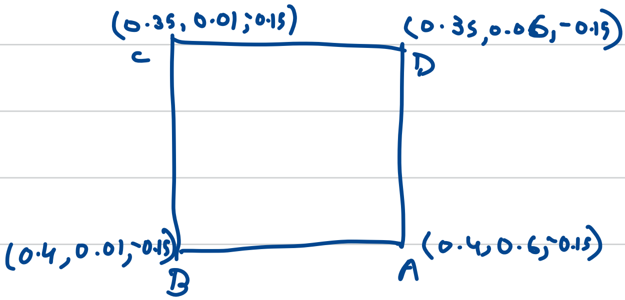
Ans-2b

Here I using Cubic trajectory for each line (AB, BC, CD & DA), i.e., each cartesian coordinate will be function of time.



AB travel:

$x = 0.4$, $y = a_0 + a_1 + a_2 t^2 + a_3 t^3$, $z = -0.15$

$y(0) = 0.06$, $y(1) = 0.01$, $y'(0) = 0$, $y'(1)$

→ for calculating a_0, a_1, a_2 & a_3.

BC travel

$x = b_0 + b_1 t + b_2 t^2 + b_3 t^3$, $y = 0.01$, $z = -0.15$

$x(0) = 0.4$, $x(1) = 0.35$, $x'(0) = 0$, $x'(1) = 0$

CD travel

$x = 0.35$, $y = c_0 + c_1 t + c_2 t^2 + c_3 t^3$, $z = -0.15$

$y(0) = 0.04$, $y(1) = 0.06$, $y'(0) = 0$, $y'(1) = 0$

DA travel

$x = d_0 + d_1 t + d_2 t^2 + d_3 t^3$, $y = 0.06$, $z = 0.1$

$x(0) = 0.35$, $x(1) = 0.4$, $x'(0) = 0$, $x'(1) = 0$

Note that I am setting trajectory in such a way the each line should be traced in $t=1$ sec.

After the above process,

I will calculate joint variables as a function of time using inverse kinematics.

Ans - 2c

For error to be critically damped,

$K_1 = 0$ in

$$\ddot{e}(t) + K_1 \dot{e}(t) + K_0 e(t) = 0$$

$$\therefore \; z(t) = \ddot{q}^d(t) + K_0 q^d(t)$$

$$\therefore \; v = -K_0 q + z(t)$$
$$= -K_0 q + \ddot{q}^d(t) + K_0 q^d(t)$$

$$\boxed{\tau_c = u = D(q)\, v + C(q, \dot{q})\, \dot{q}}$$

1. Dynamics eq^n $\Rightarrow$

$$\boxed{D(q)\ddot{q} + C(q,\dot{q})\dot{q} = \tau_c + \underbrace{\tau_d}_{\text{disturbance}}}$$