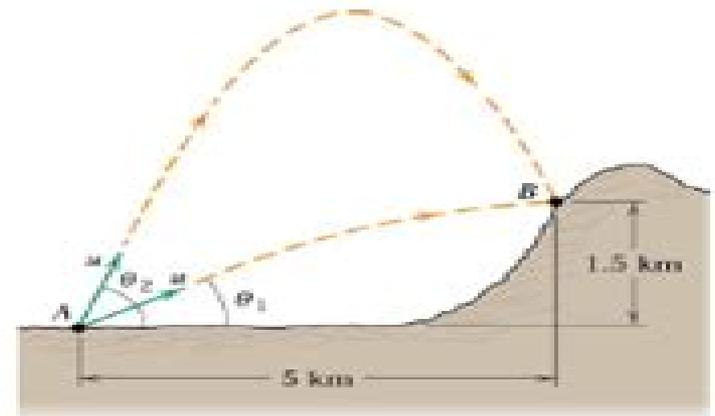## 2.2 Problem 2/87 (Rectangular Coordinates)

A long-range rifle is fired at A with the projectile hitting the mountain at B. (a) If the muzzle velocity is u V 400 m/s, determine the two angles of elevation θ which will permit the projectile to hit the mountain target B and plot the two trajectories. (b) Determine the smallest muzzle velocity that will allow the projectile to strike at B and the angle at which it must be fired. Repeat the plot for part (a) and include the trajectory of the projectile for this minimum initial velocity.

Problem Formulation

Place a coordinate system at A with x positive to the right and y positive up. The initial components of the velocity are,

$$(v_x)_0 = u\cos\theta \qquad\qquad (v_y)_0 = u\sin\theta$$

The acceleration is constant with components $a_x = 0$ and $a_y = -g$. Integrating these two accelerations twice and applying initial conditions yields (see page 44 of your text if you need additional details),

$$x = u\cos\theta\, t \qquad\qquad y = u\sin\theta\, t - 1/2 g t^2$$

Plotting y in terms of x for different times t will yield the trajectory of the projectile. This type of plot is called a *parametric plot* since the items plotted (x and y) are each known in terms of another parameter (t).

Anytime you have a projectile motion problem and you know the coordinates of a point on the trajectory (our point B) you should solve for x and y (as we have done above) and then obtain two equations by substituting the coordinates of the points. These two equations can then be solved for two unknowns. Note that in most cases one of the two unknowns will be the time of flight.

Part (a) Substituting $x = 5,000$ m, $y = 1,500$ m and $u = 400$ m/s gives

$$5000 = 400\cos\theta\, t \qquad\qquad 1500 = 400\sin\theta\, t - 1/2(9.81)t^2$$

Solving Dynamics Problems With Mathcad

Caroline Baillie,Ivan Moore

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