36.33 A pizza oven has a flame temperature of $1000°F$ and the internal walls are $700°F$. Assuming all surfaces are considered to be black, what is the rate of heat transfer per square foot due to radiation?

A. $1300 \frac{Btu}{hr \cdot ft^2}$

B. $4700 \frac{Btu}{hr \cdot ft^2}$

C. $8800 \frac{Btu}{hr \cdot ft^2}$

D. $13,000 \frac{Btu}{hr \cdot ft^2}$

The energy exchange due to Radiation is given by the equation below.

$$\dot{Q}_r = \varepsilon \sigma A \left(T_1^4 - T_2^4\right)$$

Since all surfaces are considered to be black, the emissivity is assumed to be 1.

$$\varepsilon = 1$$

The question asks for the heat transfer per square foot, so divide both sides by area.

$$\frac{\dot{Q}_r}{A} = \dot{q}_r = \sigma \left(T_1^4 - T_2^4\right)$$

σ is the Stefan-Boltzmann Constant. In order for the units to work out, absolute temperatures must be used i.e. Rankine. Solve for $\dot{q}_r$.

$$\dot{q}_r = \left(0.1713 \times 10^{-8} \frac{Btu}{hr \cdot ft^2 \cdot {}^\circ R^4}\right) \left[(1460°R)^4 - (1160°R)^4\right] = 4682 \frac{Btu}{hr \cdot ft^2}$$

Answer B