# Test No.1

| Name | Neptun code |
|---|---|
| | |

Air, which can be assumed to be an ideal gas, is compressed from 1 bar absolute pressure to 3 bar *relative* pressure. At the beginning of the compression the temperature is 5°C. The parameters of the gas are the following: $R = 285\ \frac{J}{kgK}$, $\kappa = 1.4$. In case of a polytropic compression, $n = 1.5$.

| Question | Answer | Unit |
|---|---|---|
| Find the density of the gas before the compression! | | $\frac{kg}{m^3}$ |
| Assuming *isentropic* compression, find the temperature of the compressed gas! | | K |
| Find the density of the gas at the end of the compression (assuming *isentropic* process)! | | $\frac{kg}{m^3}$ |
| Calculate the specific heat capacity at constant pressure! | | $\frac{J}{kgK}$ |
| Find the *isentropic* useful work! | | $\frac{kJ}{kg}$ |
| Find the useful work in the case of an *isotherm* compression! | | $\frac{kJ}{kg}$ |
| Find the useful work in the case of a *polytropic* compression! | | $\frac{kJ}{kg}$ |

# Solution

$$\rho_1 = \frac{p_1}{RT_1} = \frac{10^5}{285 \cdot 278.15} = 1.2615\ \frac{\mathrm{kg}}{\mathrm{m}^3}$$

$$T2 = T_1 \left(\frac{p_2}{p_1}\right)^{\frac{\kappa-1}{\kappa}} = 278.15 \cdot \left(\frac{4}{1}\right)^{\frac{1.4-1}{1.4}} = 413.33\ \mathrm{K}$$

$$\rho_2 = \frac{p_2}{RT_2} = \frac{4 \cdot 10^5}{285 \cdot 413.33} = 3.3956\ \frac{\mathrm{kg}}{\mathrm{m}^3}$$

$$c_p = \frac{\kappa}{\kappa - 1} R = \frac{1.4}{1.4 - 1} 285 = 997.5\ \frac{\mathrm{J}}{\mathrm{kg\ K}}$$

$$\Delta h = c_p \cdot (T_2 - T_1) = 997.5 \cdot (413.33 - 278.15) = 134.84\ \mathrm{kJ}$$

$$Y_{isentropic} = \Delta h = 134.84\ \mathrm{kJ}$$

$$Y_{isotherm} = R \cdot T_1 \ln\left(\frac{p_2}{p_1}\right) = 285 \cdot 278.15 \cdot \ln\left(\frac{4}{1}\right) = 109.9\ \mathrm{kJ}$$

$$Y_{polytropic} = \frac{n}{n-1} R T_1 \left( \left( \frac{p_2}{p_1} \right)^{\frac{n-1}{n}} - 1 \right) =$$

$$\frac{1.5}{1.5-1} 285 \cdot 278.15 \left( \left( \frac{4}{1} \right)^{\frac{1.5-1}{1.5}} - 1 \right) = 139.69 \text{ kJ}$$