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.

$$T = 68°F$$

$$p_{ws} = 0.34psia$$

Solve for the vapor pressure.

$$p_w = \phi p_{ws} = (0.45)(0.34psia) = 0.153psia$$

Convert from $psia$ to $in\,Hg$. Refer to Measurement Relationships for necessary converstions.

$$p_w = (0.153psia)\left(\frac{2.036in\,Hg}{1psi}\right) = 0.31in\,Hg$$

Answer B

46.29 Saturted liquid water at $50psig$ is boiled in a sealed vessel at constant pressure until one third of the water by mass has changed to a vapor phase. What is the change in entropy of the mixture during this process?

A. $0.40\frac{Btu}{lb_m \cdot °R}$

B. $0.42\frac{Btu}{lb_m \cdot °R}$

C. $0.80\frac{Btu}{lb_m \cdot °R}$

D. $0.83\frac{Btu}{lb_m \cdot °R}$

Start by finding the entropy for the initial condition, State 1. Since the water is a saturated liquid, the entropy at State 1 corresponds to s_f for the pressure given. Use the table Properties of Saturated Water and Steam (Pressure) to obtain the entropy, s_1.

$$P_1 = 50psig \approx 65psia$$

$$s_1 = s_f = 0.4344\frac{Btu}{lb_m \cdot °R}$$

Also obtain the entropy of vaporation, s_{fg}, from the same line in the steam table for use in the following step.

$$s_{fg} = 1.2035\frac{Btu}{lb_m \cdot °R}$$

Since the water is boiled at constant pressure until a third of the mass has changed to vapor, the quality at State 2, χ_2, is $\frac{1}{3}$. This is the definition of quality.

$$\chi_2 = \frac{m_{vapor}}{m_{vapor} + m_{liquid}} = \frac{m_{vapor}}{m_{total}} = \frac{1}{3}$$