6.4: How It's Done in Thermodynamics

To see how, we'll briefly review a very similar situation in thermodynamics: recall the expression that naturally arises for incremental energy, say for the gas in a heat engine, is

$$dE(S,V) = TdS - PdV \tag{6.4.1}$$

where S is the entropy and $T = \partial E/\partial S$ is the temperature. But S is not a handy variable in real life -- temperature T is a lot easier to measure! We need an energy-like function whose incremental change is some function of dT, dV rather than dS, dV The early thermodynamicists solved this problem by introducing the concept of the *free energy*,

$$F = E - TS \tag{6.4.2}$$

so that $dF = -SdT - PdV$. This change of function (and variable) was important: the free energy turns out to be more practically relevant than the total energy, it's what's available to do work.

So we've transformed from a function $E(S)$ to a function $F(T) = F(\partial E/\partial S)$ (ignoring P, V which are passive observers here).
