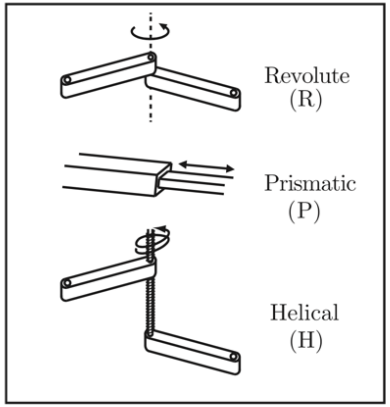
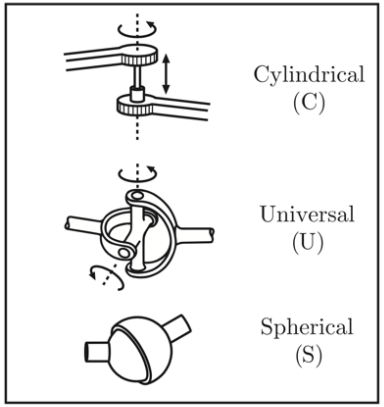
21AIE201-INTRODUCTION TO ROBOTICS

Lecture 7

Important concepts, symbols, and equations (cont.)

- mechanism dof = Σ (body freedoms) – Σ (independent constraints from joints)
- joint types:





Joint type	dof f	Constraints c between two planar rigid bodies	Constraints c between two spatial rigid bodies
Revolute (R)	1	2	5
Prismatic (P)	1	2	5
Helical (H)	1	N/A	5
Cylindrical (C)	2	N/A	4
Universal (U)	2	N/A	4
Spherical (S)	3	N/A	3

- **Grübler's formula**: $\text{dof} = m(N-1-J) + \sum_{i=1}^{J} f_i$

2-DOF Planar Robot

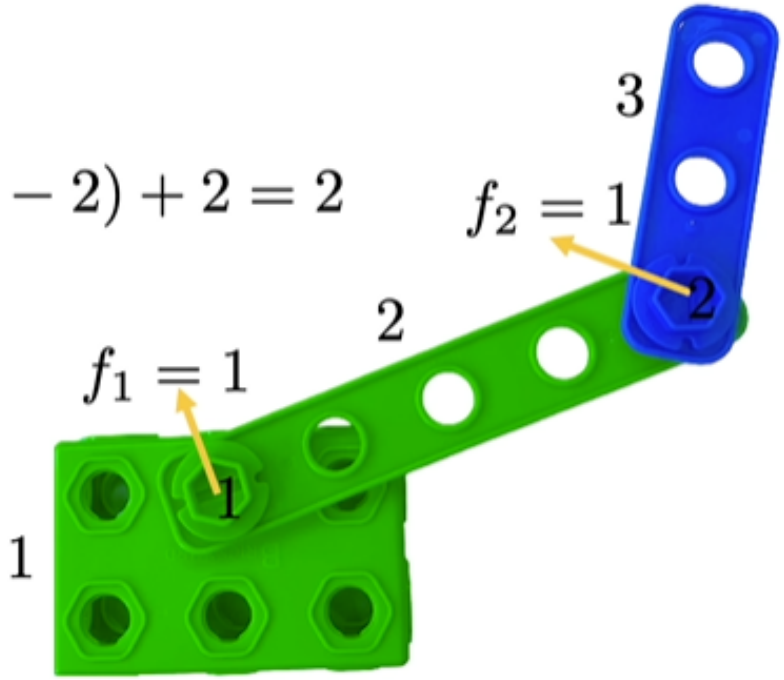
$$m = 3$$

$$N = 3$$

$$J = 2$$

$$\sum_{i=1}^{2} f_i = 2$$

$$dof = 3(3 - 1 - 2) + 2 = 2$$



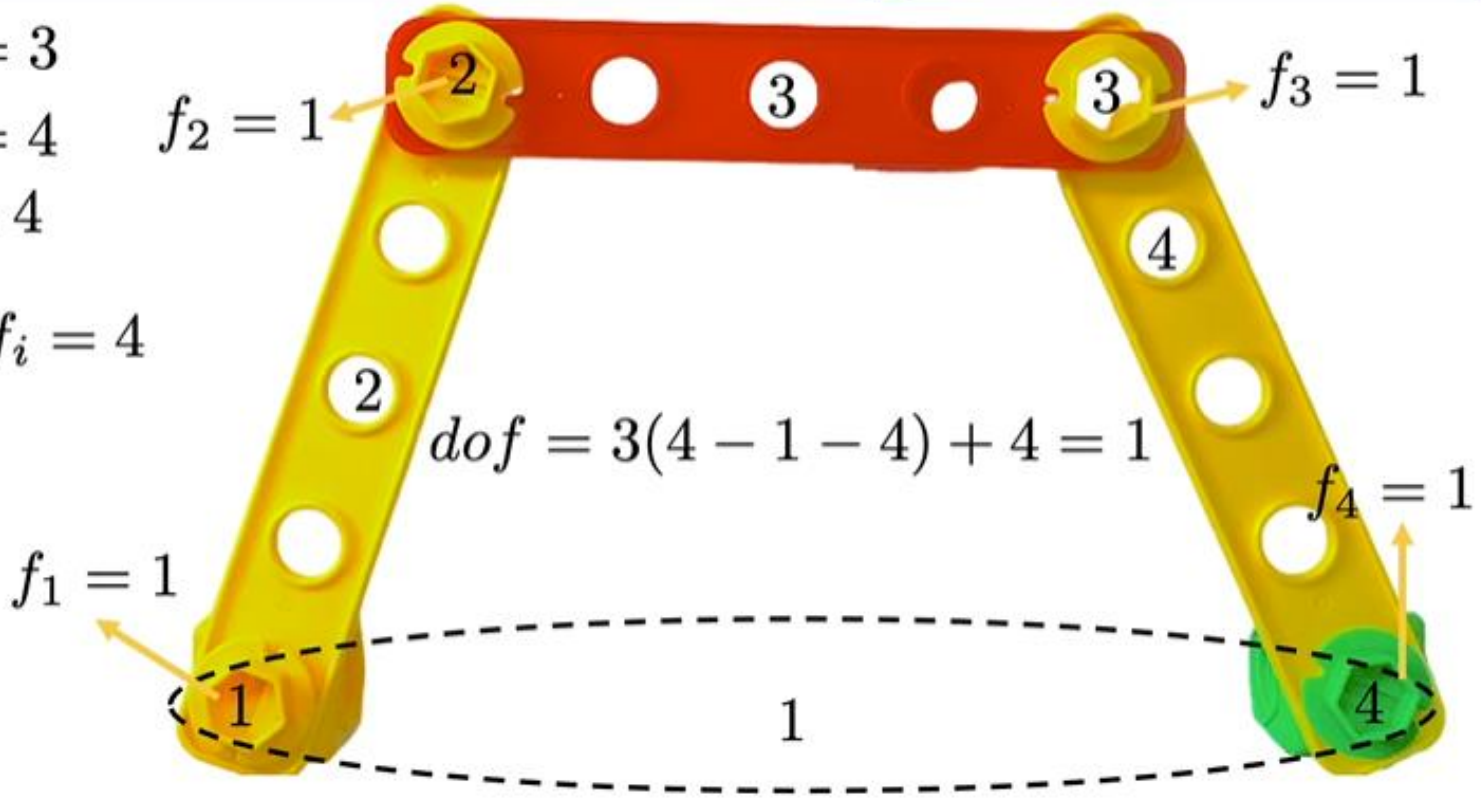
4-Bar Linkage

$m = 3$

$N = 4$

$J = 4$

$$\sum_{i=1}^{4} f_i = 4$$



Stewart Platform

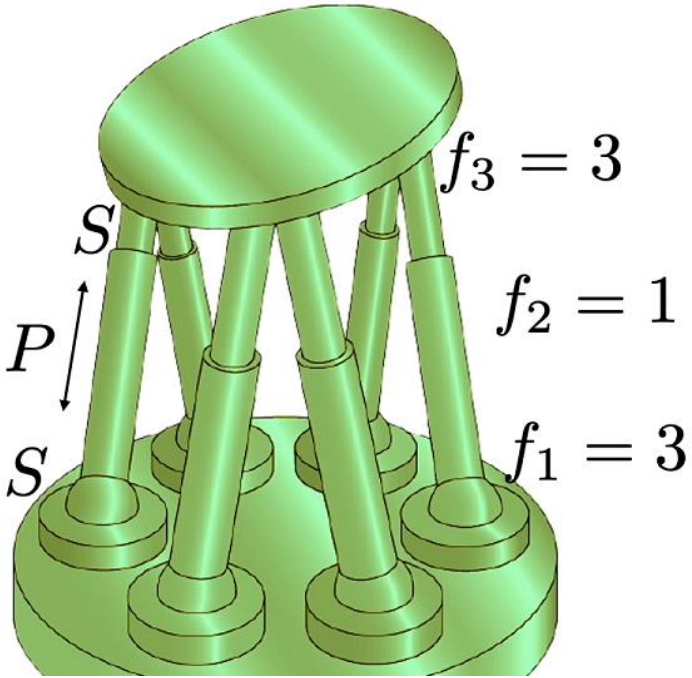
$$m = 6$$

$$N = 1 + 1 + 6(2) = 14$$

$$J = 6 \times 3 = 18$$

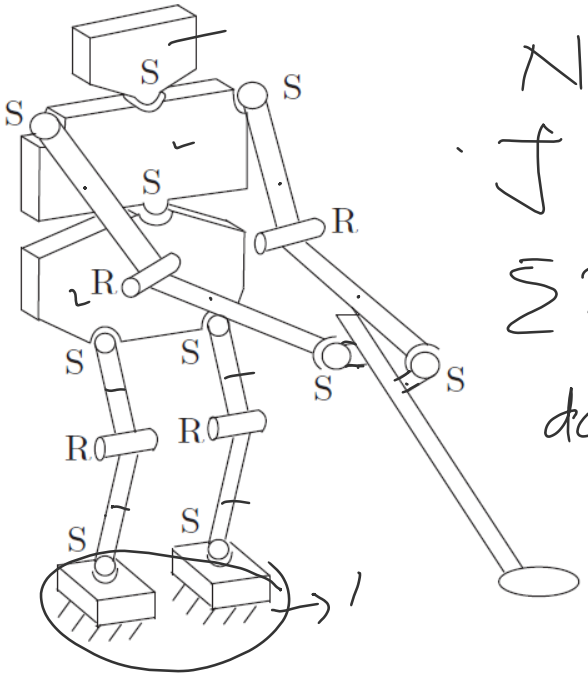
$$\sum_{i=1}^{18} f_i = 12 \times 3 + 6 \times 1 = 42$$

$$dof = 6(14 - 1 - 18) + 42 = 12$$



EXERCISE 1

Determine the degrees of freedom for the golfer of Figure: Assume that both feet are always firmly planted to the ground and that the two \hands" are rigidly attached to the golf club.



$m = 6$

$N = 14$ (15)

$f = 10(S) + 4(R) = 14$

$\sum f_i = 10 \times 3 + 4 \times 1 = 34$

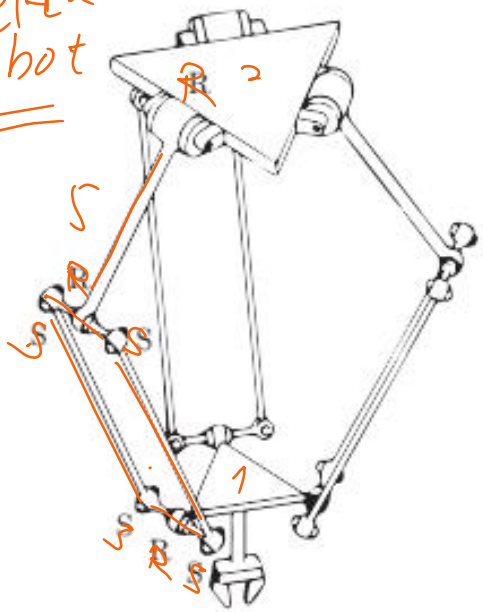
$dof = 6(14 - 1 - 14) + 34$

$= -6 + 34 = 28$

EXERCISE 2

The Delta robot in Figure consists of two platforms – the lower one mobile, and the upper one stationary – connected by three legs. Each leg contains a parallelogram closed chain and consists of three revolute joints, four spherical joints, and five links.

Delta Robot



$m = 6$

$N = 15 + 2 = 17$

$J = 21$

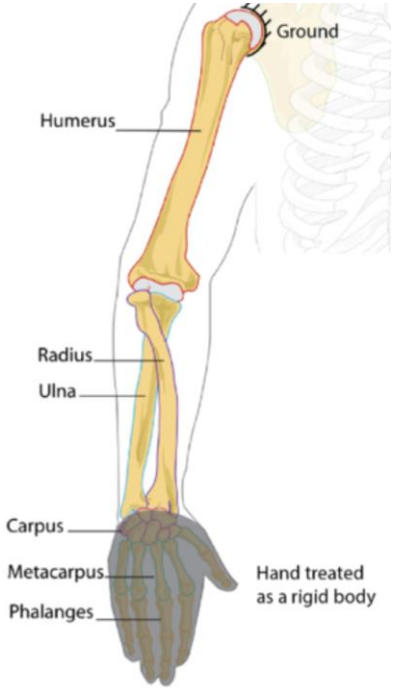
$\sum f_i = 12(5) + 9 \times 1$

$= 36 + 9 = 45$

$dof = 15$

EXERCISE 3

How many dof does the human arm have?



EXERCISE 3-Solution

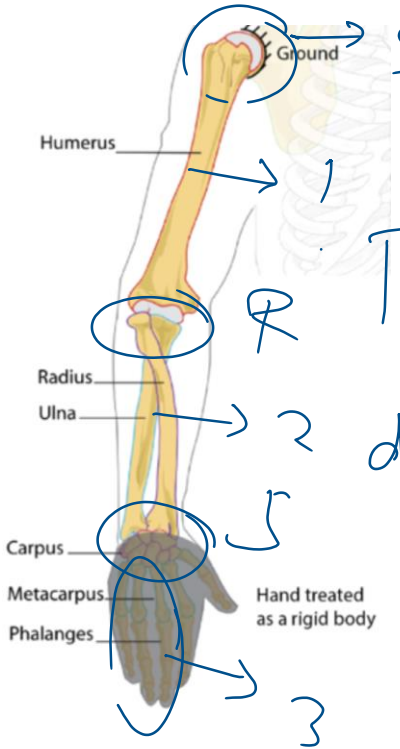
$m = 6$

$N = 3$

$J = 3 = 2(3) + (1)$

$\sum f_i = 7$

dof = 1



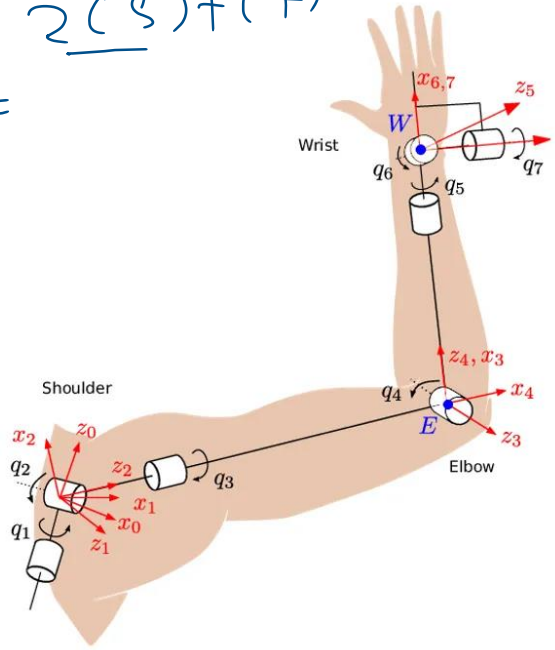
R

S

J

$dof = m(N-1-J) + \sum_{i=1}^{J} f_i$

$= 6(3-1-3) + 7 = 1$



Time for Discussions

Thank You!