San Francisco Bay University

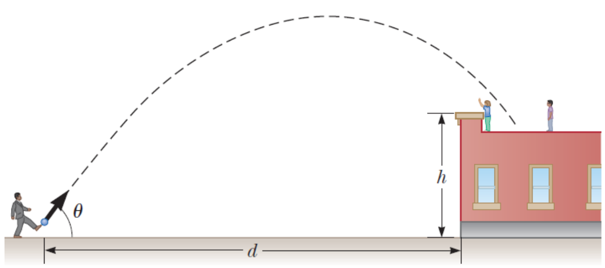
PHYS201 Physics - I
Homework #3

Due day: 6/30/2024

Instruction:

1. **Homework answer sheet should contain the original questions and corresponding answers.**
2. **Recommend writing the Python program for any calculation, and then copy & paste source code and running results on the answer sheet**
3. **Overdue homework submission could not be accepted.**
4. **Takes academic honesty and integrity seriously (Zero Tolerance of Cheating & Plagiarism)**

1. A playground is on the flat roof of a city school, 6.00 m above the street below. The vertical wall of the building is $h = 7.00\text{m}$ high, forming a 1-m-high railing around the playground. A ball has fallen to the street below, and a passerby returns it by launching it at an angle of $\theta = 53.0°$ above the horizontal at a point $d = 24.0\ m$ from the base of the building wall. The ball takes 2.20s to reach a point vertically above the wall. (a) Find the speed at which the ball was launched. (b) Find the vertical distance by which the ball clears the wall. (c) Find the horizontal distance from the wall to the point on the roof where the ball lands.



(a) For the horizontal motion, we have $x_f = d = 24\text{m}$:

$$x_f = x_i + v_{xi}t + \frac{1}{2} a_x t^2$$

$$24\text{m} = 0 + v_i\,(\text{Cos}53)\,(2.2\text{s}) + 0$$

$$v_i = 18.1\ \text{m/s}$$

b. As it passes over the wall, the ball is above the street by

$$y_f = y_i + v_{yi}t + \frac{1}{2} a_y t^2$$

$$= 0 + (18.1 m/s) (Sin53) (2.2s) + \frac{1}{2} (-9.8 m/s^2) (2.2s)^2$$

$$= 8.13m$$

Hence, it clears the ball by 8.13m – 7m = 1.13m

c. Since the highest point of the ball's trajectory is not directly above the wall. For the whole flight, we have from the trajectory equation:

$$y_f = (\tan\theta_i)\, x_f - \left(\frac{g}{2Vi^2 Cos^2\theta i}\right) x^2{}_f$$

$$6m = (\tan 53)\, x_f - \left(\frac{9.8 m/s^2}{2(18.1 ms^{-1})^2\ Cos^2 53}\right) x^2{}_f$$

Solving this, we get:

$$(0.0412\ m^{-1})\, x^2{}_f - 1.33\, x_f + 6m = 0$$

And, suppressing units,

$$x_f = \frac{1.33 \pm \sqrt{1.33^2 - 4(0.0412)(6)}}{2(0.0412)}$$

This gives us two results,

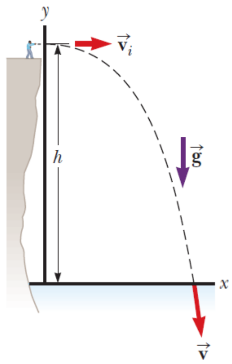
$$x_f = 26.8m \text{ or } 5.44m$$

Since the question asks for the horizontal distance from the wall to the point on the roof where the ball lands, we should consider the first intersection point which is 26.8m here.

The ball passes twice through the level of the roof.

It hits the roof at a distance from the wall 26.8m – 24m = 2.79m

2. A student stands at the edge of a cliff and throws a stone horizontally over the edge with a speed of $v_i = 18.0\ m/s$. The cliff is $h = 50.0\ m$ above a body of water as shown (a) What are the coordinates of the initial position of the stone? (b) What are the components of the initial velocity of the stone? (c) What is the appropriate analysis model for the vertical motion of the stone? (d) What is the appropriate analysis model for the horizontal motion of the stone? (e) Write symbolic equations for the x and y components of the velocity of the stone as a function of time. (f) Write symbolic equations for the position of the stone as a function of time. (g) How long after being released does the stone strike the water below the cliff? (h) With what speed and angle of impact does the stone land?



a. The coordinates of the initial velocity of the stone are:

$x_o = 0$

$y_o = 50$

b. The initial velocity has the horizontal component of Vxi = 18m/s and vertical component of Vyi = 0m/s since the stone is thrown vertically.

c. The stone's vertical motion can be analyzed as a free fall motion with constant downward acceleration due to gravity $g=9.8m/s^2$

d. The stone's horizontal motion can be analyzed as a motion with a constant horizontal velocity, since there is nothing accelerating or decelerating the object in the horizontal direction.

e. Symbolic equations for the x and y components of the velocity of the stone as a function of time:

Horizontal velocity component (constant): $V_{xf} = V_{xi} = 18m/s$

Vertical velocity component: $V_{yf} = V_{yi} + a_y t = V_y f = -gt = -9.8t$ m/s

f. Symbolic equations for the x and y components of the velocity of the stone as a function of time is:

$X_f = x_i + V_{xi}t + ½\, a_x t^2$

$X_f = V_{xi}t$

$y_f = y_i + v_{yi}t + ½\, a_y t^2$

$y_f = -½\, gt^2$

g. The time of impact is given by:

$$yf = -\frac{1}{2} gt^2$$

$$-h = -\frac{1}{2} gt^2$$

$$t = \sqrt{\frac{2h}{g}}$$

$$t = \sqrt{\frac{2(50.0)m}{9.80\ m/s^2}}$$

$$= 3.19 \text{ sec}$$

h. At impact, $V_{xf} = V_{xi} = 18.0$m/s. and the vertical component is:

$$V_{yf} = -gt$$

$$= -g\sqrt{\frac{2h}{g}}$$

$$= -\sqrt{2gh}$$
$$= -\sqrt{2 * (9.80) * 50}$$
$$= -31.3 \text{ m/s}$$

Thus,

$$V_f = \sqrt{Vxf^2 + Vyf^2}$$

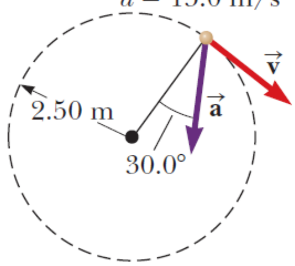
$$= \sqrt{(18.0ms^{-1})^2 + (-31.3ms^{-1})^2}$$

$$= 36.1 \text{ m/s}$$

The angle of impact is:

$$\theta_f = \mathrm{Tan}^{-1}(\ Vyf / Vxf)$$
$$= \mathrm{Tan}^{-1}(\ -31.3 / 18.0)$$
$$= -60.1 \text{ degree}$$

3. The following figure represents the total acceleration of a particle moving clockwise in a circle of radius 2.50 m at a certain instant of time. For that instant, find (a) the radial acceleration of the particle, (b) the speed of the particle, and (c) its tangential acceleration.



From the given magnitude and direction of the acceleration we can find both the centripetal and the tangential components. From the centripetal acceleration and radius we find the speed in part (b).

The radius of the circular path is, r= 2.50m
The acceleration of the particle is, a= 15m/s^2

a) The acceleration has an inward radial component. So,

a_c= a Cos30
= $15\mathrm{m/s^2}$ * Cos30
= $13\mathrm{m/s^2}$

(b) The speed at the instant shown can be found by using

$a_c = v^2 / r$
$13 = v^2 / 25$
$v^2 = 32$
v = 5.70m/s

c.) For tangential acceleration

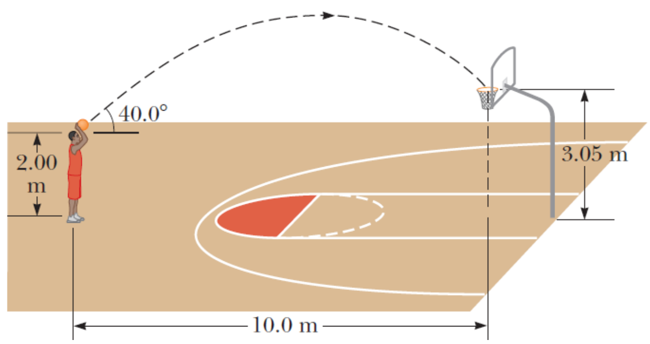
$a^2 = a_t^2 + a_r^2$

So, at = $\sqrt{a^2 - ar^2}$

= $\sqrt{(15)^2 - (13)^2}$

= $7.50\mathrm{m/s^2}$

4. A basketball player is standing on the floor 10.0 m from the basket as shown. The height of the basket is 3.05 m, and he shoots the ball at *a* 40.0° angle with the horizontal from a height of 2.00 m. (a) What is the acceleration of the basketball at the highest point in its trajectory? (b) At what speed must the player throw the basketball so that the ball goes through the hoop without striking the backboard?



For part a

At the highest point of the trajectory, the vertical velocity component of the ball is zero. However, the ball is still affected by gravity. So, the acceleration of the basketball at the highest point in its trajectory is equal to the acceleration due to gravity, which is $9.81 m/s^2$ downwards.

For part b

b) The horizontal component of the initial velocity is

$$V_{xi} = V_i \, Cos40$$
$$= 0.766V_i$$

And, the time required for the ball to move 10m horizontally is:

$$t = \Delta x / V_{xi}$$
$$= 10/ 0.766V_i$$
$$= 13.1m/ V_i$$

At this time, the vertical displacement of the ball must be

$$\Delta y = y_f - y_i$$
$$= 3.05m – 2.0m$$
$$= 1.05m$$

Thus,

$$\Delta y = V_{yi}t + \tfrac{1}{2} a_y t^2 \text{ becomes:}$$

$$1.05m = (V_i \, Sin40)\,(13.1/V_i) + \tfrac{1}{2}\,(-9.8) * ((13.1)^2 / V_i^2)$$

$$1.05m = 8.42m – (841m^3s^{-2} / Vi^2)$$

$$Vi = \sqrt{\frac{835m^3s^{-2}}{8.39m - 1.05m}}$$
$$= 10.7m/s$$

Hence, the player should throw the basketball with the speed of 10.7m/s so that the ball goes through the hoop without striking the backboard