Intro to Robotics

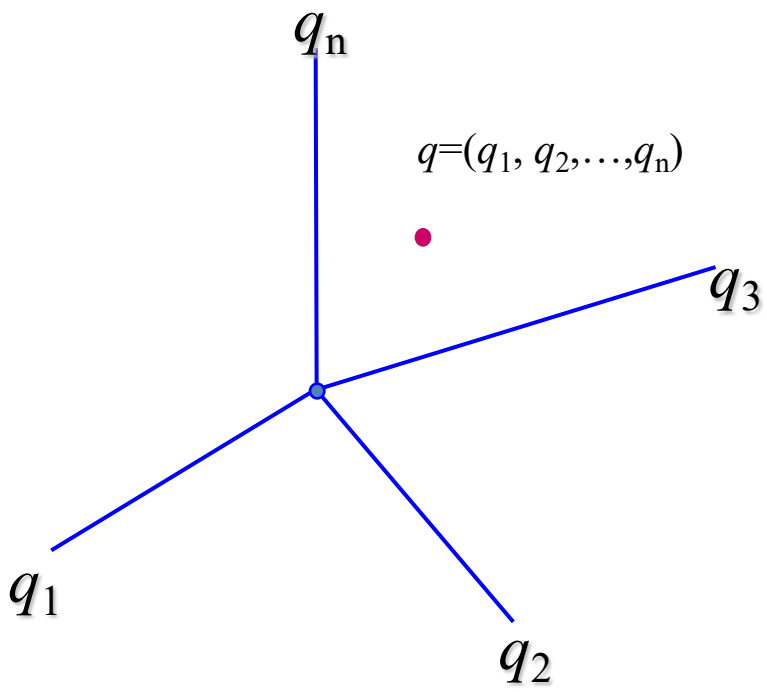
Lecture 10

The World

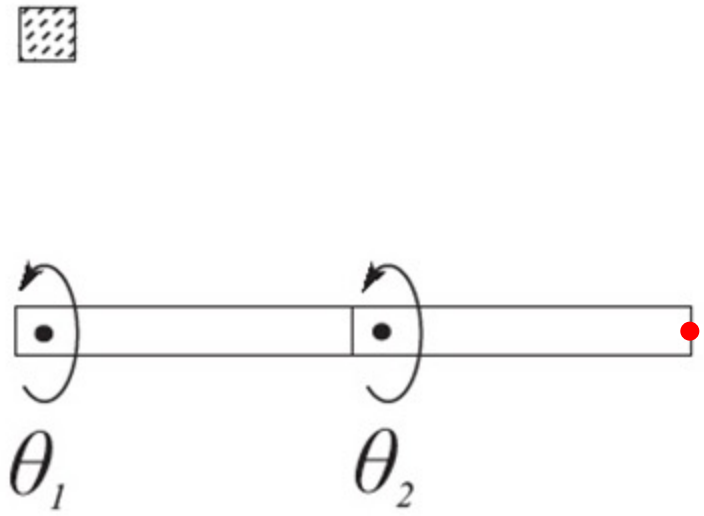
- Robot itself
- Obstacles
  - Robots can’t go there
- Free Space
  - Robots “might” be able to go here
  - Have workspace – robot-reachable

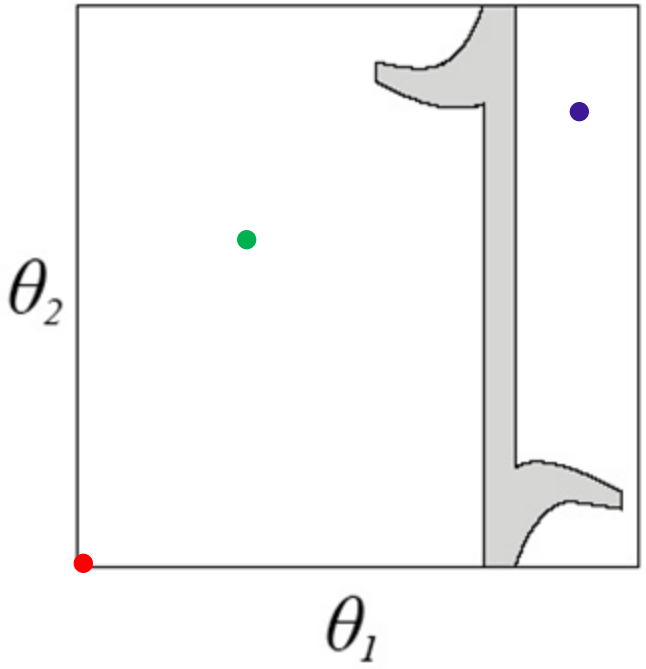
Configuration Space

- The **configuration space** C is the set of all possible configurations.
  - A configuration is a point in C.
- C can be very high dimensional while the workspace is just 2D or 3D

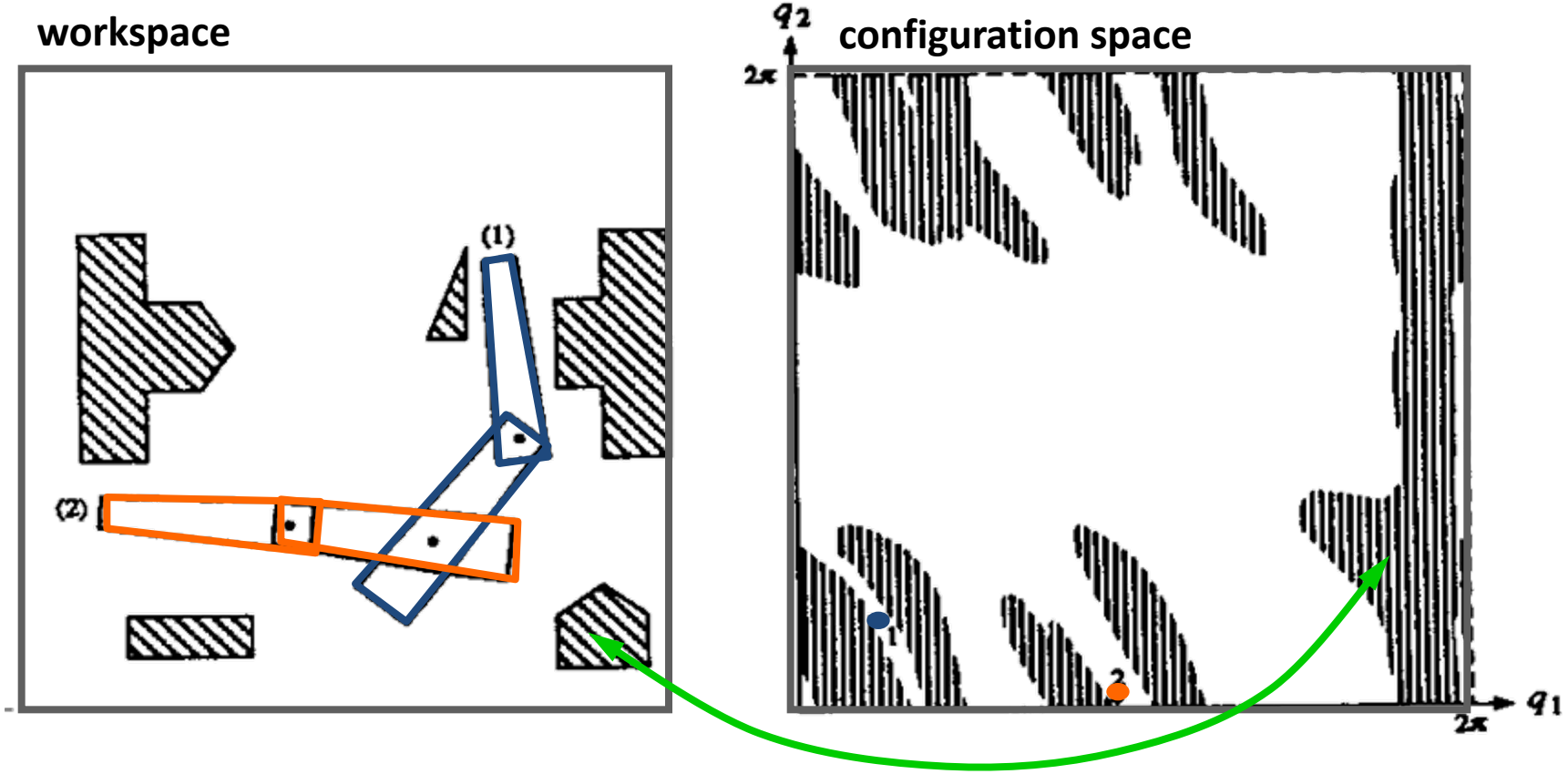


Simple Robot Example

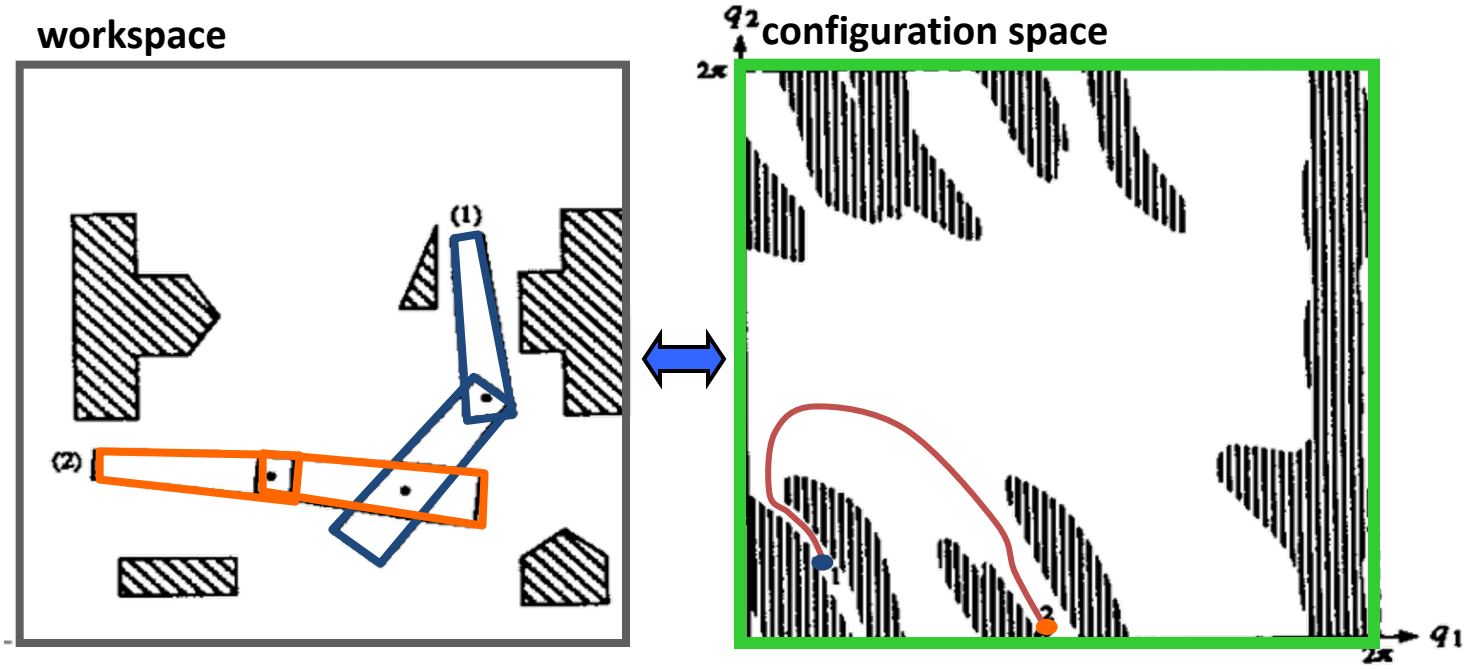




Articulated robot in 2-D workspace



Paths in the configuration space



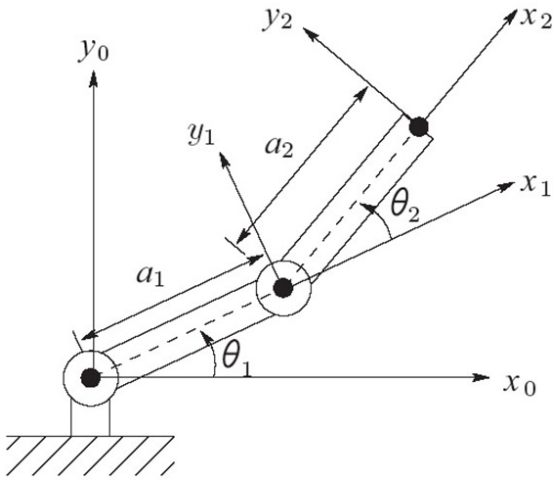
- A **path** in C is a continuous curve connecting two configurations q and q' :

$$\tau : s \in [0,1] \rightarrow \tau(s) \in C$$

such that $\tau(0) = q$ and $\tau(1) = q'$.

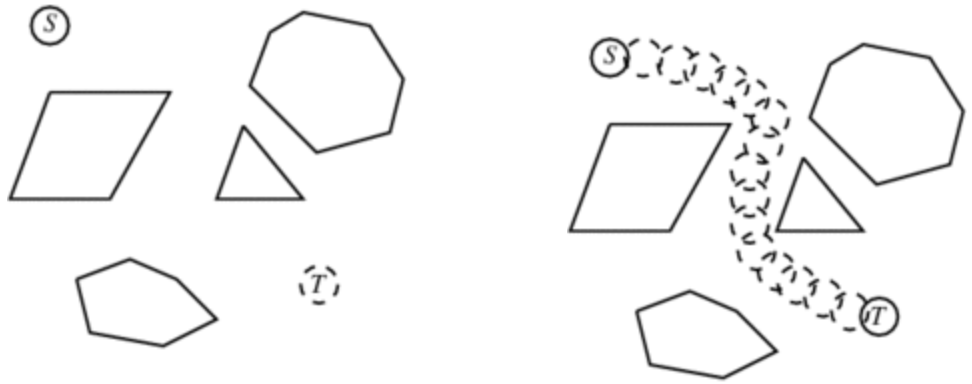
Example

- θ_1 and θ_2 have motion range as $-10 \leq \theta_1 \leq 0$ and $10 \leq \theta_1 \leq 50$, and $30 \leq \theta_2 \leq 80$ and $100 \leq \theta_2 \leq 180$ respectively.
- θ_1 and θ_2 have motion range as $-90 \leq \theta_1 \leq 90$, and $-90 \leq \theta_2 \leq 90$ respectively. In addition, θ_2 is coupled with θ_1 when $-30 \leq \theta_2 \leq 30$ as $\theta_2 = \theta_1$.

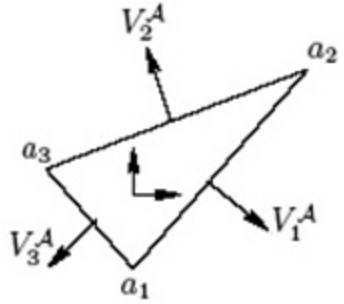


Motion Planning

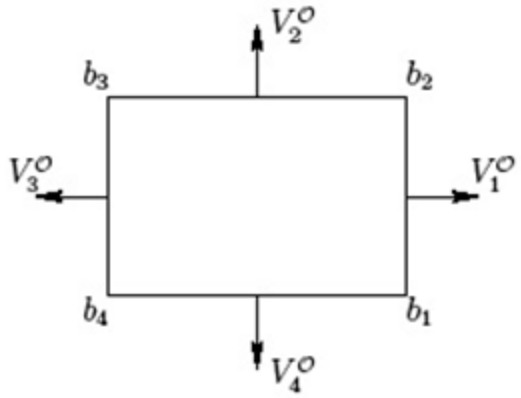
- Mobile robot



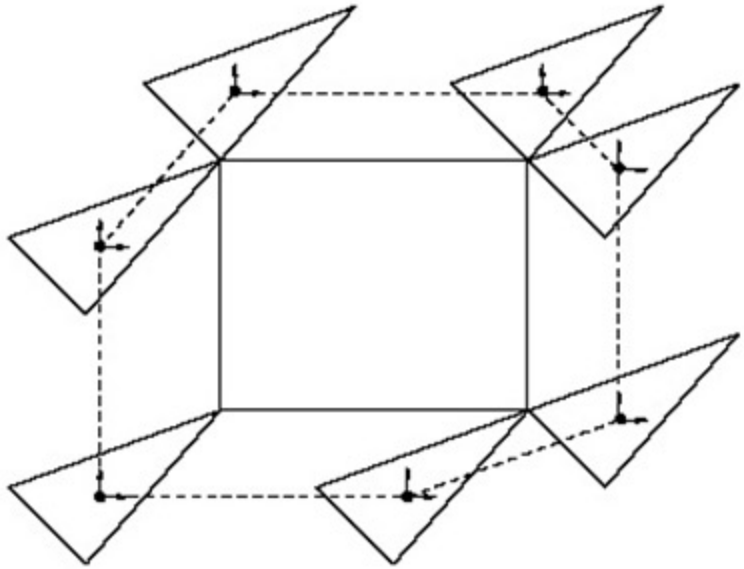
2D Configuration Space - Translation



Robot



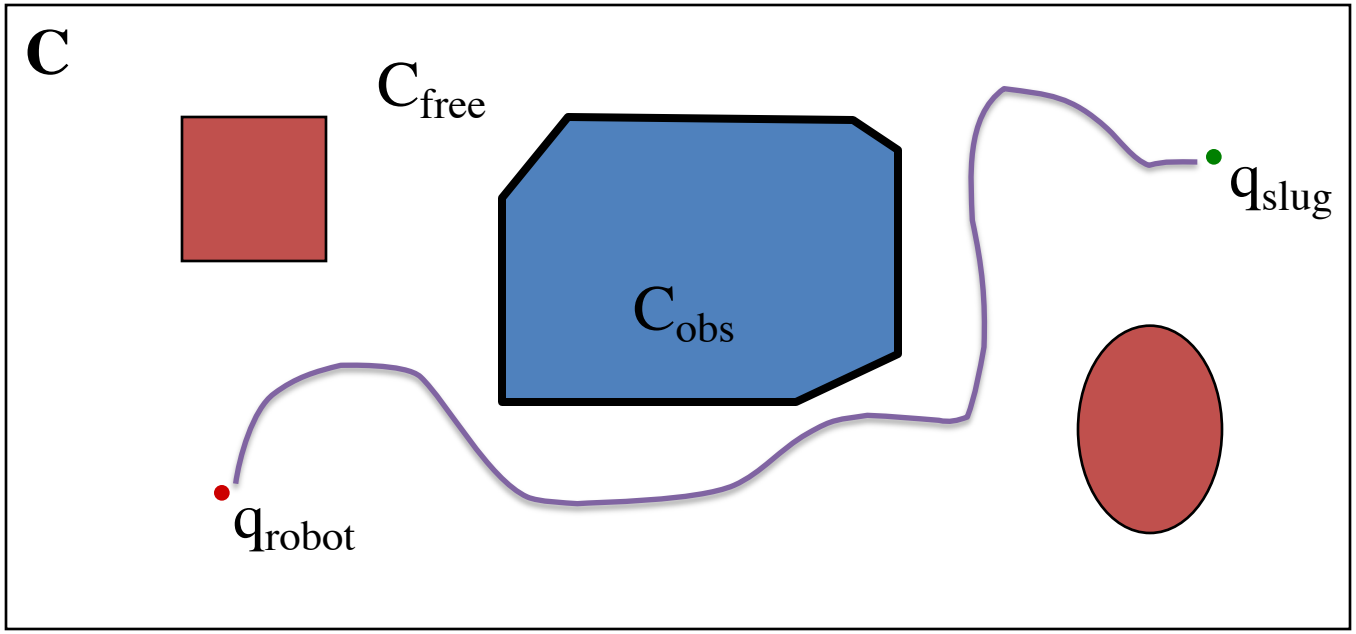
Obstacle



Obstacle in Configuration Space

Motion Planning in 2D

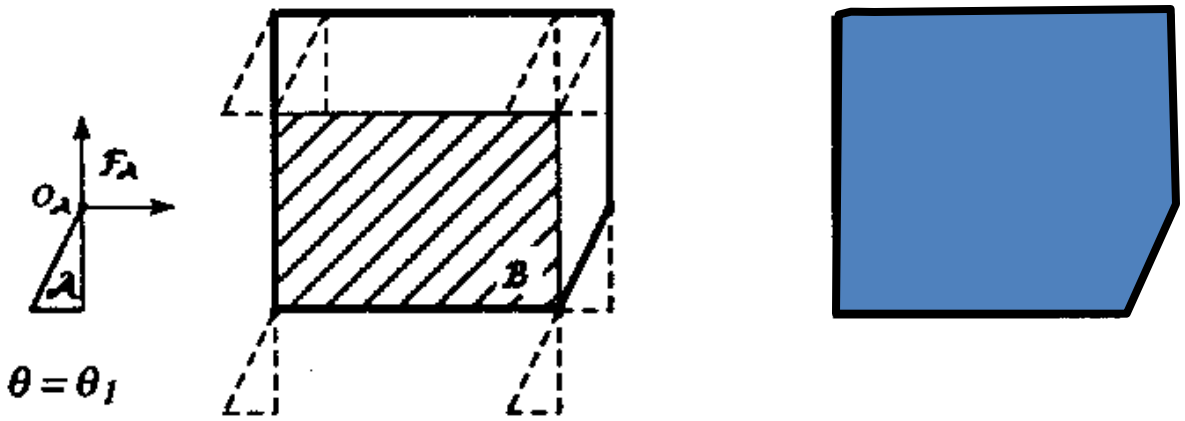
From one configuration point to another

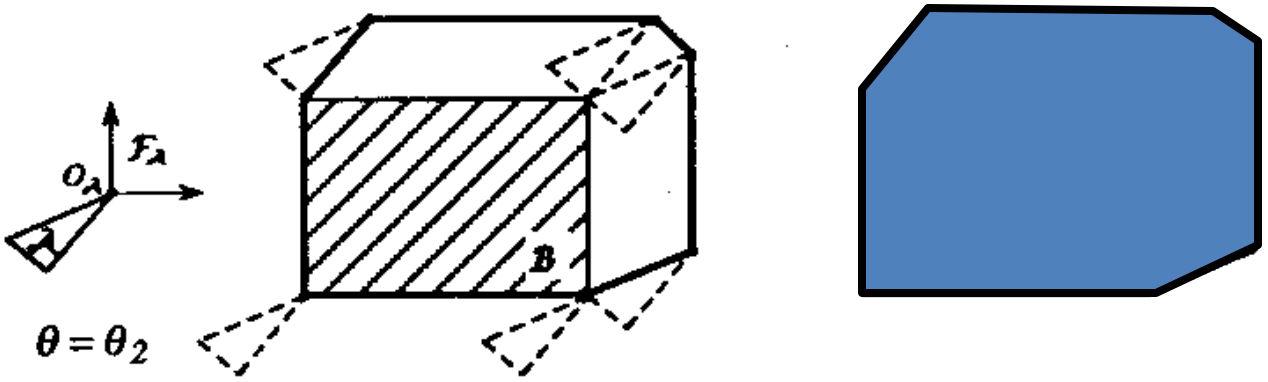


For a point robot moving in 2-D plane, *C*-space is R^2

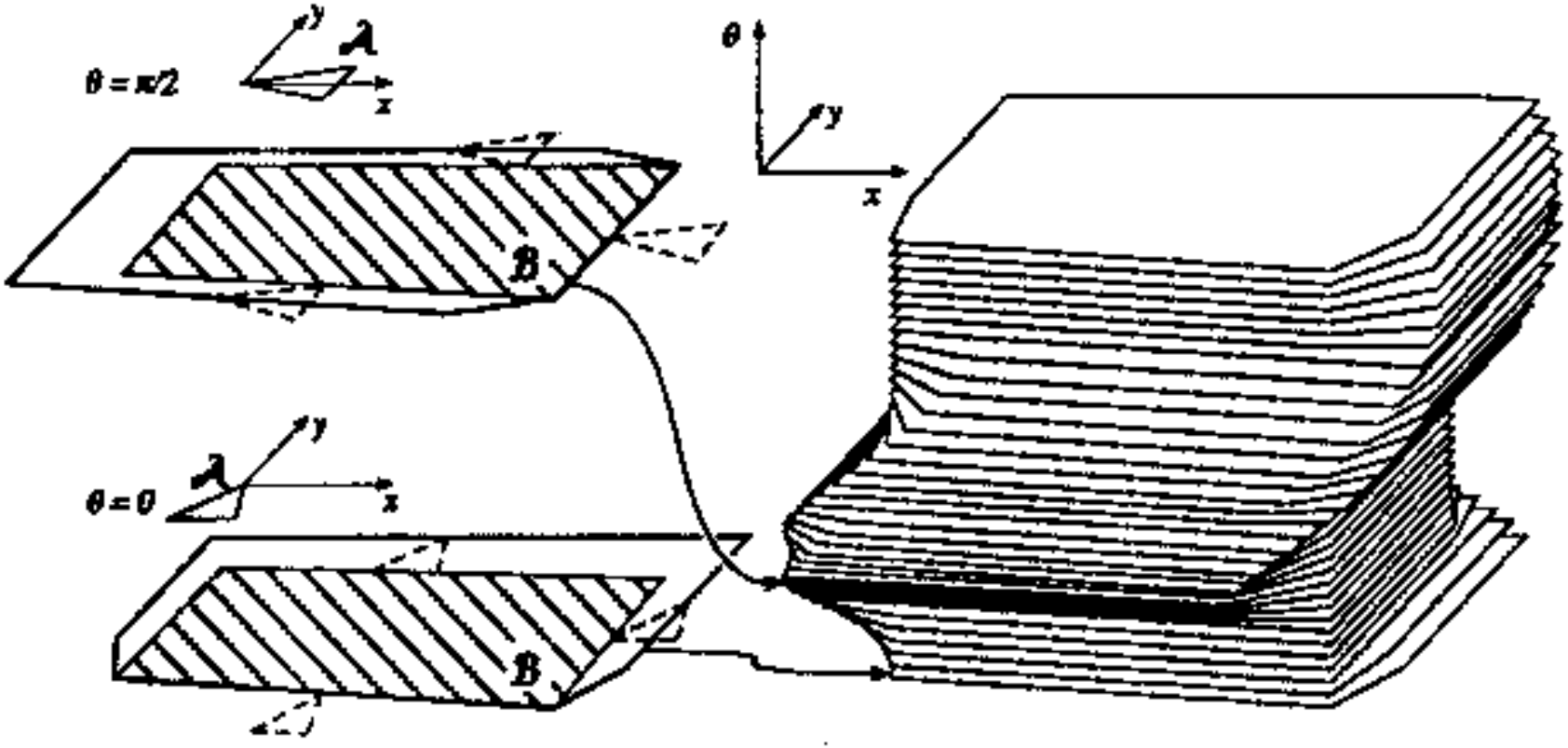
Obstacle in C-space: robot configuration at those places are not valid: collision, no reachable

3D C-Space With Rotation

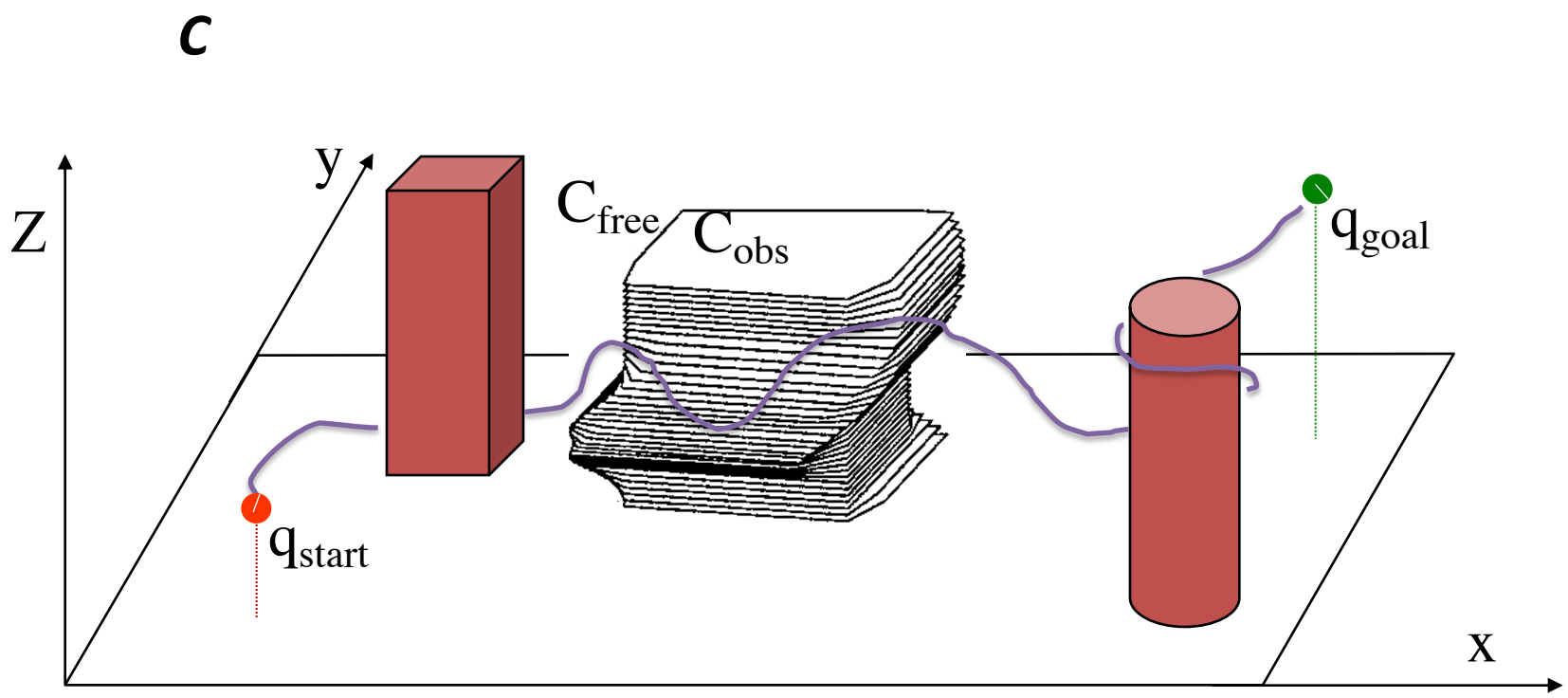




Translating & Rotating in 2-D workspace



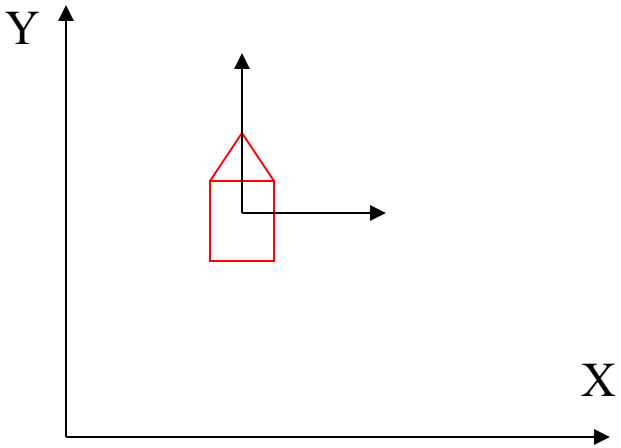
Configuration Space



For a point robot moving in 3-D, the C-space is R^3

What is the difference between Euclidean space and C-space?

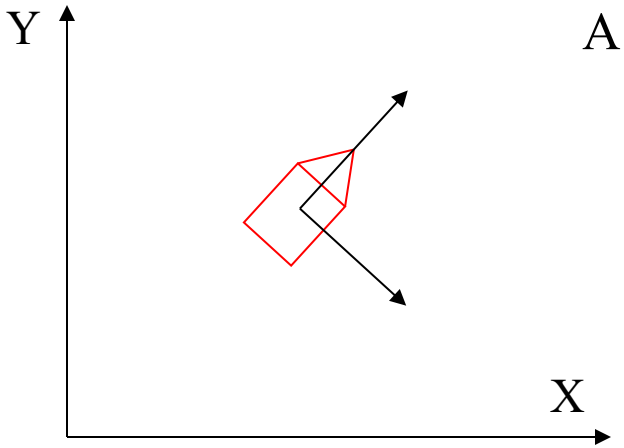
Configuration Space



A robot which can translate in the plane

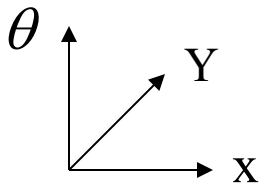
C-space: 2-D (x, y)

Euclidean space: R^2



A robot which can translate and rotate in the plane

C-space: 3-D (x, y, θ)



Free Paths in the configuration space

- A **free path** in C is a continuous curve connecting two configurations q and q' :

$$\tau : s \in [0,1] \rightarrow \tau(s) \in F$$

such that $\tau(0) = q$ and $\tau(1)=q'$.

- A **semi-free** path allows the robot and obstacles to contact (but not interpenetrate).

How to Find a Path?