$$\dot{Q}_{windows} = \left(0.7\frac{Btu}{hr \cdot ft^2 \cdot {}^\circ F}\right)\left(1920ft^2\right)\left(70^\circ F - 10^\circ F\right) = 80,640\frac{Btu}{hr}$$

Find the total heat loss through walls:

$$\dot{Q}_{walls} = U_{walls}A_{walls}\Delta T$$

$$\dot{Q}_{walls} = \left(0.2\frac{Btu}{hr \cdot ft^2 \cdot {}^\circ F}\right)\left(5760ft^2\right)\left(70^\circ F - 10^\circ F\right) = 69,120\frac{Btu}{hr}$$

Find the total heat loss:

$$\dot{Q}_{total} = \dot{Q}_{windows} + \dot{Q}_{walls} = 80,640\frac{Btu}{hr} + 69,120\frac{Btu}{hr} = 149,760\frac{Btu}{hr}$$

Answer D

43.21 A building in Chicago has a design heat loss of $300,000\frac{Btu}{hr}$. The heating season is 250 days long and there are 6000 heating degree days per season. The outside design temperature is $-10^\circ F$. The inside design temperature is initially $70^\circ F$. The heating system burns natural gas which costs $0.75 per therm on average. The total system efficiency is 80%. If the heating setpoint is reduced to $68^\circ F$, what will the annual savings be?

A. $270

B. $420

C. $6,000

D. $8,000

Determine the average ΔT using the heating degree days and and the length of the heating season:

$$\Delta T_{avg,65} = \frac{6000 degree \cdot days}{250 days} = 24^\circ F$$

It is implied (unless otherwise stated) that the indoor reference temperature for heating degree days is 65°F. Since the initial design temperature is 70°F, the average ΔT is actually $+5$°F higher.

$$\Delta T_{avg,70} = 29^\circ F$$

Use the design ΔT and the design heat loss to calculate the product of the overall coefficient of heat transfer and the area for this building. Looking at the units, think of this product as the rate of heat transfer per unit change in temperature, e.g. the rate at which heat must be added to compensate for one degree of temperature reduction for this particular building.

$$\dot{Q} = UA\Delta T$$

$$UA = \frac{\dot{Q}}{\Delta T} = \frac{300,000\frac{Btu}{hr}}{80°F} = 3750\frac{Btu}{hr \cdot °F}$$

Since the rate at which heat must be added to the building is linearly related to the temperature (UA is similar to the slope of a line, where $\dot{Q}$ and ΔT are the independent and dependent variables), a $2°F$ reduction in the internal temperature setpoint will reduce the average ΔT from $29°F$ to $27°F$.

The associated energy savings can be calculated by applying to the entire heating season:

$$Energy\,Savings = \left(3750\frac{Btu}{hr \cdot °F}\right)(250 days)\left(24\frac{hr}{day}\right)(2°F) = 4.5 \times 10^7 Btu$$

Calculate the cost savings associated with this reduction in energy, accounting for efficiency, converting units to therms, and applying the cost per therm. Look up Measurement Relationships in the Reference Handbook if necessary.

$$Cost\,Savings = \frac{\left(4.5 \times 10^7 Btu\right)\left(\frac{\$0.75}{therm}\right)}{(.8)\left(100,000\frac{Btu}{therm}\right)} = \$422$$

Answer B

43.22 A $10,000\frac{Btu}{hr}$ air conditioner with a SEER-13 rating runs 100 days per year for 12 hours per day. The unit is replaced with a more efficient model with a SEER-23 rating. The average cost of electricity is \$0.15 per kWh. What is the annual savings?

A. \$60

B. \$80

C. \$100

D. \$120

Look up SEER or Season Energy Efficiency Ratio in the Reference Handbook.

$$SEER = \frac{total\,seasonal\,cooling\,output\;(Btu)}{total\,seasonal\,input\,energy\;(W \cdot hr)}$$

The numerator, total seasonal cooling output, is a function of the unit's rating and runtime for the season. This remains unchanged regardless of the SEER.

The denominator, input energy, will vary based on the SEER. For convenience, let the input energy be represented by E_1 and E_2 for the two cases.

$$total\,seasonal\,cooling\,output = \left(10,000\frac{Btu}{hr}\right)(100 days)\left(12\frac{hr}{day}\right) = 12 \times 10^6 Btu$$

Rearrange the SEER formula and solve for E_1 and E_2:

$$total\,seasonal\,input\,energy\;(W \cdot hr) = \frac{total\,seasonal\,cooling\,output\;(Btu)}{SEER}$$