Robotics – Exercises for Chapter 2, Basics

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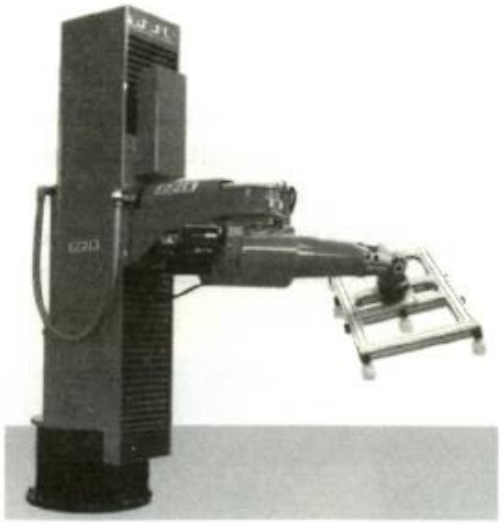
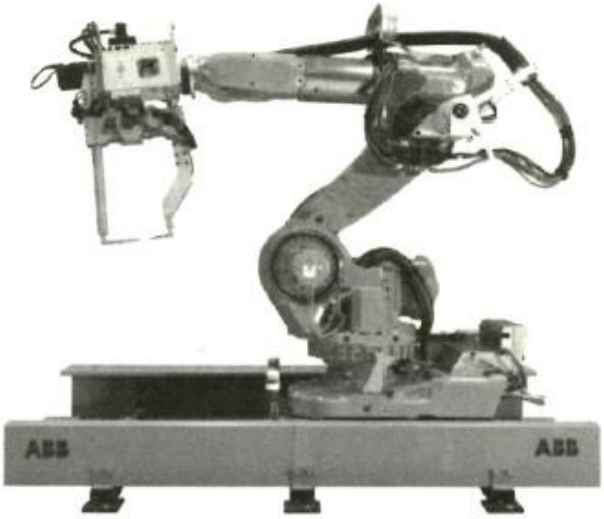
Task 1:

- Create the kinematic chain to the illustrated robots.
- Describe / Sketch the maximum accessible working space of the robot



(a)



(b)

(c)

(d)

Fig. 1: Different robot configurations

Task 2: Rotary encoder

A robot arm has a length of 0.5m and can be rotated by 360°. For this purpose, a servo motor with a reduction ratio of 10:1 is used. On the motor, there is an optical rotary encoder mounted. The positioning accuracy at the tip of the robot arm should be 0.1 mm.

- What is the necessary resolution of the encoder? Select a suitable encoder.
- What minimum counting frequency must the digital input of the control computer have in order to achieve a path speed of 1000 mm/s at the tip of the robot arm? (Assumption: resolution of the encoder 500 pulses / revolution)

Task 3: 2-jaw gripper

A two-jaw gripper grasps a steel block (m=100g) from above with a gripping force of 10 N. The coefficient of friction between gripper and block should be 0.2. The gripper is located on a robot arm with a length of 1.5m. The gripper arm is aligned horizontally after lifting the block.

- With what maximum vertical acceleration can the robot lift the block without losing it?
- After lifting, the arm rotates around its vertical axis. What is the allowed maximum rotation speed (in rpm) without the gripper losing the block?

Task 4: Vacuum gripper

The two-jaw gripper from Task 3 is replaced by a circular rubber vacuum gripper (coefficient of friction 0.5). How large does the base area of the suction cup have to be in order to maintain the values calculated for the two-jaw gripper?

Task 5: Moment of inertia, Steiner's theorem

Calculate the moment of inertia J_A and J_B of the sketched arrangement in fig. 2. The material used is aluminum. The rotation axes are perpendicular to the drawing plane and pass through the points A and B. The spheres have a radius of 5cm, the rods a length of 15cm and a thickness of 3mm.

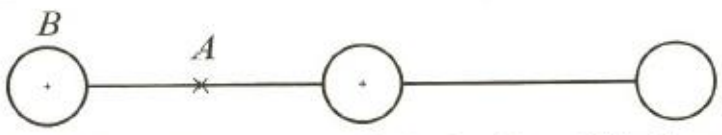


Fig. 2: Rods and spheres

Task 6: Moment of inertia and torque

The figure below shows a simple kinematic chain of a robot. Each link between two joints has a weight of 2 kg, a length of 500 mm and can be considered a long, thin rod. The gripper and each rotary drive weighs 3 kg each and can be modelled as a point mass.

1. What torque does the first rotary actuator in the kinematic chain according to Figure (a) need to apply to accelerate the robot to a rotational speed of 720°/s within 0.5s?

2. In fig. 3 (b), the 2nd rotary drive of the kinematic chain accelerates the robot parts above it with the torque calculated in (a). What (horizontal) force does the linear actuator have to apply to maintain its position?
3. The first rotary drive now accelerates the robot in position (c) with the torque calculated from (a). How big is the path acceleration on the gripper?

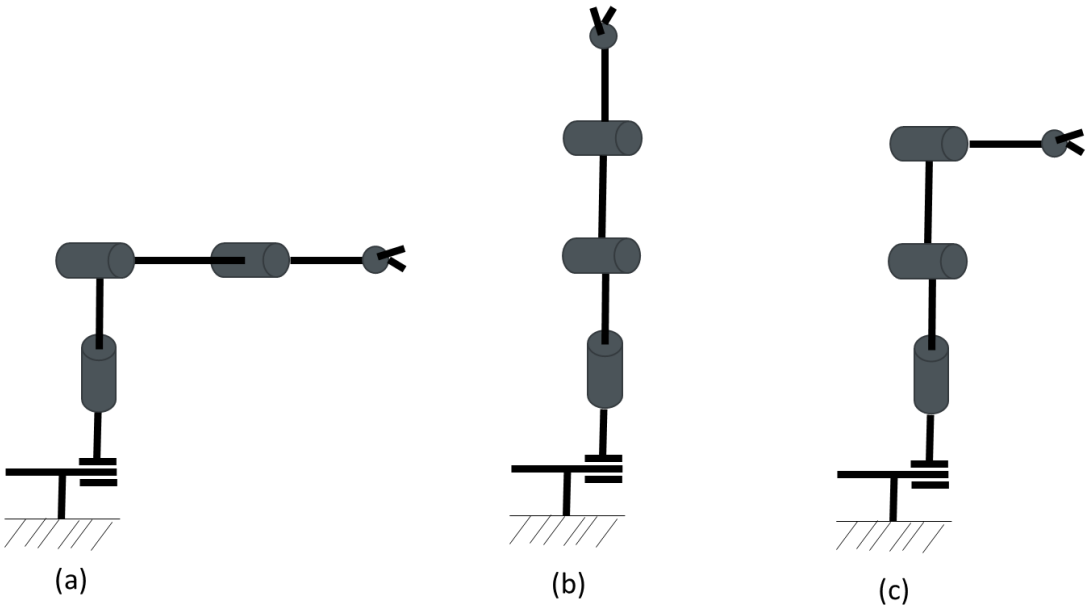


Fig. 3: Simple robot in different positions