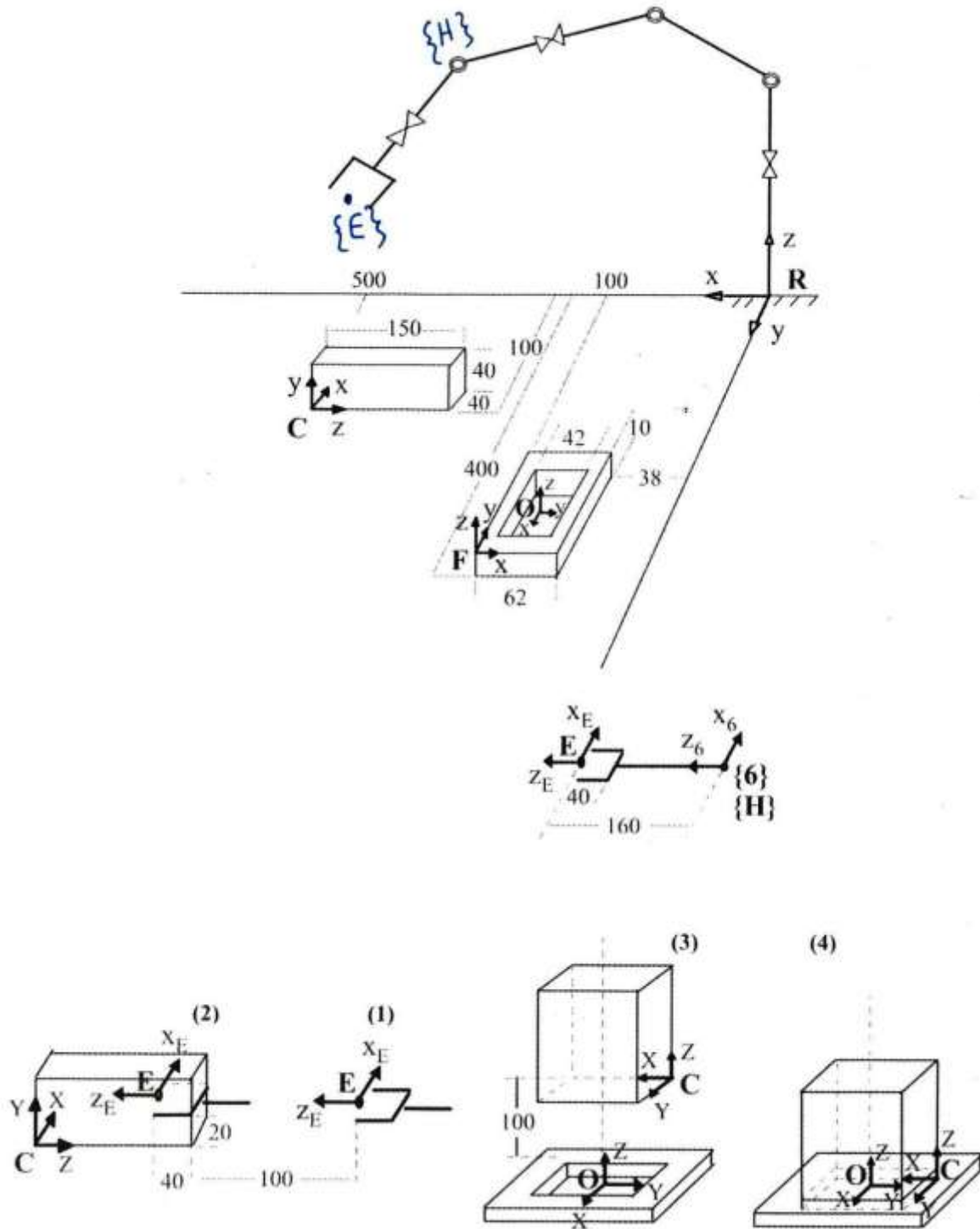


**Exercise:**

A 6 DOF robot has to lift a square section object from a specific position and then place it in a square slot which is located on the same surface at a fixed position.

The dimensions and frames of the object and slot, as well as the initial set up of the workspace, are shown in the Figure below. The base frame  $\{R\}$  of the manipulator is considered as the inertial (world) frame.  $\{O\}$  is the frame at the centre of the square slot's top surface. Note, also in the Figure, the relation between the frame of the gripper  $\{E\}$  of the manipulator and frame  $\{H\}$  of the robot's wrist.

- a. Find the homogeneous transformation matrices  $T_{he}$ ,  $T_{rc}$ ,  $T_{fo}$  and  $T_{rf}$ .



- b. In order to complete the task of placing the object in the slot, the manipulator has to go through 4 basic positions.

Position (1): the gripper is near the object

Position (2): the gripper has grasped the object

Position (3): the object and the gripper are near the slot

Position (4): the object is placed in the slot

To accomplish these subtasks, the motion commands given to the robot are in the form of transformations matrices  $T_{rh}(i)$ , where  $i = 1, 2, 3, 4$ , for each position.

Find an equation of homogeneous transformation matrices that contains  $T_{rh}(i)$  as the only unknown, and calculate it for each position.