47.13 What is the equivalent diameter of a $18in \times 24in$ rectangular duct?

A. $20in$

B. $21in$

C. $22in$

D. $23in$

Use the formula under Rectangular Ducts to find the circular equivalent of a rectangular duct with sides lengths a and b. Substitute into the equation the known side lengths in in and the final result will be determined in in as well. Assignment of a and b is arbitrary as both addition and multiplication are commutative.

$$D_e = \frac{1.30\,(ab)^{0.625}}{(a+b)^{0.25}}$$

$$D_e = \frac{1.30\,(18 \cdot 24)^{0.625}}{(18+24)^{0.25}} = \frac{1.3\,(432)^{0.625}}{(42)^{0.25}} = 22.7in$$

Answer D

47.14 An unoccupied space has $10KW$ of computer equipment and lighting and a moisture load of $12\frac{lb}{hr}$ of water vapor. What is the sensible heat ratio?

A. 0.25

B. 0.34

C. 0.75

D. 2.93

Use the formula for the Sensible Heat Ratio. The total heat gain is the sum of the sensible load and latent load.

$$SHR = \frac{sensible\,heat\,gain}{total\,heat\,gain} = \frac{\dot{Q}_S}{\dot{Q}_S + \dot{Q}_L}$$

The sensible load is composed of the computer equipment and lighting. Convert the units of KW to $\frac{Btu}{hr}$.

$$\dot{Q}_S = (10KW)\left(3412\frac{Btu}{hr \cdot KW}\right) = 34,120\frac{Btu}{hr}$$

The latent load (i.e. moisture load) is a function of the mass flow rate of water vapor being added to the air and the latent heat of vaporation, h_{fg}, of that water vapor, which depends on temperature and pressure. Since no temperature or pressure information is given, assume standard atmospheric conditions. Use the Properties of Saturated Water and Steam (Pressure) table to obtain the value of h_{fg} at atmospheric pressure.

$$P = 14.7psia$$

$$h_{fg} \approx 970\frac{Btu}{lb}$$

Hint: When making approximations of latent load due to moisture, consider assuming $h_{fg} \approx 1000\frac{Btu}{lb}$ to save time.

Calculate the latent load.

$$\dot{Q}_L = \dot{m}\Delta h = \dot{m}\Delta h_{fg} = \left(12\frac{lb}{hr}\right)\left(970\frac{Btu}{lb}\right) = 11,640\frac{Btu}{hr}$$

Solve for SHR.

$$SHR = \frac{\dot{Q}_S}{\dot{Q}_S + \dot{Q}_L} = \frac{34,120\frac{Btu}{hr}}{34,120\frac{Btu}{hr} + 11,640\frac{Btu}{hr}} = 0.746$$

Answer C

47.15 A $10lb_m$ mass hangs from a spring and damper assembly. The spring has a spring constant of $100\frac{lb_f}{in}$. The damping ratio is 0.6. What is the damped frequency of the system?

A. $6Hz$

B. $8Hz$

C. $10Hz$

D. $12Hz$

Find the natural frequency of the system as though no damping was present. The undamped natural circular frequency is given by the equation below.

$$\omega_n = \sqrt{\frac{kg_c}{m}} = \sqrt{\frac{\left(100\frac{lb_f}{in}\right)\left(12\frac{in}{ft}\right)\left(32.2\frac{lb_m \cdot ft}{lb_f \cdot s^2}\right)}{10lb_m}} = 62.2\frac{rad}{s}$$

Find the Damped Natural Frequency which accounts for the damping ratio.

$$\omega_d = \omega_n\sqrt{1-\varsigma^2} = \left(62.2\frac{rad}{s}\right)\sqrt{1-(0.6)^2} = 49.7\frac{rad}{s}$$

Since the answer choices are in Hz, find the corresponding damped *linear* frequency. Note the final units of "cycles per second" is the same as Hz.

$$f_d = \frac{\omega_d}{2\pi} = \frac{49.7\frac{rad}{s}}{2\pi\frac{rad}{cycle}} = 7.9Hz$$

Answer B