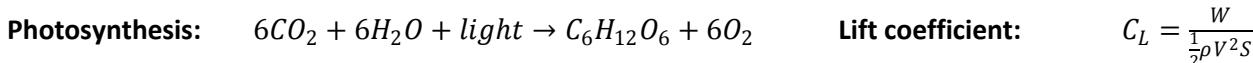
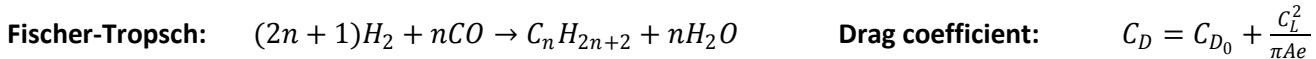
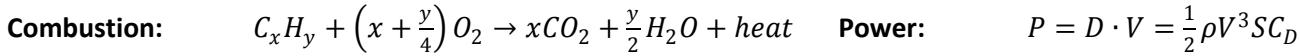


Energy absorption: $E_{in} = (1 - \alpha)S_0 A_{sun} = (1 - \alpha)S_0 \pi R^2 = 1.2247 \cdot 10^{11} W$

Boltzmann's law: $E_{out} = \sigma T^4 A_{earth} = \sigma T^4 4\pi R_{earth}^2 = 1.2247 \cdot 10^{11} W$

Water isotopes: $\delta^{18}O = \frac{\%^{18}O \text{ in vapour} - \%^{18}O \text{ in water}}{\%^{18}O \text{ in water}} = \frac{0.208\% - 0.210\%}{0.210\%} = -0.01 = -1\%$

Doubling time: $T_2 = \frac{\ln 2}{\text{rate of growth}}$ **Heat flow:** $\dot{Q} = -A \frac{\Delta T}{R_{total}}$ **Wing load:** $WL = \frac{W}{S}$



Plank's radiation: $E(\lambda, T) = \frac{2hc^2}{\lambda^5} \frac{1}{e^{\frac{hc}{\lambda kT}} - 1}$ **Boltzmann's law:** $E(T) = \int_0^\infty E(\lambda, T) d\lambda = \sigma T^4 = \varepsilon \sigma T_s^4$

Solar power: $P_{sun} = I_{sun} A_f = I_{sun} \pi R_{earth}^2 = 1.74 \times 10^{15}$ **Aspect ratio:** $A = \frac{b^2}{S}$

Intensity: $I_{ground, av} = \frac{P_{sun}}{4\pi R^2} = \frac{I_{sun}}{4} = 342 W/m^2$ **Sun hours:** $sh = \frac{2}{15} \cos^{-1}[-\tan \delta \tan \varphi]$

Tip speed: $U = \Omega R = \frac{2\pi RN}{60}$ **Tip speed ratio:** $\lambda = \frac{U}{V} = \frac{\Omega R}{V}$ $\left(\frac{C_D}{C_L}\right)_{\min} \rightarrow C_L = \sqrt{C_{D_0} \pi A e}$

Wind power: $P = E_{kin} = \frac{1}{2} \rho A V^3$ **Annual electricity production:** $E = KV_m^3 A_t T$ with $K = 3.2$

Air mass: $\text{air mass} = \frac{\text{actual distance atmosph here}}{\text{minimal distance atmosph here}} = \frac{1}{\cos \theta_i}$ $\delta = -23.45 \sin \left[\frac{360}{365} (284 + n) \right]$

Incidence angle: $\cos \theta_i = (\cos \varphi \cos \beta + \sin \varphi \sin \beta \cos \gamma) \cos \delta \cos \omega + \cos \delta \sin \omega \sin \beta \sin \gamma + \sin \delta (\sin \varphi \cos \beta - \cos \varphi \sin \beta \cos \gamma)$ **for $\beta = 0$:** $\cos \theta_i = \cos \varphi \cos \delta \cos \omega + \sin \delta \sin \varphi$

	Conduction	Convection
Heat flow	$\dot{Q} = -kA \frac{dT}{dt}$	$\dot{Q} = hA\Delta T$
Thermal resistance	$R = \frac{t}{k}$	$R = \frac{1}{h}$
Thermal diffusivity	$\alpha = \frac{\text{heat conducted}}{\text{heat stored}} = \frac{k}{\rho c_p}$	
Constants	$k = \text{thermal conductivity}$	$h = \text{local heat transfer coefficient}$

Sun's black body temp.: $T = 5777 K$ **Sun's diameter:** $d_s = 1.4 \cdot 10^6 km$

Plank's constant: $h = 6.626 \cdot 10^{-34} Js$ **Speed of light:** $c = 2.998 \cdot 10^8 m/s$

Boltzmann's constant: $k = 1.381 \cdot 10^{-23} J/K$ **Stefan's constant:** $\sigma = 5.670 \cdot 10^{-8} W/m^2 K^4$

Solar intensity: $S_0 = I_{sun} = 1366 W/m^2$ **Earth's radius:** $R_{earth} = 6371 km$

Earth's rotation: $\omega = 15^\circ/hr$ **Earth's albedo:** $\alpha = 30\% = 0.30$

Equilibrium temperature: $T_{eq} = -17.9^\circ C$ **kWh/y to kW:** $E = \frac{x}{365 \cdot 24}$

From/to	Chemical	Electrical	Heat	Light	Mechanical
Chemical	Reaction	Battery/fuel cell	Fire	Fire	Engine/rocket
Electrical	Battery	Transformer	Radiator	Light bulb	Electric engine
Heat	Gasification	Thermocouple	Heat exchanger	Fire	Steam engine
Light	Photosynthesis	Solar cell	Radiation	Prisma	Solar sail
Mechanical	Heat cell	Dynamo/Generator	Friction	Flint spark	Gearbox