Hydrostatic pressure

The chemical potential in a homogeneous fluid is a function \( \mu = \mu_0(p, T) \) such as calculated in [tex17] for the classical ideal gas. What remains uniform throughout the fluid in the presence of a uniform gravitational field is the potential

\[ \mu = \mu_0(p, T) + mgz = \text{const.}, \]

where \( m \) is the mass of the fluid particle, \( g \) is the acceleration due to gravity, and the \( z \)-direction is against the field. For a fluid of negligible compressibility derive from the condition \( d\mu/dz = 0 \) the familiar result for the hydrostatic pressure,

\[ p(z) = p_0 - \rho gz, \]

where \( \rho = Nm/V \) is the (average) mass density of the fluid.

Solution: