# Practice Set 1

**Robotics & Automation**
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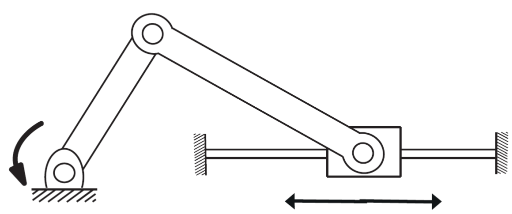
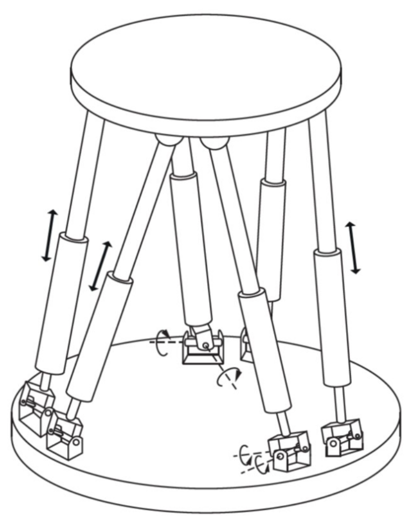
Using your textbook and what we covered in lecture, try solving the following problems. For some problems you may find it convenient to use Matlab (or another programming language of your choice). The solutions are on the next page.

## Problem 1



How many degrees of freedom does this robot have?

## Problem 2

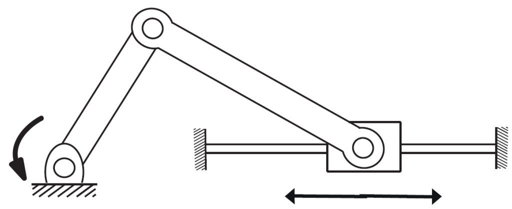


How many degrees of freedom does this robot have? This particular robot is fairly common, and is called a *Stewart platform*.

## Problem 3

Are the two robots shown above serial robots (open kinematic chains) or parallel robots (closed kinematic chains)?

## Problem 1

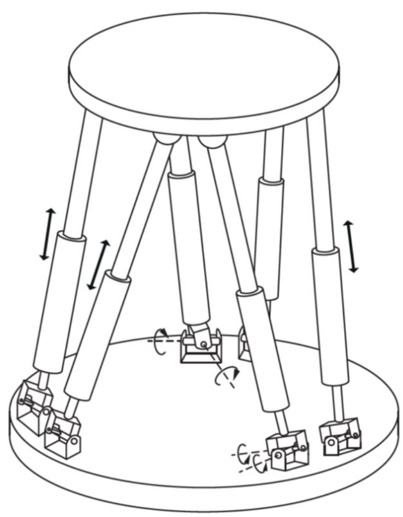


Applying Grübler's Formula, we find this robot has **1 DoF**. The planar robot has 4 links (including the ground), 3 revolute joints, and 1 prismatic joint. Each individual joint has one degree of freedom. We plug in with $N = 4$, $K = 4$, and $m = 3$:

$$DoF = m(N - 1 - K) + \sum_{i=1}^{K} f_i \tag{1}$$

$$DoF = 3(4 - 1 - 4) + 4 = 1 \tag{2}$$

## Problem 2



This robot has **6 DoF**. The robot is moving in 3D space, so $m = 6$. There are a total of 14 links: each leg has 2 links, plus one for the top and one for the bottom platform (this bottom platform is ground). There are three joints on each leg: a universal joint at the base, a prismatic joint in the middle, and a spherical joint at the top. Universal joints have 2 DoF, prismatic joints have 1 DoF, and spherical joints have 3 DoF. Plugging everything into Grübler's Formula:

$$DoF = m(N - 1 - K) + \sum_{i=1}^{K} f_i \tag{3}$$

$$DoF = 6(14 - 1 - 18) + 6 \cdot 2 + 6 \cdot 1 + 6 \cdot 3 = 6 \tag{4}$$

## Problem 3

Both of these robots are **parallel robots**. You can tell because the kinematic chain has loops (multiple connections to the ground). For instance, the robot in Problem 1 is connected to the ground on the left, and returns to the ground on the right.