

ECE 470: Introduction to Robotics Homework 5

Question 1.

Consider the single-link manipulator arm in Figure 1(a) as shown also in Figure 10.4 (Craig, Introduction to Robotics 3rd Ed.).

- a) Given that the revolute joint moves the link over 2 cubic segments in **6s** from an initial angle $\theta_0 = 15 \text{ deg}$ to rest at a final position $\theta_f = 90 \text{ deg}$ through a via point $\theta_v = 30 \text{ deg}$ at $t_v = 3 \text{ s}$ with a velocity of $\dot{\theta}_v = 15 \text{ deg/s}$, obtain the 8 parameters of the 2-segment cubic polynomial. (10 Points)

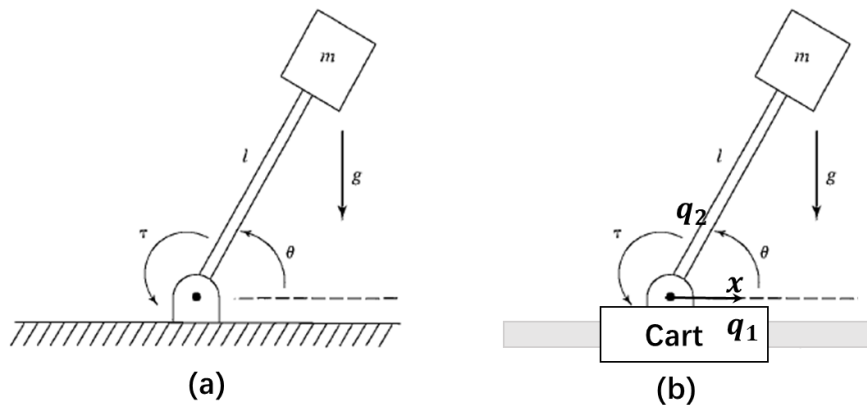


Figure 1

- b) Imagine you decided to create a prismatic-revolute (PR) 2-dof robotic manipulator and mounted the single-link on a horizontally moving cart as shown in Figure 1(b),
- I. Illustrate the configuration space of this PR manipulator with a sketch given that the joint limits are $x \in [-d, d]$ and $\theta \in [-\pi, \pi]$. (2 Points)
 - II. Describe a possible path in the configuration space if a vertical straight path is desired from point $(0, -l)$ to $(0, l)$ in the workspace (Hint: circular motion projects to orthogonal axes as sinusoidal motion) (3 Points)
 - III. Assuming the motor at q_2 rotates at a constant speed of ω , suggest a trajectory for q_1 (2 Points)
 - IV. Suggest a control scheme if the manipulator is tasked to performance ultrasound imaging over a region by sliding the probe along the x direction at a vertically downward controlled contact force with the surface. You may assume an additional joint q_3 to orientate the ultrasound transducer as shown in Figure 2 (3 Points)

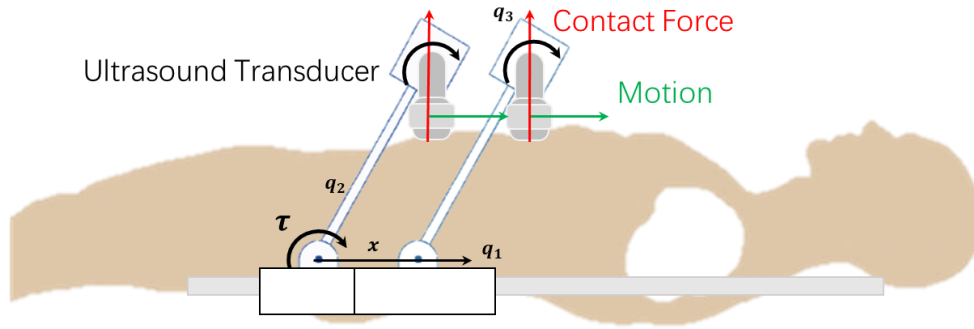


Figure 2

Question 2 (Optional Bonus Question)

Find the new equation of motion relating f and τ to $\ddot{x}, \dot{x}, x, \ddot{\theta}, \dot{\theta}$ and θ if the single-link manipulator is mounted on a horizontally moving cart as shown in Figure 1(b).
(10 Points)