

Where we are:

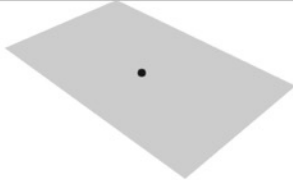

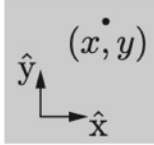
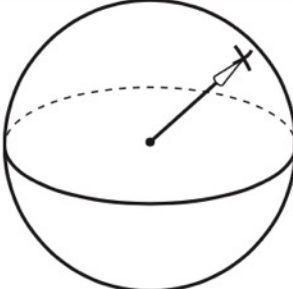

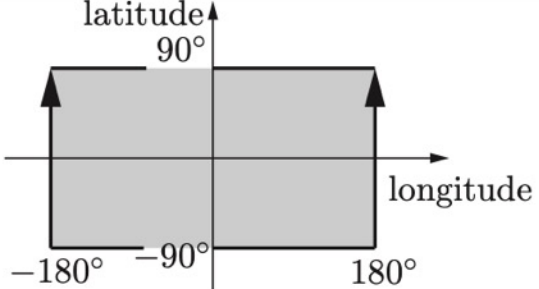
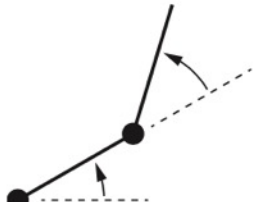

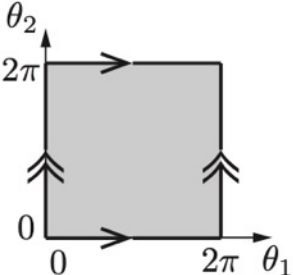
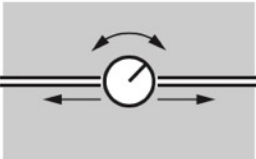

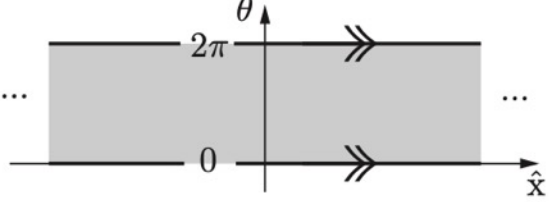
Chap 2	Configuration Space
	2.1 DOF of a Rigid Body
	2.2 DOF of a Robot
	2.3 C-space: Topology and Representation
Chap 3	Rigid-Body Motions
Chap 4	Forward Kinematics
Chap 5	Velocity Kinematics and Statics
Chap 6	Inverse Kinematics
Chap 8	Dynamics of Open Chains
Chap 9	Trajectory Generation
Chap 11	Robot Control
Chap 13	Wheeled Mobile Robots

Important concepts, symbols, and equations

- Two C-spaces may have the same dof but differ in other ways. The **topology** (“shape”) of a space is independent of how we **represent** it.
- Two spaces are **topologically equivalent** if one can be continuously deformed to the other without cutting or pasting.
- Some spaces are **Cartesian products** of spaces of lower dimension, e.g.,

$$\text{(1d)} \mathbb{E}, S = T \quad \text{(2d)} \mathbb{E} \times \mathbb{E} = \mathbb{E}^2, S \times S = T^2, S^2, \mathbb{E} \times S \quad \text{(higher)} \mathbb{E}^k \times S^m \times T^n$$

- Represent Euclidean (“flat”) spaces \mathbb{E}^n as \mathbb{R}^n . For curved spaces, choose
 - minimum-parameter **explicit parameterizations** (choose between **singularities** or an **atlas** of **coordinate charts**), OR
 - **implicit representation** (use more numbers subject to constraints).

system	topology	sample representation
 point on a plane	 \mathbb{E}^2	 \mathbb{R}^2
 spherical pendulum	 S^2	 $[-180^\circ, 180^\circ) \times [-90^\circ, 90^\circ]$
 2R robot arm	 $T^2 = S^1 \times S^1$	 $[0, 2\pi) \times [0, 2\pi)$
 rotating sliding knob	 $\mathbb{E}^1 \times S^1$	 $\mathbb{R}^1 \times [0, 2\pi)$

Any value in an atlas of coordinate charts?
 An implicit representation?

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hexrotor with two 5-DOF arms

<https://www.prodrone.com/archives/1420/>

C-space topology, with and without
arm joint limits, rotor angles?
Implicit/explicit representations?
Grübler's formula?



C-space topology and representation?
Include gripper, wheel angles?

KUKA youBot

mecanum-wheel omnidirectional base

moving on flat ground

plus 5-DOF robot arm + gripper