Problem 6.6.
Unlike an ideal gas, which cools down during an adiabatic expansion, a one dimensional rubber band (with spring constant K and rest position $x_0 = 0$) is increasing its temperature when elongated in an adiabatic way. Write down the first law of thermodynamics for this case, looking at possible similarities with the case of the ideal gas. If the rubber band is elongated isothermally, what happens to the entropy? For the first part make sure that the signs are appropriate, according to experimental observations. In the second part, use Maxwell-type relations derived from the appropriate thermodynamic potential.

$$Tds = dU - dW \qquad W = -\int F \cdot dl \quad /dl$$

$$\delta Q = Tds = dU - kx\,dx \qquad \frac{dW}{dx} = -F \qquad \{F = -kX\}$$

en adiabatico: $\delta Q = 0 \left\{ \boxed{dU = dW = +kX\,dx} \right.$ $\qquad dW = +kx\,dx$

$dE = kX\,dx$ para transformaciones adiabaticas

La energia libre: $dF = dU - d(Ts) = Tds + dW - Tds - sdT = -sdT + kx\,dx$

$$dF = -SdT + kx\,dx$$

$$dF = \left(\frac{\partial F}{\partial T}\right)_x dT + \left(\frac{\partial F}{\partial x}\right)_T dx$$

$$\left(\frac{\partial F}{\partial T}\right)_x = -S \quad ; \quad \left(\frac{\partial F}{\partial x}\right)_T = kX$$

$$\& \quad \frac{\partial^2 F}{\partial x \partial T} = \frac{\partial^2 F}{\partial T \partial x} = -\left(\frac{\partial s}{\partial x}\right)_T = \left(\frac{\partial kx}{\partial T}\right)_x = K\left(\frac{\partial X}{\partial T}\right)_X = 0$$

por tan

en una isoterma, la entropia $\left(\frac{\partial S}{\partial x}\right)_T = 0$

se mantiene constante

a pesar de expandirla