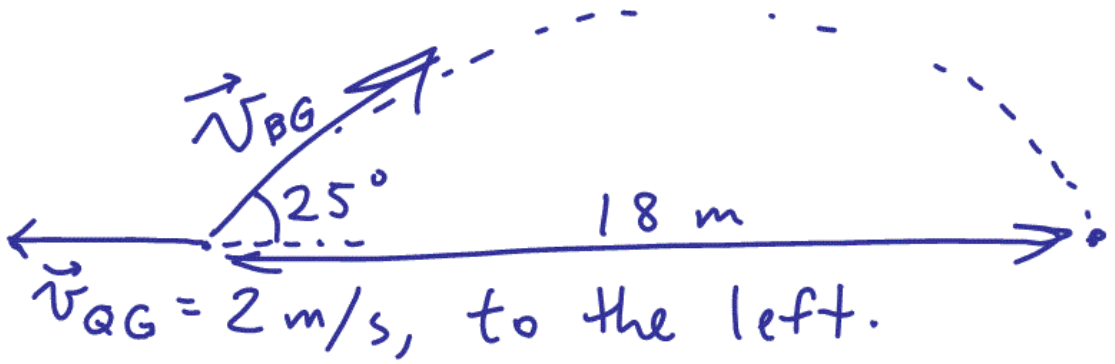
Problem 3.77

A football quarterback is moving straight backward at a speed of 2.00 m/s when he throws a pass to a player 18.0 m straight downfield. The ball is thrown at an angle of 25.0° relative to the ground and is caught at the same height as it is released. What is the initial velocity of the ball *relative to the quarterback*?



Range = 18 m.. This was solved in the lesson 8 video:

$$R = \frac{v_0^2 \sin 2\theta_0}{g}$$

v_0 = magnitude of $\vec{v}_{BG}$

$\theta_0 = 25°$, $R = 18\,m$ Solve for v_{BG}:

$$R = \frac{v_{BG}^2 \sin 2\theta_0}{g}$$

$$v_{BG}^2 = \frac{Rg}{\sin 2\theta_0}$$

$$v_{BG} = \sqrt{\frac{Rg}{\sin 2\theta}} = \sqrt{\frac{18(9.8)}{\sin(2\times 25)}}$$

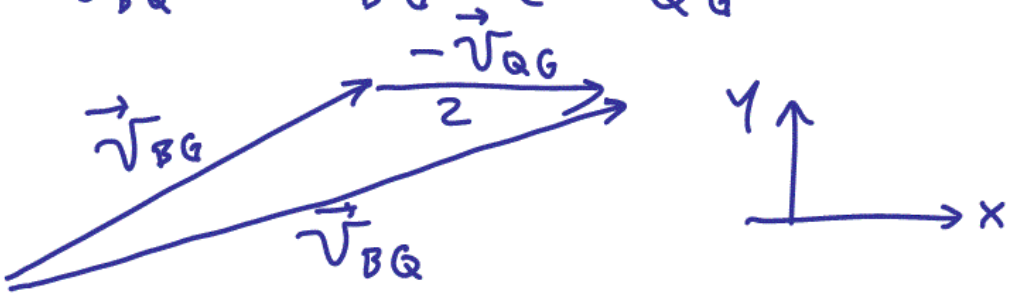
$$= 15.1748 \text{ m/s}$$

So $\vec{v}_{BG} = 15.1748$ m/s, 25° above horizontal to the right.

We want $\vec{v}_{BQ}$:

$$\vec{v}_{BQ} = \vec{v}_{BG} + \vec{v}_{GQ}$$

$$\vec{v}_{BQ} = \vec{v}_{BG} + (-\vec{v}_{QG})$$



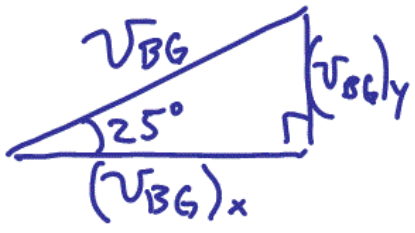
Use components:

$$(-v_{QG})_x = +2 \text{ m/s}$$

$$(-v_{QG})_y = 0$$

$$(v_{BG})_x = v_{BG}\cos 25°$$

$$(v_{BG})_y = v_{BG}\sin 25°$$



$$(v_{BQ})_x = v_{BG}\cos 25° + 2 = 15.1748\cos 25° + 2$$

$$= 15.75302 \text{ m/s}$$

$$(v_{BQ})_y = 15.1748 \sin 25 + 0 = 6.4131 \text{ m/s}$$

$$v_{BQ} = \sqrt{(v_{BQ})_x^2 + (v_{BQ})_y^2}$$

$$= 17.0084 \text{ m/s}$$

$$\theta = \tan^{-1}\left(\frac{(v_{BQ})_y}{(v_{BQ})_x}\right) = 22.1515^\circ$$

$\vec{v}_{BQ} = 17.0$ m/s, 22.2° above horizontal