

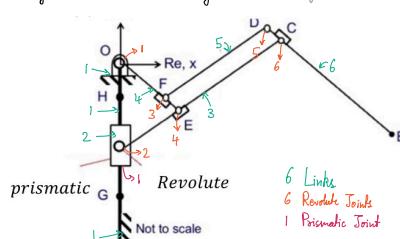
EC4.401 - Robotics: Dynamics and Control - Assignment I

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A1 - Mobility Analysis

1.1 - DoF of following mechanisms

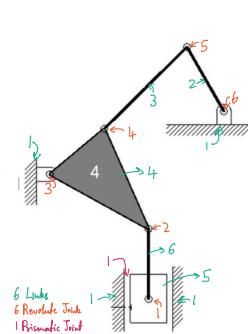
a) Assuming the rod HG is fixed to ground (it becomes ground)



$$DoF = \frac{2(2D)}{3} - 3(6) - 2(6) - 2(1) = 15 - 12 - 2 = 1$$

1 DoF

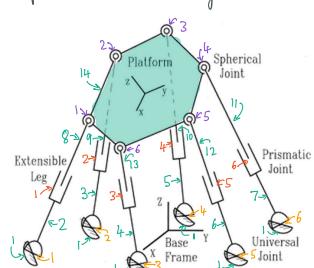
b)



$$\begin{aligned} DoF &= 3(6) - 2(6) - 2(1) \\ &= 15 - 12 - 2 = 1 \end{aligned}$$

1 DoF

c) Spatial mechanism, analysis in 3D



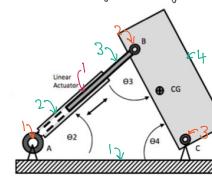
- ~6 DoF each in 3D space (includes one ground)
- Restricts 3 DoF / Allows 3 DoF projected
- 3 Axis Rotation
- 6 Spherical Joints
- 6 Prismatic Joints
- Universal Joints (2 Axis Rotation)

$$DoF = 6(14) - 5(6) - 4(6) - 3(6) = 78 - 30 - 24 - 18 = 6$$

6 DoF

d)

All planar joints, analysis in 2D



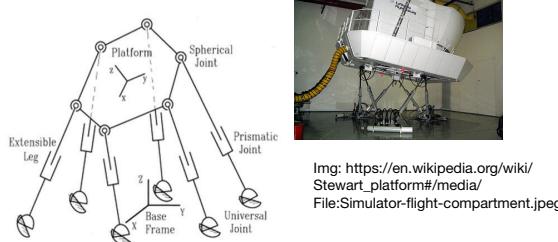
$$DoF = 3(4) - 2(3) - 2(1) = 9 - 6 - 2 = 1$$

1 DoF

1.2 - Name or application (at least 2)

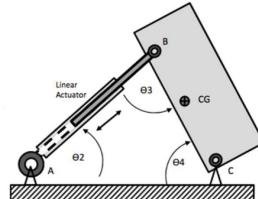
c) Stewart Platform

(c)



Img: https://en.wikipedia.org/wiki/Stewart_platform#/media/File:Simulator-flight-compartment.jpeg

d) Tipping Truck Mechanism



Img: [https://en.wikipedia.org/wiki/Dump_truck#/media/File:LKW_Kipper_DSCF6469_\(crop\).jpg](https://en.wikipedia.org/wiki/Dump_truck#/media/File:LKW_Kipper_DSCF6469_(crop).jpg)

Used by trucks to unload materials. Seen at construction sites.

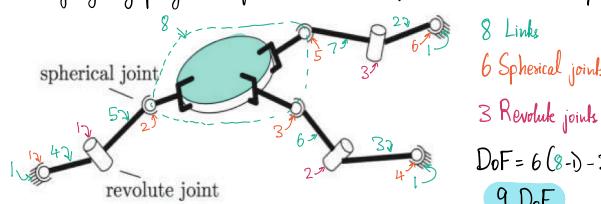
Used in flight simulator platforms for pilot training

Questions a) and b) seem to be straight line mechanisms

A2 - SRS Arms Grasping

2.1 - DoF of System

Assuming tight grip by end effectors \Rightarrow All end effectors are fixed with respect to grasped object \rightarrow They all form a single link



$$DoF = 6(8) - 3(6) - 5(6) = 48 - 18 - 15 = 9$$

9 DoF

6 DoF for fully defining the grasped object

+ 1 Free DoF for revolution of entire arm along axis from X n one S (base) to other S (to gripper) for each of 'n' arms

$$6+n$$

2.2 - n arms - DoF

Ground, object grasped + load, links

$$No. \text{ of } \text{links} = 1 + 1 + 2n = 2n + 2$$

$$No. \text{ of } \text{Revolute joints} = n$$

$$DoF = 6(2n+2) - 3(2n) - 5n = 12n + 12 - 6n - 5n = n + 12$$

$$\text{Two per arm} \quad \text{1 per arm}$$

$$n+12$$

2.3 - Spherical Joints replaced by Universal Joints

Spherical \rightarrow 3 restricted, 3 allowed; Universal \rightarrow 4 restricted, 2 allowed

No. of links = $l+1+2n$; No. of Universal joints = $2n$; No. of Revolute joints = n

$$DoF = 6(2n+2-l) - 4(2n) - 5(n) = 12n + 6 - 8n - 5n = 6-n$$

$$DoF = \max(6-n, 0)$$

Eg:

1. $n=1 \rightarrow$ One 5R manipulator $\Rightarrow 5 DoF = 6-1^3$

2. $n=2 \rightarrow$ Two 5R manipulators = 10 DoF if independent, object introduces 6 constraints $\Rightarrow 10-6 = 4 DoF = 6-2^3$

3. Every new manipulator will get 5 DoF (5R) but with 6 DoF (for end effector) $\Rightarrow -1$ for each new manipulator $\Rightarrow DoF = 6 + 5n - 6n = 6-n$

-ve DoF \Rightarrow indefinite system, so min value 0 is logical