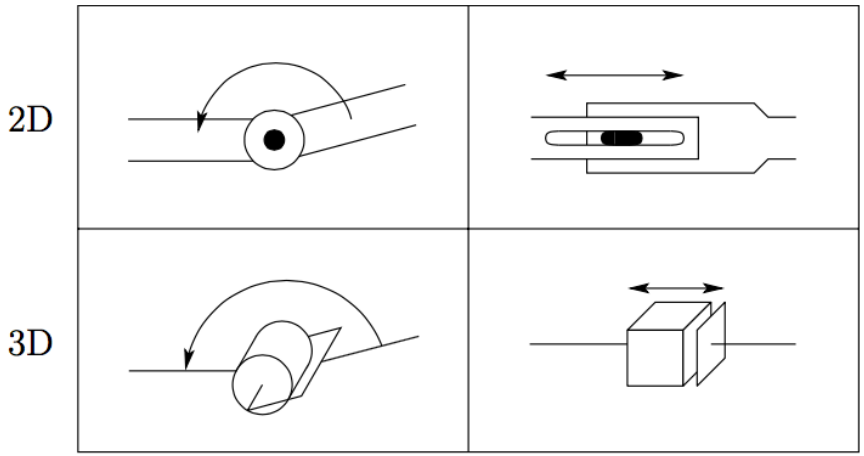
$$\xi_B = \begin{bmatrix} x' \\ y' \\ \theta' \end{bmatrix}$$

- Point: Convert from $\mathbf{A_I}$ to $\mathbf{B_I}$ by changing ξ_R

Manipulator Kinematics

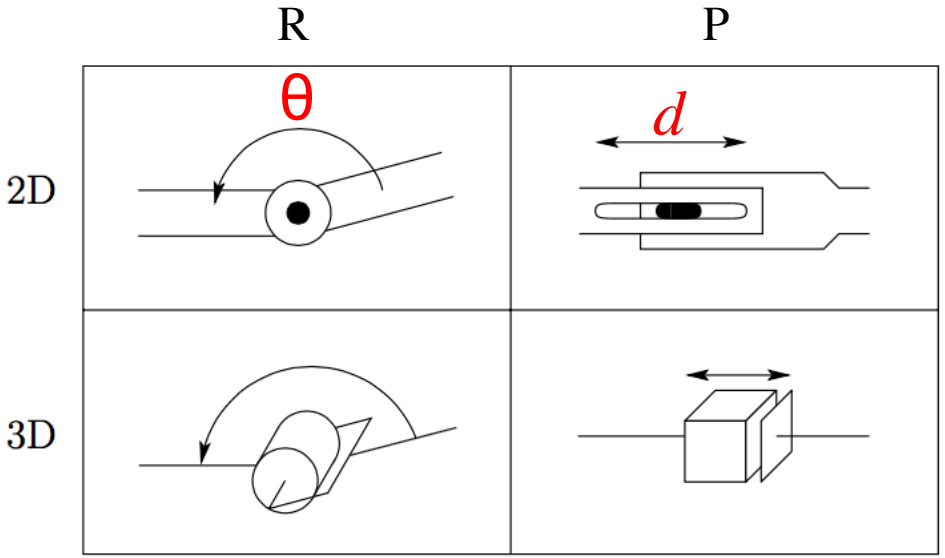
- Kinematics:
  - Geometrically possible motion of a body or system of bodies
- For manipulator robots
  - End effector position and orientation, wrt. an arbitrary initial frame

- A manipulator is moved by changing its…
  - Joints: revolute and prismatic

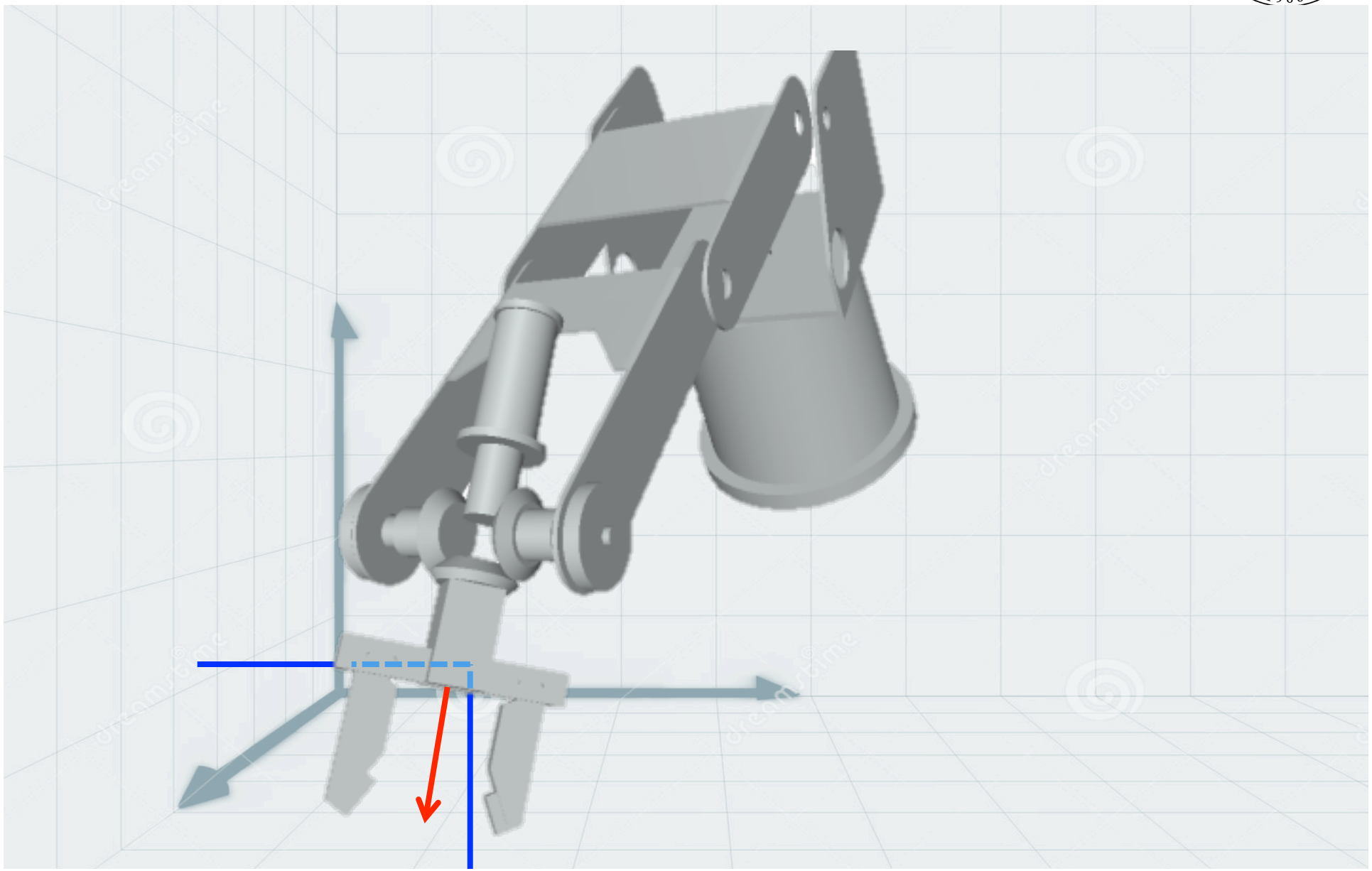


Manipulator State

- Configuration: where is every point on manipulator?
  - Instantaneous description of geometry of a manipulator
- State: a set of variables which describe
  - *Change of configuration in time* in response to joint forces
    - Control inputs
    - External influences



Position & Orientation



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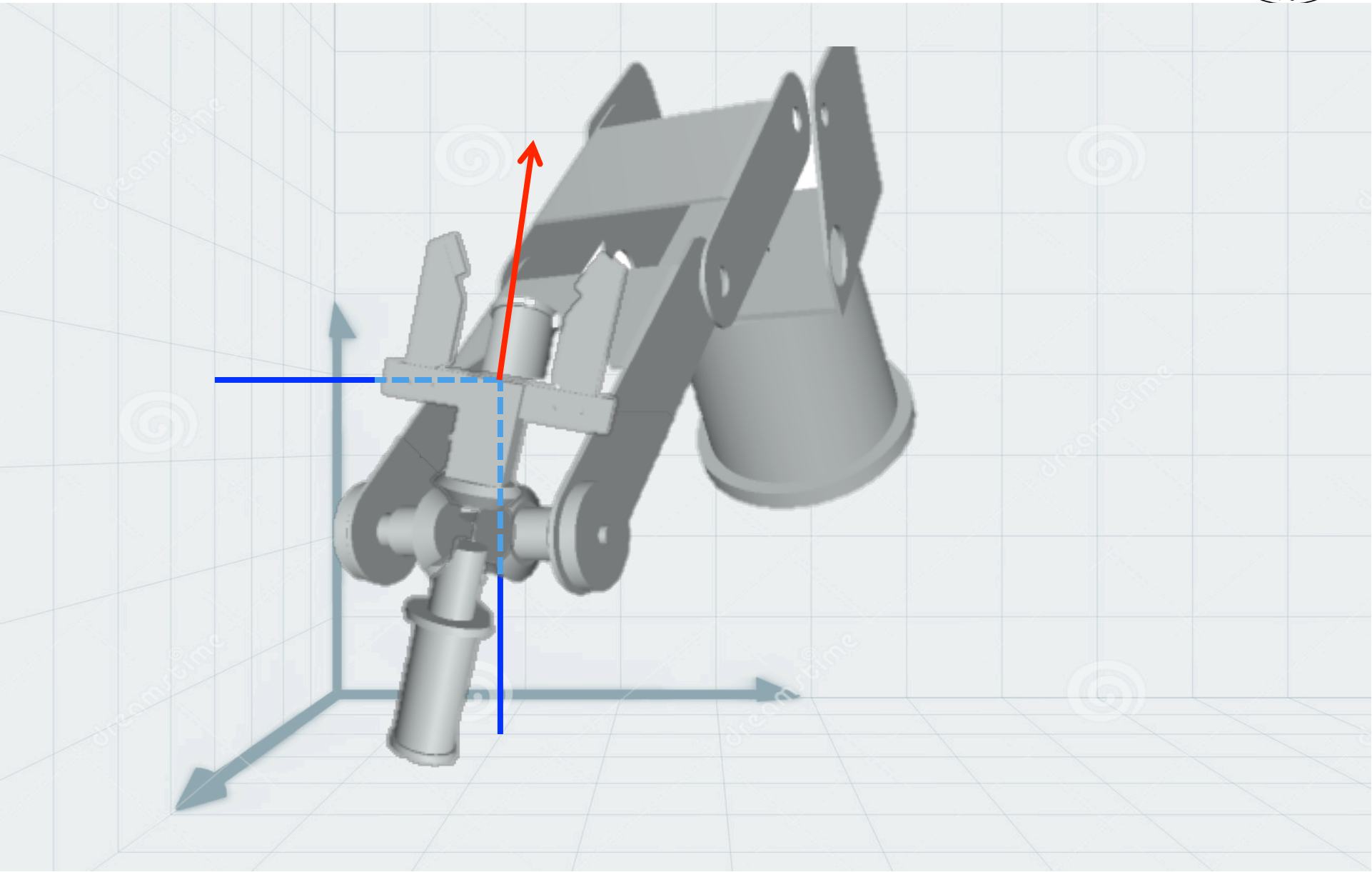
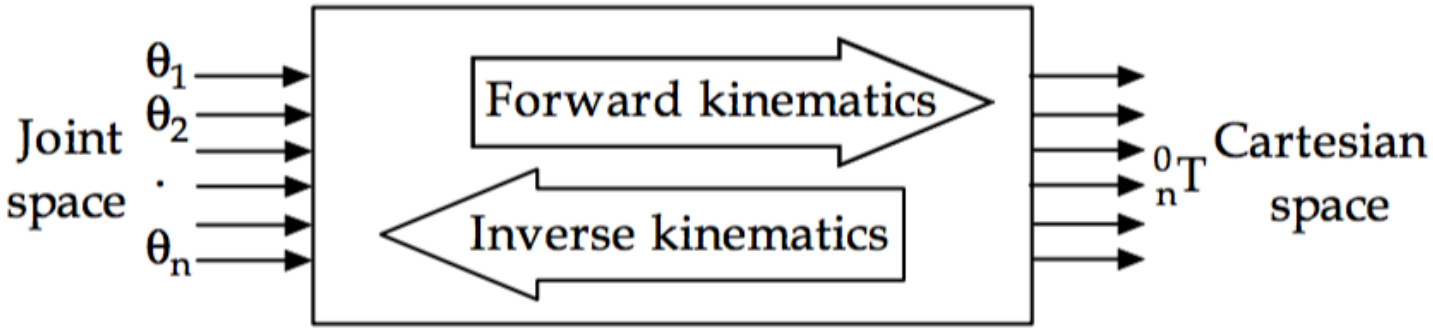
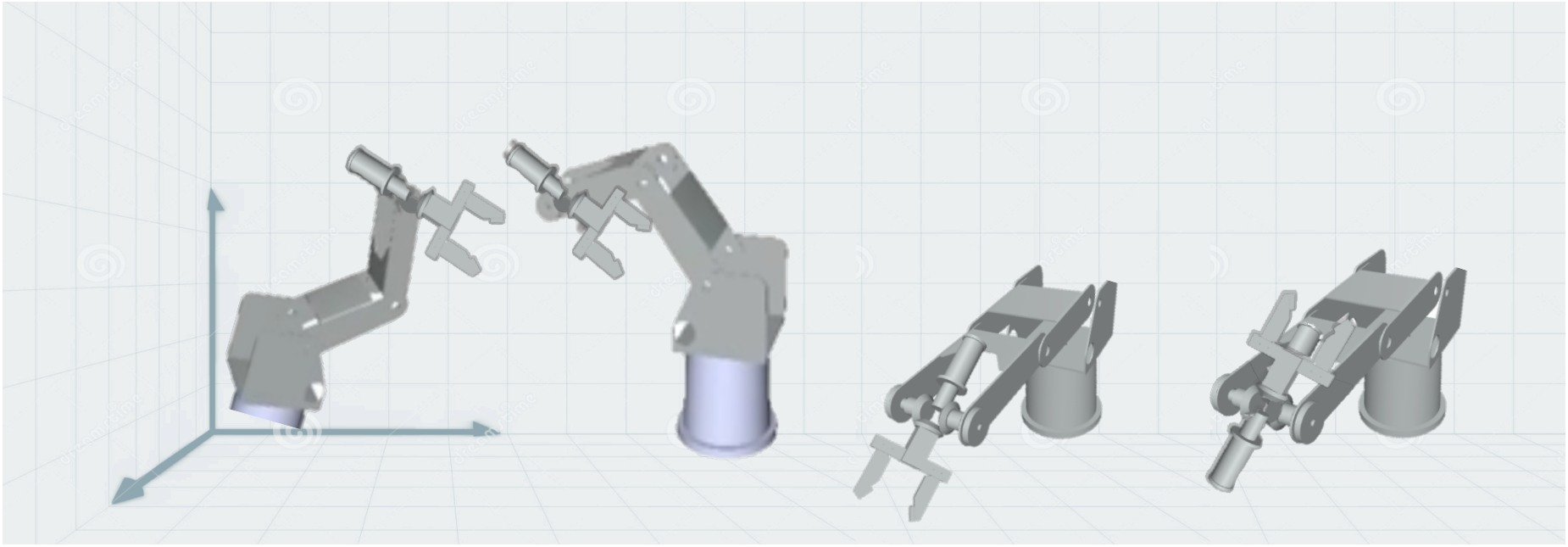


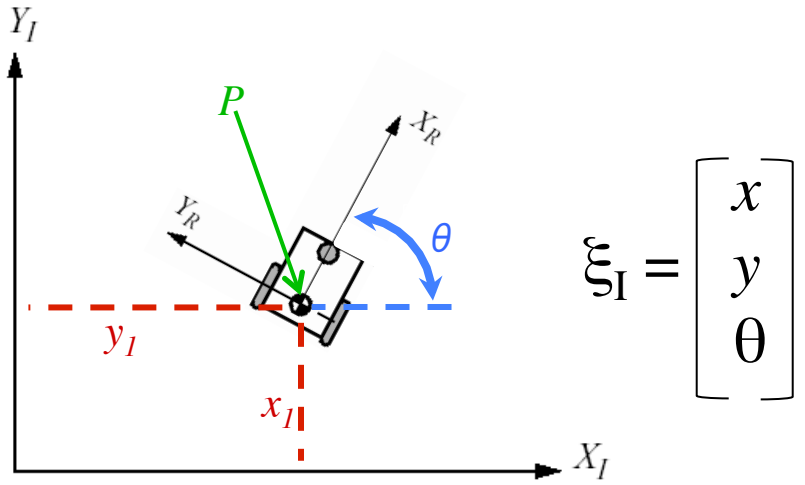
Forward Kinematics & IK

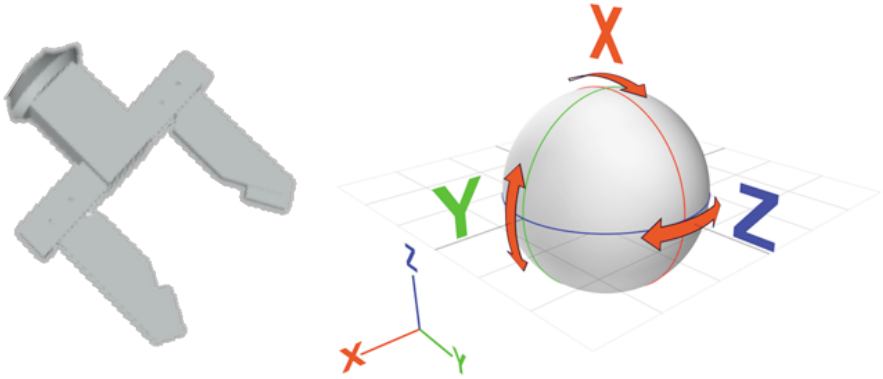




Mobile vs. Manipulator

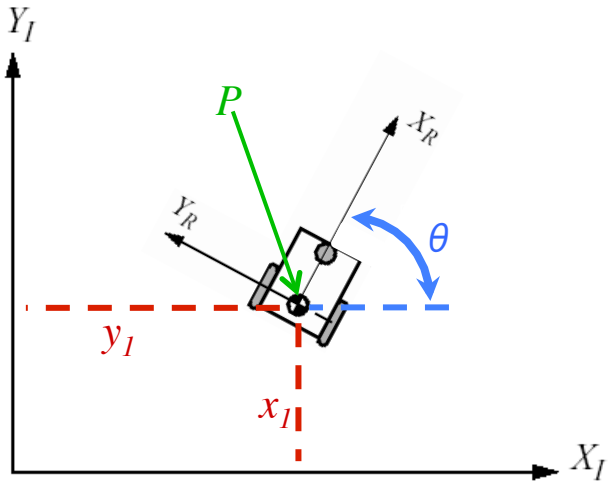
- Description: how many terms…
  - …to describe planar position & orientation?
  - …to describe 3D position & orientation?
- AKA, how many
  - Degrees of freedom





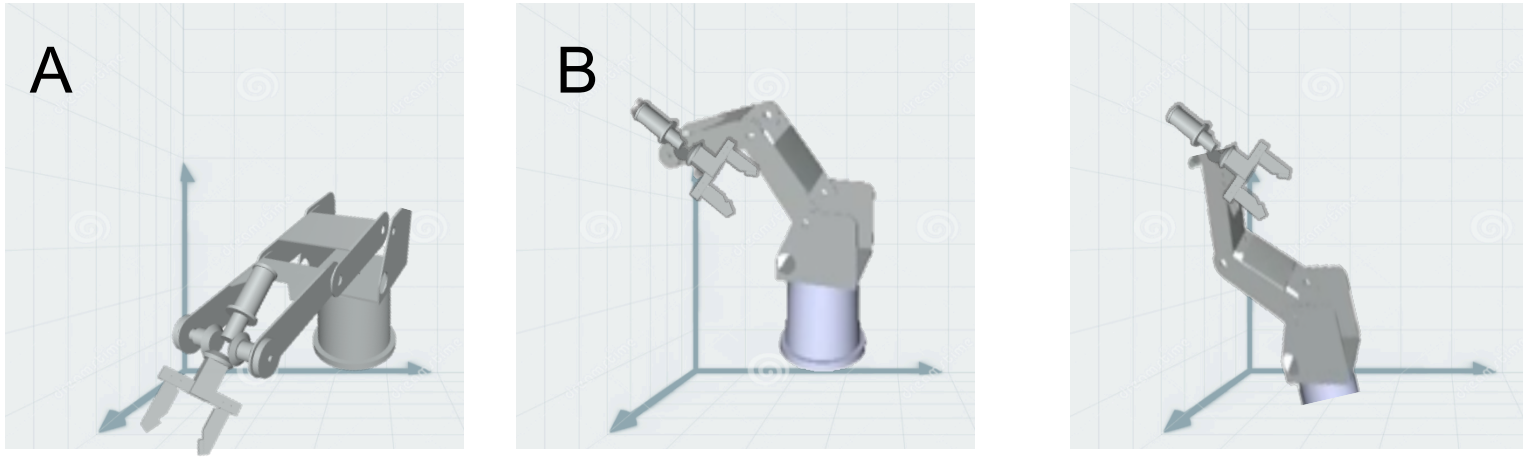
Kinematics Problem

- The **state space** is the set of all possible states
- The **state** of the manipulator is:
  - A set of variables which describe changes in **configuration** over time, in response to joint forces + external forces
- Where do joint forces come from?
  - Controllers!
- So, given some set of joints, what signals do we send?
- In joint space vs. Cartesian space



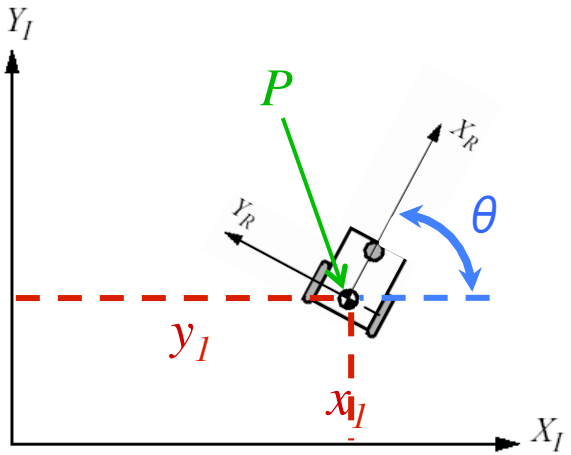
Goal

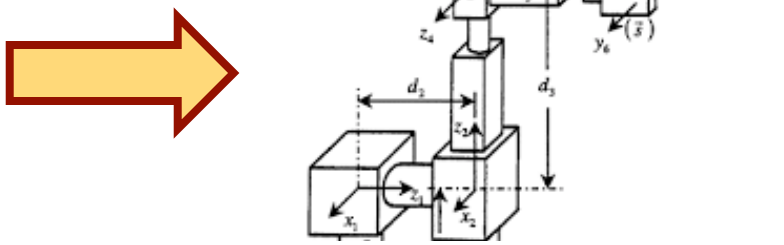
- Goal: take ~~robot~~ end effector from $\mathbf{A_I}$ to $\mathbf{B_I}$
  - We know where we want it in the *global* setting
  - What do we actually control? (In what frame of reference?)
- Point: Convert from $\mathbf{A_I}$ to $\mathbf{B_I}$

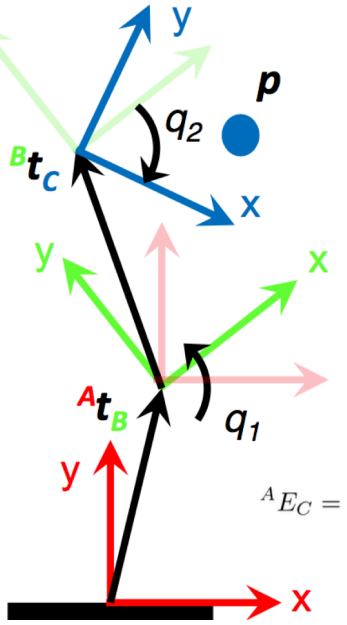


- Now a 6 ←→ 6 transformation

Mobile to Manipulator

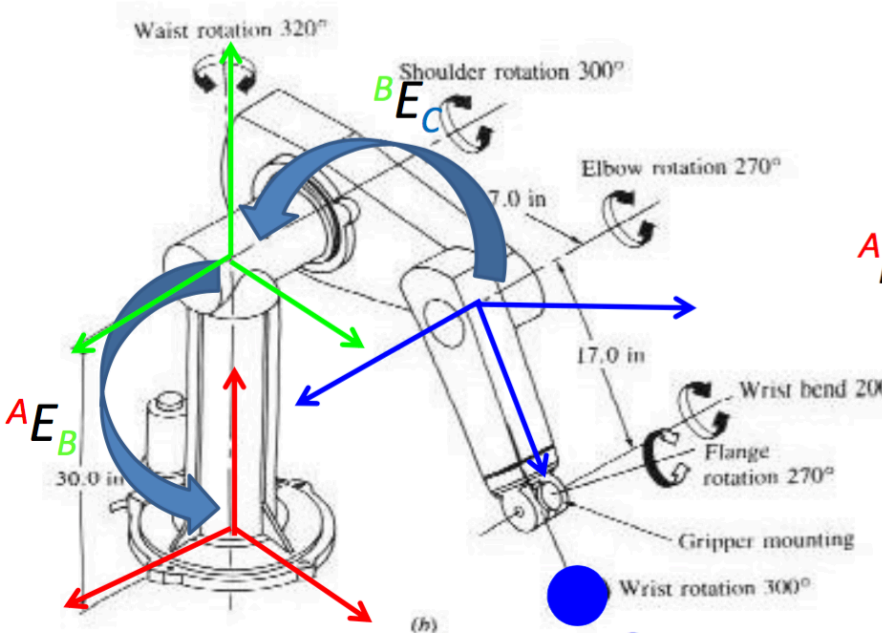


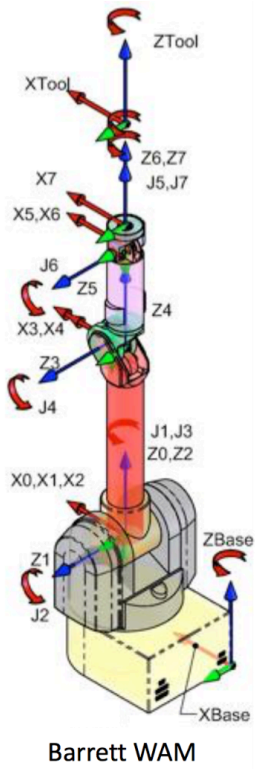




Multiframe Kinematics

- How many frames of reference do we have?
  - We've been translating among frames based on possible motion
- How do they relate?





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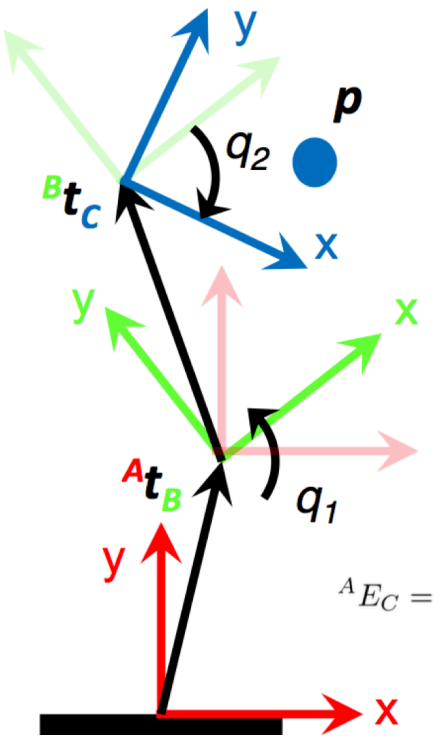
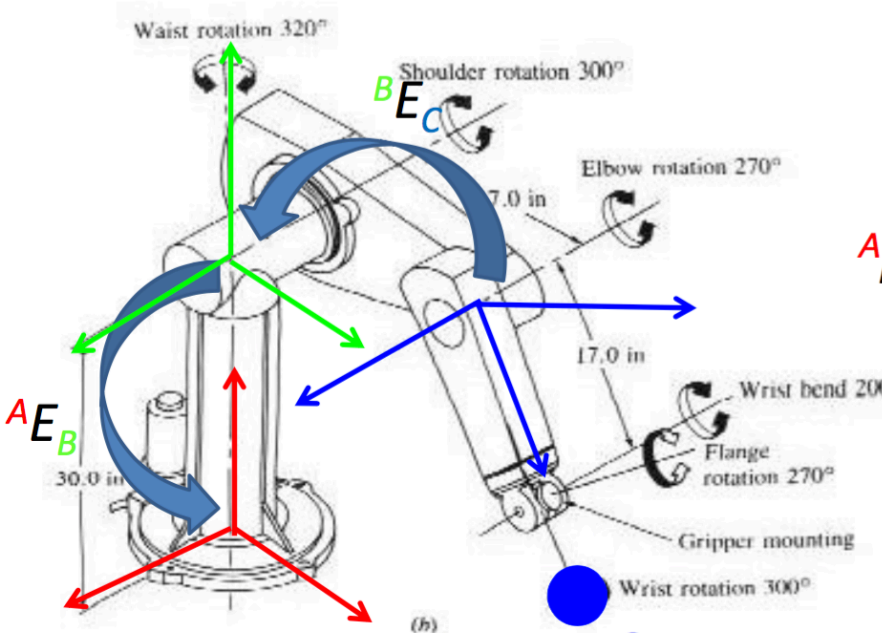
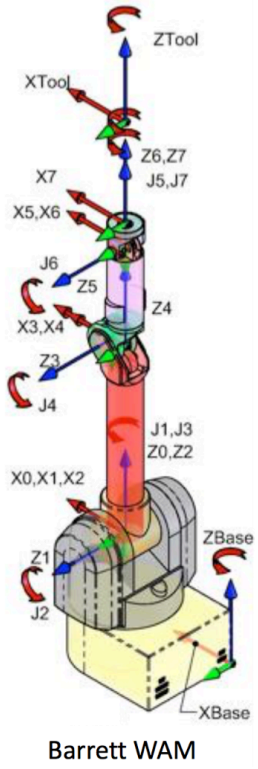


Kinematic Chaining

- Do you need to do every transformation?
- What do we really care about?





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