Entropy of Substances and Processes

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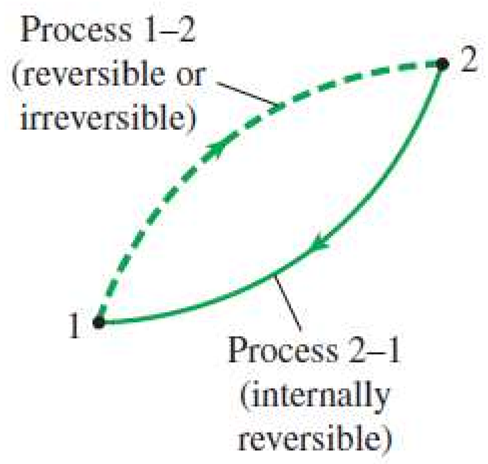
Last Lecture: "Entropy always increases"-when & why?!

$$\oint \frac{\delta Q}{T} \leq 0 \qquad \int_1^2 \frac{\delta Q}{T} + \int_2^1 \left(\frac{\delta Q}{T}\right)_{\text{int rev}} \leq 0$$



$$\int_1^2 \frac{\delta Q}{T} + S_1 - S_2 \leq 0 \qquad S_2 - S_1 \geq \int_1^2 \frac{\delta Q}{T}$$

- (In)equality for (Ir)reversible $dS \geq \frac{\delta Q}{T}$

$$\Delta S_{\text{sys}} = S_2 - S_1 = \int_1^2 \frac{\delta Q}{T} + S_{\text{gen}}$$

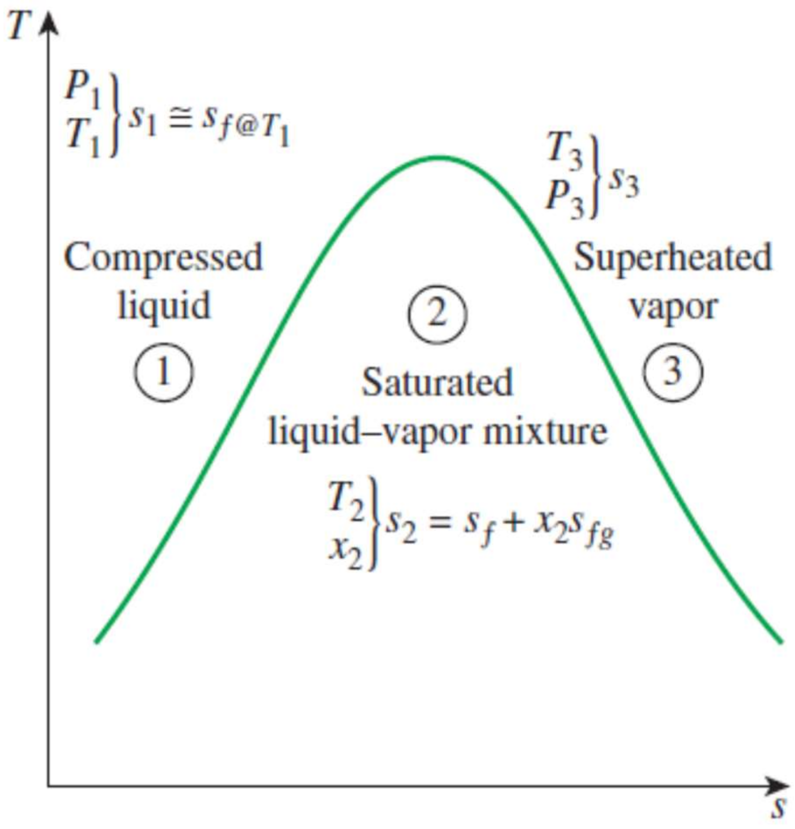
$$\Delta S_{\text{isolated}} \geq 0$$

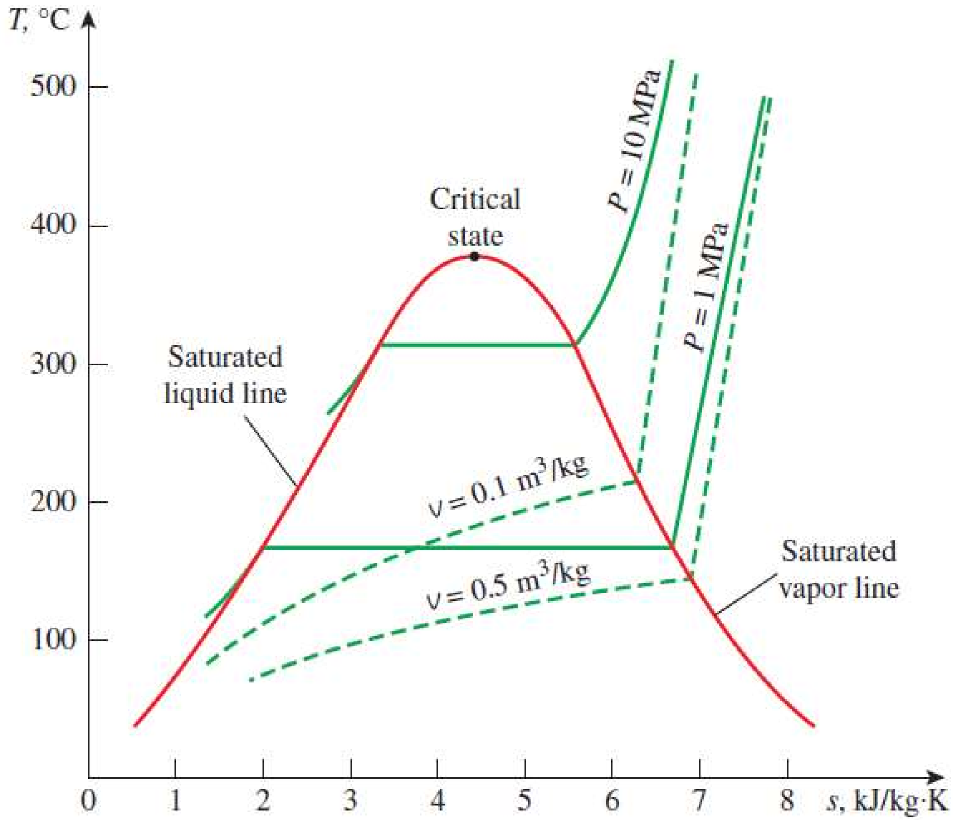
$$S_{\text{gen}} = \Delta S_{\text{total}} = \Delta S_{\text{sys}} + \Delta S_{\text{surr}} \geq 0$$

- Entropy is not a conserved quantity!!!

Figs: TD-Cengel & Boles

Entropy of pure substances





Figs: TD-Cengel & Boles

T-S diagram for water

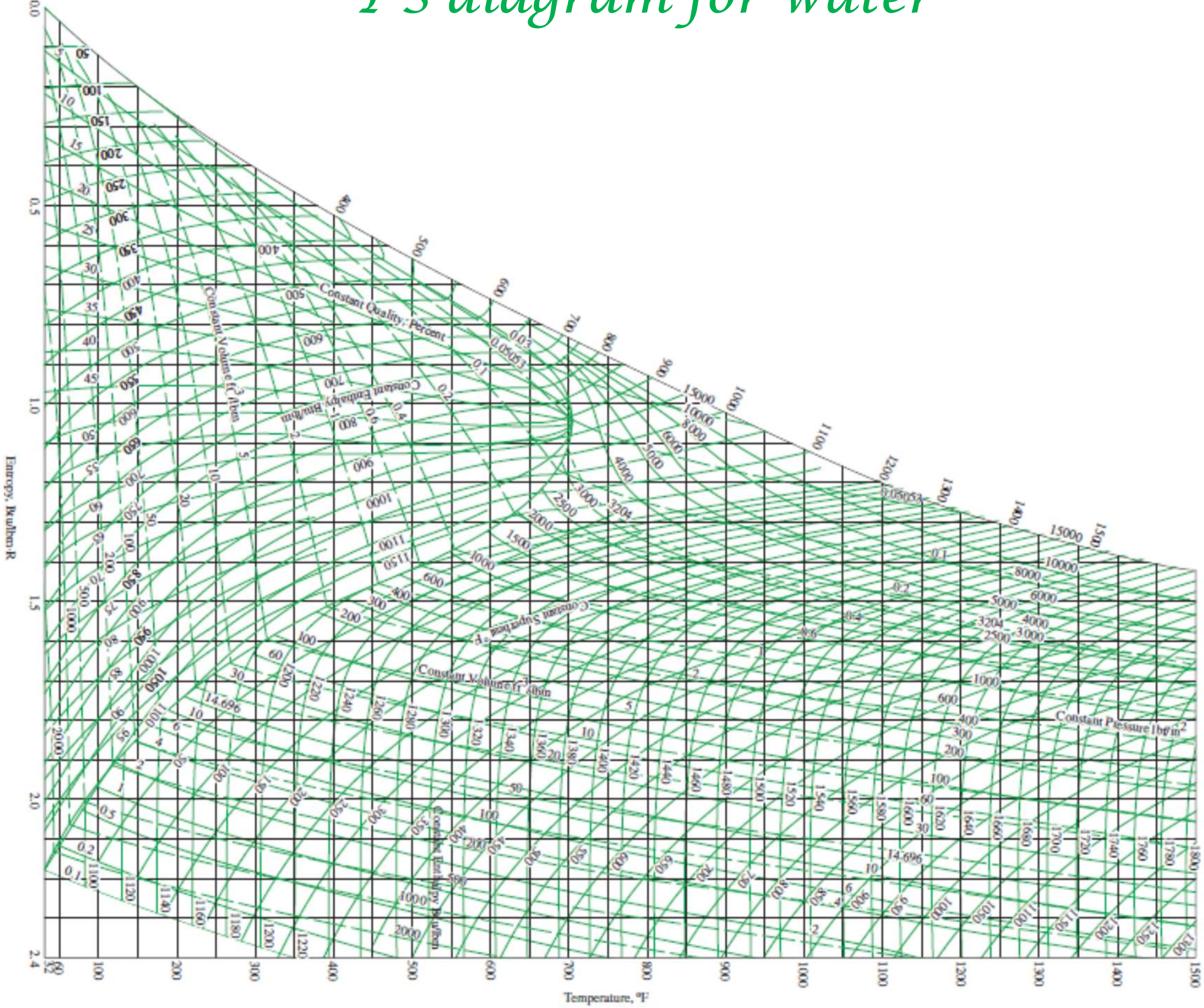
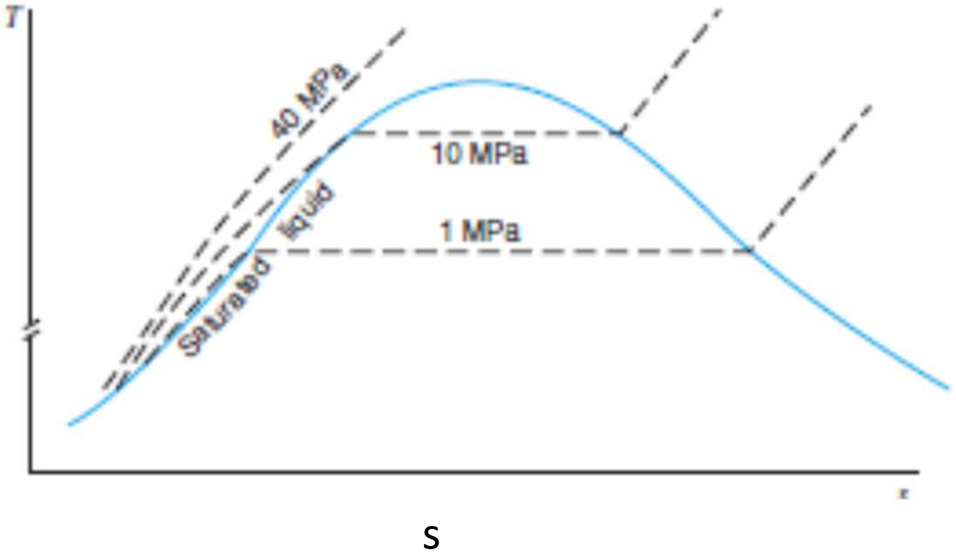
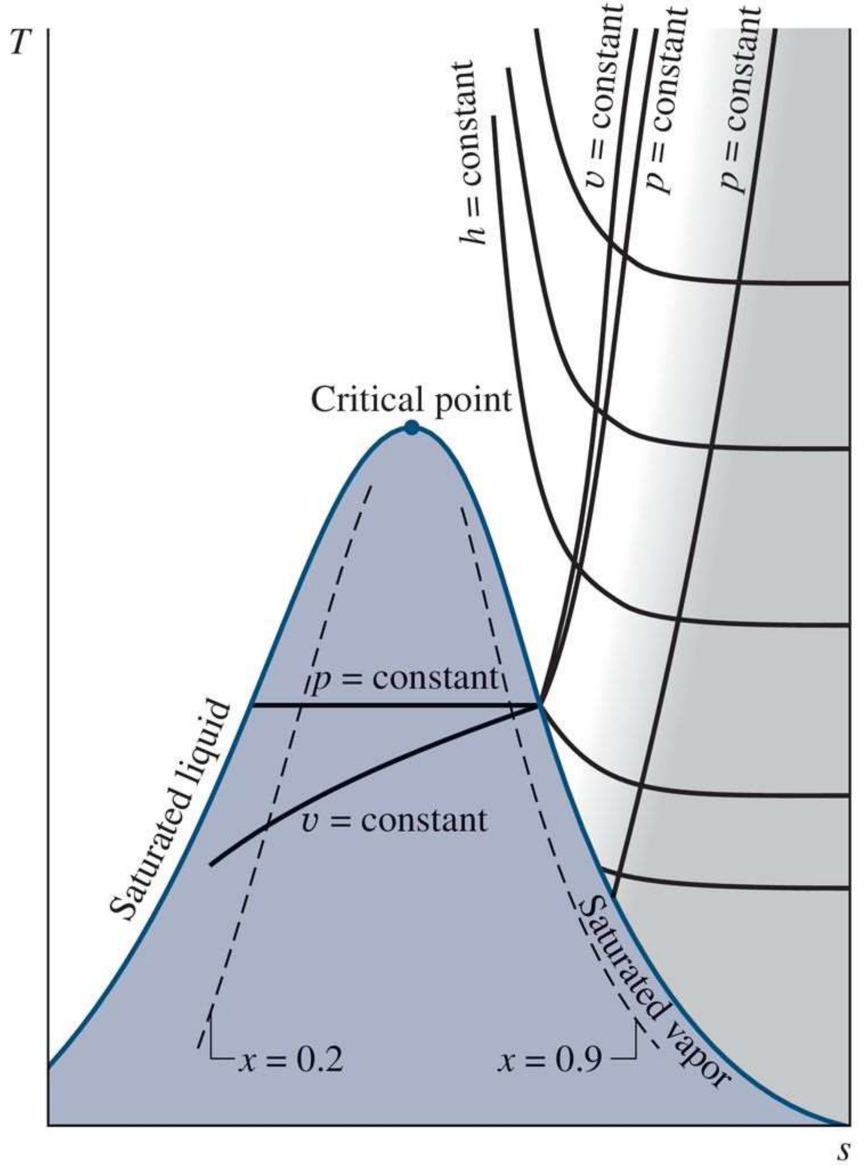


Fig: TD-Cengel & Boles

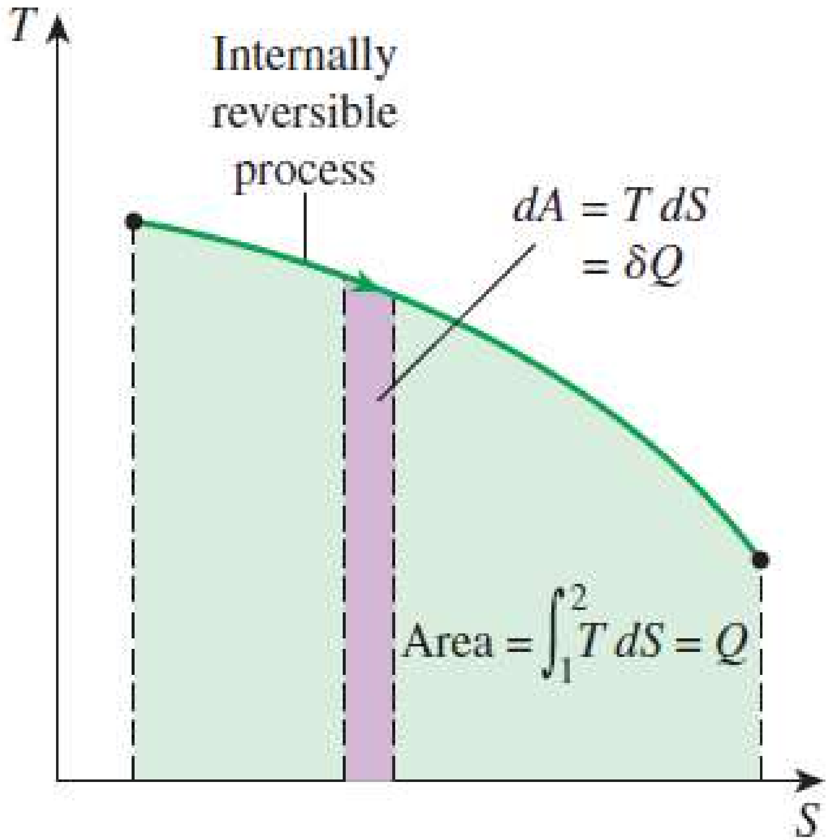
Trends & approximations





Figs: TD-Borgnakke & Sonntag; TD-Moran, Shapiro, Boettner & Bailey

Computing Properties from T-S diagrams



$$\delta Q_{\text{int rev}} = T\,dS \qquad Q_{\text{int rev}} = \int_1^2 T\,dS$$

$$\delta q_{\text{int rev}} = T\,ds \qquad q_{\text{int rev}} = \int_1^2 T\,ds$$

$$Q_{\text{int rev}} = T_0\,\Delta S \qquad q_{\text{int rev}} = T_0\,\Delta s$$

Figs: Cengel & Boles

Mollier diagram for water

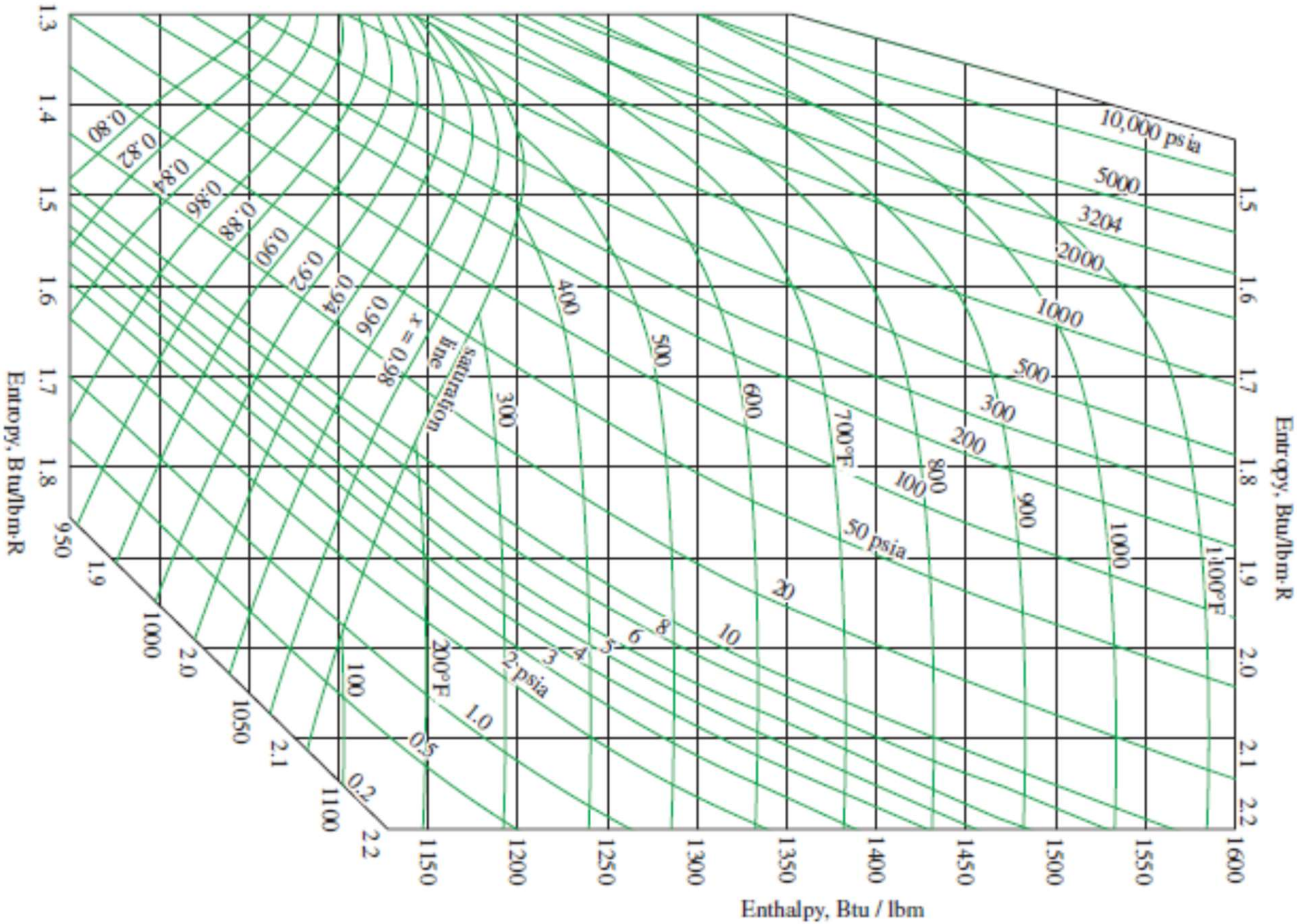
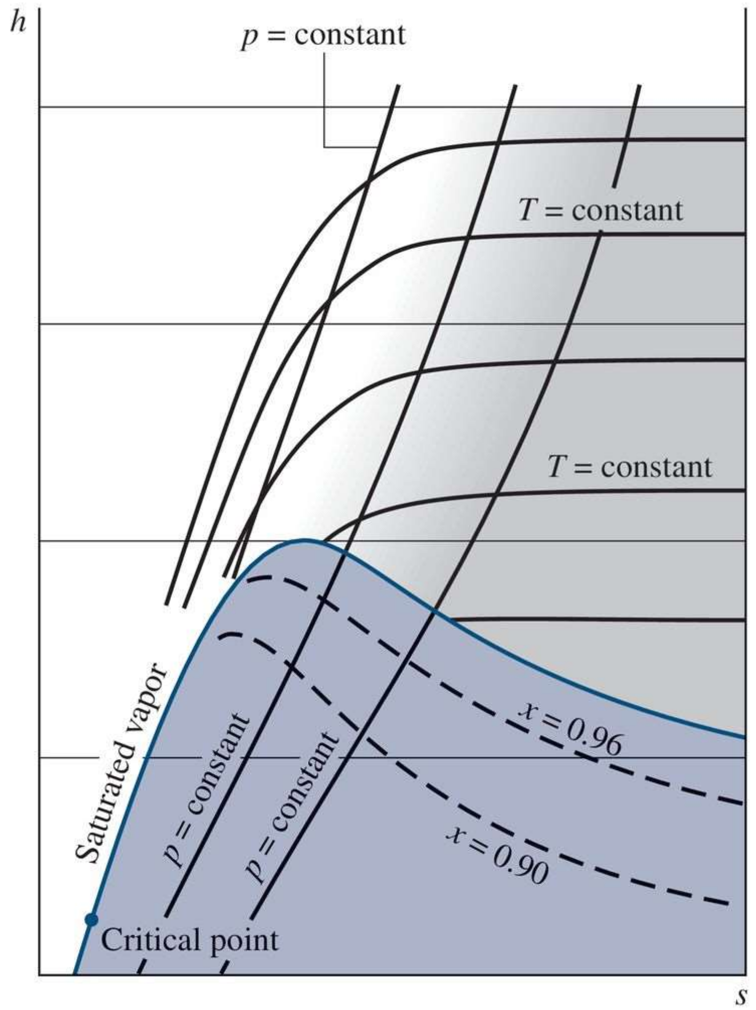


Fig: TD-Cengel & Boles

Mollier diagram for water-Essential information



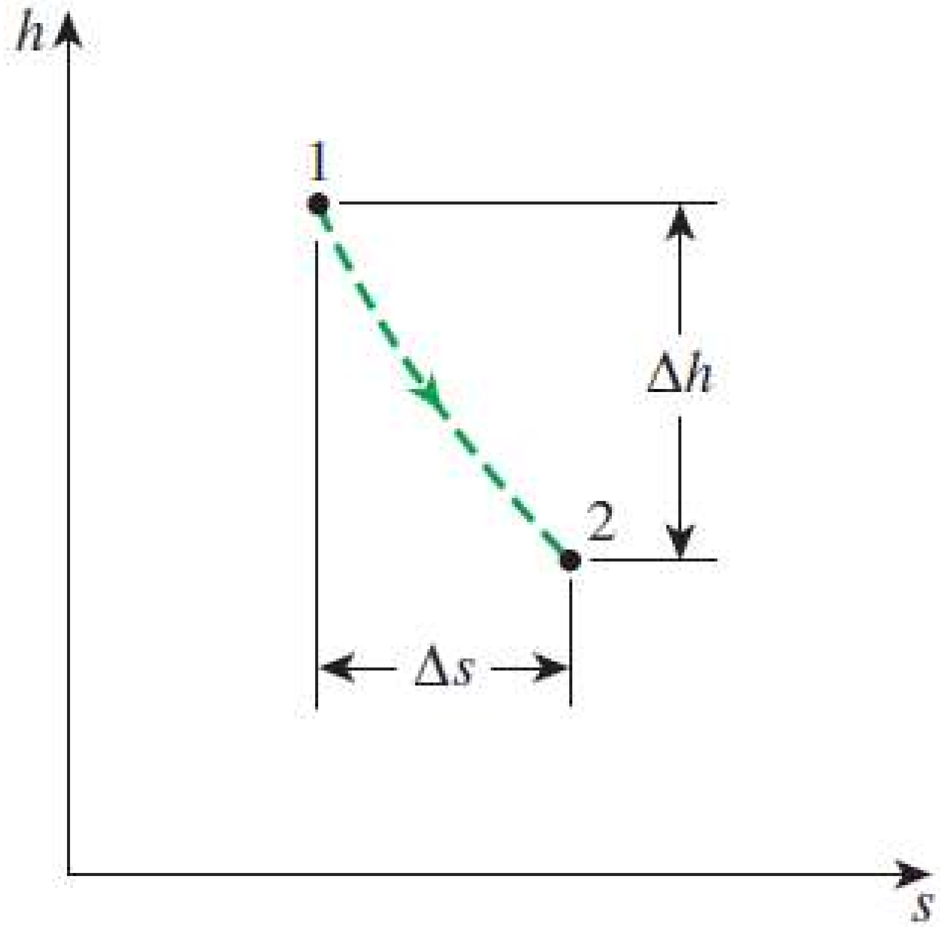
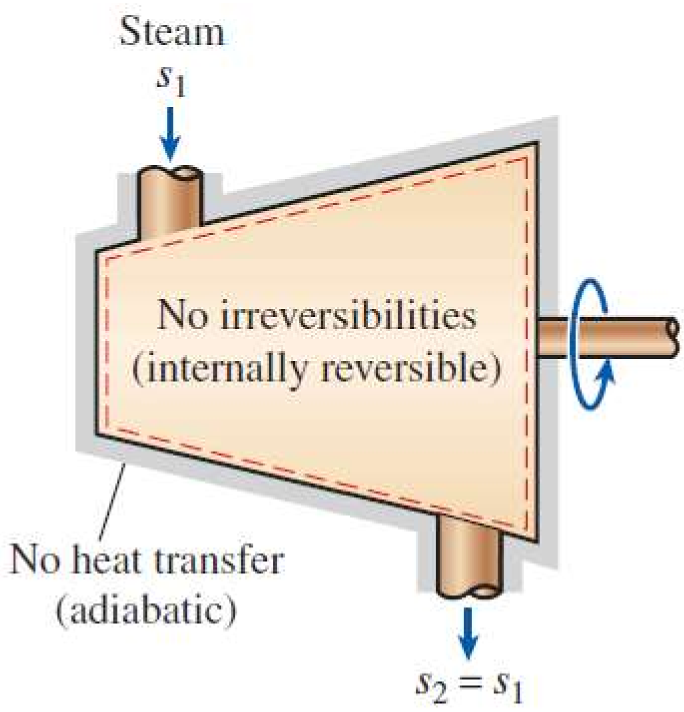


Fig: TD-Moran, Shapiro, Boettner & Bailey

Get a break in calculations-Isoentropic processes!



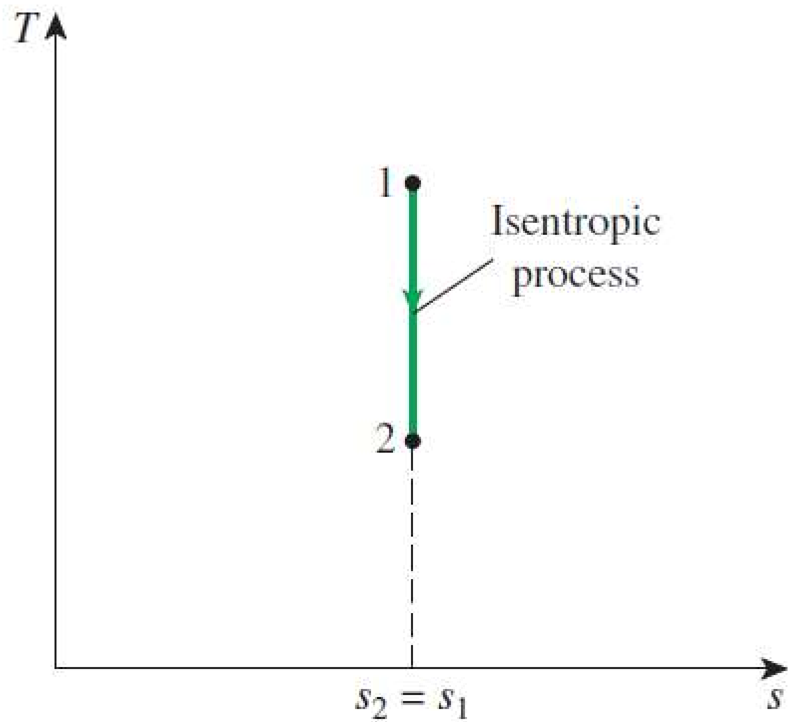
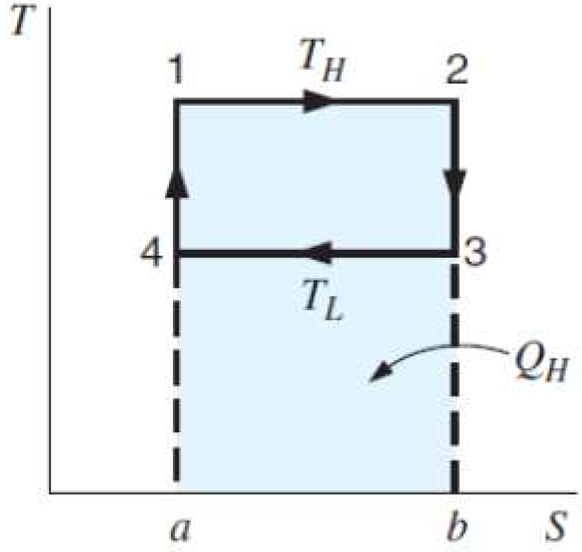


Fig: TD-Cengel & Boles

Carnot Cycle & Isoentropic processes



$$S_4 - S_3 = \int_3^4 \left(\frac{\delta Q}{T}\right)_{\text{rev}} = \frac{{}_3Q_4}{T_L}$$

$$\eta_{\text{th}} = \frac{W_{\text{net}}}{Q_H} = \frac{\text{area } 1\text{–}2\text{–}3\text{–}4\text{–}1}{\text{area } 1\text{–}2\text{–}b\text{–}a\text{–}1}$$

Fig: TD-Borgnakke & Sonntag

What's next?

- Tds relations & Entropy changes in liquids & solids