

**Physics 151: Accelerated Physics I—Mechanics and Thermodynamics**

**Problem 1:** (20 pts.) A nuclear power plant operates with a high-temperature reservoir of  $600^{\circ}\text{C}$  and a cool-temperature reservoir of  $350^{\circ}\text{C}$ . The plan operates at 75 percent of its maximum theoretical efficiency. If the plant produces electric energy at the rate of 1.3 GW, how much exhaust heat is discharged per hour?

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First, compute the maximum theoretical efficiency. Be sure to convert the temperatures to Kelvin.

$$e_{\max} = 1 - \frac{T_c}{T_h} = 1 - \frac{350 + 273}{600 + 273} = 0.286$$

Then the power plant's actual efficiency is 75% of the maximum, or

$$e = 0.75 e_{\max} = 0.214.$$

The amount of work done in 1 hour is  $1.3 \times 10^9 \text{ J/s} \times 3600 \text{ s} = 4.68 \times 10^{12} \text{ J}$ .

Then, use the efficiency to compute  $Q_h$

$$e = \frac{W}{Q_h} \Rightarrow Q_h = \frac{W}{e} = \frac{4.68 \times 10^{12} \text{ J}}{0.214} = 2.187 \times 10^{13} \text{ J}$$

Finally, use conservation of energy to compute  $Q_c$ .

$$Q_h = W + Q_c \Rightarrow Q_c = Q_h - W = 1.71 \times 10^{13} \text{ J}$$