3.18 The free energy as an example for a thermodynamic potential

The **free energy** is the corresponding thermodynamic potential for the thermal contact of section 3.15.
Therefore the corresponding coordinates are V, N, and T.
It is well known that

$$F(V,N,T) = U(V,N,T) - S(V,N,T)T \tag{3.32}$$

and

$$dF = \mu dN - pdV - SdT \tag{3.33}$$

Mathematical interpretation: total differential, partial derivative

$\frac{\partial F}{\partial N}\big\vert_{V,T} = \mu$	$\frac{\partial F}{\partial V}\big\vert_{N,T} = -p$	$\frac{\partial F}{\partial T}\big\vert_{V,N} = -S$

Physical interpretation: gradient, forces

μ: "force" changing the particle number	$-p$: "force" changing the volume	$-S$: "force" changing the temperature

here: V, N, T: generalized coordinates
$-p, \mu, -S$: generalized forces
For "normal" physical quantities:
Coordinates: extensive parameters
Forces: intensive parameters
Forces and coordinates can be exchanged. There exists no fundamental difference between these parameters since they are equivalent and just depend on the choice of the thermodynamic contact.