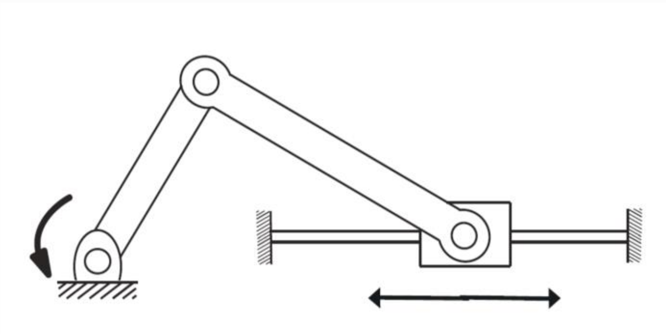
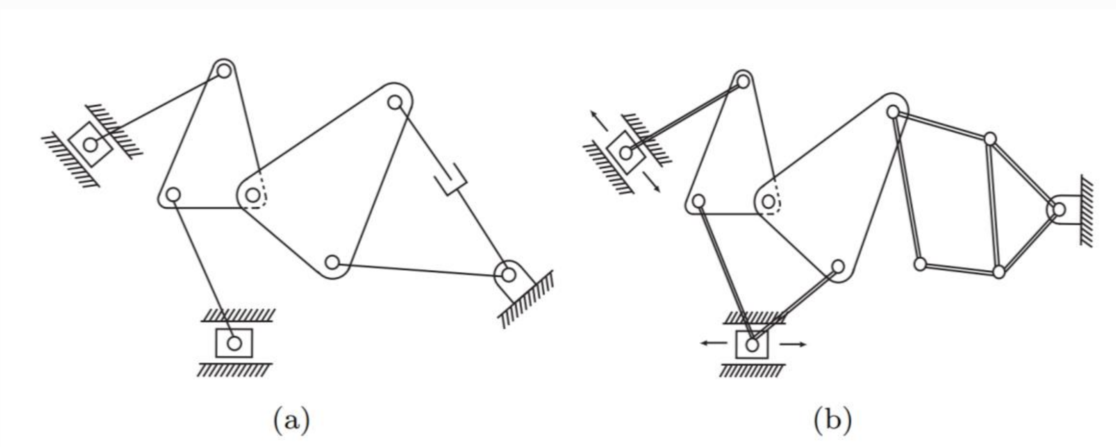
Foundations of Robotics

Homework 2

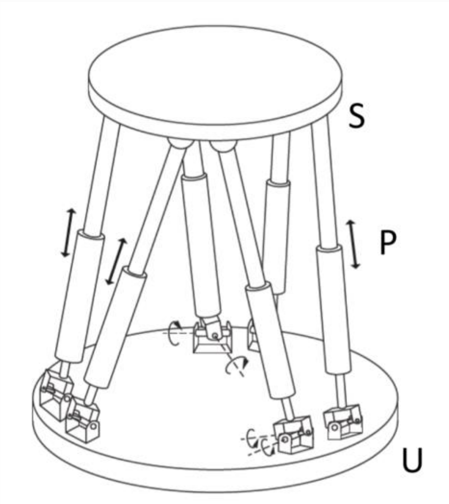
1. Use the planar version of Grübler's formula to determine the number of degrees of freedom of the following mechanism.



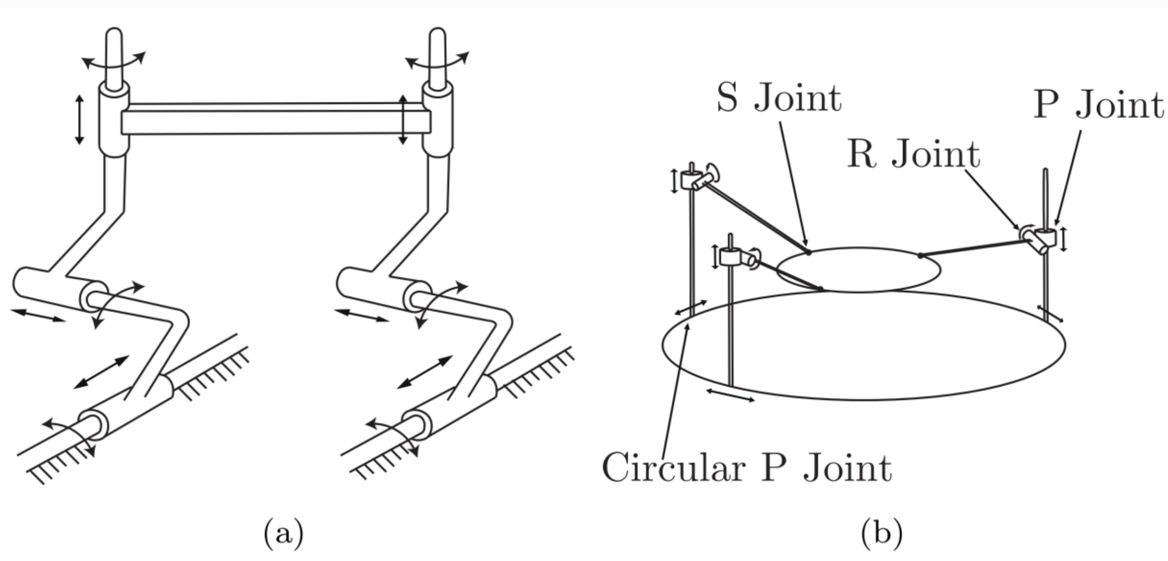
2. (Exercise 2.9 a-b) Use the planar version of Grübler's formula to determine the number of degrees of freedom of the following mechanisms.



3. Use the spatial version of Grübler's formula to determine the number of degrees of freedom of the following mechanisms.



4. (Exercise 2.11 a-b) Use the spatial version of Grübler's formula to determine the number of degrees of freedom of the following mechanisms.



5. (Exercise 2.1) Derive a formula, in terms of n, for the number of degrees of freedom of a rigid body in n-dimensional space. Indicate how many of these dof are translational and how many are rotational. Describe the topology of the C-space (e.g., for $n = 2$, the topology is $R^2 \times S^1$).

6. (Exercise 2.29) Please solve the exercise discussed as follows.

Exercise 2.29 Give a mathematical description of the topologies of the C-spaces of the following systems. Use cross products, as appropriate, of spaces such as a closed interval $[a, b]$ of a line and $\mathbb{R}^k$, S^m, and T^n, where k, m, and n are chosen appropriately.

(a) The chassis of a car-like mobile robot rolling on an infinite plane.
(b) The car-like mobile robot (chassis only) driving around on a spherical asteroid.
(c) The car-like mobile robot (chassis only) on an infinite plane with an RRPR robot arm mounted on it. The prismatic joint has joint limits, but the revolute joints do not.
(d) A free-flying spacecraft with a 6R arm mounted on it and no joint limits.