Homework – DC Motor Theory and Open-Loop Step Response

1. Given that the Open Loop Transfer Function for the NXT motor is given by $G_{OL} = \frac{b}{s+a} = \frac{\Omega(s)}{V(s)}$ where the input is the motor command $V(s)$and the output is motor velocity $\Omega(s)$ **(10 points; 5 points each)**

   Given a step input $v(t) = \begin{cases} 0: & t \leq 0 \\ M: & t > 0 \end{cases}$

   A. Show using ordinary differential equations that $\omega(t) = \frac{Mb}{a}(1 - e^{-at})$

   B. Show using Laplace transform techniques that $\omega(t) = \frac{Mb}{a}(1 - e^{-at})$

2. In lab, you performed an open-loop step response to an NXT motor. The resulting time plot looked similar to (exact speed values may be different):

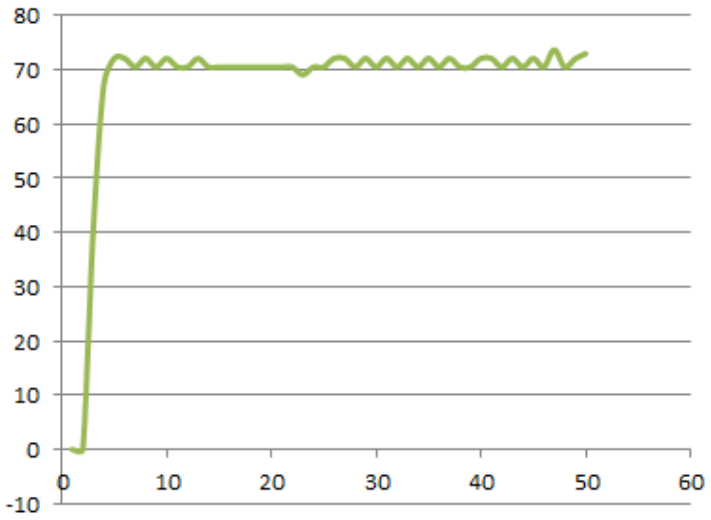

Figure 1A: Excel plot of `nxtMotorData.csv`

Figure 1A is an example of an open-loop step (velocity) response to a 75% motor command.

- Provide a copy of your plot (provide units!)
- On your plot, show what the steady-state velocity is (provide units!)
- On your plot, show the rise time, also known as a time constant. Recall that rise time is defined as 63.3% of the steady-state value.

(**5 points**)

3. Theory states for a first-order system, that at 3 time constants, the response will be within 1% of steady-state.
   - On your plot, show the time and motor value at 3 time constants
   - Show that the velocity at 3 time constants is indeed with 1% of the steady-state velocity

(5 points)