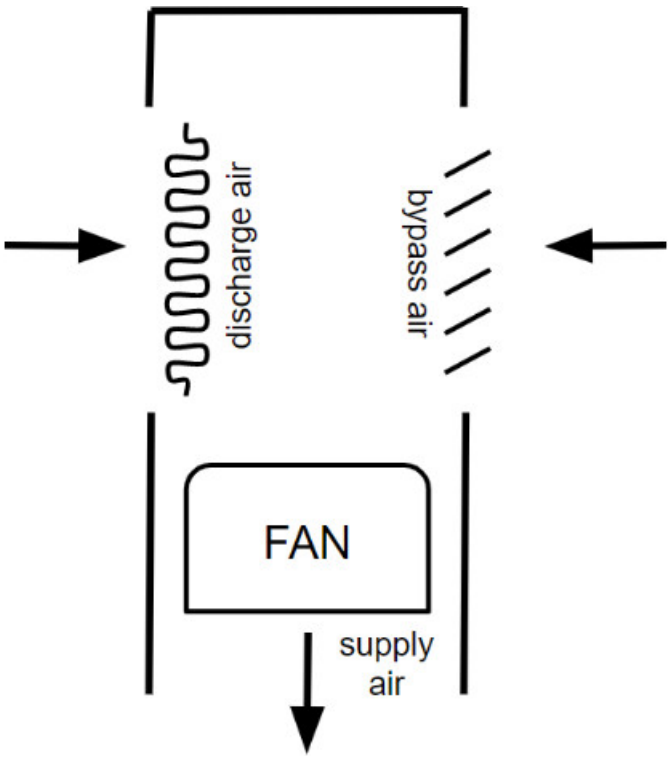
43.23 **A room with a sensible cooling load of $10tons$ and a latent load of $5\frac{gal}{hr}$ is maintained at $74°F$ and 50% RH by an air column with bypass as shown. After bypass air is mixed with fully saturated discharge air from the coil, the mixed air is supplied to the room at $63°F$. What percentage of the total supply air volume bypasses the coil?**



A. 37%

B. 43%

C. 57%

D. 63%

Determine the sensible load in $\frac{Btu}{hr}$:

$$\dot{Q}_s = (10tons)\left(12,000\frac{\frac{Btu}{hr}}{ton}\right) = 120,000\frac{Btu}{hr}$$

Determine the latent load in $\frac{Btu}{hr}$. Look up the latent vaporization of steam, h_{fg}, at the room (return) temperature, $T = 74°F$ using the steam table, Properties of Saturated Water. If pressed for time, assume $h_{fg} \approx 1000\frac{Btu}{lb}$.

$$\dot{Q}_L = \dot{m}\Delta h = \rho \dot{V} h_{fg}$$

$$\dot{Q}_L = \left(5\frac{gal}{hr}\right)\left(\frac{1ft^3}{7.48gal}\right)\left(\frac{62.4lb}{1ft^3}\right)\left(1051\frac{Btu}{lb}\right) = 43,839\frac{Btu}{hr}$$

Calculate the Sensible Heat Ratio:

$$SHR = \frac{\dot{Q}_s}{\dot{Q}_t} = \frac{\dot{Q}_s}{\dot{Q}_s + \dot{Q}_L} = \frac{120,000\frac{Btu}{hr}}{120,000\frac{Btu}{hr} + 43,839\frac{Btu}{hr}} = 0.73$$

Use the protractor on the top left corner of the Psychrometric Chart to draw a line with the slope $SHR = 0.73$ and draw a parallel line on the actual psych chart passing through the room condition, $T = 74°F$, $\phi = 50\%$. The intersection of this process line with the saturation curve is the physical temperature of the coil, i.e. apparatus dew point (ADP).

$$T_{ADP} = 44°F$$

Calculate the coil efficiency and bypass factor for the air column. The bypass factor represents the percentage of supply air volume bypassing the coil.

$$\eta_{coil} = \frac{T_{return} - T_{supply}}{T_{return} - T_{ADP}} = \frac{74°F - 63°F}{74°F - 44°F} = .37$$

$$BF = 1 - \eta_{coil} = 1 - .37 = .63 = 63\%$$

Note the large amount of bypass is an intentional aspect of the design for dehumidification purposes and not a reflection of poor performance in this application.

Answer D