# USEFUL CONSTANTS

| Constant | Symbol | Value | Units |
| --- | --- | --- | --- |
| **Speed of light in vacuum** | c | $2.998\ 10^{8}$ | m/s |
| **Elementary charge** | q | $1.6\ 10^{-19}$ | C |
| **Planck's constant** | h | $6.626\ 10^{-34}$ | J s |
| **Boltzmann's constant** | k | $1.38\ 10^{-23}$ | J/K |
| **Vacuum permittivity** | $\varepsilon_0$ | $8.854\ 10^{-12}$ | F/m |

# USEFUL FORMULAS

| Week 1 | Formula |
| --- | --- |
| **Speed of light in vacuum** | $c = \lambda\nu$ |
| **Energy of a photon** | $E = h\nu = \frac{hc}{\lambda}$ |
| **Irradiance** | $I = \int_0^\lambda P(\lambda)d\lambda$ |
| **Air mass** | $AM = \frac{1}{cos\theta}$ |
| **Spectral photon flux** | $\Phi(\lambda) = P(\lambda)\frac{\lambda}{hc}$ |
| **Photon flux** | $\phi = \int_0^\lambda \Phi(\lambda)d\lambda$ |

| Week 2 | Formula |
|---|---|
| **Law of mass action** | $np = n_i^2$ |
| **Diffusion current density (electrons)** | $J_{diff,e} = qD_e \frac{dn}{dx}$ |
| **Diffusion current density (holes)** | $J_{diff,h} = qD_h \frac{dp}{dx}$ |
| **Drift current density (electrons)** | $J_{drift,e} = nq\mu_e E$ |
| **Drift current density (holes)** | $J_{drift,h} = pq\mu_h E$ |
| **Diffusion length (electrons)** | $L_e = \sqrt{D_e \tau_e}$ |
| **Diffusion length (holes)** | $L_h = \sqrt{D_h \tau_h}$ |

| Week 3 | Formula |
|---|---|
| **J-V curve of an ideal solar cell** | $J = J_{ph} - J_{dark} = J_{ph} - J_0 \left[\exp\left(\frac{qV}{kT}\right) - 1\right]$ |
| **J-V curve of a non-ideal solar cell** | $J = J_{ph} - J_{dark} - J_{SH} = = J_{ph} - J_0 \left[\exp\left(\frac{q(V + JR_S)}{kT}\right) - 1\right] - \frac{V + JR_S}{R_{SH}}$ |
| **Open-circuit voltage** | $V_{oc} = \frac{kT}{q} \ln\left(\frac{J_{ph}}{J_0} + 1\right) = \frac{2kT}{q} \ln\left(\frac{G_L \tau_0}{n_i}\right)$ |
| **Fill factor** | $FF = \frac{J_{mp} V_{mp}}{J_{sc} V_{oc}}$ |
| **Efficiency** | $\eta = \frac{J_{mp} V_{mp}}{P_{in}}$ |
| **Short-circuit current** | $J_{sc} = q \int_{\lambda_1}^{\lambda_2} \Phi_{AM1.5}(\lambda)\, EQE(\lambda)\, d\lambda$ |
| **Lambert-Beer´s law** | $I(\lambda, x) = I_0(\lambda) e^{-\alpha(\lambda)x}$ |
| **Snell´s law** | $n_1 sin\theta_i = n_2 sin\theta_t$ |

| | |
|---|---|
| **Fresnel reflection coefficient, p-polarization** | $R_p = \left(\frac{n_1 cos\theta_t - n_2 cos\theta_i}{n_1 cos\theta_t + n_2 cos\theta_i}\right)^2$ |
| **Fresnel transmission coefficient, p-polarization** | $T_p = 1 - R_p$ |
| **Fresnel reflection coefficient, s-polarization** | $R_s = \left(\frac{n_1 cos\theta_i - n_2 cos\theta_t}{n_1 cos\theta_i + n_2 cos\theta_t}\right)^2$ |
| **Fresnel transmission coefficient, s-polarization** | $T_s = 1 - R_s$ |

| Week 4 | Formula |
|---|---|
| **Finger's resistance** | $R = \frac{\rho L}{WH}$ |
| **Fick's law** | $J = D\frac{dn}{dx}$ |

| Week 6 | Formula |
| --- | --- |
| **Sensible heat** | $Q = mC_p(T_2 - T_1)$ |
| **Latent heat** | $Q = m\lambda$ |
| **Fourier's law** | $Q_{cond} = -kA\frac{dT}{dx}$ |
| **Newton's law** | $Q_{conv} = -hA\Delta T$ |
| **Energy per area emitted by a black body** | $Q = \sigma AT^4$ |
| **Energy per area emitted by a grey body** | $Q = \varepsilon\sigma AT^4$ |
| **Heat in a collector** | $Q_{col} = Q_{sun} - Q_{refl} - Q_{rad} - Q_{conv}$ |
| **Energy stored in a water tank** | $Q_s = V\rho C_p\Delta T$ |
| **Heat loss of a water tank** | $Q_{loss} = UA(T_s - T_a)$ |
| **Heat stored in a phase change material** | $Q_s = m[C_s(T^* - T_1) + \lambda + C_l(T_2 - T^*)]$ |
| **Solar-to-hydrogen efficiency** | $\eta_{STH} = \frac{J_{photo} \cdot 1.23V}{P_0}$ |

| Week 7 | Formula |
|---|---|
| Temperature coefficient | $X(T)=X_{STC}+\frac{dX}{dT}\times(T-T_{STC})$ |
| NOCT Model | $T_{cell}=T_{ambient}+G\times\frac{(NOCT-20°C)}{800\ W/m^2}$ |
| Module Ideality Factor | $MIF=\frac{E_{PV,T}}{E_{expected}}$ |
| At MPP | $\frac{\Delta I}{\Delta V}=-\frac{I}{V}$ |
| To the right of MPP | $\frac{\Delta I}{\Delta V}<-\frac{I}{V}$ |
| To the left of MPP | $\frac{\Delta I}{\Delta V}=>-\frac{I}{V}$ |
| Battery capacity | $E_{batt}=C_{batt}V$ |
| C-rate | $C-rate=\frac{I}{C_{batt}/1h}$ |
| Storage round-trip efficiency | $\eta=\frac{E_{out}}{E_{in}}\times100$ |
| Battery Voltaic efficiency | $\eta_V=\frac{V_{discharge}}{V_{charge}}\times100$ |
| Battery Coulombic efficiency | $\eta_C=\frac{Q_{discharge}}{Q_{charge}}\times100$ |
| Total battery efficiency | $\eta_{batt}=\eta_V\eta_C$ |
| State of charge | $SOC=\frac{E_{available}}{C_{batt}V}\times100$ |
| Depth of discharge | $DOD=\frac{E_{discharged}}{C_{batt}V}\times100$ |