8-80C The entropy change relations of an ideal gas simplify to
\[ \Delta s = c_p \ln \left( \frac{T_2}{T_1} \right) \] for a constant pressure process
and \[ \Delta s = c_v \ln \left( \frac{T_2}{T_1} \right) \] for a constant volume process.
Noting that \( c_p > c_v \), the entropy change will be larger for a constant pressure process.

8-83E The entropy change of air during an expansion process is to be determined.
**Assumptions** Air is an ideal gas with constant specific heats.
**Properties** The specific heat of air at the average temperature of \((500+50)/2=275\) °F is \( c_p = 0.243 \text{ Btu/lbm} \cdot \text{R} \) (Table A-2Eb). The gas constant of air is \( R = 0.06855 \text{ Btu/lbm} \cdot \text{R} \) (Table A-2Ea).
**Analysis** From the entropy change relation of an ideal gas,
\[
\begin{align*}
\Delta s_{\text{air}} &= c_p \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} \\
&= (0.243 \text{ Btu/lbm} \cdot \text{R}) \ln \left( \frac{50 + 460}{500 + 460} \right) R - (0.06855 \text{ Btu/lbm} \cdot \text{R}) \ln \frac{200 \text{ psia}}{100 \text{ psia}} \\
&= -0.1062 \text{ Btu/lbm} \cdot \text{R}
\end{align*}
\]

8-84 The final temperature of air when it is expanded isentropically is to be determined.
**Assumptions** Air is an ideal gas with constant specific heats.
**Properties** The specific heat ratio of air at an anticipated average temperature of 550 K is \( k = 1.381 \) (Table A-2b).
**Analysis** From the isentropic relation of an ideal gas under constant specific heat assumption,
\[
T_2 = T_1 \left( \frac{P_2}{P_1} \right)^{(k-1)/k} = (477 + 273) \text{ K} \left( \frac{100 \text{ kPa}}{1000 \text{ kPa}} \right)^{0.381/1.381} = 397 \text{ K}
\]
**Discussion** The average air temperature is \((750+397.4)/2=573.7\) K, which is sufficiently close to the assumed average temperature of 550 K.

8-88 An insulated cylinder initially contains air at a specified state. A resistance heater inside the cylinder is turned on, and air is heated for 15 min at constant pressure. The entropy change of air during this process is to be determined for the cases of constant and variable specific heats.
**Assumptions** At specified conditions, air can be treated as an ideal gas.
**Properties** The gas constant of air is \( R = 0.287 \text{ kJ/kg} \cdot \text{K} \) (Table A-1).
**Analysis** The mass of the air and the electrical work done during this process are
The energy balance for this stationary closed system can be expressed as:

\[
E_{\text{in}} - E_{\text{out}} = \Delta E_{\text{system}}
\]

Net energy transfer by heat, work, and mass

\[
W_{\text{e,in}} - W_{\text{b,out}} = \Delta U \rightarrow W_{\text{e,in}} = m(h_2 - h_1) \cong c_p(T_2 - T_1)
\]

since \(\Delta U + W_b = \Delta H\) during a constant pressure quasi-equilibrium process.

(a) Using a constant \(c_p\) value at the anticipated average temperature of 450 K, the final temperature becomes

\[
T_2 = T_1 + \frac{W_{\text{e,in}}}{mc_p} = 290 \text{ K} + \frac{180 \text{ kJ}}{(0.4325 \text{ kg})(1.02 \text{ J/kg·K})} = 698 \text{ K}
\]

Then the entropy change becomes

\[
\Delta S_{\text{sys}} = m(s_2 - s_1) = m \left( c_{p,\text{avg}} \ln \frac{T_2}{T_1} - R \ln \frac{P_2}{P_1} \right) = mc_{p,\text{avg}} \ln \frac{T_2}{T_1}
\]

\[
= (0.4325 \text{ kg})(1.02 \text{ J/kg·K}) \ln \left( \frac{698 \text{ K}}{290 \text{ K}} \right) = 0.387 \text{ kJ/K}
\]

(b) Assuming variable specific heats,

\[
W_{\text{e,in}} - m(h_2 - h_1) \rightarrow h_2 = h_1 + \frac{W_{\text{e,in}}}{m} = 290.16 \text{ kJ/kg} + \frac{180 \text{ kJ}}{0.4325 \text{ kg}} = 706.34 \text{ kJ/kg}
\]

From the air table (Table A-21, we read \(s_2^{\text{o}} = 2.5628 \text{ kJ/kg·K}\) corresponding to this \(h_2\) value. Then,

\[
\Delta S_{\text{sys}} = m \left( s_2^{\text{o}} - s_1^{\text{o}} + R \ln \frac{P_2}{P_1} \right) = m(s_2^{\text{o}} - s_1^{\text{o}}) = (0.4325 \text{ kg})(2.5628 - 1.66802) \text{ kJ/kg·K} = 0.387 \text{ kJ/K}
\]

8-89 A cylinder contains \(\text{N}_2\) gas at a specified pressure and temperature. The gas is compressed polytropically until the volume is reduced by half. The entropy change of nitrogen during this process is to be determined.

**Assumptions**

1. At specified conditions, \(\text{N}_2\) can be treated as an ideal gas.
2. Nitrogen has constant specific heats at room temperature.

**Properties**

The gas constant of nitrogen is \(R = 0.297 \text{ kJ/kg·K}\) (Table A-1). The constant volume specific heat of nitrogen at room temperature is \(c_v = 0.743 \text{ kJ/kg·K}\) (Table A-2).

**Analysis**

From the polytropic relation,

\[
\frac{T_2}{T_1} = \left( \frac{v_1}{v_2} \right)^{n-1} \rightarrow T_2 = T_1 \left( \frac{v_1}{v_2} \right)^{n-1} = (300 \text{ K})(2)^{1.3-1} = 369.3 \text{ K}
\]

Then the entropy change of nitrogen becomes

\[
\Delta S_{\text{sys}} = m\left( s_2^{\text{o}} - s_1^{\text{o}} + R \ln \frac{P_2}{P_1} \right) = m(s_2^{\text{o}} - s_1^{\text{o}}) = (0.4325 \text{ kg})(2.5628 - 1.66802) \text{ kJ/kg·K} = 0.387 \text{ kJ/K}
\]
8-91E A fixed mass of helium undergoes a process from one specified state to another specified state. The entropy change of helium is to be determined for the cases of reversible and irreversible processes.

**Assumptions**
1. At specified conditions, helium can be treated as an ideal gas.
2. Helium has constant specific heats at room temperature.

**Properties**
- The gas constant of helium is $R = 0.4961$ Btu/lbm·R (Table A-1E).
- The constant volume specific heat of helium is $c_v = 0.753$ Btu/lbm·R (Table A-2E).

**Analysis**
From the ideal-gas entropy change relation,

$$
\Delta S_{\text{He}} = m \left( c_{v,\text{avg}} \ln \frac{T_2}{T_1} + R \ln \frac{\nu_2}{\nu_1} \right)
$$

$$
= (15 \text{ lbm}) \left( 0.753 \text{ Btu/lbm} \cdot \text{R} \right) \ln \frac{660 \text{ R}}{540 \text{ R}} + \left( 0.4961 \text{ Btu/lbm} \cdot \text{R} \right) \ln \left( \frac{10 \text{ ft}^3/\text{lbm}}{50 \text{ ft}^3/\text{lbm}} \right)
$$

$$
= -9.71 \text{ Btu/R}
$$

The entropy change will be the same for both cases.