PROBLEM 1

PART A:

FOR TOOTH #1:

$$T_c(\phi) = \begin{cases} RK_1 a s_t \left[\sin\phi + h^*/h_{eq}\right]; & 0 \le \phi \le \pi/3 \\ 0\ ; & \text{OTHERWISE} \end{cases}$$

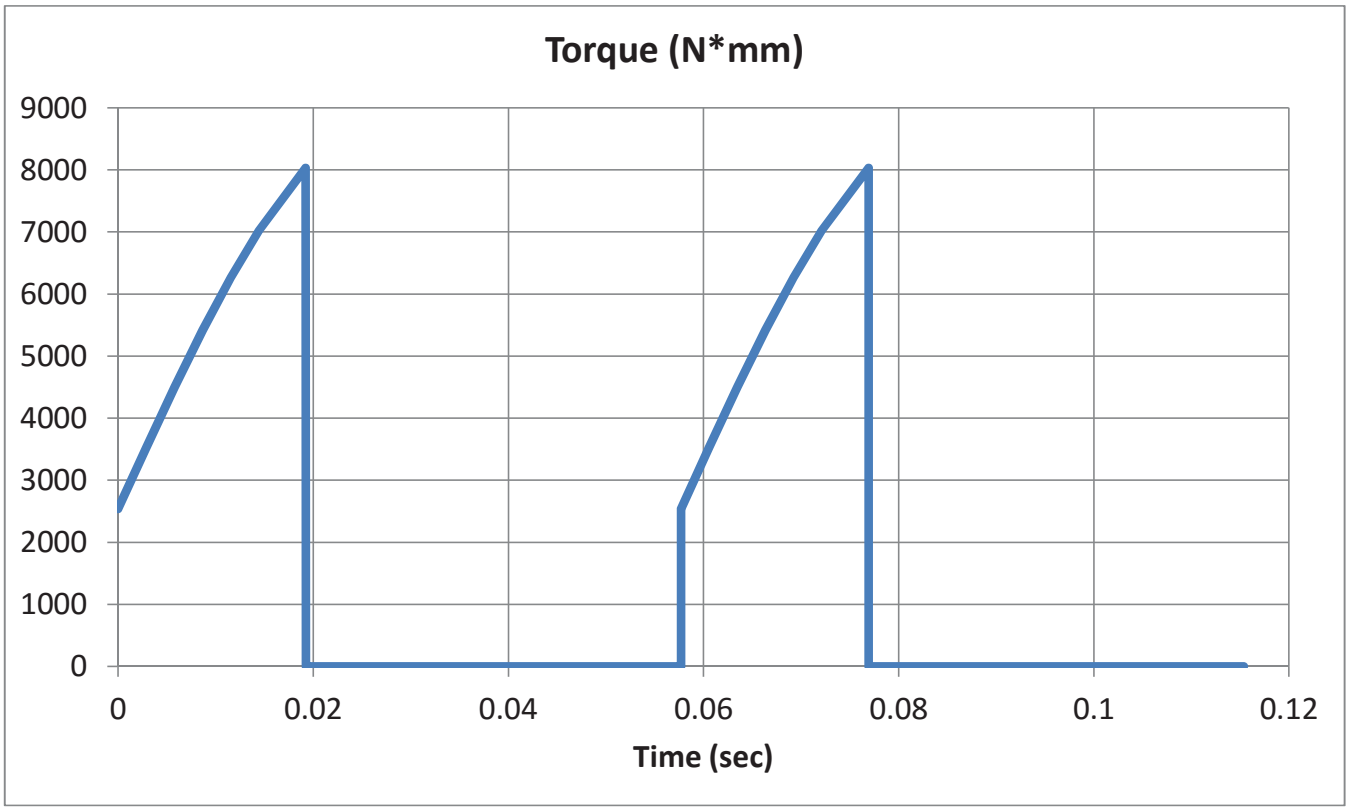
FOR TOOTH #2:

$$T_c(\phi) = \begin{cases} RK_1 a s_t \left[\sin(\phi-\pi) + h^*/h_{eq}\right]; & 0 \le \phi-\pi \le \pi/3 \\ 0\ ; & \text{OTHERWISE} \end{cases}$$

USING THE PARAMETERS LISTED, AND SETTING $s_t = 0.1\,mm/2 = 0.05\,mm/tooth$

$$h_{eq} = s_t$$

THE PLOT OF TOTAL CUTTING TORQUE IS SHOWN ON THE FOLLOWING PAGE.


Torque (N*mm)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
0
0.02
0.04
0.06
0.08
0.1
0.12
Time (sec)

PART B:

NOTING THAT $F_z = F_{TH} \sin\psi_e$, PEAK VALUES OF THRUST FORCE CAN BE FOUND AS:

$$F_{TH}(\text{ROUGHING}) = 243\,N / \sin(\pi/4) = 343.6\,N \quad (i)$$

$$F_{TH}(\text{FINISHING}) = 222\,N / \sin(\pi/4) = 314\,N \quad (ii)$$

NOW, GIVEN THAT

$$F_{TH} = K_1 a_{s_t} [r_1 \sin\phi + r_2 h^*/h_{eq}]$$

AND NOTING THAT PEAK VALUES WILL OCCUR AT $\phi = \pi/3$ (FOR TOOTH #1), PARAMETER VALUES CAN BE SUBSTITUTED INTO (i) AND (ii) TO YIELD:

$$343.6 = 366.3 \cdot r_1 + 169.2 \cdot r_2 \quad (iii)$$

$$314 = 219.8 \cdot r_1 + 169.2 \cdot r_2 \quad (iv)$$

$\Rightarrow$

$$r_1 = 0.2$$

$$r_2 = 1.6$$

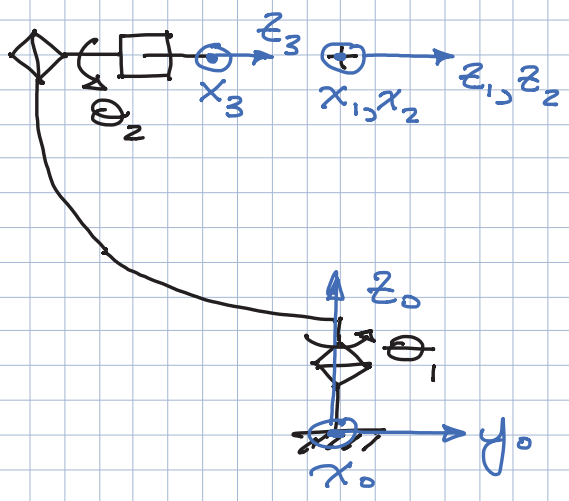
PROBLEM 2

PART A:

$$A_{01} = \begin{bmatrix} 1 & 0 & 0 & -2 \\ 0 & -1 & 0 & 4 \\ 0 & 0 & -1 & 1 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

PART B:

ASSIGNING FRAMES:



DH PARAMETERS

JOINT	a_i	α_i	d_i	θ_i
1	0	$-\pi/2$	5.5	θ_1
2	0	0	0	θ_2
3	0	0	$d_3 - 4.5$	0

RECALLING THAT $\cos(-\pi/2) = 0$, $\sin(-\pi/2) = -1$:

$$\Rightarrow \quad A_{01} = \begin{bmatrix} c\theta_1 & 0 & -s\theta_1 & 0 \\ s\theta_1 & 0 & c\theta_1 & 0 \\ 0 & -1 & 0 & 5.5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_{12} = \begin{bmatrix} c\theta_2 & -s\theta_2 & 0 & 0 \\ s\theta_2 & c\theta_2 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$A_{23} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & d_3 - 4.5 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

PART C:

$$A_{3t} = \begin{bmatrix} 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$