1. For the beam shown in Figure 1, calculate the $C_b$ value. Lateral bracing is provided at the support points only.

2. Assuming the length $L$ in Figure 2 is long enough that lateral-torsional buckling controls, which of the following is true about the flexural strength of beam segments A? It is:
   a) Equal to the flexural strength of segment B
   b) Greater than the flexural strength of segment B
   c) Less than the flexural strength of segment B

3. Given: From AISC Manual Table 3-6, the $L_p$ value for a W18x35 beam is equal to 4.31 ft. The beam below has an unbraced length of 6 ft. True or False: The nominal flexural strength of the beam will be less than $M_p = F_y Z_x$.

4. True or False: $C_b$ values are routinely useful in the design of HSS used as beams.

This month’s Steel Quiz looks at the use of design tables in the AISC Steel Construction Manual.
1. Use Specification Equation (F1-1) to determine $C_b$.

$$M_{max} = M_B = \frac{w \times L^2}{8} = \frac{1.5 \text{kip} - \text{ft} \times 30 \text{ft}^2}{8} = 169 \text{ kip - ft}$$

$$M_A = M_C = \frac{w \times x}{2} (L-x) = \frac{1.5 \text{kip} - \text{ft} \times 7.5 \text{ft}}{2} (30 \text{ft} - 7.5 \text{ft}) = 127 \text{ kip - ft}$$

$$C_b = \frac{12.5M_{max}}{2.5M_{max} + 3M_A + 4M_B + 3M_C} = \frac{12.5 \times 169}{6.5 \times 169 + 6 \times 127} = 1.14$$

Note that this $C_b$ value, and many others for common cases, are provided in AISC Manual Table 3-1.

2. Greater than the flexural strength of segment B. The $C_b$ value for segments A is greater than that for segment B. Given that LTB controls the design, this is true because all other variables in AISC Specification Equation F2-2 are constant. The $C_b$ value for each segment is shown in Figure 4 below and can be determined via the User Note in Section F1, where $C_b = 1.0$ for the case of equal end moments of opposite sign (uniform moment) and $C_b = 1.67$ when one end moment equals zero. Also, see AISC Manual Table 3-1.

3. False. Per AISC Specification Equation F2-2, the nominal flexural strength is equal to the plastic bending moment, $M_p = F_yZ_x$ (because of the effect of $C_b$). Per AISC Manual Table 3-6, $L_L = 4.31 \text{ ft}$ and $L_C = 12.3 \text{ ft}$. Per AISC Manual Table 3-1, $C_b = 1.11$ for the two interior segments (the outer segments have a higher value of $C_b$). Per Table 1-1, $S_x = 57.6 \text{ in.}^3$, $Z_x = 66.5 \text{ in.}^3$.

$$M_p = F_yZ_x = 50 \text{ ksi} \times 66.5 \text{ in.}^3 = 3,330 \text{ kip - in.}$$

$$M_n = C_b(M_p - 0.7F_yS_x)\left(\frac{L_L - L_C}{L_L - L_C}\right) \leq M_p$$

$$= 1.11 \left[3,330 - (3,330 - 0.7 \times 50 \times 57.6)\left(\frac{6 - 4.31}{12.3 - 4.31}\right)\right] \leq$$

$$= 3,380 \text{ kip - in.} \leq 3,330 \text{ kip - in.}$$

Therefore, the design is controlled by yielding and $M_n = M_p$. Note that AISC Specification Commentary Figure C-F1.2 clearly illustrates the effect $C_b$ can have on the nominal flexural strength, $M_n$.

4. False. HSS beams are generally not sensitive to lateral-torsional buckling—because their torsional strength and stiffness are so high—and so their strength is governed by the yield or local buckling strength of the member. Therefore, $C_b$ rarely impacts the design of an HSS beam.