Physics 2414, Spring 2005
Group Exercise 4, Feb 24, 2005

Name 1: _____ OUID 1: _____

Name 2: Solutions OUID 2: Solutions

Name 3: _____ OUID 3: _____

Name 4: _____ OUID 4: _____

Section Number: ____

Kinematics

Notation

a_x is the component of the vector $\vec{\mathbf{a}}$ along the x direction.

a_y is the component of the vector $\vec{\mathbf{a}}$ along the y direction.

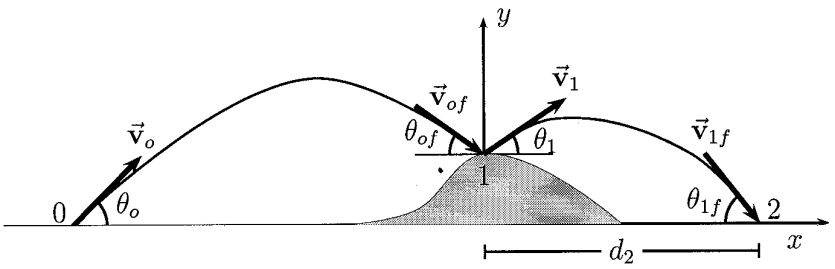

Figure 1

Problems

Gimp the golfer hits a ball at point '0' in x direction with an initial speed v_o at an angle θ_o with respect to the horizontal. The ball lands at point '1' on a hill 7.6 meters above the point '0'. The ball lands with a speed $v_{of} = 49\ ^m/_s$ at an angle of 31^o to the horizontal.

1. *Swinging up the hill:*

(a) The equations governing the motion of the ball in the uphill swing are

$$(1a) \quad v_x = v_{ox} \qquad v_y = v_{oy} - gt \tag{1}$$

$$(2a) \quad x_x = v_{ox}t \qquad y = v_{oy}t - \frac{1}{2}gt^2 \tag{2}$$

$$v_y^2 = v_{oy}^2 - 2gy \tag{3}$$

(b) Find the x-component and y-component of the velocity $\vec{\mathbf{v}}_{of}$ with which the ball hits the hill

$$v_{ofx} = + V_{of} \cos\theta_{of} = 49 \cos 31 = 42.1 \text{ m/s} \tag{4}$$

$$v_{ofy} = - V_{of} \sin\theta_{of} = -49 \sin 31 = -25.5 \text{ m/s} \tag{5}$$

(c) Before calculating the initial velocity $\vec{\mathbf{v}}_o$; why is it wrong to conclude that the magnitude of the initial velocity $\vec{\mathbf{v}}_o$ is equal to the magnitude of the final velocity $\vec{\mathbf{v}}_{of}$. Give a qualitative argument.

Because, point '0' and point '1' are at different heights.

(d) Determine the x-component of the initial velocity $\vec{\mathbf{v}}_o$.

$$v_{ox} = V_{ofx} \quad (\text{using } (1a)) \tag{6}$$
$$= 42.1 \text{ m/s} \quad (\text{using } (4))$$

(e) Determine the y-component of the initial velocity $\vec{\mathbf{v}}_o$.

$$v_{oy} = \sqrt{V_{ofy}^2 + 2gy} \quad (\text{using } (3)) \tag{7}$$
$$= \sqrt{(-25.5)^2 + 2 \times 9.8 \times 7.6} = +28.3 \text{ m/s}$$

(f) What was the initial speed (magnitude of $\vec{\mathbf{v}}_o$) of the ball?

$$|\vec{\mathbf{v}}_o| = \sqrt{V_{ox}^2 + V_{oy}^2} \tag{8}$$
$$= \sqrt{(42.1)^2 + (28.3)^2} = 50.7 \text{ m/s}$$

(g) At what direction with the horizontal (θ_o) was the ball hit?

$$\theta_o = \tan^{-1}\left(\frac{V_{oy}}{V_{ox}}\right) = \tan^{-1}\left(\frac{28.3}{42.1}\right) = 34^\circ \quad (9)$$

$\theta_o = 34^\circ$ with positive x-axis

2. *Swinging down the hill:*

Gimp hits the ball again, again in the x direction. He hits the ball from point '1' with a speed $v_1 = 40\ ^m/_s$ at an angle $\theta_1 = 30^o$ with the horizontal. The ball lands at point '2' with a speed $v_{1f} = 42\ ^m/_s$ at an angle $\theta_{1f} = 34^o$ with the horizontal.

(a) Write the equations governing the motion of the ball in the downhill swing.

(9a) — $V_x = V_{ix}$ $\qquad V_y = V_{iy} - gt$

(9b) — $x = V_{ix}\,t$ $\qquad y = V_{iy}\,t - \frac{1}{2}gt^2$

$V_y^2 = V_{iy}^2 - 2gy$

(b) Find the x-component and y-component of the velocity $\vec{v}_1$ with which the ball lands

$$v_{1x} = V_i \cos\theta_1 = 40 \cos 30 = 34.8\ m/s \quad (10)$$

$$v_{1y} = V_i \sin\theta_1 = 40 \sin 30 = 20\ m/s \quad (11)$$

(c) Find the x-component and y-component of the velocity $\vec{v}_{1f}$ with which the ball lands

$$v_{1fx} = V_{if} \cos\theta_{if} = 42 \cos 34 = 34.8\ m/s \quad (12)$$

$$v_{1fy} = -V_{if} \sin\theta_{if} = -42 \sin 34 = -23.4\ m/s \quad (13)$$

(d) How much time 't' did the ball take to reach point '2' from point '1'. (Hint: Use the equation $v_y = v_{1y} - gt$.)

$$t = \frac{V_{iy} - V_{ify}}{g} = \frac{20 - (-23.4)}{9.8} = 4.4\ sec. \quad (14)$$

(e) What is the distance d_2 between the point '1' and point '2'.

$$d_2 = V_{ix}\, t \quad (\text{using } 9b) \tag{15}$$

$$= 34.8 \times 4.4$$

$$= 153 \text{ meter}$$