PHYS-E6570 Solar Energy Engineering (5 cr) – 1st mid-term exam

The following equations will be given in the 1st mid-term exam if they are needed in the solution of a specific calculation problem. Other basic and central equations, that were used in the lecture notes, demo exercises or homework model solutions, are expected to be known by heart.

Note: the exam may nevertheless involve a derivation problem for incidence angle of beam radiation in some simplified cases of collector orientation, tilt, and/or tracking case, without knowing the general solutions shown below. In that case you are expected to be derive the solution starting from the vector representation of the Sun's position on the sky and the collector surfaces orientation on the ground.

$$n(E) = \varepsilon \frac{2\pi}{c^2 h^3} \frac{E^2}{e^{E/kT} - 1} \qquad \tau_b = a_0 + a_1 e^{-kAM} \qquad G_{T,H} = G_0\left(a + b\frac{n}{N}\right)$$

$$\cos\theta_z = \sin\delta \sin\phi + \cos\delta \cos\omega \cos\phi \qquad \mathbf{a} \cdot \mathbf{b} = \|\mathbf{a}\| \, \|\mathbf{b}\| \cos(\theta)$$

$$\delta = 23.45° \sin\left(360 \frac{284 + n}{365}\right) \qquad \sin\gamma_s = \frac{\cos\delta \sin\omega}{\sin\theta_z} \qquad F_{c\leftrightarrow s} = \frac{1 + \cos s}{2} \qquad F_{c\leftrightarrow g} = \frac{1 - \cos s}{2}$$

$$\cos\theta_i = \sin s \sin\theta_z \cos(\gamma - \gamma_s) + \cos s \cos\theta_z \qquad (s = \beta)$$
$$= \sin\delta \sin\phi \cos s - \sin\delta \cos\phi \sin s \cos\gamma + \cos\delta \cos\phi \cos s \cos\omega$$
$$+ \cos\delta \sin\phi \sin s \cos\gamma \cos\omega + \cos\delta \sin s \sin\gamma \sin\omega$$

$$C = \frac{2a}{2a'} = \frac{n' \sin\theta'}{n \sin\theta} \qquad C_{\max}^{2D} = \frac{1}{\sin\theta} \qquad C_{\max}^{3D} = \left(C_{\max}^{2D}\right)^2 = \frac{1}{\sin^2\theta} \qquad \omega_p^2 = \frac{Ne^2}{\varepsilon_0 m_e}$$

$$\theta = \theta''$$

$$\frac{\sin\theta}{\sin\theta'} = \frac{n_1}{n_2} = n_{21} \qquad \rho_{\parallel} = \frac{\tan^2(\theta - \theta')}{\tan^2(\theta + \theta')} \qquad \rho_{\perp} = \frac{\sin^2(\theta - \theta')}{\sin^2(\theta + \theta')} \qquad \rho = \frac{1}{2}\left(\rho_{\perp} + \rho_{\parallel}\right) = \frac{G_r}{G}$$

$$\tau_N = \frac{1}{2}\left[\frac{1 - \rho_{\perp}}{1 + (2N-1)\rho_{\perp}} + \frac{1 - \rho_{\parallel}}{1 + (2N-1)\rho_{\parallel}}\right] \qquad h_c = \frac{k_f Nu}{L} \qquad \Delta q = \frac{A\sigma}{\frac{1}{\varepsilon_1} + \frac{1}{\varepsilon_2} - 1}(T_1^4 - T_2^4)$$

$$F_R = \frac{\dot{m} c_p}{A_c U_L}\left[1 - \exp\left[-\frac{A_c U_L F'}{\dot{m} c_p}\right]\right]$$

$$F = \frac{\tanh(m(W-D)/2)}{m(W-D)/2} = \frac{\tanh x}{x} \qquad m = \sqrt{\frac{U_L}{k\delta}}$$

$$\frac{S - U_L(T_p - T_a)}{S - U_L(T_p^{(0)} - T_a)} = \exp\left[-\frac{A_c U_L t}{(mc)_e}\right] = e^{\frac{-t}{\tau}} \qquad K_{\tau\alpha} = \frac{(\tau\alpha)}{(\overline{\tau\alpha})}$$

$$\eta = F_R(\overline{\tau\alpha}) - a\left(\frac{T_{f,i} - T_a}{G}\right) - b\left(\frac{T_{f,i} - T_a}{G}\right)^2 \qquad K_{\tau\alpha} \approx b_0 + \frac{b_1}{\cos\theta} \approx a_0 + a_1\theta + a_2\theta^2$$