

## Section 3.4 – Solving Trigonometry Equations

### Example

Find the solutions of the equation  $\sin \theta = \frac{1}{2}$  if

- a)  $\theta$  is in the interval  $[0, 2\pi)$
- b)  $\theta$  is any real number

### Solution

a)  $\theta = \sin^{-1} \frac{1}{2} = \frac{\pi}{6}$  and  $\theta = \pi - \frac{\pi}{6} = \frac{5\pi}{6}$

b) Since the sine function has period  $2\pi$ .

$$\theta = \frac{\pi}{6} + 2\pi n \quad \text{and} \quad \theta = \frac{5\pi}{6} + 2\pi n$$

### Example

Solve the equation  $\sin x \tan x = \sin x$

### Solution

$$\sin x \tan x - \sin x = 0$$

$$\sin x (\tan x - 1) = 0$$

$$\sin x = 0$$

$$\hat{x} = \sin^{-1} 0 = 0$$

$$x = 0, \pm \pi, \pm 2\pi, \dots$$

$$x = \pi n$$

$$\tan x - 1 = 0$$

$$\tan x = 1$$

$$\hat{x} = \tan^{-1} 1 = \frac{\pi}{4}$$

$$x = \pm \frac{\pi}{4}, \pm \frac{5\pi}{4}, \dots$$

$$x = \frac{\pi}{4} + \pi n$$

The solutions are:  $x = \pi n$  and  $x = \frac{\pi}{4} + \pi n$  for every integer  $n$ .

### Example

Solve the equation  $2\sin^2 t - \cos t - 1 = 0$ , and express the solutions both in radians and degrees.

### Solution

$$2\sin^2 t - \cos t - 1 = 0$$

$$2(1 - \cos^2 t) - \cos t - 1 = 0$$

$$\sin^2 t + \cos^2 t = 1$$

$$2 - 2\cos^2 t - \cos t - 1 = 0$$

$$-2\cos^2 t - \cos t + 1 = 0$$

*Multiply by -1*

$$2\cos^2 t + \cos t - 1 = 0$$

*Factor or use quadratic formula*

$$(2\cos t - 1)(\cos t + 1) = 0$$

$$2\cos t - 1 = 0$$

$$\cos t + 1 = 0$$

$$2\cos t = 1$$

$$\cos t = -1$$

$$\cos t = \frac{1}{2}$$

$$t = \frac{\pi}{3} \quad \text{or} \quad t = 2\pi - \frac{\pi}{3} = \frac{5\pi}{3}$$

$$t = \pi$$

$$t = \frac{\pi}{3} + 2\pi n, \quad t = \frac{5\pi}{3} + 2\pi n,$$

$$t = \pi + 2\pi n$$

$$t = 60^\circ + 360^\circ n, \quad 300^\circ + 360^\circ n, \quad \text{and} \quad 180^\circ + 360^\circ n$$

### Example

Solve the equation  $4\sin^2 x \tan x - \tan x = 0$  in the interval  $[0, 2\pi)$ .

### Solution

$$4\sin^2 x \tan x - \tan x = 0$$

$$\tan x(4\sin^2 x - 1) = 0$$

*Factor out tan x*

$$\tan x = 0$$

$$4\sin^2 x - 1 = 0$$

$$\sin^2 x = \frac{1}{4}$$

$$\tan x = 0$$

$$\sin x = \frac{1}{2}$$

$$\sin x = -\frac{1}{2}$$

$$x = 0, \pi$$

$$x = \frac{\pi}{6}, \frac{5\pi}{6}$$

$$x = \frac{7\pi}{6}, \frac{11\pi}{6}$$

### Example

Find the solutions of  $\csc^4 2u - 4 = 0$

#### Solution

$$(\csc^2 2u - 2)(\csc^2 2u + 2) = 0$$

$$\csc^2 2u - 2 = 0 \quad \csc^2 2u + 2 = 0$$

$$\csc^2 2u = 2 \quad \csc^2 2u = -2 \times$$

$$\csc 2u = \pm\sqrt{2}$$

$$\sin 2u = \pm \frac{1}{\sqrt{2}}$$

$$\sin 2u = \frac{\sqrt{2}}{2} \Rightarrow 2u = \frac{\pi}{4} + 2\pi n \rightarrow u = \frac{\pi}{8} + \pi n$$

$$\Rightarrow 2u = \frac{3\pi}{4} + 2\pi n \rightarrow u = \frac{3\pi}{8} + \pi n$$

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$$\sin 2u = -\frac{\sqrt{2}}{2} \Rightarrow 2u = \frac{5\pi}{4} + 2\pi n \rightarrow u = \frac{5\pi}{8} + \pi n$$

$$\Rightarrow 2u = \frac{7\pi}{4} + 2\pi n \rightarrow u = \frac{7\pi}{8} + \pi n$$

### Example

Approximate to the nearest degree, the solutions of the following equation in the interval  $[0^\circ, 360^\circ)$ :

$$5\sin \theta \tan \theta - 10 \tan \theta + 3\sin \theta - 6 = 0$$

#### Solution

$$\tan \theta (5\sin \theta - 10) + (3\sin \theta - 6) = 0$$

$$5 \tan \theta (\sin \theta - 2) + 3(\sin \theta - 2) = 0$$

$$(\sin \theta - 2)(5 \tan \theta + 3) = 0$$

$$\sin \theta - 2 = 0$$

$$5 \tan \theta + 3 = 0$$

$$\sin \theta = 2 > 1$$

$$\tan \theta = -\frac{3}{5}$$

$$\theta \in \text{QII, QIV}$$

$$\hat{\theta} = \tan^{-1}\left(\frac{3}{5}\right) = 31^\circ$$

$$\begin{cases} \theta = 180^\circ - 31^\circ = 149^\circ \\ \theta = 360^\circ - 31^\circ = 329^\circ \end{cases}$$

## Exercises      Section 3.4 – Trigonometric Equations

Find all solutions of the equation

1.  $\sin x = \frac{\sqrt{2}}{2}$

2.  $\cos x = -\frac{\pi}{3}$

3.  $2\cos\theta - \sqrt{3} = 0$

4.  $\sqrt{3}\tan\frac{1}{3}x = 1$

5.  $\cos\left(4x - \frac{\pi}{4}\right) = \frac{\sqrt{2}}{2}$

6.  $(\cos\theta - 1)(\sin\theta + 1) = 0$

7.  $\cot^2 x - 3 = 0$

8.  $\cos x + 1 = 2\sin^2 x$

9.  $\cos(\ln x) = 0$

Find the solutions of the equation that are in the interval  $[0, 2\pi)$

10.  $2\sin^2 x = 1 - \sin x$

11.  $\tan^2 x \sin x = \sin x$

12.  $1 - \sin x = \sqrt{3}\cos x$

13.  $\sin x + \cos x \cot x = \csc x$

14.  $2\sin^3 x + \sin^2 x - 2\sin x - 1 = 0$

15.  $2\tan x \csc x + 2\csc x + \tan x + 1 = 0$

16.  $5\cos t + \sqrt{12} = \cos t$

17.  $2\sin^2 x - \cos x - 1 = 0$

18.  $2\cos^2 t - 9\cos t = 5$

19.  $\tan^2 x + \tan x - 2 = 0$

20.  $\tan x + \sqrt{3} = \sec x$

21.  $2\sin^2 \theta + 2\sin \theta - 1 = 0$

22.  $2\cos x - 1 = \sec x$

23.  $4\cos^2 x + 4\sin x - 5 = 0$

24.  $\sin \theta - \cos \theta = 1$

Find the solutions of the equation that are in the interval if  $0^\circ \leq \theta < 360^\circ$

25.  $2\cos\theta + \sqrt{3} = 0$

26.  $\tan\theta - 2\cos\theta \tan\theta = 0$

27.  $2\sin^2 \theta - 2\sin \theta - 1 = 0$

28.  $4\cos\theta - 3\sec\theta = 0$

29.  $\sin\theta - \sqrt{3}\cos\theta = 1$

30.  $7\sin^2 \theta - 9\cos 2\theta = 0$

31.  $\sin\theta \tan\theta = \sin\theta$

32.  $2\sin\theta - 3 = 0$

33.  $3\sin\theta - 2 = 7\sin\theta - 1$

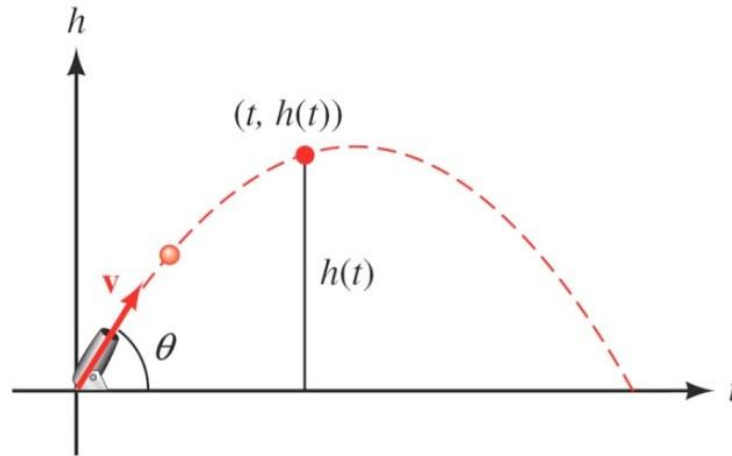
34.  $\cos 2\theta + 3\sin\theta - 2 = 0$

35.  $\sin 2\theta + \sqrt{2}\cos\theta = 0$

36. Solve  $\cos\left(A - \frac{\pi}{9}\right) = -\frac{1}{2}$

37. Solve  $\cos(A - 25^\circ) = -\frac{1}{\sqrt{2}}$

38. If a projectile (such as a bullet) is fired into the air with an initial velocity  $v$  at an angle of elevation  $\theta$ , then the height  $h$  of the projectile at time  $t$  is given by:  $h(t) = -16t^2 + vt \sin \theta$



- Give the equation for the height, if  $v$  is 600 *ft./sec* and  $\theta = 45^\circ$ .
- Use the equation in part (a) to find the height of the object after  $\sqrt{3}$  seconds.
- Find the angle of elevation of  $\theta$  of a rifle barrel, if a bullet fired at 1,500 *ft./sec* takes 3 seconds to reach a height of 750 feet. Give your answer in the nearest of a degree.