

**Ex:** An inventor claims to have developed a heat engine that receives 700 kJ of heat from a source at 500 K and produces 300 kJ of net work while rejecting the waste heat to a sink at 290 K. Is this a reasonable claim? Why?

**Sol:**

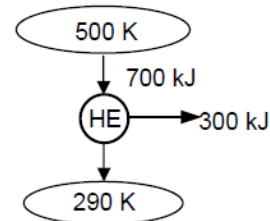
An inventor claims to have developed a heat engine. The inventor reports temperature, heat transfer, and work output measurements. The claim is to be evaluated.

**Analysis** The highest thermal efficiency a heat engine operating between two specified temperature limits can have is the Carnot efficiency, which is determined from

$$\eta_{th,max} = \eta_{th,C} = 1 - \frac{T_L}{T_H} = 1 - \frac{290 \text{ K}}{500 \text{ K}} = 0.42 \text{ or } 42\%$$

The actual thermal efficiency of the heat engine in question is

$$\eta_{th} = \frac{W_{net}}{Q_H} = \frac{300 \text{ kJ}}{700 \text{ kJ}} = 0.429 \text{ or } 42.9\%$$



which is greater than the maximum possible thermal efficiency. Therefore, this heat engine is a PMM2 and the claim is **false**.

**Ex:** An air-conditioning system operating on the reversed Carnot cycle is required to transfer heat from a house at a rate of 750 kJ/min to maintain its temperature at 24°C. If the outdoor air temperature is 35°C, determine the power required to operate this air-conditioning system.

**Sol:**

The cooled space and the outdoors temperatures for a Carnot air-conditioner and the rate of heat removal from the air-conditioned room are given. The power input required is to be determined.

**Assumptions** The air-conditioner operates steadily.

**Analysis** The COP of a Carnot air conditioner (or Carnot refrigerator) depends on the temperature limits in the cycle only, and is determined from

$$\text{COP}_{R,C} = \frac{1}{(T_H/T_L) - 1} = \frac{1}{(35 + 273 \text{ K})/(24 + 273 \text{ K}) - 1} = 27.0$$

The power input to this refrigerator is determined from the definition of the coefficient of performance of a refrigerator,

$$\dot{W}_{net,in} = \frac{\dot{Q}_L}{\text{COP}_{R,max}} = \frac{750 \text{ kJ/min}}{27.0} = 27.8 \text{ kJ/min} = 0.463 \text{ kW}$$

