University Physics | (14th Edition)

Chapter 3, Problem 16E | 6 Bookmarks | Show all steps: ON

Problem

On level ground a shell is fired with an initial velocity of 40.0 m/s at 60.0° above the horizontal and feels no appreciable air resistance. (a) Find the horizontal and vertical components of the shell's initial velocity. (b) How long does it take the shell to reach its highest point? (c) Find its maximum height above the ground. (d) How far from its firing point does the shell land? (e) At its highest point, find the horizontal and vertical components of its acceleration and velocity.

Step-by-step solution

Step 1 of 8

Towards the direction of the shell's motion assume $+x$ be the horizontal, and $+y$ be vertical that is upward. Therefore, the acceleration of shell in horizontal and vertical direction are a_x, and a_y respectively.

Comment

Step 2 of 8

(a)

Assume the horizontal initial velocity component be v_{0x}, thus

$$v_{0x} = v_0 \cos\alpha_0$$

Substitute $40.0\ \text{m/s}$ for v_0 and $60.0°$ for α_0,

$$\begin{aligned} v_{0x} &= (40.0\ \text{m/s})\cos 60.0° \\ &= 20.0\ \text{m/s} \end{aligned}$$

Comment

Step 3 of 8

Assume the vertical initial velocity component be v_{0y}, thus

$$v_{0y} = v_0 \sin\alpha_0$$

Substitute $40.0\ \text{m/s}$ for v_0 and $60.0°$ for α_0,

$$\begin{aligned} v_{0y} &= (40.0\ \text{m/s})\sin 60.0° \\ &= 34.6\ \text{m/s} \end{aligned}$$

Therefore the horizontal and vertical component components of the shell's initial velocity are $\boxed{20.0\ \text{m/s}}$ and $\boxed{34.6\ \text{m/s}}$ respectively.

Comment

(b)

At the maximum height,

$$v_y = 0$$

But the velocity is calculated by,

$$v_y = v_{0y} + a_y t$$

Rewrite the above equation in terms of t,

$$t = \frac{v_y - v_{0y}}{a_y}$$

Substitute 0 for v_y, $34.6\ \text{m/s}$ for v_{0y} and $-9.8\ \text{m/s}^2$ for a_y,

$$t = \frac{0-(34.6\ \text{m/s})}{(-9.8\ \text{m/s}^2)} = 3.53\ \text{s}$$

Hence, the highest point reach by the shell is $\boxed{3.53\ \text{s}}$.

Comment

Step 5 of 8

(c)

Here, the maximum height above the ground is calculated by $y - y_0$.

The known formula is,

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

Rewrite the above equation in terms of $y - y_0$,

$$y - y_0 = \frac{v_y^2 - v_{0y}^2}{2a_y}$$

Substitute 0 for v_y, $34.6\ \text{m/s}$ for v_{0y} and $-9.8\ \text{m/s}^2$ for a_y,

$$y - y_0 = \frac{(0)^2 - (34.6\ \text{m/s})^2}{2(-9.8\ \text{m/s}^2)} = 61.2\ \text{m}$$

Hence, the maximum height above the ground is $\boxed{61.2\ \text{m}}$.

Comment

Step 6 of 8

(d)

The distance at which the shell land is $x - x_0$ which is calculated by the following formula,

$$x - x_0 = v_{0x}t + \frac{1}{2}a_x t^2$$

Substitute $20.0\ \text{m/s}$ for v_{0x}, $(2)(3.53\ \text{s})$ for t and 0 for a_x,

$$x - x_0 = (20.0\ \text{m/s})(2)(3.53\ \text{s}) + \left(\frac{1}{2}\right)(0)((2)(3.53\ \text{s}))^2 = 141\ \text{m}$$

Hence, the distance of fringing point does the shell land is $\boxed{141\ \text{m}}$.

Comment

(e)

At maximum height,

$$v_x = v_{0x}$$
$$= 20.0 \text{ m/s}$$

And,

$$v_y = 0$$

Hence, the horizontal and vertical component components of the velocity are $\boxed{20.0 \text{ m/s}}$ and $\boxed{0 \text{ m/s}}$ respectively.

Comment

Step 8 of 8

At all point in motion,

$$a_x = 0$$

And,

$$a_y = -9.80 \text{ m/s}^2$$

Hence, the horizontal and vertical component components of the acceleration are $\boxed{0 \text{ m/s}^2}$ and $\boxed{-9.80 \text{ m/s}^2}$ respectively.

Comment

Was this solution helpful? 17 0

Recommended solutions for you in Chapter 3

Chapter 3, Problem 7E

CALC The coordinates of a bird flying in the xy-plane are given by x(t) = αt and y(t) = 3.0 m - βt2, where α = 2.4 m/s and β =...

See solution

Chapter 3, Problem 11E

Crickets Chirpy and Milada jump from the top of a vertical cliff. Chirpy drops downward and reaches the ground in 2.70 s, while...

See solution

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