Useful Equations

$F = mA$	$p = F \cdot V$	Relative Motion:
$PE = mgh$ (gravity)	$KE = \frac{1}{2}mV^2$	$V_A = V_B + V_{A/B}$
$PE = \frac{1}{2}kx^2$ (spring)		$\alpha_A = \alpha_B + \alpha_{A/B}$

Kinematics & Dynamics

$v = r\dot{\theta} = r\vec{e}_r + r\dot{\theta}\vec{e}_0 \quad a_n = \frac{v^2}{r} = r\dot{\theta}^2 \quad a_t = r\ddot{\theta} = \dot{v} \quad a = (\ddot{r} - r\dot{\theta}^2)\vec{e}_r + (r\ddot{\theta} + 2\dot{r}\dot{\theta})\vec{e}_0$

Fluid Mechanics

$P_2 - P_1 = \rho g(y_2 - y_1)$ $\quad M_a = \frac{V}{C}$ $\quad C = \sqrt{RTk}$

$\frac{P}{\rho} = \frac{1}{2}V^2 + gZ$ $\quad (1 - M_a^2)\frac{dV}{V} = -\frac{da}{A}$ $\quad Q = VA$

$D_h = \frac{4 \cdot \text{cross-sectional area of flow}}{\text{wetted perimeter}}$ $\quad \delta^* = \int_0^\infty (1 - \frac{U(y)}{U})\, dy$ $\quad \theta = \int_0^\infty \frac{U(y)}{U}(1 - \frac{U(y)}{U})\, dy$

$\Delta s = C_v \ln(\frac{T_2}{T_1}) + R\ln(\frac{P_2}{P_1} = C_p \ln(\frac{T_2}{T_1}) - R\ln(\frac{P_2}{P_1})$ $\quad \dot{m} = \rho V A$

$$R_e = \frac{\rho V D}{\mu} = \begin{cases} < 2300 & : \text{laminar pipe flow} \\ > 2300 & : \text{turbulent pipe flow} \end{cases}$$

For $k = 1.4$: $(\frac{P^*}{P_0}) = 0.528$, $(\frac{T^*}{T_0}) = 0.833$, $(\frac{\rho^*}{\rho_0}) = 0.634$, $(\frac{k}{k-1}) = 3.5$ $(\frac{1}{k-1}) = 2.5$

Solid Mechanics

$t = \frac{VQ}{It}$ $\quad \sigma = \frac{P}{A} = E\varepsilon$ $\quad \sigma_{\text{avg}} = \frac{\sigma_x + \sigma_y}{2}$ $\quad \sigma_x = \frac{\sigma_x + \sigma_y}{2} + \frac{\sigma_x + \sigma_y}{2}\cos 2\theta + \tau_{xy}\sin 2\theta$

$I_{\text{rect}} = \frac{bh^3}{12}$ $\quad \tau = \frac{V}{A_s} = G\gamma$ $\quad \tau_{\text{abs,max}} = \frac{\sigma_1 - \sigma 3}{2}$ $\quad \tan 2\theta_s = \frac{-(\sigma_x - \sigma_y)}{2\tau_{xy}}$

$I_x = Ix' + Ad_x^2$ $\quad v = \frac{\varepsilon_{\text{trans}}}{\varepsilon_{\text{long}}}$ $\quad \tau_{\text{avg}} = \frac{\sigma_1 + \sigma 3}{2}$ $\quad \tan 2\theta_p = \frac{2\tau_{xy}}{\sigma_x - \sigma_y}$

$\varepsilon_{\text{temp}} = \alpha_{\text{temp}}\Delta T$ $\quad \tau = \frac{Tc}{J}$ $\quad \phi = \frac{TL}{JG}$ $\quad \sigma_{1,2} = \frac{\sigma_x + \sigma_y}{2} \pm \sqrt{(\frac{\sigma_x - \sigma_y}{2})^2 + \tau_{xy}^2}$

$\sigma_{\text{long}} = \frac{Pr}{2t}$ $\quad \sigma = \frac{My}{I}$ $\quad J = \frac{\pi C^4}{2}$ $\quad \tau_{\max} = \sqrt{(\frac{\sigma_x - \sigma_y}{2})^2 + \tau_{xy}^2}$

$\varepsilon_x = \frac{1}{E}[\sigma_x - v(\sigma_y + \sigma_z)]$ $\quad \varepsilon_y = \frac{1}{E}[\sigma_y - v(\sigma_x + \sigma_z)]$ $\quad \varepsilon_z = \frac{1}{E}[\sigma_z - v(\sigma_x + \sigma_y)]$

$\varepsilon_a = \varepsilon_x \cos^2\theta_a + \varepsilon_y \sin^2\theta_a + \gamma_{xy}\sin\theta_a\cos\theta_a$

Thermodynamics

$W > 0$: work done by the system $\quad Q > 0$: heat transferred to the system

$W < 0$: work done on the system $\quad Q < 0$: heat transferred from the system

Quality of a substance:

$x = \frac{m_{\text{vapor}}}{m_{\text{liquid}} + m_{\text{vapor}}}$

$v = v_f + x(v_g + v_f)$

For ideal gases:

$U(T_2) - U(T_1) = \int_{T1}^{T2} C_v(T)\, dT$ $\quad h(T_2) - h(T_1) = \int_{T1}^{T2} C_p(T)\, dT$ $\quad C_p = C_v + R$

$$\frac{\delta E_{\text{CV}}}{\delta t} = \dot{Q} - \dot{W} + \dot{m}_2(h_2 + \frac{V_2^2}{2} + gZ_2) - \dot{m}_1(h_1 + \frac{V_1^2}{2} + gZ_1)$$

$$\frac{\delta E_{\text{CM}}}{\delta t} = \dot{Q} - \dot{W} + \dot{m}_2(U_2 + \frac{V_2^2}{2} + gZ_2) - \dot{m}_1(U_1 + \frac{V_1^2}{2} + gZ_1)$$

Heat Transfer

$q = \frac{kA}{L}\Delta T$ [conduction] $\quad q = hA(T_2 - T_1)$ [convection] $\quad q = \sigma\varepsilon A(T_{\text{surr}}^4 - T_{\text{surf}}^4)$ [radiation]

Corrections, Omissions or Other Good Ideas?

The collection of formulæ above has been diligently compiled for your use both in and outside of the classroom. While far from a comprehensive collection, we hope to provide a handy reference for commonly used or commonly forgotten concepts and formulæ within our faculty.

Given this intention, we're always looking to improve. If you spot any errors or omissions, or have a great idea to improve this section, please email Engenda Chair Dario Schor, `dario_schor@umanitoba.ca`.