Callen

2.2-4. $u = \left(\frac{\theta}{k}\right) s^2 - \left(\frac{R\theta}{v_0^2}\right) v^2$

$$T = \frac{du}{ds} = 2\left(\frac{\theta}{k}\right) s.$$

$$p = -\frac{du}{dv} = \left(\frac{R\theta}{v_0^2}\right) 2v$$

$$\mu = \frac{dU}{dN} = \frac{d}{dN}(Nu)$$

$$= u + N\frac{du}{dN}$$

$$= u + N\left(\frac{du}{ds}\frac{ds}{dN} + \frac{du}{dv}\frac{dv}{dN}\right).$$

$$= u + N\left(T\left(-\frac{s}{N^2}\right) - p\left(-\frac{v}{N^2}\right)\right)$$

$$= u + N\left[\frac{pv}{N^2} - \frac{Ts}{N^2}\right]$$

$$= u + \frac{1}{N}[pv - Ts]$$

$$= u + [pv - Ts]$$

$$= u + \left[\frac{R\theta}{v_0^2} 2v^2 - 2\left(\frac{\theta}{k}\right) s^2\right]$$

$$= u + [-2u] = \boxed{-u}$$