CSD2301 Practice Solutions
2. Kinematics in 1D

LIN QINJIE

Practice Question 1

A brick is dropped (zero initial speed) from the roof of a building. The brick strikes the ground in 2.50 s. You may ignore air resistance, so the brick is in free fall.

a) How tall, in meters, is the building?

b) What is the magnitude of the brick's velocity just before it reaches the ground?

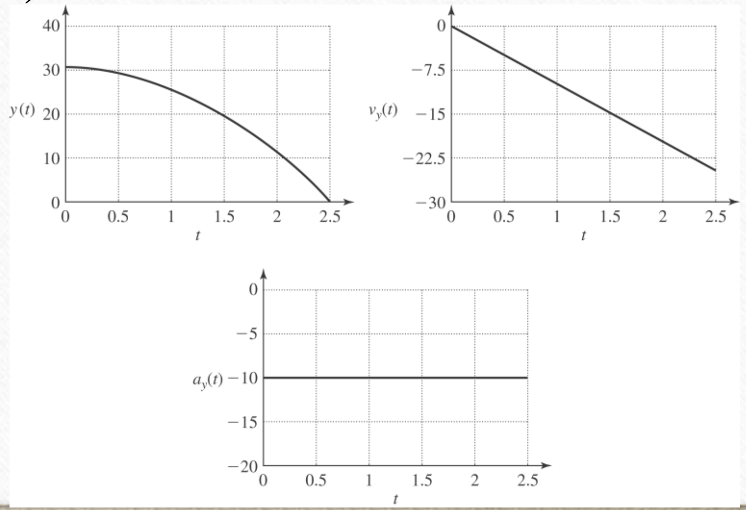
c) Sketch the y-t, v_y-t and a_y-t graphs for the motion of the brick.

Answer:

2.42: a) $(1/2)gt^2 = (1/2)(9.80\ \mathrm{m/s^2})(2.5\ \mathrm{s})^2 = 30.6\ \mathrm{m}$.

b) $gt = (9.80\ \mathrm{m/s^2})(2.5\ \mathrm{s}) = 24.5.\mathrm{m/s}$.

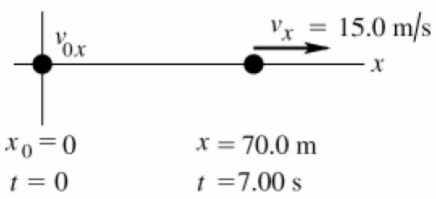
c)



Practice Question 2

An antelope moving with constant acceleration covers the distance between two points 70.0 m apart in 7.00 s. Its speed as it passes the second point is 15.0 m/s. (a) What is its speed at the first point? (b) What is its acceleration?

(a) SET UP: The situation is sketched in Figure 2.21.



$x - x_0 = 70.0$ m

$t = 7.00$ s

$v_x = 15.0$ m/s

$v_{0x} = ?$

Figure 2.21

EXECUTE: Use $x - x_0 = \left(\dfrac{v_{0x} + v_x}{2}\right)t$, so $v_{0x} = \dfrac{2(x - x_0)}{t} - v_x = \dfrac{2(70.0\text{ m})}{7.00\text{ s}} - 15.0\text{ m/s} = 5.0\text{ m/s}$.

(b) Use $v_x = v_{0x} + a_x t$, so $a_x = \dfrac{v_x - v_{0x}}{t} = \dfrac{15.0\text{ m/s} - 5.0\text{ m/s}}{7.00\text{ s}} = 1.43\text{ m/s}^2$.

EVALUATE: The average velocity is $(70.0\text{ m})/(7.00\text{ s}) = 10.0\text{ m/s}$. The final velocity is larger than this, so the antelope must be speeding up during the time interval; $v_{0x} < v_x$ and $a_x > 0$.

Practice Question 3

A rocket carrying a satellite is accelerating straight up from the earth's surface. At 1.15 s after liftoff, the rocket is 63 m above the ground. After an additional 4.75 s, it is 1.00 km above the ground. Calculate the magnitude of the average velocity of the rocket for (a) the 4.75 s part of its flight and (b) the first 5.90 s of its flight.

IDENTIFY: The average velocity is $v_{\text{av-}x} = \dfrac{\Delta x}{\Delta t}$.

SET UP: Let $+x$ be upward.

EXECUTE: **(a)** $v_{\text{av-}x} = \dfrac{1000\text{ m} - 63\text{ m}}{4.75\text{ s}} = 197\text{ m/s}$

(b) $v_{\text{av-}x} = \dfrac{1000\text{ m} - 0}{5.90\text{ s}} = 169\text{ m/s}$

EVALUATE: For the first 1.15 s of the flight, $v_{\text{av-}x} = \dfrac{63\text{ m} - 0}{1.15\text{ s}} = 54.8\text{ m/s}$. When the velocity isn't constant the average velocity depends on the time interval chosen. In this motion the velocity is increasing.

Practice Question 4

In the fastest measured tennis serve, the ball left the racquet at 73.14 m/s. A served tennis ball is typically in contact with the racquet for 30.0 ms and starts from rest. Assume constant acceleration. (a) What was the ball's acceleration during this serve? (b) How far did the ball travel during the serve?

SET UP: Assume the ball moves in the $+x$ direction.

EXECUTE: **(a)** $v_x = 73.14 \text{ m/s}$, $v_{0x} = 0$ and $t = 30.0 \text{ ms}$. $v_x = v_{0x} + a_x t$ gives

$$a_x = \frac{v_x - v_{0x}}{t} = \frac{73.14 \text{ m/s} - 0}{30.0 \times 10^{-3} \text{ s}} = 2440 \text{ m/s}^2 .$$

(b) $x - x_0 = \left(\frac{v_{0x} + v_x}{2}\right)t = \left(\frac{0 + 73.14 \text{ m/s}}{2}\right)(30.0 \times 10^{-3} \text{ s}) = 1.10 \text{ m}$

EVALUATE: We could also use $x - x_0 = v_{0x}t + \frac{1}{2}a_x t^2$ to calculate $x - x_0$:

$x - x_0 = \frac{1}{2}(2440 \text{ m/s}^2)(30.0 \times 10^{-3} \text{ s})^2 = 1.10 \text{ m}$, which agrees with our previous result. The acceleration of the ball is very large.

Practice Question 5

(a) If a flea can jump straight up to a height of 0.440 m, what is its initial speed as it leaves the ground? (b) How long is it in the air?

(a) SET UP: At the maximum height $v_y = 0$.

$v_y = 0 \quad y - y_0 = 0.440 \text{ m} \quad a_y = -9.80 \text{ m/s}^2 \quad v_{0y} = ?$

$v_y^2 = v_{0y}^2 + 2a_y(y - y_0)$ why is v^2 = 0

EXECUTE: $v_{0y} = \sqrt{-2a_y(y - y_0)} = \sqrt{-2(-9.80 \text{ m/s}^2)(0.440 \text{ m})} = 2.94 \text{ m/s}$

(b) SET UP: When the flea has returned to the ground $y - y_0 = 0$.

$y - y_0 = 0 \quad v_{0y} = +2.94 \text{ m/s} \quad a_y = -9.80 \text{ m/s}^2 \quad t = ?$

$y - y_0 = v_{0y}t + \frac{1}{2}a_y t^2$

EXECUTE: With $y - y_0 = 0$ this gives $t = -\dfrac{2v_{0y}}{a_y} = -\dfrac{2(2.94 \text{ m/s})}{-9.80 \text{ m/s}^2} = 0.600 \text{ s}.$

Practice Question 6

A baseball left a pitcher's hand at a speed of 45.0 m/s. If the pitcher was in contact with the ball over a distance of 1.50 m and produced constant acceleration, (a) what acceleration did he give the ball, and (b) how much time did it take him to pitch it?

SET UP: Assume the ball starts from rest and moves in the $+x$-direction.

EXECUTE: **(a)** $x - x_0 = 1.50\text{ m}$, $v_x = 45.0\text{ m/s}$ and $v_{0x} = 0$. $v_x^2 = v_{0x}^2 + 2a_x(x - x_0)$ gives

$$a_x = \frac{v_x^2 - v_{0x}^2}{2(x - x_0)} = \frac{(45.0\text{ m/s})^2}{2(1.50\text{ m})} = 675\text{ m/s}^2 .$$

(b) $x - x_0 = \left(\dfrac{v_{0x} + v_x}{2}\right)t$ gives $t = \dfrac{2(x - x_0)}{v_{0x} + v_x} = \dfrac{2(1.50\text{ m})}{45.0\text{ m/s}} = 0.0667\text{ s}$

EVALUATE: We could also use $v_x = v_{0x} + a_x t$ to find $t = \dfrac{v_x}{a_x} = \dfrac{45.0\text{ m/s}}{675\text{ m/s}^2} = 0.0667\text{ s}$ which agrees with our previous result. The acceleration of the ball is very large.

The End