

Problem 1.32

[Difficulty: 2]

1.32 From thermodynamics, we know that the coefficient of performance of an ideal air conditioner (COP_{ideal}) is given by

$$COP_{ideal} = \frac{T_L}{T_H - T_L}$$

where T_L and T_H are the room and outside temperatures (absolute). If an AC is to keep a room at 20°C when it is 40°C outside, find the COP_{ideal} . Convert to an EER value, and compare this to a typical Energy Star-compliant EER value.

Given: Equation for COP_{ideal} and temperature data.

Find: COP_{ideal} , EER , and compare to a typical Energy Star compliant EER value.

Solution: Use the COP equation. Then use conversions from Table G.2 or other sources (e.g., www.energystar.gov) to find the EER.

The given data is $T_L = (20 + 273) \cdot \text{K}$ $T_L = 293 \text{ K}$ $T_H = (40 + 273) \cdot \text{K}$ $T_H = 313 \text{ K}$

The COP_{ideal} is $COP_{Ideal} = \frac{293}{313 - 293} = 14.65$

The EER is a similar measure to COP except the cooling rate (numerator) is in BTU/hr and the electrical input (denominator) is in W:

$$EER_{Ideal} = COP_{Ideal} \times \frac{\frac{\text{BTU}}{\text{hr}}}{\text{W}} \quad EER_{Ideal} = 14.65 \times \frac{2545 \cdot \frac{\text{BTU}}{\text{hr}}}{746 \cdot \text{W}} = 50.0 \cdot \frac{\text{BTU}}{\text{hr} \cdot \text{W}}$$

This compares to Energy Star compliant values of about 15 BTU/hr/W! We have some way to go! We can define the isentropic efficiency as

$$\eta_{isen} = \frac{EER_{Actual}}{EER_{Ideal}}$$

Hence the isentropic efficiency of a very good AC is about 30%.