1. Example: Basic Conversions

$15\,\mathrm{kW\,h} = 54\,\mathrm{MJ}$

We can use Ohm's law: $U = R \cdot I \Leftrightarrow I = \frac{U}{R}$. When applying $115\,\mathrm{V}$ on a $0.22\,\mathrm{M\Omega}$ resistor, the current is $0.523\,\mathrm{mA}$.

2. Example: Switching Converter

The Buck converter is defined by

- Input voltage is given as $V_I = 5\,\mathrm{V}$
- Output voltage is given as $V_O = 2.2\,\mathrm{V}$
- Therefore, the duty cycle can be calculated to $D = 0.44$
- Switching frequency is determined by the controller which uses $f_S = 300\,\mathrm{kHz}$
- Output current is given as $I = 10\,\mathrm{A}$ and inductor current ripple ratio shall be $CR = 30\,\%$
- Therefore, the current ripple can be calculated to $\Delta I_L = 3\,\mathrm{A}$

With this information, we can calculate the inductor and output capacitor:

$$L = \frac{D(V_I - V_O)}{\Delta I_L f_S} = 1.369\,\mathrm{\mu H}$$

Now we require the output voltage ripple to be less than $\Delta V_O = 10\,\mathrm{mV}$.

$$C_O \geq \frac{\Delta I_L}{8 f_S \Delta V_O} = 125\,\mathrm{\mu F}$$

3. Example: Pressure Conversion and Defining Custom Units

4. Example: Stress Analysis

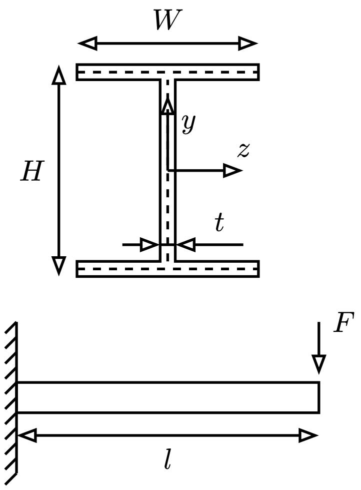

Figure 1: I-beam profile (simplified)

A simple I beam is defined using

- Height $H = 140\,\mathrm{mm}$
- Width $W = 120\,\mathrm{mm}$
- Constant thickness $t = 8\,\mathrm{mm} \ll H, W$
- Beam length $l = 3\,\mathrm{m}$
- Applied force at the end $F = 16\,\mathrm{kN}$
- Yield strength $\sigma_y = 355\,\mathrm{MPa}$ (S355 material)

The area moment of inertia may be approximated in thin-walled profiles like this:

$$\begin{aligned} I_{yy} &= \int x^2 \,\mathrm{d}a = t \int x^2 \,\mathrm{d}s \\ &= 2t \int_{-\frac{W}{2}}^{+\frac{W}{2}} s^2 \,\mathrm{d}s = 2t \left[\frac{1}{3} s^3\right]_{-\frac{W}{2}}^{+\frac{W}{2}} = 2t \cdot \frac{1}{3} \cdot 2 \cdot \frac{W^3}{8} = \underline{\underline{\frac{W^3 t}{6}}} \end{aligned}$$

As well as

$$I_{zz} = t \int y^2 \,\mathrm{d}s = t \left(\frac{W H^2}{2} + \frac{1}{3} \cdot 2 \cdot \frac{W^3}{8} \right) = \underline{\underline{\frac{W H^2 t}{2} + \frac{W^3 t}{12}}}$$

Using the specific sizes, we calculate $I_{yy} = 2\,304\,000\,\mathrm{mm}^4$ and $I_{zz} = 10\,560\,000\,\mathrm{mm}^4$.

The section modulus measures the resistance against a bending moment: $W_y = \frac{I_{yy}}{W/2} = 38\,400\,\mathrm{mm}^3$ and $W_z = \frac{I_{yy}}{H/2} = 150\,857\,\mathrm{mm}^3$.

Now we can calculate the stress under load: $\sigma = \frac{M}{W} = \frac{F \cdot l}{W} = 318\,\mathrm{MPa}$.

In this scenario, the reserve factor were $RF = \frac{\text{strength}}{\text{load}} = 111.6\,\%$.