

- 1 a $x = 30, 180 - 30$
 $x = 30^\circ, 150^\circ$ b $x = 60, 180 + 60$
 $x = 60^\circ, 240^\circ$ c $x = 90^\circ, 270^\circ$ d $x = 270^\circ$
- e $x = 30, 360 - 30$
 $x = 30^\circ, 330^\circ$ f $x = 45, 180 - 45$
 $x = 45^\circ, 135^\circ$ g $x = 180 - 45, 360 - 45$
 $x = 135^\circ, 315^\circ$ h $x = 180 - 60, 180 + 60$
 $x = 120^\circ, 240^\circ$
- i $x = 180 + 60, 360 - 60$
 $x = 240^\circ, 300^\circ$ j $x = 30, 180 + 30$
 $x = 30^\circ, 210^\circ$ k $x = 180 - 45, 180 + 45$
 $x = 135^\circ, 225^\circ$ l $x = 180 - 60, 360 - 60$
 $x = 120^\circ, 300^\circ$
- 2 a $\theta = 66.4, 360 - 66.4$
 $\theta = 66.4^\circ, 293.6^\circ$ b $\theta = 15.7, 180 - 15.7$
 $\theta = 15.7^\circ, 164.3^\circ$ c $\theta = 58.0, 180 + 58.0$
 $\theta = 58.0^\circ, 238.0^\circ$ d $\theta = 54.4, 180 - 54.4$
 $\theta = 54.4^\circ, 125.6^\circ$
- e $\theta = 5.7, 180 + 5.7$
 $\theta = 5.7^\circ, 185.7^\circ$ f $\theta = 79.3, 360 - 79.3$
 $\theta = 79.3^\circ, 280.7^\circ$ g $\theta = 180 + 36.9,$
 $360 - 36.9$
 $\theta = 216.9^\circ, 323.1^\circ$ h $\theta = 180 - 35.0,$
 $360 - 35.0$
 $\theta = 145.0^\circ, 325.0^\circ$
- i $\theta = 180 - 67.0,$
 $180 + 67.0$
 $\theta = 113.0^\circ, 247.0^\circ$ j $\theta = 180 - 73.6,$
 $360 - 73.6$
 $\theta = 106.4^\circ, 286.4^\circ$ k $\theta = 180 - 50.5,$
 $180 + 50.5$
 $\theta = 129.5^\circ, 230.5^\circ$ l $\theta = 180 + 11.7,$
 $360 - 11.7$
 $\theta = 191.7^\circ, 348.3^\circ$
- 3 a $x - 60 = 30, 180 - 30$
 $= 30, 150$
 $x = 90, 210$ b $x + 30 = 45, 180 + 45$
 $= 45, 225$
 $x = 15, 195$ c $x - 45 = 78.5, 360 - 78.5$
 $= 78.5, 281.5$
 $x = 123.5, 326.5$
- d $x + 30 = 38.0, 180 + 38.0$
 $= 38.0, 218.0$
 $x = 8.0, 188.0$ e $x + 45 = 180 - 60, 180 + 60$
 $= 120, 240$
 $x = 75, 195$ f $x - 60 = 180 + 62.9, 360 - 62.9$
 $= 242.9, 297.1$
 $x = 302.9, 357.1$
- g $x + 45 = 360 - 25.8,$
 $360 + 25.8$
 $= 334.2, 385.8$
 $x = 289.2, 340.8$ h $x + 30 = 180 - 8.0,$
 $360 + 8.0$
 $= 172.0, 368.0$
 $x = 142.0, 338.0$ i $x - 60 = -53.1, 53.1$
 $x = 6.9, 113.1$
- j $x - 30 = -17.5, 180 + 17.5$
 $= -17.5, 197.5$
 $x = 12.5, 227.5$ k $x - 60 = -51.6, 180 - 51.6$
 $= -51.6, 128.4$
 $x = 8.4, 188.4$ l $2x = 30, 180 - 30,$
 $360 + 30, 540 - 30$
 $= 30, 150, 390, 510$
 $x = 15, 75, 195, 255$
- m $2x = 50.208,$
 $360 - 50.208,$
 $360 + 50.208,$
 $720 - 50.208$
 $= 50.208, 309.792,$
 $410.208, 669.792$
 $x = 25.1, 154.9, 205.1, 334.9$ n $2x = 180 + 10.370,$
 $360 - 10.370,$
 $540 + 10.370,$
 $720 - 10.370$
 $= 190.370, 349.630,$
 $550.370, 709.630$
 $x = 95.2, 174.8, 275.2, 354.8$ o $2x = 180 - 69.950,$
 $360 - 69.950,$
 $540 - 69.950,$
 $720 - 69.950$
 $= 110.050, 290.050,$
 $470.050, 650.050$
 $x = 55.0, 145.0, 235.0, 325.0$
- p $\frac{1}{2}x = 44.668, 180 - 44.668$
 $= 44.668, 135.332$
 $x = 89.3, 270.7$ q $3x = 30.583, 180 + 30.583,$
 $360 + 30.583,$
 $540 + 30.583,$
 $720 + 30.583,$
 $900 + 30.583$
 $= 30.583, 210.583,$
 $390.583, 570.583,$
 $750.583, 930.583$
 $x = 10.2, 70.2, 130.2$
 $190.2, 250.2, 310.2$ r $2x = 180 - 65.481,$
 $180 + 65.481,$
 $540 - 65.481,$
 $540 + 65.481$
 $= 114.519, 245.481,$
 $474.519, 605.481$
 $x = 57.3, 122.7, 237.3, 302.7$

4 a $x = 0, \pi, 2\pi$

b $x = \frac{\pi}{3}, 2\pi - \frac{\pi}{3}$

c $x = \frac{\pi}{4}, \pi + \frac{\pi}{4}$

$x = \frac{\pi}{3}, \frac{5\pi}{3}$

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

d $x = \pi$

e $x = \pi - \frac{\pi}{6}, 2\pi - \frac{\pi}{6}$

f $x = \pi + \frac{\pi}{4}, 2\pi - \frac{\pi}{4}$

$x = \frac{5\pi}{6}, \frac{11\pi}{6}$

$x = \frac{5\pi}{4}, \frac{7\pi}{4}$

g $x + \frac{\pi}{6} = \frac{\pi}{3}, \pi + \frac{\pi}{3}$

h $x - \frac{\pi}{4} = \frac{\pi}{6}, \pi - \frac{\pi}{6}$

i $x + \frac{\pi}{3} = \pi - \frac{\pi}{6}, \pi + \frac{\pi}{6}$

$= \frac{\pi}{3}, \frac{4\pi}{3}$

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

$= \frac{5\pi}{6}, \frac{7\pi}{6}$

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

$x = \frac{5\pi}{12}, \frac{13\pi}{12}$

$x = \frac{\pi}{2}, \frac{5\pi}{6}$

j $x + \frac{\pi}{3} = \pi - \frac{\pi}{4}, 2\pi + \frac{\pi}{4}$

k $2x = \pi - \frac{\pi}{4}, \pi + \frac{\pi}{4},$

l $3x = \frac{\pi}{6}, \pi + \frac{\pi}{6}, 2\pi + \frac{\pi}{6},$

$= \frac{3\pi}{4}, \frac{9\pi}{4}$

$3\pi - \frac{\pi}{4}, 3\pi + \frac{\pi}{4}$

$3\pi + \frac{\pi}{6}, 4\pi + \frac{\pi}{6}, 5\pi + \frac{\pi}{6}$

$x = \frac{5\pi}{12}, \frac{23\pi}{12}$

$= \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{11\pi}{4}, \frac{13\pi}{4}$

$= \frac{\pi}{6}, \frac{7\pi}{6}, \frac{13\pi}{6}, \frac{19\pi}{6}, \frac{25\pi}{6}, \frac{31\pi}{6}$

$x = \frac{3\pi}{8}, \frac{5\pi}{8}, \frac{11\pi}{8}, \frac{13\pi}{8}$

$x = \frac{\pi}{18}, \frac{7\pi}{18}, \frac{13\pi}{18}, \frac{19\pi}{18}, \frac{25\pi}{18}, \frac{31\pi}{18}$

5 a $\theta = -90^\circ, 90^\circ$

b $\tan 2\theta = -1$

c $\theta + 60 = 16.9, 180 - 16.9$

$2\theta = 180 - 45, 360 - 45$

$= 16.9, 163.1$

$-45, -45 - 180$

$\theta = -43.1^\circ, 103.1^\circ$

$= -225, -45, 135, 315$

$\theta = -112.5^\circ, -22.5^\circ,$

$67.5^\circ, 157.5^\circ$

d $\tan(\theta - 15) = 1.85$

e $\sin 2\theta = 0.3$

f $\cos 3\theta = 0.5$

$\theta - 15 = 61.6, 61.6 - 180$

$2\theta = 17.458, 180 - 17.458,$

$3\theta = 60, 360 - 60, 360 + 60,$

$= -118.4, 61.6$

$17.458 - 360,$

$-60, 60 - 360, -60 - 360$

$\theta = -103.4^\circ, 76.6^\circ$

$-17.458 - 180$

$= -420, -300, -60,$

$= -342.542, -197.458,$

$60, 300, 420$

$17.458, 162.542$

$\theta = -140^\circ, -100^\circ, -20^\circ$

$\theta = -171.3^\circ, -98.7^\circ$

$20^\circ, 100^\circ, 140^\circ$

$8.7^\circ, 81.3^\circ$

g $\sin(\theta + 110) = -1$

h $\cos(\theta - 27) = 0.6$

i $\tan \theta = \frac{7}{3}$

$\theta + 110 = 270$

$\theta - 27 = 53.1, -53.1$

$\theta = 66.8, 66.8 - 180$

$\theta = 160^\circ$

$\theta = -26.1^\circ, 80.1^\circ$

$\theta = -113.2^\circ, 66.8^\circ$

j $\cos 2\theta = -0.375$

k $\tan(\theta + 92) = -\frac{1}{3}$

l $\sin \frac{1}{3}\theta = 0.25$

$2\theta = 180 - 67.976,$

$\theta + 92 = 180 - 18.4, -18.4$

$\frac{1}{3}\theta = 14.478$

$180 + 67.976,$

$= -18.4, 161.6$

$\theta = 43.4^\circ$

$67.976 - 180,$

$\theta = -110.4^\circ, 69.6^\circ$

$-67.976 - 180$

$= -247.976, -112.024,$

$112.024, 247.976$

$\theta = -124.0^\circ, -56.0^\circ,$

$56.0^\circ, 124.0^\circ$

- 6**
- a** $2x + 30 = 45, 180 + 45$
 $= 45, 225$
 $2x = 15, 195$
 $x = 7.5^\circ, 97.5^\circ$
- b** $2x - 15 = 0, 180$
 $2x = 15, 195$
 $x = 7.5^\circ, 97.5^\circ$
- c** $2x + 70 = 360 - 60, 360 + 60$
 $= 300, 420$
 $2x = 230, 350$
 $x = 115^\circ, 175^\circ$
- d** $2x + 210 = 360 + 15.070,$
 $540 - 15.070$
 $= 375.070, 524.930$
 $2x = 165.070, 314.930$
 $x = 82.5^\circ, 157.5^\circ$
- e** $2x - 38 = 180 - 50.208,$
 $180 + 50.208$
 $= 129.792, 230.208$
 $2x = 167.792, 268.208$
 $x = 83.9^\circ, 134.1^\circ$
- f** $2x - 56 = 180 - 17.745,$
 -17.745
 $= -17.745, 162.256$
 $2x = 38.256, 218.256$
 $x = 19.1^\circ, 109.1^\circ$
- g** $3x - 24 = 42.862,$
 $360 - 42.862,$
 $360 + 42.862$
 $= 42.862, 317.138,$
 402.862
 $3x = 66.862, 341.138,$
 426.862
 $x = 22.3^\circ, 113.7^\circ, 142.3^\circ$
- h** $3x + 60 = 180 - 62.241,$
 $360 - 62.241,$
 $540 - 62.241$
 $= 117.759, 297.759,$
 477.759
 $3x = 57.759, 237.759,$
 417.759
 $x = 19.3^\circ, 79.3^\circ, 139.3^\circ$
- i** $\frac{1}{2}x + 18 = 34.890$
 $\frac{1}{2}x = 16.890$
 $x = 33.8^\circ$
- 7**
- a** $x = 0.48, \pi + 0.4795$
 $x = 0.48^\circ, 3.62^\circ$
- b** $2x = 1.2503, 2\pi - 1.2503,$
 $2\pi + 1.2503, 4\pi - 1.2503$
 $= 1.2503, 5.0328,$
 $7.5335, 11.3160$
 $x = 0.63^\circ, 2.52^\circ, 3.77^\circ, 5.66^\circ$
- c** $x + \frac{\pi}{4} = \pi - 0.7754,$
 $2\pi + 0.7754$
 $= 2.3662, 7.0586$
 $x = 1.58^\circ, 6.27^\circ$
- d** $\cos x = -\frac{1}{3}$
 $x = \pi - 1.2310, \pi + 1.2310$
 $= 1.91^\circ, 4.37^\circ$
- e** $\frac{1}{2}x = 0.0901, \pi - 0.0901$
 $= 0.0901, 3.0515$
 $x = 0.18^\circ, 6.10^\circ$
- f** $2x = \pi - 0.2213, 2\pi - 0.2213$
 $3\pi - 0.2213, 4\pi - 0.2213$
 $= 2.9203, 6.0619,$
 $9.2035, 12.3451$
 $x = 1.46^\circ, 3.03^\circ, 4.60^\circ, 6.17^\circ$
- g** $\sin(x - \frac{\pi}{3}) = 0.75$
 $x - \frac{\pi}{3} = 0.8481, \pi - 0.8481$
 $= 0.8481, 2.2935$
 $x = 1.90^\circ, 3.34^\circ$
- h** $2x + \frac{\pi}{6} = 1.1071, \pi + 1.1071,$
 $2\pi + 1.1071, 3\pi + 1.1071$
 $= 1.1071, 4.2487,$
 $7.3903, 10.5319$
 $2x = 0.5835, 3.7251,$
 $6.8667, 10.0083$
 $x = 0.29^\circ, 1.86^\circ, 3.43^\circ, 5.00^\circ$
- i** $3x = \pi - 0.6266, \pi + 0.6266,$
 $3\pi - 0.6266, 3\pi + 0.6266,$
 $5\pi - 0.6266, 5\pi + 0.6266$
 $= 2.5149, 3.7682, 8.7981,$
 $10.0514, 15.0813, 16.3346$
 $x = 0.84^\circ, 1.26^\circ, 2.93^\circ,$
 $3.35^\circ, 5.03^\circ, 5.44^\circ$
- j** $\tan x = -\frac{5}{3}$
 $x = \pi - 1.0304, 2\pi - 1.0304$
 $x = 2.11^\circ, 5.25^\circ$
- k** $2x - \frac{\pi}{2} = \pi - 1.2239, \pi + 1.2239,$
 $3\pi - 1.2239, 3\pi + 1.2239$
 $= 1.9177, 4.3655,$
 $8.2009, 10.6487$
 $2x = 3.4885, 5.9363,$
 $9.7717, 12.2195$
 $x = 1.74^\circ, 2.97^\circ, 4.89^\circ, 6.11^\circ$
- l** $\sin 2x = -\frac{1}{6}$
 $2x = \pi + 0.1674, 2\pi - 0.1674,$
 $3\pi + 0.1674, 4\pi - 0.1674$
 $= 3.3090, 6.1157,$
 $9.5922, 12.3989$
 $x = 1.65^\circ, 3.06^\circ, 4.80^\circ, 6.20^\circ$

8 a $(2y - 1)(y - 1) = 0$

$y = \frac{1}{2}, 1$

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

$x = 30, 180 - 30$ or 90

$x = 30^\circ, 90^\circ, 150^\circ$

9 a $\sin \theta = \pm \frac{\sqrt{3}}{2}$

$\theta = 60, 180 - 60$ or $180 + 60, 360 - 60$

$\theta = 60, 120, 240, 300$

c $\cos \theta(2 \cos \theta + 1) = 0$

$\cos \theta = 0$ or -0.5

$\theta = 90, 270$ or $180 - 60, 180 + 60$

$\theta = 90, 120, 240, 270$

e $\sin \theta(4 - \tan \theta) = 0$

$\sin \theta = 0$ or $\tan \theta = 4$

$\theta = 0, 180, 360$ or $76.0, 180 + 76.0$

$\theta = 0, 76.0, 180, 256.0, 360$

g $(\tan \theta - 1)(\tan \theta - 2) = 0$

$\tan \theta = 1$ or 2

$\theta = 45, 180 + 45$ or $63.4, 180 + 63.4$

$\theta = 45, 63.4, 225, 243.4$

i $\tan^2 \theta - \tan \theta - 6 = 0$

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

$\tan \theta = -2$ or 3

$\theta = 180 - 63.4, 360 - 63.4$ or $71.6, 180 + 71.6$

$\theta = 71.6, 116.6, 251.6, 296.6$

k $4 \sin^2 \theta - 8 \sin \theta + 3 = 0$

$(2 \sin \theta - 1)(2 \sin \theta - 3) = 0$

$\sin \theta = 0.5$ or 1.5 [no solutions]

$\theta = 30, 180 - 30$

$\theta = 30, 150$

m $\tan \theta = \frac{-3 \pm \sqrt{9+4}}{2}$

$\tan \theta = \frac{1}{2}(-3 \pm \sqrt{13})$

$\theta = 180 - 73.2, 360 - 73.2$ or $16.8, 180 + 16.8$

$\theta = 16.8, 106.8, 196.8, 286.8$

b $\tan \theta = \pm 1$

$\theta = 45, 180 + 45$ or $180 - 45, 360 - 45$

$\theta = 45, 135, 225, 315$

d $\sin \theta = 0$ or $\cos \theta = 0.25$

$\theta = 0, 180, 360$ or $75.5, 360 - 75.5$

$\theta = 0, 75.5, 180, 284.5, 360$

f $\cos \theta = -1$ or 0.5

$\theta = 180$ or $60, 360 - 60$

$\theta = 60, 180, 300$

h $(3 \sin \theta - 1)(\sin \theta - 2) = 0$

$\sin \theta = \frac{1}{3}$ or 2 [no solutions]

$\theta = 19.5, 180 - 19.5$

$\theta = 19.5, 160.5$

j $(3 \cos \theta - 2)(2 \cos \theta + 1) = 0$

$\cos \theta = -0.5$ or $\frac{2}{3}$

$\theta = 180 - 60, 180 + 60$ or $48.2, 360 - 48.2$

$\theta = 48.2, 120, 240, 311.8$

l $\cos \theta = \frac{-2 \pm \sqrt{4+4}}{2}$

$\cos \theta = -1 + \sqrt{2}$ or $-1 - \sqrt{2}$ [no solutions]

$\theta = 65.5, 360 - 65.5$

$\theta = 65.5, 294.5$

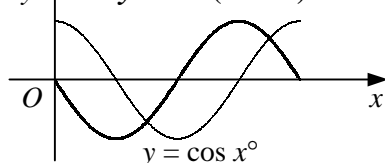
n $3 \sin^2 \theta + \sin \theta - 1 = 0$

$\sin \theta = \frac{-1 \pm \sqrt{1+12}}{6} = \frac{1}{6}(-1 \pm \sqrt{13})$

$\theta = 180 + 50.1, 360 - 50.1$ or $25.7, 180 - 25.7$

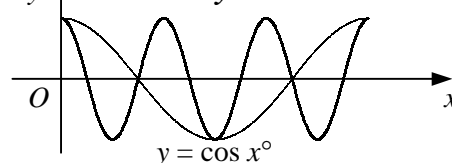
$\theta = 25.7, 154.3, 230.1, 309.9$

10 a, b $y = \cos(x + 90^\circ)$



c $x = 135, 315$

11 a $y = \cos 3x^\circ$



b $x = 0, 90, 180, 270, 360$

c $x = 0, 45, 90, 135, 180$