37.19 How much power is required to isentropically compress $100\frac{lb}{min}$ of air at atmospheric pressure and $80°F$ to $150psia$? Assume air is an ideal gas with constant specific heat capacity.

A. $50hp$

B. $200hp$

C. $290hp$

D. $1920hp$

Look up Constant Entropy Processes and find the formula relating temperature and pressure. Determine the temperature after the compression process, T_2. The ratio of specific heats may be taken as $k = 1.4$ since air is to be considered an ideal gas. Be sure to use the absolute temperature scale ie. Rankine rather than Farenheit.

$$\frac{T_2}{T_1} = \left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}}$$

$$T_2 = T_1\left(\frac{P_2}{P_1}\right)^{\frac{k-1}{k}} = (540°R)\left(\frac{150psia}{14.7psia}\right)^{\frac{1.4-1}{1.4}} = 1048.6°R = 588.6°F$$

The power for a compressor can be expressed most generally as the product of the mass flow rate and the change in enthalpy. If the gas being compressed has constant specific heats, it is valid to express the enthalpy change in terms of the change in temperature. Calculate the power required and convert the final units to horsepower to be consistent with the answer choices. Look up Measurement Relationships for unit conversions that may be useful.

$$\dot{W} = \dot{m}\Delta h = \dot{m}c_p\Delta T = \left(100\frac{lb}{min}\right)\left(0.24\frac{Btu}{lb°F}\right)(588.6°F - 80°F) = 12,207\frac{Btu}{min}$$

$$\dot{W} = 12,207\frac{Btu}{min}\left(\frac{1hp}{42.4\frac{Btu}{min}}\right) = 288hp$$

Answer C