47.7 A fan delivers $10,000cfm$ of $70°F$ air at sea level. How much volume will the same fan deliver when used at $4000ft$ elevation to distribute $50°F$ air?

A. $8,000cfm$

B. $9,000cfm$

C. $11,000cfm$

D. $12,000cfm$

Qualitatively, it stands to reason that increasing the elevation at which the fan is used will increase the capacity of the fan in terms of volume flow rate because air is less dense higher in the atmosphere. However, reducing the temperature of the air makes it more dense, and reduces the capacity of the fan. These factors will compete and must be considered separately.

Search for Temperature and Altitude Corrections and use the table to look up the Density Factors for both the temperature and elevation change.

The Density Factor for the temperature requires interpolation.

Temperature [$°F$]	Density Factor
0	1.152
50	DF_T
70	1

$$\frac{70-50}{70-0} = \frac{1-DF_T}{1-1.152} = 0.2857$$

$$1 - DF_T = -0.0434 \rightarrow DF_T = 1.043$$

Look up the Density Factor for the altitude.

$$DF_A = 0.864$$

Although it is not explicitly stated in the reference handbook whether the original cfm should be multiplied or divided by the density factors, the previous reasoning provides the expectation that the decreased temperature will tend to reduce the fan capacity and the increased altitude will tend to increase the fan capacity. Therefore, the original cfm should be *divided* by the density factors.

$$Q_{4000ft} = \frac{Q_{sea\ level}}{DF_T \cdot DF_A} = \frac{10,000cfm}{(1.043)\,(0.864)} = 11,097cfm$$

Answer C

47.8 A heat recovery ventilator is used to pre-heat $30°F$, 40% RH outside air with $75°F$, 50% RH exhaust air. The HRV effectiveness is 60%. What quantity of heat is recovered?

A. $4.3\frac{Btu}{lb}$

B. $6.5\frac{Btu}{lb}$

C. $10.8\frac{Btu}{lb}$

D. $27.1\frac{Btu}{lb}$

Let State 1 refer to the entering outside air condition. Let State 2 refer to the leaving outside air after being heated through the ventilator. Let State 3 refer to the entering return air condition. Ignore the leaving exhaust air as it is not relevant.

Recall the distinction between *heat* recovery and *energy* recovery. Energy recovery devices transmit latent energy in addition to sensible heat. Heat-Recovery devices drive exclusively Sensible Energy Recovery and the humidity need not be considered. Therefore, the effectivenss of a heat recovery ventilator is given by a the ratio of ΔT_{actual} to ΔT_{ideal}. (Energy recovery effectiveness would depend on changes in enthalpy rather than temperature.)

$$\varepsilon = \frac{\Delta T_{actual}}{\Delta T_{ideal}} = \frac{T_2 - 30°F}{75°F - 30°F} = 0.6$$

$$T_2 = 57°F$$

The total heat transfer by the heat recovery device is given by the equation below. Sicne there is no mass flow rate or volume rate given and the problem is asking for the quantity of heat rather than the rate of heat transfer, divide both sides by $\dot{m}$ and solve for q, heat per unit mass. The delta T is the actual increase in temperature experienced by the outside air.

$$\dot{Q} = \dot{m} c_p \Delta T$$

$$\frac{\dot{Q}}{\dot{m}} = q = c_p \Delta T = \left(0.24\frac{Btu}{lb \cdot °F}\right)(57°F - 30°F) = 6.48\frac{Btu}{lb}$$

Answer B