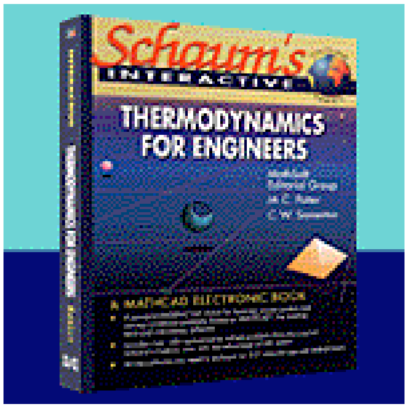
Schaums Interactive Outline Series:

Thermodynamics for Engineers



Platform: Windows
Includes the Mathcad Engine; requires 4 MB hard disk space
Available for ground shipment

This Electronic Book presents and solves over 90 diverse thermodynamic problems as they apply to mechanical systems and emphasizes the connections between related problems. It summarizes key theoretical points and provides tabulated data for reference, including interpolated forms of common steam tables. Students will learn and explore the laws of thermodynamics as applied to engineering and the relationships between thermodynamic properties. The comprehensive lab and homework exercises will help educators with course material. And professionals can review theory and applications or refer to tabular data on basic elements.

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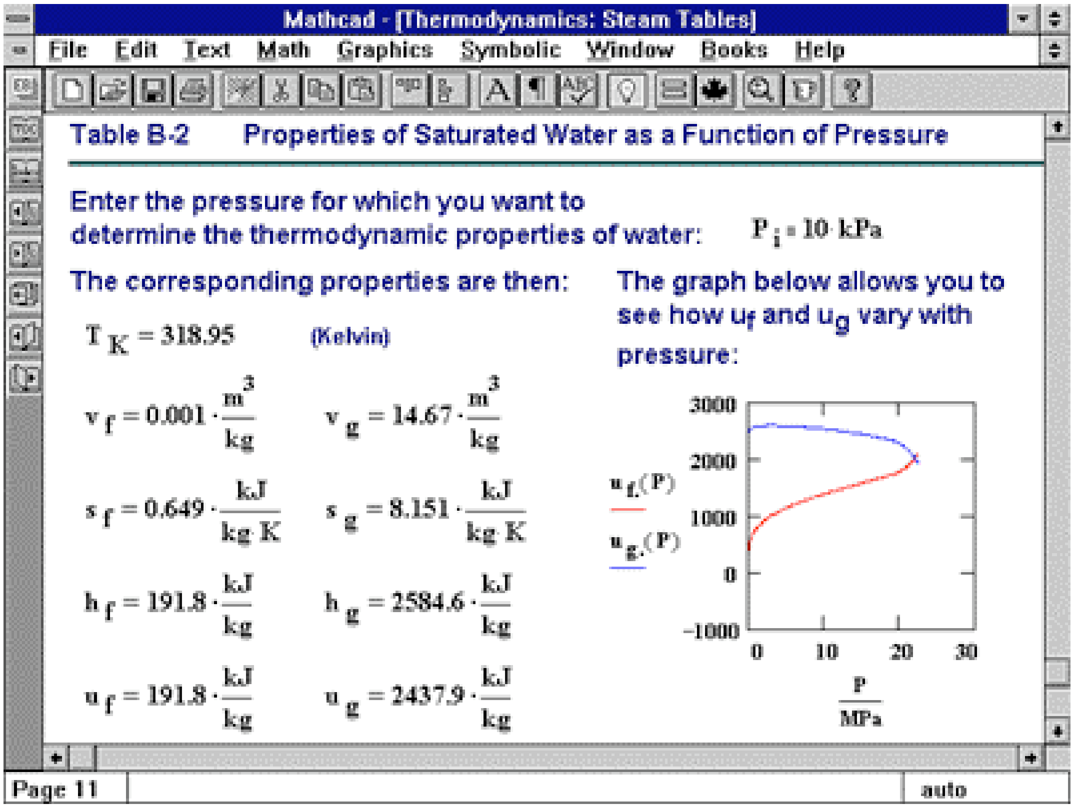

Determine the thermodynamic properties of water as a function of pressure.

Topics include: Properties of Ideal and Real Gases, The First and Second Laws of Thermodynamics, Entropy and Enthalpy, Reversible Work, Irreversibility and Availability, Power and Refrigeration Vapor Cycles, Power and Refrigeration Gas Cycles, Combustion, and much more.

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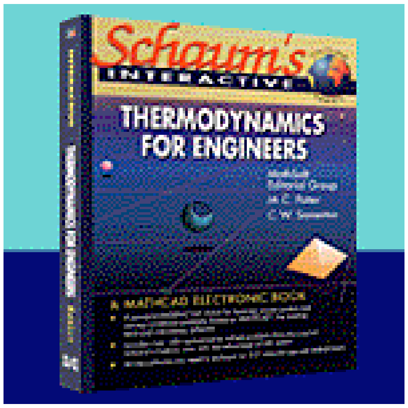

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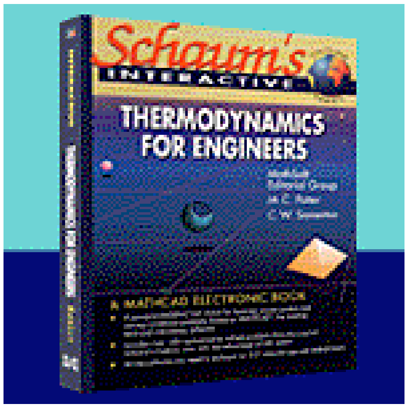

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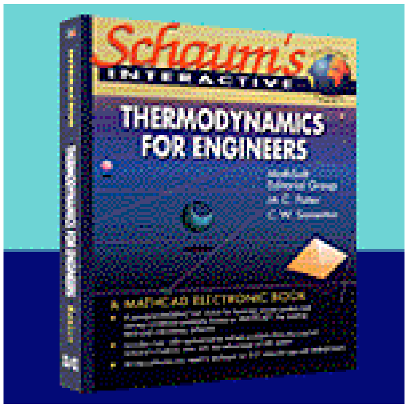

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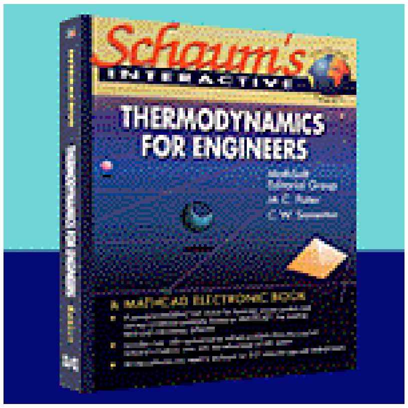

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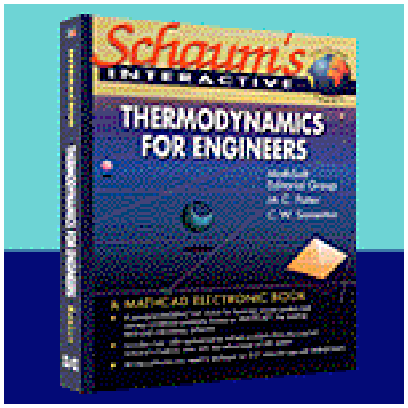

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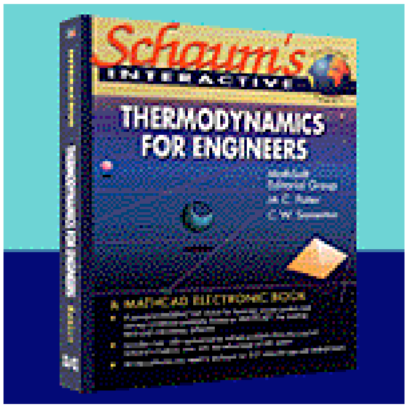

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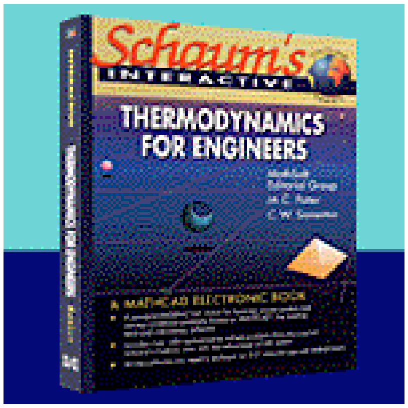

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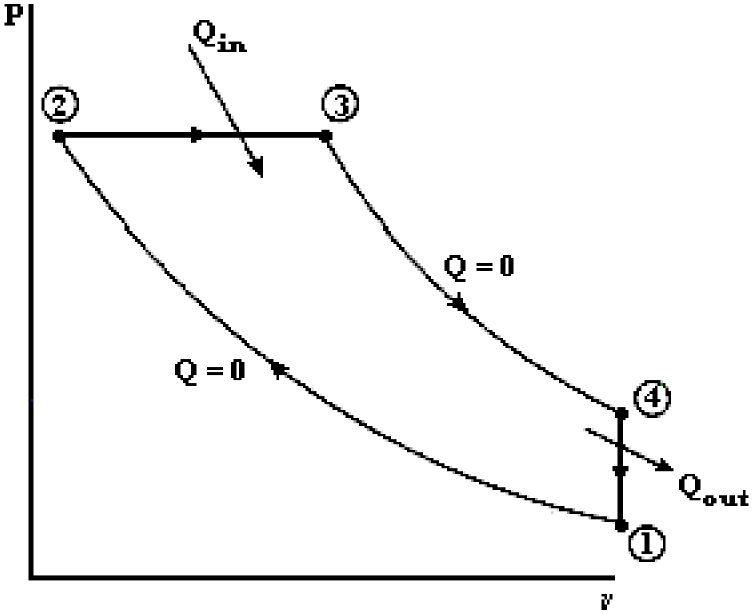
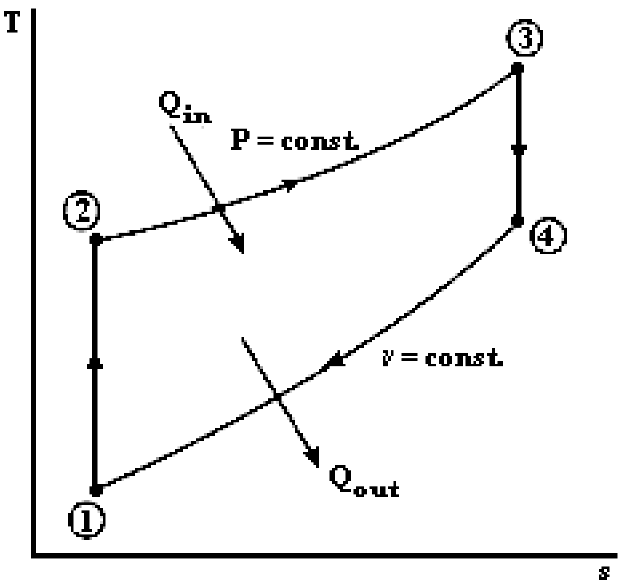
Diesel Cycle

Statement

A diesel engine intakes atmospheric air at temperature **T1** and adds **qin** of energy. If the maximum pressure is **P2** and the air mass flow rate is **m'**, calculate the cutoff ratio **rc**, the thermal efficiency **h**, and the power output **W'out**.





System Parameters

Inlet air pressure: $P_1 := 14.7 \cdot psi$

Inlet air temperature: $T_1 := 520 \cdot R$

Maximum air pressure: $P_2 := 1200 \cdot psi$

Specific energy input: $q_{in} := 800 \cdot \frac{BTU}{lb}$

Mass flow rate: $m' := 0.2 \cdot \frac{lb}{sec}$

Units: $R \equiv \frac{K}{1.8}$

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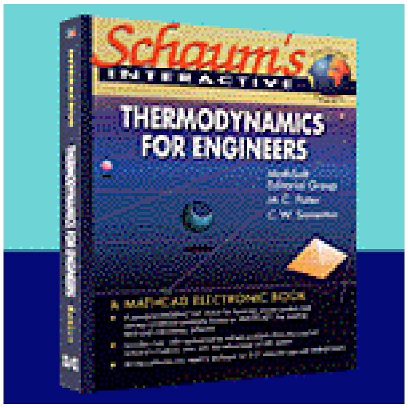

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Constants

Specific heat ratio for air: $k := 1.4$

Gas constant for air: $R_{air} := 53.34 \cdot \frac{ft \cdot lbf}{lb \cdot R}$

Solution

To determine the cutoff ratio and the thermal efficiency, it is first necessary to find the pressure, temperature and specific volumes at the various states.

Since the compression process 1 --> 2 is isentropic **(Ds = 0)**,

$$T_2 := T_1 \cdot \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} \qquad T_2 = 1829 \cdot R$$

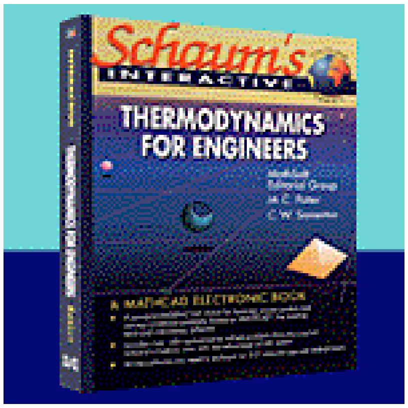
and the temperature at state 3 is found from the **first law** (Chapter 4a):

$$q_{in} = c_p \cdot (T_3 - T_2) = \frac{R_{air} \cdot k}{k-1} \cdot (T_3 - T_2)$$

$$T_3 := T_2 + \frac{q_{in} \cdot (k-1)}{R_{air} \cdot k} \qquad T_3 = 5164 \cdot R$$

The pressure remains constant between states 2 and 3, giving

$$P_3 := P_2 \qquad P_3 = 1200 \cdot psi$$



The specific volumes of the three states are found from the **ideal-gas equation of state Pv = RT** (Chapter 2)

$$v_1 := \frac{R_{air} \cdot T_1}{P_1} \qquad v_1 = 13.103 \cdot \frac{ft^3}{lb}$$

$$v_2 := \frac{R_{air} \cdot T_2}{P_2} \qquad v_2 = 0.565 \cdot \frac{ft^3}{lb}$$

$$v_3 := \frac{R_{air} \cdot T_3}{P_3} \qquad v_3 = 1.594 \cdot \frac{ft^3}{lb}$$

The cutoff ratio is then

$$r_c := \frac{v_3}{v_2} \qquad r_c = 2.823$$

and the compression ratio is

$$r := \frac{v_1}{v_2} \qquad r = 23.207$$

Thus the thermal efficiency is

$$\eta := 1 - r^{1-k} \cdot \frac{r_c^{\,k} - 1}{k \cdot (r_c - 1)} \qquad \eta = 0.635$$

and the power output is

$$W'_{out} := \eta \cdot m' \cdot q_{in} \qquad W'_{out} = 143.78 \cdot hp$$

Try inputting **r** into 9.2 Otto Cycle to compare the efficiency of the two cycles.