Thermodynamics

1 Simple systems

- at rest
- homogeneous and isotropic
- no chemistry
- pressure only

2 Properties

- **extensive** properties are proportional to the amount of fluid: mass, volume, mole number, ...
- **Intensive** properties are independent of the amount of fluid: pressure, temperature, density, specific volume, ...

We will be concentrating on intensive properties.

3 Parameters

To fix the state of a simple system, you need to know *any two* of $p, \rho, T, s, e, ...$

4 Entropy

For reversible processes,

$$dS = \frac{dQ}{T}$$

5 Second law

Two forms of the second law (combined with the first):

$$T \, ds = de + p \, dv \quad T \, ds = dh - v \, dp$$

Enthalpy:

$$h = e + pv$$

Canonical equations of state:

$$\left( \frac{\partial e}{\partial s} \right)_v = T \quad \left( \frac{\partial e}{\partial v} \right)_s = -p$$

Exercise:
Give the canonical equations for $h$ instead of $e$.

6 Ideal gas

\[
\frac{p}{\rho} = RT \quad R = \frac{R_0}{M}
\]

where $R$ is the gas constant and $R_0$ the universal gas constant.

\[
e, h, c_p, c_v = e, h, c_p, c_v(T) \quad c_p - c_v = R \quad \gamma \equiv \frac{c_p}{c_v}
\]