Jeddah University

PHYSICS (101)

Chapter (3)
Motion in two dimensions

Mahmoud Al-Zamil

0508601922

Position and Velocity Vectors

Example 1:

A particle moving from $\vec{r_1} = 2\hat{i} + 5\hat{j} + 8\hat{k}$ to $\vec{r_2} = 12\hat{i} + 10\hat{j} + 8\hat{k}$, then the displacement is:

Solution:

(C)

(A) $10\hat{i} - 3\hat{j}$
(B) $4\hat{i} + 6\hat{j}$
(C) $10\hat{i} + 5\hat{j}$
(D) $5\hat{j}$

$$\boxed{\Delta r = r_2 - r_1}$$

$$\Delta r = 12\hat{i} + 10\hat{j} + 8\hat{k} - (2\hat{i} + 5\hat{j} + 8\hat{k})$$
$$= 12\hat{i} + 10\hat{j} + 8\hat{k} - 2\hat{i} - 5\hat{j} - 8\hat{k}$$
$$= 10\hat{i} + 5\hat{j}$$ ✓

 2

Example 2:

A particle moves in xy plane as $x(t) = 2t$ (m) and $y(t) = t^2 - 1$ (m). The velocity of the particle at t=1 s is:

Solution:

(D)

(A) $\hat{\imath} + \hat{\jmath}$ (m/s)
(B) $2\hat{\imath} + \hat{\jmath}$ (m/s)
(C) $2\hat{\imath} - \hat{\jmath}$ (m/s)
(D) $2\hat{\imath} + 2\hat{\jmath}$ (m/s)

$x = 2t$ | $y = t^2 - 1$

$v_x = 2$ | $v_y = 2t$

$v_x = 2$ | $v_y = 2 \times 1 = 2$

$v = 2i + 2j$ m/s

The Acceleration Vector

3

Example 3:

At t=0, a car moves with velocity $\vec{v_0} = 2\hat{\imath} + \hat{\jmath}$ (m/s) and acceleration $\vec{a} = 2\hat{\jmath}$ (m/s²). The velocity of the car at t=2 is:

Solution:

(B)

(A) $6\hat{\imath} + \hat{\jmath}$
(B) $2\hat{\imath} + 5\hat{\jmath}$
(C) $2\hat{\imath} + \hat{\jmath}$
(D) $\hat{\imath} + 5\hat{\jmath}$

$$\boxed{v = v_0 + at}$$

$$v = 2\hat{i} + \hat{j} + 2(2\hat{j})$$
$$= 2\hat{i} + \hat{j} + 4\hat{j}$$
$$= 2\hat{i} + 5\hat{j}$$

B

Projectile Motion

4

Example 4:

A boy kicks a ball at an angle of 40^0 to the horizontal with speed of 14.0 m/s. The time it takes to reach the highest point is:

$v_0 = 14$ m/s

$\theta = 40°$

Solution:

~~(A)~~ 0.92 s
(B) 0.77 s
(C) 0.15 s
(D) 1.12 s

(A)

$$t = \frac{2v_0 \sin(\theta)}{g}$$

$$t = \frac{2 \times 14 \sin(40)}{9.8}$$

$t = 1.84$ s (الزمن الكلي)

للصعود $t = \frac{1.84}{2} = 0.92 \Leftarrow$

جامعة جدة
University of Jeddah

Projectile Motion

5

Example 5:

A boy kicks a ball at an angle of 40^0 to the horizontal with speed of 14.0 m/s. The maximum height that the ball can reach is:

Solution:

(B)

(A) 9.87 m
~~(B)~~ 4.13 m
(C) 15.33 m
(D) 12.68 m

$$H = \frac{v_0^2 \sin(\theta)^2}{2g}$$

$$H = \frac{14^2 \sin(40)^2}{2 \times 9.8}$$

$$H = 4.13 \quad m$$

B

Projectile Motion

6

Example 6:

Referring to question 5, the horizontal range that the ball can reach is:

Solution:

(A) 9.87 m
(B) 14.7 m
(C) 15.33 m
~~(D)~~ 19.7 m

(D)

$$R = \frac{v_0^2 \sin(2\theta)}{g}$$

$$R = \frac{(14)^2 \sin(2 \times 40)}{9.8}$$

$$R = 19.7 \quad m$$

Projectile Motion

7//

Example 7:

A projectile is launched to achieve a maximum range of 140 m, the speed of the projectile must be:

Solution:

(A) 17 m/s
(B) 27 m/s
~~(C)~~ 37 m/s
(D) 45 m/s

$\theta = 45^\circ$

(C). $R_{max} = 140\ m$

$$R_{max} = \frac{v_0^2}{g}$$

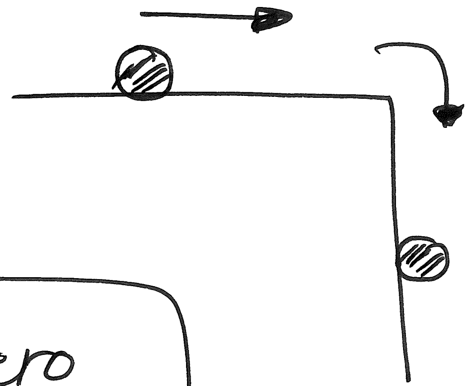
$$140 = \frac{v_0^2}{9.8} \qquad v_0 = 37\ m/s$$

Example 8:

A toy car runs on a horizontal table with 3 m/s. The angle it makes with the horizontal when it leaves the table is:

Solution:

(A)



$$\boxed{\theta = \text{zero}}$$

(A) Zero

(B) 45^0

(C) 60^0

(D) 90^0

Projectile Motion

9

Example 9:

A stone is thrown horizontally from the top of a tall building. It follows a path that is:

Solution:

(D)

(A) circular
(B) two straight lines
(C) a straight line
(D) parabolic

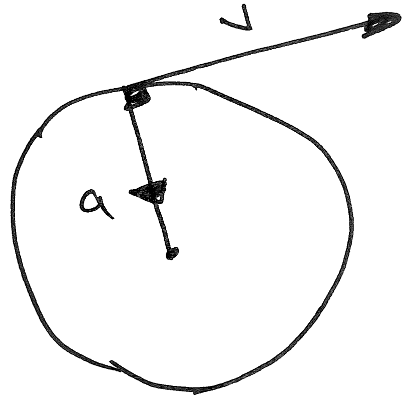
Example 10:

السرعة التسارع الحركة الدائرية المنتظمة

The velocity and acceleration of a body in a uniform circular motion are:

Solution:

(B)



(A) differed by 45^0
~~(B)~~ perpendicular
(C) differed by 135^0
(D) parallel

Motion in a Circle

11

Example 11:

A car rounds a 20 m radius curve at 10 m/s. The magnitude of its acceleration is:

$R = 20$ m

$v = 10$ m/s

Solution:

(D)

(A) zero

(B) 2 m/s^2

(C) 4 m/s^2

~~(D)~~ 5 m/s^2

$$\boxed{a = \frac{v^2}{R}}$$

$$a = \frac{(10)^2}{20} = 5 \ m/s^2$$

12

Example 12:

حركة

A truck is traveling with a constant speed of 20 m/s. When the truck follows a curve in the road, its centripetal acceleration is 4.0 m/s^2. The radius of the curve is:

Solution:

(A) 225 m
(B) 144 m
~~(C)~~ 100 m
(D) 81 m

(C)

$v = 20 \quad m/s$

$a = 4 \quad m/s^2$

$R = ?$

$$\boxed{a = \frac{v^2}{R}}$$

$$4 = \frac{(20)^2}{R}$$

$R = 100 \quad m$

$\boxed{CH-3}$

* Example 3-1 $\longrightarrow$ 69

$X = 2 - 0.25t^2$	$Y = t + 0.025t^3$
$X = 2 - 0.25(2)^2$	$Y = 2 + 0.025(2)^3$
$X = 1$	$Y = 2.2$

$$r = \sqrt{x^2 + y^2}$$

المقدار $r = \sqrt{1^2 + (2.2)^2} = 2.4 \; m$

$$r = (2 - 0.25t^2)i + (t + 0.025t^3)j$$

$\boxed{\text{at } t_1 = 0}$

$$r_1 = (2 - 0.25(0))i + (0 + 0.025 \times 0)j$$

$$r_1 = 2i$$

$t_2 = 2$

$$r_2 = (2 - 0.25(2)^2)i + (2 + 0.025(2)^3)j$$

$$r_2 = i + 2.2j$$

$\boxed{\Delta r = r_2 - r_1}$ $= i + 2.2j - 2i$

$$= -i + 2.2j$$

$$V_{ave} = \frac{\Delta r}{\Delta t} = \frac{-i + 2.2j}{2 - 0}$$

$$V_{ave} = -0.5i + 1.1j$$

* $V_{ave-x} = -0.5$ مركبات
* $V_{ave-y} = 1.1$ السرعة المتوسطة

---

* Example 3.6 → 78

---

* $t = 0.50$ s

$$\boxed{X = v_{0x} t}$$

$X = 9 \times 0.50$

$X = 4.5$ m

$$\boxed{Y = -\frac{1}{2} g t^2}$$

$= -\frac{1}{2} \times 9.8 \times (0.5)^2$

$= -1.2$ m

---

* Negative (below the starting point)
* distance at $t = 0.50$

$r = \sqrt{X^2 + Y^2}$ $\qquad r = 4.7$ m

$\boxed{* \text{ at } t = 0.50 \text{ s}}$

* $V_x = V_{ox} = 9 \text{ m/s}$

$\boxed{V_y = V_{oy} + gt}$

$V_y = 0 - 9.8 \times 0.5$

$V_y = -4.9 \text{ m/s}$

$$\boxed{\begin{aligned} * \; V &= V_x i + V_y j \\ V &= 9i - 4.5j \end{aligned}}$$

$V = \sqrt{V_{\cancel{x}}^2 + V_y^2}$

* $V = \sqrt{9^2 + (-4.9)^2} = 10.2 \text{ m/s}$

* $\theta = \tan^{-1}\left(\frac{y}{x}\right)$

$\theta = \tan^{-1}\left(\frac{-4.9}{9}\right)$ $\theta = -29^\circ$

* Example 3-7

$V_0 = 37 \ m/s$

$\theta = 53.1^\circ \quad t = 2$

$\boxed{V_{0x} = V_0 \cos(\theta)}$ $V_{0x} = 37 \cos(53.1)$

$= 22.2 \ m/s$

$\boxed{V_{0y} = V_0 \sin\theta}$ $V_{0y} = 37 \sin(53.1)$

$= 29.6 \ m/s$

---

* $X = V_{0x} t = 22.2 \times 2 = 44.4 \ m$

$\boxed{* \ Y = V_{0y} t + \frac{1}{2} g t^2}$

$= 29.6 \times 2 + \frac{1}{2} \times (-9.8) \times (2)^2 = 39.6 \ m$

---

* $V_x = V_{0x} = 22.2 \ m/s$

$\boxed{* \ V_y = V_{0y} + gt}$

$V_y = 29.6 + (-9.8) \times 2 = 10 \ m/s$

$$v = \sqrt{v_x^2 + v_y^2}$$

$$v = \sqrt{22.2^2 + 10^2} = 24.2 \ m/s$$

* $\theta = \tan^{-1}\left(\frac{y}{x}\right)$
* $\theta = \tan^{-1}\left(\frac{10}{22.2}\right)$ $\quad \theta = 24.2^\circ$

---

* **Example : 3-12**

$R = 5 \ m$

$T = 4 \ s$

$$T = \frac{2\pi r}{v} \qquad v = \frac{2\pi r}{T}$$

$$v = \frac{2 \times 3.14 \times 5}{4}$$

$$v = 7.9 \ m/s$$

$$a = \frac{v^2}{R} \qquad a = \frac{7.9^2}{5} = 12 \ m/s^2$$