

Physics 2414, Spring 2008

Group Exercise 3, Feb 7, 2008

Name 1: _____ OUID 1: _____
Name 2: _____ OUID 2: _____
Name 3: solutions OUID 3: _____
Name 4: _____ OUID 4: _____

Section Number: _____

Kinematics

Notation

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

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

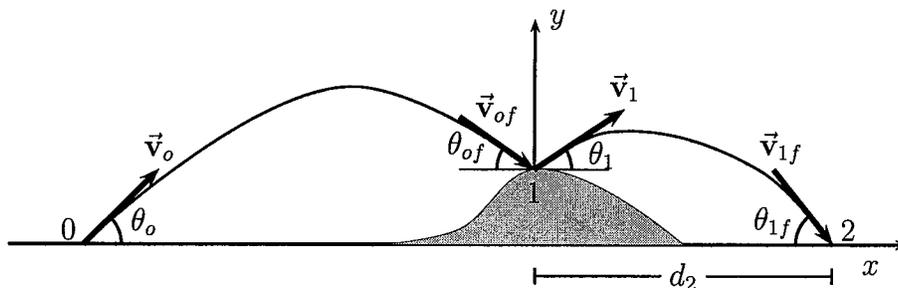


Figure 1

Problems

Given 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 $v_{of} = 49 \text{ m/s}$ at an angle of 31° to the horizontal.

1. *Swinging up the hill:*

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

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

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

$$v_y^2 = v_{oy}^2 - 2gy \quad (3)$$

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

$$v_{ofx} = V_{of} \cos \theta_{of} = 49 \text{ m/s} \cos 31^\circ = \boxed{42.0 \text{ m/s}} \quad (4)$$

$$v_{ofy} = -V_{of} \sin \theta_{of} = -49 \text{ m/s} \sin 31^\circ = \boxed{-25.5 \text{ m/s}} \quad (5)$$

(c) Before calculating the initial velocity \vec{v}_o ; why is it wrong to conclude that the magnitude of the initial velocity \vec{v}_o is equal to the magnitude of the final velocity \vec{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{v}_o .

$$v_{ox} = V_{ofx} \quad \text{no acceleration in } x\text{-direction} \quad (6)$$

$$\boxed{42.0 \text{ m/s}}$$

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

$$v_{oy} = \sqrt{v_{ofy}^2 + 2gy} \quad \text{using (3)} \quad (7)$$

$$= \sqrt{(-25.5 \text{ m/s})^2 + 2 \cdot 9.8 \text{ m/s}^2 \cdot 7.6 \text{ m}} = \boxed{+28.3 \text{ m/s}}$$

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

$$|\vec{v}_o| = \sqrt{v_{ox}^2 + v_{oy}^2} \quad (8)$$

$$= \sqrt{(42.0 \text{ m/s})^2 + (28.3 \text{ m/s})^2} = \boxed{50.7 \text{ m/s}}$$

(g) At what direction with the horizontal (θ_0) was the ball hit?

$$\theta_0 = \tan^{-1} \left(\frac{v_{0y}}{v_{0x}} \right) = \tan^{-1} \left(\frac{28.3 \text{ m/s}}{42.1 \text{ m/s}} \right) = 34^\circ \quad (9)$$

$$\theta_0 = 34^\circ \text{ with positive } x\text{-axis}$$

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 $v_1 = 40 \text{ m/s}$ at an angle $\theta_1 = 30^\circ$ with the horizontal. The ball lands at point '2' with a speed $v_{1f} = 42 \text{ m/s}$ at an angle $\theta_{1f} = 34^\circ$ with the horizontal.

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

$$\begin{aligned} v_x &= v_{1x} & v_y &= v_{1y} - gt \\ x &= v_{1x} t & y &= v_{1y} t - \frac{1}{2} g t^2 \\ & & v_y^2 &= v_{1y}^2 - 2gy \end{aligned}$$

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

$$v_{1x} = v_1 \cos \theta_1 = 40 \text{ m/s} \cos 30^\circ = 34.8 \text{ m/s} \quad (10)$$

$$v_{1y} = v_1 \sin \theta_1 = 40 \text{ m/s} \sin 30^\circ = 20 \text{ m/s} \quad (11)$$

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

$$v_{1fx} = v_{1f} \cos \theta_{1f} = 42 \text{ m/s} \cos 34^\circ = 34.8 \text{ m/s} \quad (12)$$

$$v_{1fy} = -v_{1f} \sin \theta_{1f} = -42 \text{ m/s} \sin 34^\circ = -23.4 \text{ m/s} \quad (13)$$

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

$$t = \frac{v_{1y} - v_{1fy}}{g} = \frac{20 \text{ m/s} - (-23.4 \text{ m/s})}{9.8 \text{ m/s}^2} = 4.4 \text{ s} \quad (14)$$

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

$$d_2 = v_1 t \quad (15)$$

$$= 34.8 \text{ m/s} \cdot 4.4 \text{ s}$$

$$= \boxed{153 \text{ m}}$$