function can be used to determine the constant of integration C_3. A line is drawn in Figure 10-12*b* from the origin to the point on the curve at $z = 5$ where the function should be zero. The slope of this straight line is the constant C_3 for the *y* direction, which is found from

$$C_{3_y} = \tan^{-1}\frac{error_y}{z_{R2}} = \tan^{-1}\frac{0.0007}{5.0} = 0.00014 \text{ rad} \tag{f}$$

The constant for the *x* direction is found in similar manner. The functions are then recalculated using the correct values of C_3.

7 These deflection functions are plotted in Figure 10-13 for the shaft diameters of $d_0 = 0.875$, $d_1 = 0.750$, $d_2 = 0.669$, $d_3 = 0.531$ from Example 10-2. The magnitude of the deflection at the gear is 0.000 3 in, which is well within the requested specification. At the sheave the deflection is 0.001 in, also within the specification. The deflection at the right-hand end of the shaft is 0.002 in. Files EX10-03a and EX09-02b are on the CD-ROM.

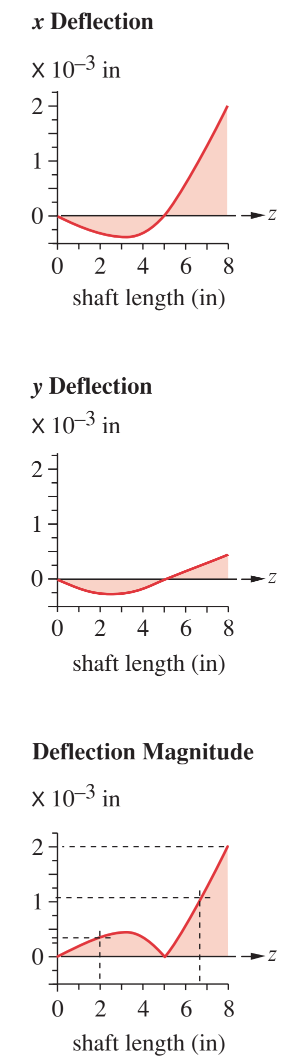

FIGURE 10-13

Deflection Functions for Example 10-3

10.10 KEYS AND KEYWAYS

The ASME defines a **key** as "*a demountable machinery part which, when assembled into keyseats, provides a positive means for transmitting torque between the shaft and hub*." Keys are standardized as to size and shape in several styles.* A **parallel key** is square or rectangular in cross section and of constant height and width over its length. (See Figure 10-14*a*.) A **tapered key** is of constant width but its height varies with a linear taper of 1/8 in per foot, and it is driven into a tapered slot in the hub until it locks. It may either have no head or have a **gib head** to facilitate removal. (See Figure 10-14b.) A **Woodruff key** is semicircular in plan and of constant width. It fits in a semicircular keyseat milled in the shaft with a standard circular cutter. (See Figure 10-14*c*.) The tapered key serves to lock the hub axially on the shaft, but the parallel or Woodruff keys require some other means for axial fixation. Retaining rings or clamp collars are sometimes used for this purpose.

Parallel Keys

Parallel keys are the most commonly used. The ANSI and ISO standards each define particular key cross-sectional sizes and keyseat depths as a function of shaft diameter at the keyseat. A partial reproduction of this information is provided in Table 10-2 for the lower range of shaft diameters. Consult the respective standards for larger shaft sizes. Square keys are recommended for shafts up to 6.5-in dia (US), or 25 mm-dia (ISO), and rectangular keys for larger diameters. The parallel key is placed with half of its height in the shaft and half in the hub, as shown in Figure 10-14*a*.

Parallel keys are typically made from standard cold-rolled bar stock, which is conventionally "negatively toleranced," meaning it will never be larger than its nominal dimension, only smaller. For example, a nominal 1/4-in square bar will have a tolerance on width and height of +0.000, –0.002 in. Thus, the keyseat can be cut with a standard 1/4-in milling cutter and the bar stock key will fit with slight clearance. A special

* ANSI standard B17.1-1967, *Keys and Keyseats*, and B17.2-1967, *Woodruff Keys and Keyseats*, available from the American Society of Mechanical Engineers, 345 East 47th St., New York, N.Y. 10017.