

**43.24** A flat-roofed building in Arizona has an inside design temperature of  $75^\circ F$  and an outside design temperature of  $105^\circ F$  in the summer. The overall coefficients of heat transfer for the walls, windows, and roof are  $0.15 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$ ,  $1.5 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$ , and  $0.1 \frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$ , respectively. The east and west facades are  $75 ft \times 100 ft$  with (30)  $4 ft \times 6 ft$  windows each. The north and south facades are  $75 ft \times 50 ft$  with no windows. The roof dimensions are  $50 ft \times 100 ft$ . The equivalent cooling load temperature differences for the walls and roof are: North  $25^\circ F$ , South  $45^\circ F$ , East  $30^\circ F$ , West  $30^\circ F$ , Roof  $80^\circ F$ . What is the building cooling load? Ignore internal loads.

- A.  $205,000 \frac{Btu}{hr}$
- B.  $212,000 \frac{Btu}{hr}$
- C.  $216,000 \frac{Btu}{hr}$
- D.  $222,000 \frac{Btu}{hr}$

The total cooling load is the sum of the heat gain from the windows, roof, and 4 walls. Use the overall heat transfer equation where the given *Cooling Load Temperature Differences* (CLTD) is used in lieu of the actual  $\Delta T$  to account for the solar influence specific to the local climate. Use the actual  $\Delta T$  for the windows for which no CLTD has been given.

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

Consider creating a table to organize your work:

	$U$	$\frac{Btu}{hr \cdot ft^2 \cdot ^\circ F}$	$A [ft^2]$	$CLTD [^\circ F]$	$\dot{Q} [\frac{Btu}{hr}]$
North Wall	.15		3750	$25^\circ F$	14,063
South Wall	.15		3750	$45^\circ F$	25,313
East Wall	.15		6780	$30^\circ F$	30,510
West Wall	.15		6780	$30^\circ F$	30,510
Roof	.1		5000	$80^\circ F$	40,000
Windows	1.5		1440	$30^\circ F$	64,800

Calculate the total load:

$$\dot{Q}_t = 14,063 + 25,313 + 30,510 + 30,510 + 40,000 + 64,800 = 205,196 \frac{Btu}{hr}$$

**Answer A**

**43.25** Under original design conditions a fan using 5.5hp rotates at 750rpm against a static pressure loss of 2in wg. Due to a design change, the length of the duct served by the fan increases, adding an additional 0.5in of static pressure. What is the fan speed after the system modification?

- A. 810rpm
- B. 840rpm
- C. 920rpm
- D. 940rpm

Make a quick table to organize the original and new operating conditions for the fan:

	Original (1)	New (2)
$W$ [hp]	5.5	$W_2$
$N$ [rpm]	750	$N_2$
$P$ [in wg]	2	2.5

The fan speed and power will both increase to meet the new static pressure requirements; however, the horsepower is extra information and may be ignored. Look up **Fan Affinity Laws** or **Fan Laws** and select formula 1b from the table. Since the diameter and density are not changing from one case to the next, ratios of those parameters are equal to 1 and may be omitted.

$$P_1 = P_2 \left( \frac{N_1}{N_2} \right)^2$$

It may be advisable to internalize the most common fan laws such as the relationships between speed, volume flow rate, pressure, and power.

Rearrange the formula to isolate  $N_2$  and solve:

$$\left( \frac{N_2}{N_1} \right)^2 = \frac{P_2}{P_1} \rightarrow \frac{N_2}{N_1} = \left( \frac{P_2}{P_1} \right)^{\frac{1}{2}} \rightarrow N_2 = N_1 \left( \frac{P_2}{P_1} \right)^{\frac{1}{2}}$$

$$N_2 = (750rpm) \left( \frac{2.5in\ wg}{2in\ wg} \right)^{\frac{1}{2}} = 839rpm$$

**Answer B**