Homework – DC Motor Theory, Open-Loop Step Response, Files and Timing

1. Fill in the blanks (10-points)

A. Lorentz's law states that a current-carrying wire in a _____ field will induce an electromotor force
B. In a DC motor, _____ allow the loops of copper wire to rotate 180 degrees
C. An _____ is another term for a coil or loop of wire
D. Inductors _____ the change in current
E. Induced ____ is called the back EMF
F. In DC motors, torque is _____ of voltage
G. Motor speed _____ then torque decreases
H. A DC motor with negligible inductance is a ____ order system
I. The rise time (or time constant) is the time to reach _____ of the steady-state value
J. It takes ___ time constants for the system to reach 99% of the steady-state value.

2. Refer to lecture notes. 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 total)

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 $\omega(t) = \frac{Mb}{a}(1 - e^{-at})$. NB: explicitly show any partial fraction expansion techniques if used.

3. Write an NXC program using best practices. The program Iterates integers from -10 to +10 incrementally by 1. Compute the cube and save to a file named "`cubic.csv`". Export the data file and plot the curve in Excel. Show your NXC code (10-points) and Excel plot (10-points)

4. Refer to the lab on NXC Timers. Using best practices, write an NXC program that mimics a smart phone's timer (10-points)

On the left is a screenshot of a smartphone timer. One sets a time to count down from e.g. 1 minute and 10 seconds. Once the timer reaches zero, a sound is played.

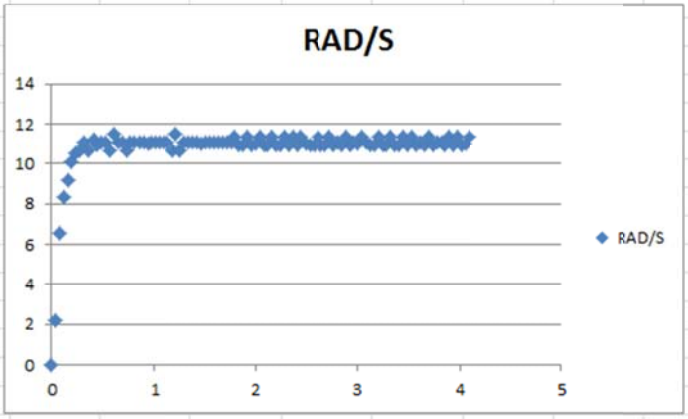
Include: (1) your NXC code for a timer that counts down from 1 minute and 10 seconds; and (2) URL to a YouTube video demoing your Brick counting down and playing a sound when the timer reaches 0.

5. Refer to the lab on the Open-Loop Step Response of a Lego NXT motor. Using best practices, write an NXC program that writes the motor's rotational speed (RPM and rad/sec) and time (at 40 msec sampling rate) to a step input of 75% motor power (10-points total)

A. Below is an example of what's expected. Provide a screen shot of your scatter plot of the data your Brick collected. (5-points)

olsr.csv

	A	B	C
1	Time [s]	RAD/S	RPM
2	0	0	0
3	0.04	2.188	20.83
4	0.08	6.563	62.5
5	0.12	8.313	79.17
6	0.16	9.188	87.5
7	0.2	10.063	95.83
8	0.24	10.5	100
9	0.28	10.671	101.63
10	0.32	11.098	105.69
11	0.36	10.671	101.63
12	0.41	11.25	107.14
13	0.44	10.938	104.17
14	0.49	11.098	105.69
15	0.53	11.098	105.69
16	0.57	10.671	101.63
17	0.61	11.524	109.76



B. Eyeball your plot. What is the steady-state RPM and rise time (i.e. 63% value of steady-state)? (5-points)