Mechanics of Mechanisms and Robots

0. Introduction

Yanan Li

Contact details

- Email: yl557@sussex.ac.uk
- Zoom meeting: send me an email and we can agree on a time

Teaching method

- 4 weeks: Oct 10-23; Nov 21-Dec 4

- Online lectures: Mon, Tue, Thur
- an additional session on Nov 30

- Online workshops/tutorials: Fri

- Find Zoom links on Canvas

Assessment

- 30%: coursework
- released in the middle of the term
- submitted at the end of the term

- 70%: closed book exam

Reading list

- John J Craig, Introduction to robotics: mechanics and control, Pearson (Chapters 1-6)

- Mark W Spong and M Vidyasagar, Robot dynamics and control, Wiley (Chapters 1-5, 9)

Learning outcomes

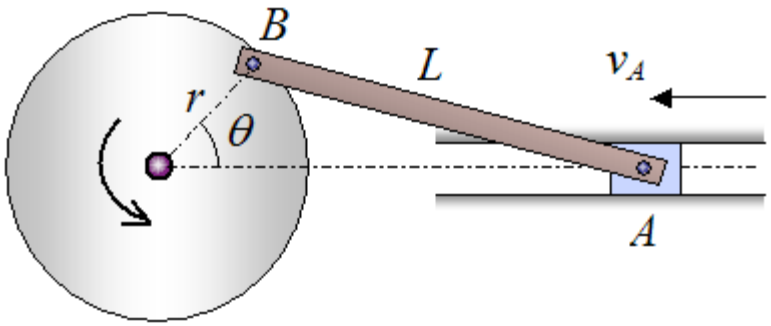
- Demonstrate a systematic understanding and analysis of the fundamental principles of motion of rigid bodies and relative motion of various parts of interconnected systems. (Kinematics)

- Apply theoretical principles and methods to the evaluation of kinematics of robotic and autonomous systems.

- Critically evaluate the effect of forces upon the motion of mechanisms and robots. (Statics and Dynamics)

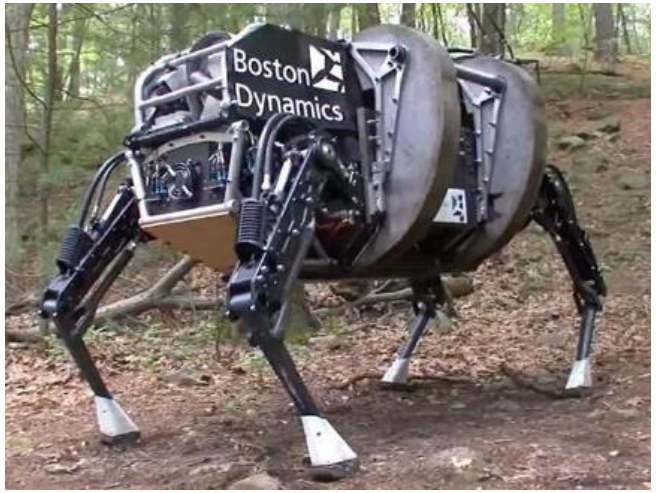
Mechanisms

- a device that transforms input forces and motion into output forces and motion
- gears, belt, linkage, frame, bearings, springs, pins, etc

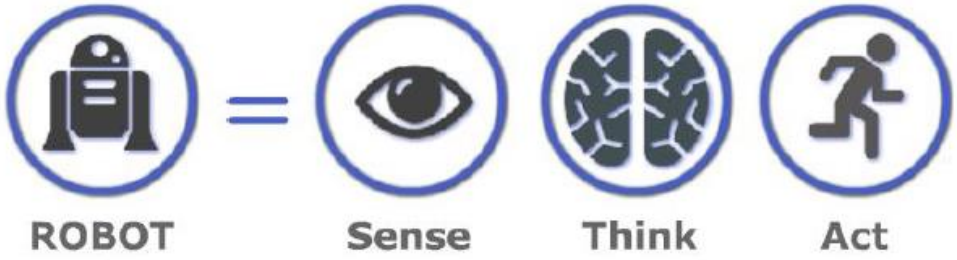


Robots

- Asimo
- Big dog
- Da Vinci
- Adept
- Super ball bot
- Drone
- Kuka



What make a robot?

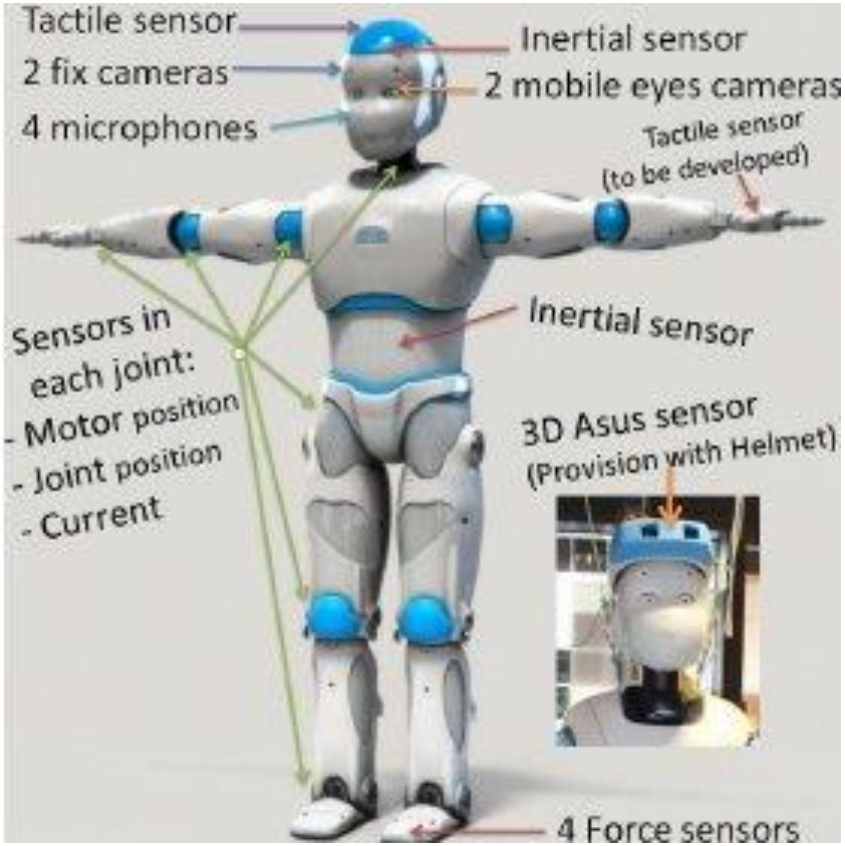


- Sense - light, temperature, pressure, proximity, distance, etc
- Think - artificial intelligence, decision marking, motion planning, etc
- Act - moving around, manipulating objects, interacting with humans, etc

What make a robot?

Sense

- force/torque sensor
- camera
- encoder
- potentiometer
- tactile sensor

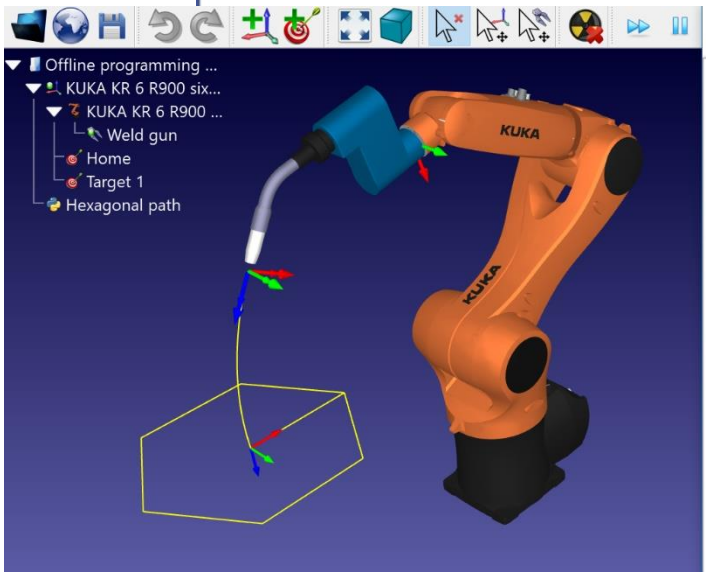


What make a robot?

Think

- computer
- smart phone
- programming
- artificial intelligence

```
Hexagonal_path.py - C:\Users\Albert\AppData\Local\Temp\Hexagonal_path.py (3.4.3)
File  Edit  Format  Run  Options  Window  Help
from robolink import *    # API to communicate with RoboDK
from robodk import *      # robodk robotics toolbox

# Any interaction with RoboDK must be done through RDK:
RDK = Robolink()

# get the robot by name:
robot = RDK.Item('', ITEM_TYPE_ROBOT)

# get the home target and the welding targets:
home = RDK.Item('Home')
target = RDK.Item('Target 1')

# get the pose of the target (4x4 matrix representing positi
poseref = target.Pose()

# move the robot to home, then to the Target 1:
robot.MoveJ(home)
robot.MoveJ(target)

# make an hexagon around the Target 1:
for i in range(7):
    ang = i*2*pi/6 #angle: 0, 60, 120, ...
    posei = poseref*rotz(ang)*transl(200,0,0)*rotz(-ang)
    robot.MoveL(posei)

# move back to the center, then home:
robot.MoveL(target)
robot.MoveJ(home)
```



What make a robot?

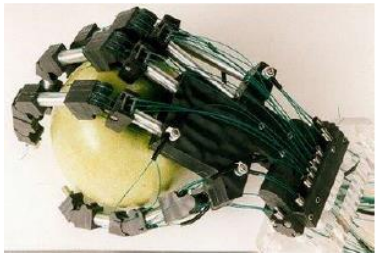
Act

- actuators
- electric
- hydraulic
- pneumatic



- grippers





- stationary, legged, wheeled, tracked, flying, etc

What is not a robot?

- Cooling fan
- Washing machine
- Hair dryer
- Vacuum cleaner
- Autonomous driving car
- A spring-driven toy

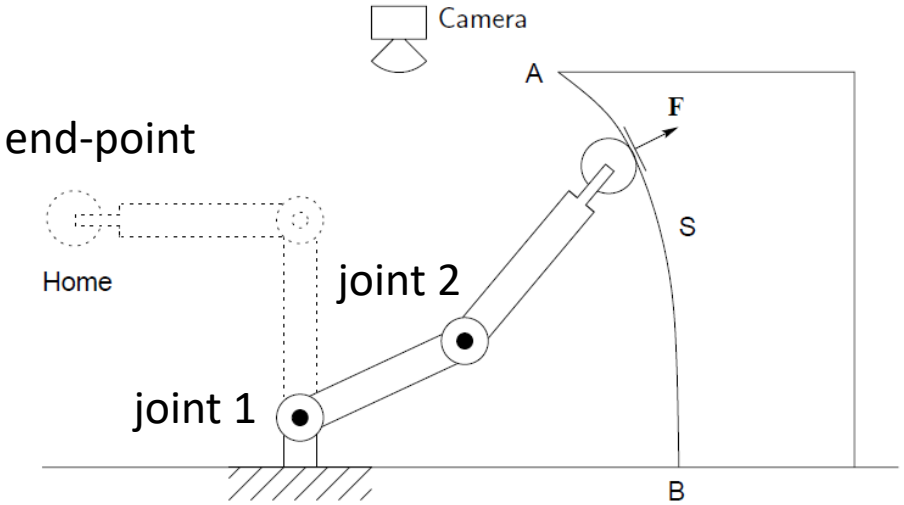
Mechanics

- Mechanics: science of motion and forces

Video: robotic polishing

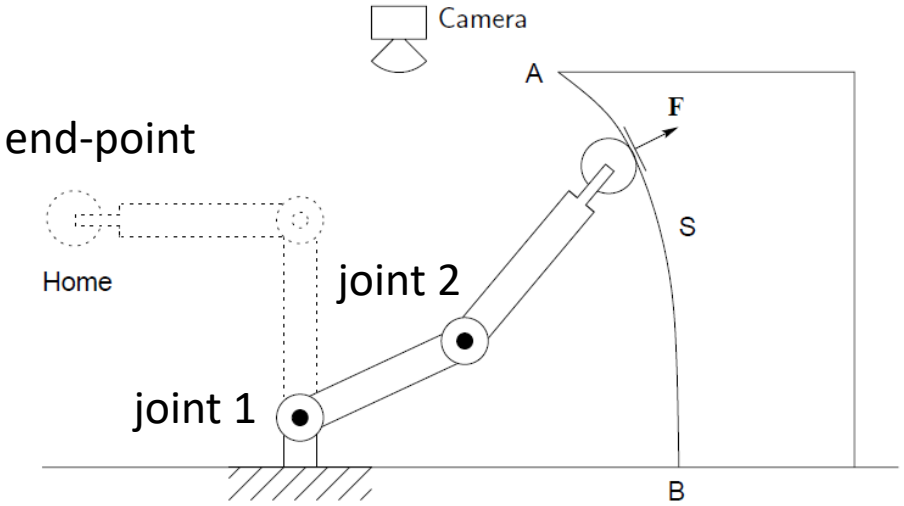
Mechanics

- Task 1: how to move the robot end-point between ‘Home’ and a target position?
- Task 2: how to apply a force F to the surface S?



Task 1

- Task 1: how to move the robot end-point between ‘Home’ and a target position?
- Suppose we can measure the angles of joints 1 and 2, we can determine the position of the end-point – Kinematics.



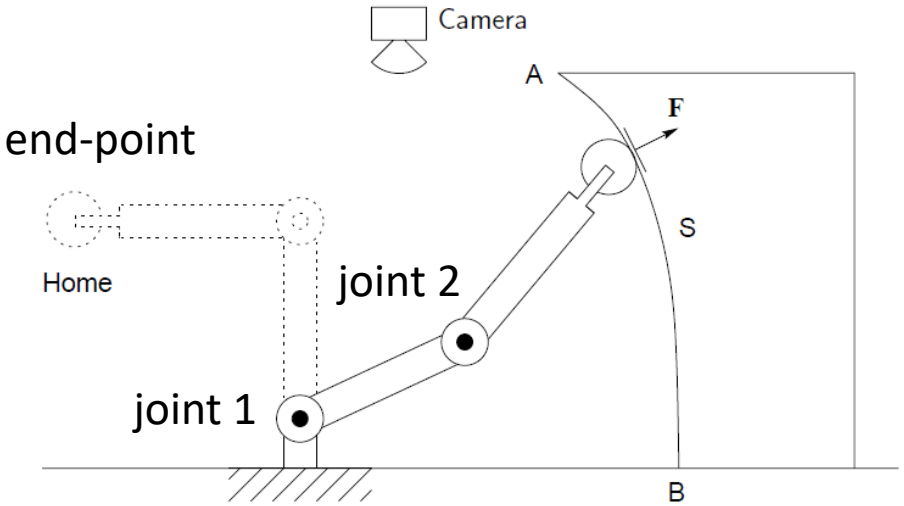
Kinematics

- Kinematics studies the relative motion of various parts of a mechanism.

- It does not consider what causes the motion, i.e., force.

Task 2

- Task 2: how to apply a force F to the surface S?
- Suppose the robot does not move and two motors at joints 1 and 2 provide certain torques, we can determine the force applied by the robot to the surface S – Statics.

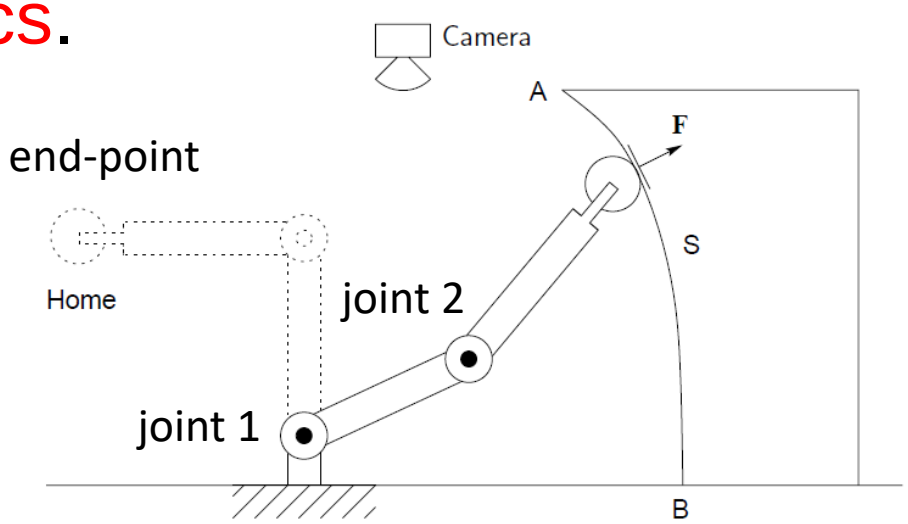


Statics

- Statics studies the relationship between forces of different parts, when the mechanism does not move, or more strictly, has a zero acceleration.

Tasks 1&2

- Tasks 1&2: the robot end-point moves between ‘Home’ and a target position; it may also apply a force to the surface S.
- With the motion of the mechanism, we can determine the required torques at joints 1&2 – Dynamics.



Dynamics

- Dynamics studies the relationship between forces and motion of the mechanism.

- In above example, motor torques partly contribute to the motion of the robot (dynamics) and partly contribute to the force applied to the surface (statics).

Module content

- Fundamental I: basics about motion analysis
- Kinematics
- Fundamental II: basics about force analysis
- Statics
- Dynamics

Why mechanics?

- It is a prerequisite of control of a mechanism.
- It provides a mathematical model that can predict the behaviour of a mechanism and simulate it in software – useful for prototyping and design of the mechanism.