ME for ECEs Equation Sheet

I. Vectors

$$\vec{v}_R = \sum v_x\hat{x} + \sum v_y\hat{y} + \sum v_z\hat{z}$$

$$\|\vec{v}\| = \sqrt{v_x^2 + v_y^2 + v_z^2}$$

$$\begin{aligned}\vec{u}\cdot\vec{v} &= \|\vec{u}\|\|\vec{v}\|\cos(\theta)\\ &= (u_x v_x) + (u_y v_y) + (u_z v_z)\end{aligned}$$

$$\begin{aligned}\vec{u}\times\vec{v} &= \begin{vmatrix}\hat{x} & \hat{y} & \hat{z}\\ u_x & u_y & u_z\\ v_x & v_y & v_z\end{vmatrix}\\ &= (u_y v_z - u_z v_y)\hat{x} - (u_x v_z - u_z v_x)\hat{y} + (u_x v_y - u_y v_x)\hat{z}\end{aligned}$$

II. Statics

$$\vec{F} = m\vec{a}$$

$$\vec{M} = \vec{r}\times\vec{F}$$

$$\vec{r} = \vec{s}_f - \vec{s}_0$$

$$\sum F = 0$$

$$\sum M = 0$$

III. Dynamics

A. Kinematic Equations

$$\vec{s}_f - \vec{s}_0 = \vec{v}_0 t + \frac{1}{2}\vec{a}t^2$$

$$\vec{v}_f^2 = \vec{v}_0^2 + 2\vec{a}\cdot(\vec{s}_f - \vec{s}_0)$$

$$\vec{v}_f = \vec{v}_0 + \vec{a}t$$

$$\vec{s}_f = \vec{s}_0 + \vec{v}t$$

B. Projectile Motion

$$\vec{g} = -9.81\hat{y}\left[\frac{\text{m}}{\text{s}^2}\right] = -32.2\hat{y}\left[\frac{\text{ft}}{\text{s}^2}\right]$$

Without air resistance:

$$v_{x_0} = v_{x_f}$$

IV. Heat Transfer

A. Conduction

$$q_x'' = k\frac{dT}{dx}$$

$$\frac{dT}{dx} = \frac{T_2 - T_1}{L}$$

$$q_x = q_x'' A$$

Where:

- q_x'' is heat flux
- q_x is heat rate
- T is temperature
- L is length
- A is the contact area

B. Convection

$$q'' = hA(T_s - T_\infty)$$

Where:

- h is the heat transfer coefficient
- A is the contact area between the surface and the fluid
- T_s is the surface temperature
- T_∞ is the fluid temperature very far away from the surface

C. Radiation

$$q''_{\text{ideal}} = \sigma T_s^4$$

$$q''_{\text{real}} = \varepsilon\sigma T_s^4$$

Where:

- T_s is the absolute temperature
- σ is the Stefan-Boltzmann constant
- ε is the emissivity

V. Fluids

Pascal's Law:

$$\frac{F_1}{A_1} = \frac{F_2}{A_2}$$

Density:

$$\rho = \frac{m}{v}$$

Specific Weight:

$$\gamma = \frac{mg}{v} = \rho g$$

Pressure in a fluid:

$$P_2 = P_1 + \rho g z$$

Bernoulli Equation:

$$p_1 + \frac{1}{2}\rho v_1^2 + \rho g h_1 = p_2 + \frac{1}{2}\rho v_2^2 + \rho g h_2$$

Fluid Velocity Between Plates:

$$\frac{U}{b} = \frac{u}{y}$$

Where:

- U is the velocity of the moving plate
- b is the distance between the plates
- u is the velocity of the fluid at between the plates at some distance above the stationary plate
- y is the distance above the stationary plate.

Continuity Equation

$$A_1 v_1 \Delta t = A_2 v_2 \Delta t$$

$$\dot{m} = \rho_1 A_1 v_1 = \rho_2 A_2 v_2$$

VI. Gears

$$N = Pd$$

$$N = \frac{d}{m}$$

$$c = \frac{d_1 + d_2}{2} = \frac{N_1 + N_2}{2P} = \frac{(N_1 + N_2)m}{2}$$

Where:

- N is the number of teeth
- d is the pitch diameter
- c is the center distance
- P is the diametral pitch (Customary)
- m is the module (SI)

Gear Ratio:

$$R = \frac{T_2}{T_1} = \frac{N_2}{N_1} = \frac{d_2}{d_1} = \frac{\omega_1}{\omega_2}$$

$$\omega = \frac{\pi}{30}\text{RPM}$$

Big Gear to Small Gear:

- Speed increases
- Torque decreases

Small Gear to Big Gear:

- Speed decreases
- Torque increases

Power:

$$P = \omega T$$

If no power losses:

$$P_{\text{in}} = P_{\text{out}}$$

$$\omega_1 T_1 = \omega_2 T_2$$