46.26 $200\frac{lb}{hr}$ **of** $5psig$ **saturated steam enters a heating coil which supplies** $100MBH$**. What percent of the exiting steam is in a liquid phase?**

A. 44%

B. 48%

C. 52%

D. 56%

Consider the saturated steam entering the coil as State 1 and the saturated mixture leaving the coil as State 2.

Use the Properties of Saturated Water and Steam table to obtain the enthalpy at State 1.

$$P_1 = 5psig \approx 20psia$$

$$h_1 = h_g = 1156.19\frac{Btu}{lb}$$

The total heat transfer and mass flow rate are given. Determine the enthalpy at State 2.

$$\dot{Q} = \dot{m}\Delta h = \dot{m}\left(h_1 - h_2\right)$$

$$h_2 = h_1 - \frac{\dot{Q}}{\dot{m}} = 1156.19\frac{Btu}{lb} - \frac{100,000\frac{Btu}{hr}}{200\frac{lb}{hr}} = 656.19\frac{Btu}{lb}$$

Determine the quality at State 2. Use the steam table to obtain enthalpy values h_f and h_{fg}. The quality is the fraction of the saturated mixture that is in a *vapor* phase.

$$h_f = 196.25\frac{Btu}{lb}$$

$$h_{fg} = 959.94\frac{Btu}{lb}$$

$$\chi_2 = \frac{h_2 - h_f}{h_{fg}} = \frac{656.19\frac{Btu}{lb} - 196.25\frac{Btu}{lb}}{959.94\frac{Btu}{lb}} = 0.479$$

The fraction of the water that is in a *liquid* phase is the complement of the quality.

$$1 - \chi_2 = 1 - 0.479 = 0.521 \approx 52\%$$

Answer C

46.27 A $5lbm$ mass hangs from a spring with a spring constant of $15\frac{lbf}{in}$. What is the linear frequency of vibration for the system?

A. $1Hz$

B. $5Hz$

C. $11Hz$

D. $34Hz$

Sketch and label the system. Search for Free Vibration and apply the formula for the natural frequency which is a function of the mass and the spring constant. Since the problem uses US Customary units, it will be necessary to include the gravitational constant, g_c, for consistency. This is not required for similar problems using SI units. Solve for the natural frequency.

$$\omega_n = \sqrt{\frac{kg_c}{m}} = \sqrt{\frac{\left(15\frac{lbf}{in}\right)\left(12\frac{in}{ft}\right)\left(32.2\frac{ft \cdot lb_m}{s^2 \cdot lb_f}\right)}{5lb_m}} = 34.05\frac{rad}{s}$$

Infer the relationship between linear frequency, f, and natural frequency, ω_n, using the equations for the period shown on the same page under the phrase: Undamped Natural Period of Vibration. Solve for the linear frequency, f. The units associated with 2π are implied to be radians per cycle, such that the linear frequency ultimately has units of cycles (or oscillations) per second aka Hz.

$$\frac{2\pi}{\omega_n} = \frac{1}{f}$$

$$f = \frac{\omega_n}{2\pi} = \frac{34.05\frac{rad}{s}}{2\pi\frac{rad}{cycle}} = 5.42\frac{cycles}{s} = 5.42Hz$$

Answer B

46.28 A museum is maintained at $68°F$ and 45% relative humidity. What is the vapor pressure of the space?

A. $0.15in\,Hg$

B. $0.31in\,Hg$

C. $0.34in\,Hg$

D. $0.69in\,Hg$

Use the definition of Relative Humidity, which is the ratio of the vapor pressure and the maximum possible pressure of water vapor in air at a given temperature, the saturation pressure.

$$\phi = \frac{p_w}{p_{ws}}$$

Use the table Properties of Saturated Water and Steam (Temperature) to obtain the saturation pressure for $68°F$ water.