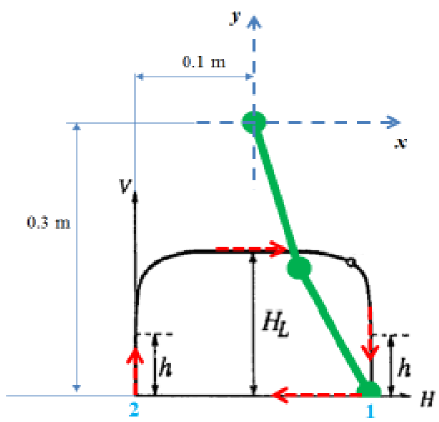
Problem (Motion Control of a Walking Robot's Leg)

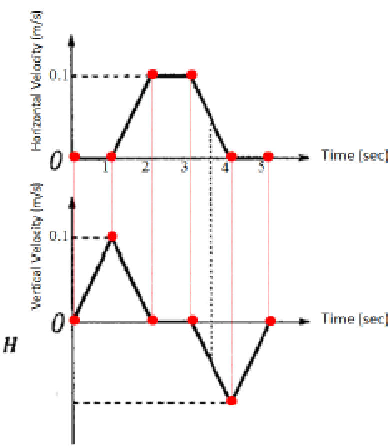
Consider the Pelican robot shown in Figure 5.1, Chapter 5 of Kelly's Book. All parameters of the robot can be found in Table 5.1. Let's assume that we want to use the Pelican robot as the legs of a quadruped walking robot. For each leg then, we need to control the motion of the tip of the leg (foot tip) to follow a desired trajectory in order for the quadruped to be able to walk properly. For this specific test, the leg is considered to move without any ground contact while following the desired trajectory.

Two phases of motion has been considered for the leg; In the first phase (phase I), the foot tip of the leg starts from Point 1 shown in the figure below at time $t = 0$ and then moves towards point 2 following the straight horizontal line in total time of 10 sec. In the second phase (Phase II) of motion, the foot tip goes back from point 2 to point 1 following the curved path in 5 sec. Therefore, the total time to accomplish both phases is 15 sec. The velocity of the leg in point 1 and point 2 is zero. The horizontal distance between point 1 and 2 is 0.2 m. In Phase II, both the horizontal and vertical velocity graphs are shown in the right hand side of the figure below. The schematic of Pelican robot in the figure is shown in green. The x-y origin of the robot (leg) is placed 0.3 m above the middle of the horizontal trajectory as shown in the figure. Please note that this is all the information we have! If you think some data is missing, just make your own assumptions and clarify them in your solution.

Having the above information, design an appropriate controller(s) and write a MATLAB script, which will implement your designed controller satisfying the required motion. For this problem:



(a) Trajectory Plane



(b) Velocity Template

a) What is your choice of control law(s) i.e. controller(s) (write it down)? Why did you think it is an appropriate choice for this problem? Please explain your answer clearly.
b) Generate a plot of the joint angles versus time corresponding to the closed-loop system for both phases i.e. 15 seconds in a single graph.
c) Generate a plot of the joint velocities versus time corresponding to the closed-loop system for both phases i.e. 15 seconds in a single graph.
d) Generate a plot of the control input as a function of time for both phases in a single graph.
e) Generate a plot of the resultant end-effector's path (foot tip's path) in x-y plane. Show this graph on top of the above figure (a) i.e. the trajectory plane for comparison purpose.
f) Generate a plot of the end-effector position (both x and y) as a function of time for both phases in a single graph.
g) Generate a plot of the end-effector velocity (both horizontal and vertical velocities) as a function of time for both phases i.e. 15 seconds in a single graph.
h) Generate a stick model of the robot and show a simulation (animation) of the leg performing the task i.e. following the trajectory (both phases) in the vertical plane.