31. We adopt the positive direction choices used in the textbook so that equations such as Eq. 4-22 are directly applicable. The coordinate origin is at the the initial position for the football as it begins projectile motion in the sense of §4-5), and we let θ_0 be the angle of its initial velocity measured from the $+x$ axis.

(a) $x = 46\,\text{m}$ and $y = -1.5\,\text{m}$ are the coordinates for the landing point; it lands at time $t = 4.5\,\text{s}$. Since $x = v_{0x}t$,

$$v_{0\,x} = \frac{x}{t} = \frac{46\,\text{m}}{4.5\,\text{s}} = 10.2\ \text{m/s}\ .$$

Since $y = v_{0y}t - \frac{1}{2}gt^2$,

$$v_{0\,y} = \frac{y + \frac{1}{2}gt^2}{t} = \frac{(-1.5\,\text{m}) + \frac{1}{2}(9.8\,\text{m/s}^2)(4.5\,\text{s})^2}{4.5\,\text{s}} = 21.7\ \text{m/s}\ .$$

The magnitude of the initial velocity is

$$v_0 = \sqrt{v_{0\,x}^2 + v_{0\,y}^2} = \sqrt{(10.2\,\text{m/s})^2 + (21.7\,\text{m/s})^2} = 24\ \text{m/s}\ .$$

(b) The initial angle satisfies $\tan\theta_0 = v_{0\,y}/v_{0\,x}$. Thus, $\theta_0 = \tan^{-1}(21.7/10.2) = 64.8°$.