Paddle Controller Physics

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# Problem Statement

A belt-driven slider mechanism powered by a DC motor must be designed that can accelerate the air hockey paddle to a linear speed of 10m/s over a distance of 0.76m. In this design document we shall consider the y-axis design which includes two DC motors and belt-drive mechanisms that apply force to either side of the x-axis assembly.

# Solution

Linear acceleration of the x-axis assembly is found from Newton’s second of motion.

The force applied to the x-axis assembly is a function of motor torque and the mechanical system parameters. Reference: *‘Timing Belt Theory’* by Gates. In this case the force applied to the x-axis assembly is doubled as there are two separate motors applying torque to two separate belts.

Neglecting the force required to accelerate the belt and the idler pulley, this becomes:

Where dpulley is the pitch diameter of the driven pulley, ur is the coefficient of dynamic friction of the linear bearings, and Ffi is the load independent resistance to linear motion.

For a DC motor, torque is linearly related to speed based on the no-load speed and stall-torque parameters for the motor.

Substituting [5] into [3] gives:

Substituting [6] into [2] produces a 1st order non-linear ODE which can be solved for linear velocity as a function of time.

Obtaining a solution from Wolfram Alpha:

*Input: v'(t) = [[4 / d \* (q - (S\*v(t)))] - (2\*f)] / m*

*Interpretation:*



*Solution:*



Applying initial condition v(0) = 0



v(t) = ((d f)/(2 S) - (q/S)) e^(-(4 S t)/(d m)) - (d f)/(2 S) + q/S

Integrating to find d(t):

integrate [((d\*f)/(2\*S) - (q/S)) e^(-(4\*S\*t)/(d\*m)) - (d\*f)/(2\*S) + q/S]dt

