Formulae sheet

This formulae sheet contains the most commonly used formulae encountered within the MECH5170M01 module. The equations are grouped under the main section headings associated with the delivery of the module. You may assume that all symbols have their usual meaning.

General:

$P = TE\,V$ $\quad P = T\omega$ $\quad A = \frac{\pi d^2}{4}$ $\quad I_x = I_y = \frac{\pi d^4}{64}$ $\quad J = \frac{\pi d^4}{32}$

$D = \frac{1}{2} C_d A \rho V^2$ $\quad R_R = mg\, C_r$ $\quad R_s = 2mg\, C_r$ $\quad G_R = mg \sin\theta$ $\quad 1mile = 1609m$ $\quad 1\ in\ 3\ slope = 18.4°$

Transmission:

$\Sigma Fx = TE - Rr - Gr - D = 0$ $\quad TE = \frac{Te\,(n_g \cdot n_f)(\eta_g \cdot \eta_f)}{r}$ $\quad TE = \frac{T_w}{r} = \mu N$ $\quad T_w = T_e\,(n_g \cdot n_f)(\eta_g \cdot \eta_f)$

$N_w = \frac{60 \cdot V}{2 \cdot \pi \cdot r}$ $\quad N_w = \frac{Ne}{n_g \cdot n_f}$ $\quad V = 2\pi r \frac{N_w}{60}$ $\quad R = \sqrt[(i-1)]{\frac{n1}{n_i}}$ $\quad n_i = n_{i+1} \cdot R$ $\quad m_{eq} = \frac{I_{eq}}{r^2} = \frac{I_w + I_d\, n_f^2 + I_g\, n_g^2\, n_f^2}{r^2}$

Batteries:

Indexes: c - cell, s - string, b - battery, p - pack, r - range

$U = I \cdot R\ [V]$ $\quad E = I \cdot U\ [Wh]$ $\quad C = I \cdot t\ [Ah]$

$E_{bs} = E_{bc} \cdot N_{cs}\ [Wh]$ $\quad E_{bp} = U_{bp} \cdot C_r\ [Wh]$ $\quad E_{bc} = U_{bc} \cdot C_{bc}\ [Wh]$

$N_{cs} = \frac{U_{bp}}{U_{bc}}$ $\quad N_s = \frac{E_{bp}}{E_{bs}}$ $\quad N_c = N_s \cdot N_{cs}$

LIDAR, Ultrasound sensors:

$d_L = \frac{t \cdot c_L}{2}$ $\quad d_{US} = \frac{t \cdot c_s}{2}$ $\quad f = \frac{1}{t}$ CPU: 1MHz=1 000 000 cycles (ticks) / second

Encoders: Pulse counting: $\omega = 2\pi \frac{n}{N \cdot t}$ Pulse timing: $\omega = 2\pi \frac{f}{N \cdot m}$ (rad/s)

Turn radius: $R = \frac{W_t}{2}\left(\frac{\omega_o + \omega_i}{\omega_o - \omega_i}\right)$ $\quad R = \frac{W_t}{2}\left(\frac{V_o + V_i}{V_o - V_i}\right)$

Kalman Filter:

Prediction: $\hat{x}_{k|k-1} = A\hat{x}_{k-1|k-1} + Bu_k$ $\quad P_{k|k-1} = AP_{k-1|k-1}A^T + Q$

Gain: $K_k = P_{k|k-1}H^T(HP_{k|k-1}H^T + R)^{-1}$

Update: $\hat{x}_{k|k} = \hat{x}_{k|k-1} + K_k(z_k - H\hat{x}_{k|k-1})$ $\quad P_{k|k} = (I - K_k H)P_{k|k-1}$

Error: $\sigma_x^2 = \sum_{i=1}^{N}(\sigma^2 \cdot \Delta t^2)$ $\quad \sigma_x = \sqrt{\sigma_x^2}$