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Quadratic Equations
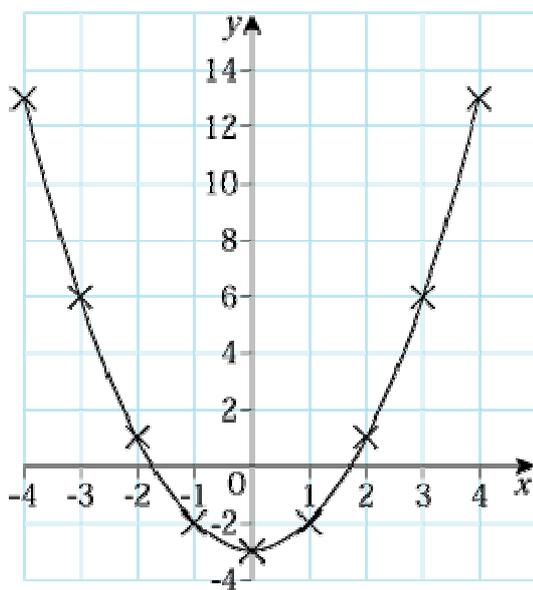Exercise A, Question 1

Question:

Draw a graph with the following equation, taking values of x from -4 to $+4$. For each graph write down the equation of the line of symmetry.

$y = x^2 - 3$

Solution:

$y = x^2 - 3$.

x	-4	-3	-2	-1	0	1	2	3	4
$x^2 - 3$	$16-3$	$9-3$	$4-3$	$1-3$	$0-3$	$1-3$	$4-3$	$9-3$	$16-3$
y	13	6	1	-2	-3	-2	1	6	13

Equation of line of symmetry is $x = 0$.

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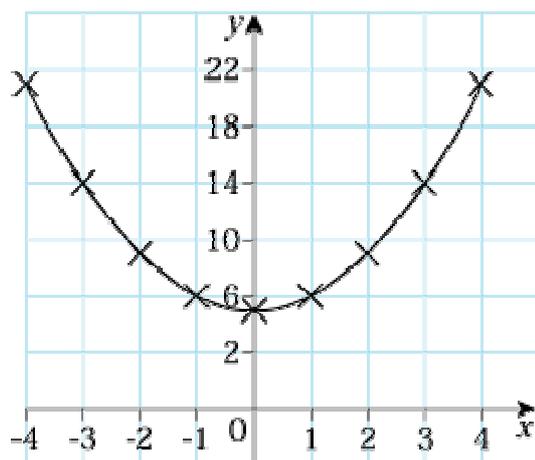**Exercise A, Question 2**

Question:

Draw a graph with the following equation, taking values of x from -4 to $+4$. For each graph write down the equation of the line of symmetry.

$y = x^2 + 5$

Solution:

$y = x^2 + 5$.

x	-4	-3	-2	-1	0	1	2	3	4
$x^2 + 5$	$16 + 5$	$9 + 5$	$4 + 5$	$1 + 5$	$0 + 5$	$1 + 5$	$4 + 5$	$9 + 5$	$16 + 5$
y	21	14	9	6	5	6	9	14	21

Equation of line of symmetry is $x = 0$.

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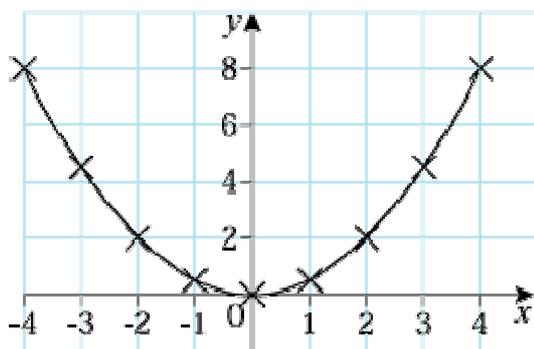**Exercise A, Question 3**

Question:

Draw a graph with the following equation, taking values of x from -4 to $+4$. For each graph write down the equation of the line of symmetry.

$y = \frac{1}{2}x^2$

Solution:

$y = \frac{1}{2}x^2$

x	-4	-3	3	-2	-1	0	1	2	3	4
$\frac{1}{2}x^2$	8	$4\frac{1}{2}$		2	$\frac{1}{2}$	0	$\frac{1}{2}$	2	$4\frac{1}{2}$	8
y	8	$4\frac{1}{2}$		2	$\frac{1}{2}$	0	$\frac{1}{2}$	2	$4\frac{1}{2}$	8

Equation of line of symmetry is $x = 0$.

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Quadratic Equations
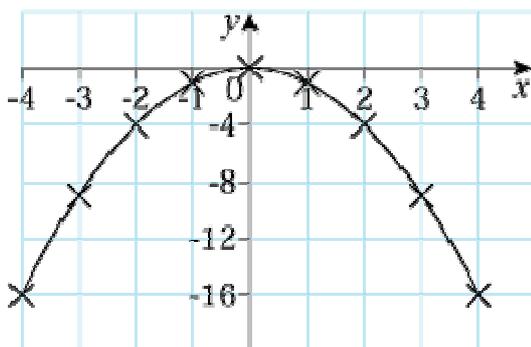**Exercise A, Question 4**

Question:

Draw a graph with the following equation, taking values of x from -4 to $+4$. For each graph write down the equation of the line of symmetry.

$y = -x^2$

Solution:

$y = -x^2$

x	-4	-3	-2	-1	0	1	2	3	4
$-x^2$	-16	-9	-4	-1	0	-1	-4	-9	-16
y	-16	-9	-4	-1	0	-1	-4	-9	-16

Equation of line of symmetry is $x = 0$.

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Quadratic Equations
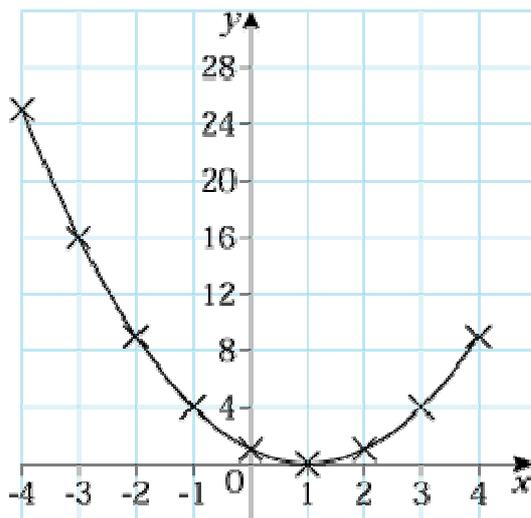**Exercise A, Question 5**

Question:

Draw a graph with the following equation, taking values of x from -4 to $+4$. For each graph write down the equation of the line of symmetry.

$y = (x - 1)^2$

Solution:

$y = (x - 1)^2$

x	-4	-3	-2	-1	0	1	2	3	4
$(x - 1)^2$	25	16	9	4	1	0	1	4	9
y	25	16	9	4	1	0	1	4	9

Equation of line of symmetry is $x = 1$.

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Quadratic Equations
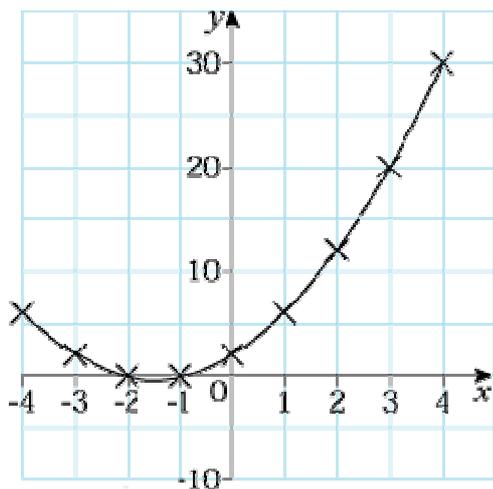**Exercise A, Question 6**

Question:

Draw a graph with the following equation, taking values of x from -4 to $+4$. For each graph write down the equation of the line of symmetry.

$y = x^2 + 3x + 2$

Solution:

$y = x^2 + 3x + 2$

x	-4	-3	-2	-1	0	1	2	3	4
$x^2 + 3x + 2$	$16-12+2$	$9-9+2$	$4-6+2$	$1-3+2$	$0+0+2$	$1+3+2$	$4+6+2$	$9+9+2$	$16+12+2$
y	6	2	0	0	2	6	12	20	30

Equation of line of symmetry is $x = -1\frac{1}{2}$.

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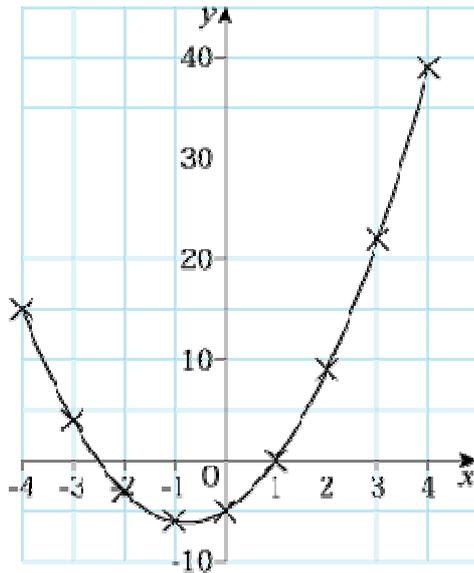**Exercise A, Question 7**

Question:

Draw a graph with the following equation, taking values of x from -4 to $+4$. For each graph write down the equation of the line of symmetry.

$y = 2x^2 + 3x - 5$

Solution:

$y = 2x^2 + 3x - 5$

x	-4	-33	-2	-1	0	1	2	3	4
$2x^2 + 3x - 5$	$32-12-5$	$18-9-5$	$8-6-5$	$2-3-5$	$0+0-5$	$2+3-5$	$8+6-5$	$18+9-5$	$32+12-5$
y	15	4	-3	-6	-5	0	9	22	39

Equation of line of symmetry is $x = -\dfrac{3}{4}$.

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Quadratic Equations
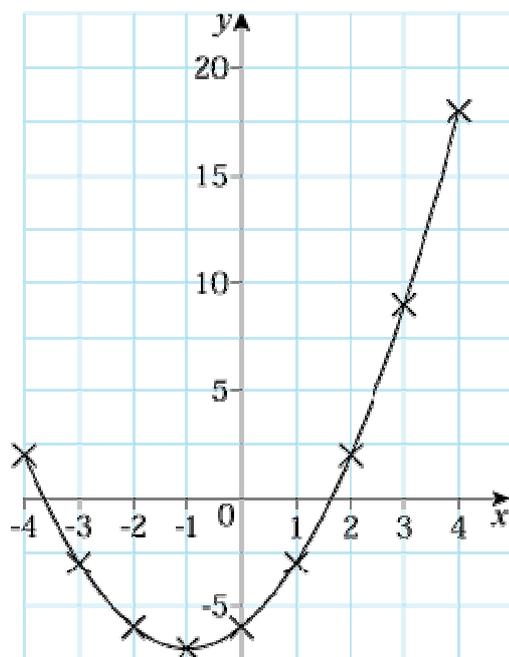**Exercise A, Question 8**

Question:

Draw a graph with the following equation, taking values of x from -4 to $+4$. For each graph write down the equation of the line of symmetry.

$y = x^2 + 2x - 6$

Solution:

$y = x^2 + 2x - 6$

x	-4	-33	-2	-1	0	1	2	3	4
$x^2 + 2x - 6$	$16 - 8 - 6$	$9 - 6 - 6$	$4 - 4 - 6$	$1 - 2 - 6$	$0 + 0 - 6$	$1 + 2 - 6$	$4 + 4 - 6$	$9 + 6 - 6$	$16 + 8 - 6$
y	2	-3	-6	-7	-6	-3	2	9	18

Equation of line of symmetry is $x = -1$.

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Quadratic Equations
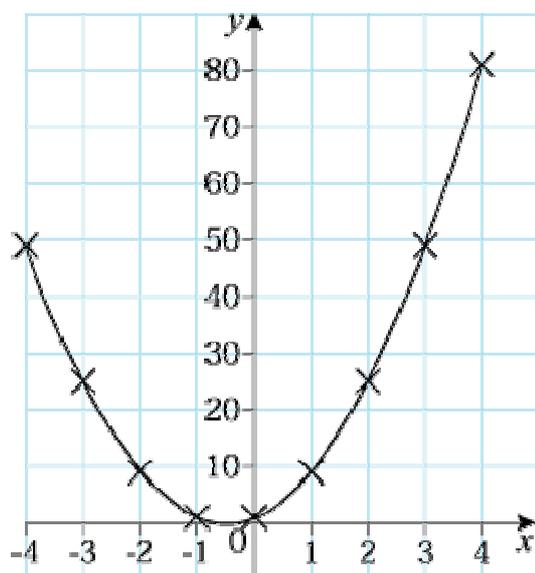**Exercise A, Question 9**

Question:

Draw a graph with the following equation, taking values of x from -4 to $+4$. For each graph write down the equation of the line of symmetry.

$y = (2x + 1)^2$

Solution:

$y = (2x + 1)^2$

x	-4	-33	-2	-1	0	1	2	3	4
$2x + 1$	$-8 + 1$	$-6 + 1$	$-4 + 1$	$-2 + 1$	$0 + 1$	$2 + 1$	$4 + 1$	$6 + 1$	$8 + 1$
$(2x + 1)$	-7	-5	-3	-1	1	3	5	7	9
$y = (2x + 1)^2$	49	25	9	1	1	9	25	49	81

Equation of line of symmetry is $x = -\frac{1}{2}$.

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Quadratic Equations
Exercise B, Question 1

Question:

Solve the following equation:

$x^2 = 4x$

Solution:

$x^2 - 4x = 0$
$x (x - 4) = 0$
$x = 0$ or $x - 4 = 0$
So $x = 0$ or $x = 4$

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Quadratic Equations
Exercise B, Question 2

Question:

Solve the following equation:

$x^2 = 25x$

Solution:

$x^2 - 25x = 0$
$x (x - 25) = 0$
$x = 0$ or $x - 25 = 0$
So $x = 0$ or $x = 25$

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Quadratic Equations
Exercise B, Question 3

Question:

Solve the following equation:

$3x^2 = 6x$

Solution:

$3x^2 - 6x = 0$
$3x (x - 2) = 0$
$x = 0$ or $x - 2 = 0$
So $x = 0$ or $x = 2$

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Quadratic Equations
Exercise B, Question 4

Question:

Solve the following equation:

$5x^2 = 30x$

Solution:

$5x^2 - 30x = 0$
$5x (x - 6) = 0$
$x = 0$ or $x - 6 = 0$
So $x = 0$ or $x = 6$

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Quadratic Equations
Exercise B, Question 5

Question:

Solve the following equation:

$x^2 + 3x + 2 = 0$

Solution:

$(x + 1)(x + 2) = 0$
$x + 1 = 0$ or $x + 2 = 0$
So $x = -1$ or $x = -2$

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Quadratic Equations
Exercise B, Question 6

Question:

Solve the following equation:

$x^2 + 5x + 4 = 0$

Solution:

$(x + 1)(x + 4) = 0$
$x + 1 = 0$ or $x + 4 = 0$
So $x = -1$ or $x = -4$

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Quadratic Equations
Exercise B, Question 7

Question:

Solve the following equation:

$x^2 + 7x + 10 = 0$

Solution:

$(x + 2)(x + 5) = 0$
$x + 2 = 0$ or $x + 5 = 0$
$x = -2$ or $x = -5$

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Quadratic Equations
Exercise B, Question 8

Question:

Solve the following equation:

$x^2 - x - 6 = 0$

Solution:

$(x - 3) (x + 2) = 0$
$x - 3 = 0$ or $x + 2 = 0$
So $x = 3$ or $x = -2$

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Quadratic Equations
Exercise B, Question 9

Question:

Solve the following equation:

$x^2 - 8x + 15 = 0$

Solution:

$(x - 3)(x - 5) = 0$
$x - 3 = 0$ or $x - 5 = 0$
So $x = 3$ or $x = 5$

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Quadratic Equations
Exercise B, Question 10

Question:

Solve the following equation:

$x^2 - 9x + 20 = 0$

Solution:

$(x - 4)(x - 5) = 0$
$x - 4 = 0$ or $x - 5 = 0$
So $x = 4$ or $x = 5$

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Quadratic Equations
Exercise B, Question 11

Question:

Solve the following equation:

$x^2 - 5x - 6 = 0$

Solution:

$(x - 6)(x + 1) = 0$
$x - 6 = 0$ or $x + 1 = 0$
So $x = 6$ or $x = -1$

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Quadratic Equations
Exercise B, Question 12

Question:

Solve the following equation:

$x^2 - 4x - 12 = 0$

Solution:

$(x - 6) (x + 2) = 0$
$x - 6 = 0$ or $x + 2 = 0$
So $x = 6$ or $x = -2$

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Quadratic Equations
Exercise B, Question 13

Question:

Solve the following equation:

$2x^2 + 7x + 3 = 0$

Solution:

$(2x + 1) (x + 3) = 0$
$2x + 1 = 0$ or $x + 3 = 0$
$2x = -1$ or $x = -3$
So $x = -\dfrac{1}{2}$ or $x = -3$

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Quadratic Equations
Exercise B, Question 14

Question:

Solve the following equation:

$6x^2 - 7x - 3 = 0$

Solution:

$(3x + 1) \ (2x - 3) \ = 0$
$3x + 1 = 0$ or $2x - 3 = 0$
So $x = -\frac{1}{3}$ or $x = \frac{3}{2}$

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Quadratic Equations
Exercise B, Question 15

Question:

Solve the following equation:

$6x^2 - 5x - 6 = 0$

Solution:

$(3x + 2) (2x - 3) = 0$
$3x + 2 = 0$ or $2x - 3 = 0$
So $x = -\dfrac{2}{3}$ or $x = \dfrac{3}{2}$

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Quadratic Equations
Exercise B, Question 16

Question:

Solve the following equation:

$4x^2 - 16x + 15 = 0$

Solution:

$(2x - 3)(2x - 5) = 0$
$2x - 3 = 0$ or $2x - 5 = 0$
So $x = \frac{3}{2}$ or $x = \frac{5}{2}$

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Quadratic Equations
Exercise B, Question 17

Question:

Solve the following equation:

$3x^2 + 5x = 2$

Solution:

$3x^2 + 5x - 2 = 0$
$(3x - 1)(x + 2) = 0$
$3x - 1 = 0$ or $x + 2 = 0$
So $x = \dfrac{1}{3}$ or $x = -2$

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Quadratic Equations
Exercise B, Question 18

Question:

Solve the following equation:

$(2x - 3)^2 = 9$

Solution:

$2x - 3 = \pm 3$
$2x = \pm 3 + 3$
$x = \dfrac{\pm 3 + 3}{2}$
So $x = 3$ or $x = 0$

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Quadratic Equations
Exercise B, Question 19

Question:

Solve the following equation:

$(x - 7)^2 = 36$

Solution:

$x - 7 = \pm 6$
$x = \pm 6 + 7$
So $x = 1$ or $x = 13$

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Quadratic Equations
Exercise B, Question 20

Question:

Solve the following equation:

$2x^2 = 8$

Solution:

$x^2 = 4$
$x = \pm 2$
So $x = 2$ or $x = -2$

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Quadratic Equations
Exercise B, Question 21

Question:

Solve the following equation:

$3x^2 = 5$

Solution:

$$x^2 = \frac{5}{3}$$

$$x = \pm\sqrt{\frac{5}{3}}$$

So $x = \sqrt{\frac{5}{3}}$ or $x = -\sqrt{\frac{5}{3}}$

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Quadratic Equations
Exercise B, Question 22

Question:

Solve the following equation:

$(x-3)^2 = 13$

Solution:

$x - 3 = \pm \sqrt{13}$
$x = 3 \pm \sqrt{13}$
So $x = 3 + \sqrt{13}$ or $x = 3 - \sqrt{13}$

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Quadratic Equations
Exercise B, Question 23

Question:

Solve the following equation:

$$(3x - 1)^2 = 11$$

Solution:

$3x - 1 = \pm \sqrt{11}$
$3x = 1 \pm \sqrt{11}$
$$x = \frac{1 \pm \sqrt{11}}{3}$$

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Quadratic Equations
Exercise B, Question 24

Question:

Solve the following equation:

$5x^2 - 10x^2 = -7 + x + x^2$

Solution:

$-6x^2 - x + 7 = 0$
$(1 - x)(7 + 6x) = 0$
$x = 1$ or $6x = -7$
So $x = 1$ or $x = -\dfrac{7}{6}$

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Quadratic Equations
Exercise B, Question 25

Question:

Solve the following equation:

$6x^2 - 7 = 11x$

Solution:

$6x^2 - 11x - 7 = 0$
$(3x - 7)(2x + 1) = 0$
$3x - 7 = 0$ or $2x + 1 = 0$
So $x = \dfrac{7}{3}$ or $x = -\dfrac{1}{2}$

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Quadratic Equations
Exercise B, Question 26

Question:

Solve the following equation:

$4x^2 + 17x = 6x - 2x^2$

Solution:

$6x^2 + 11x = 0$
$x (6x + 11) = 0$
$x = 0 \text{ or } 6x + 11 = 0$
So $x = 0 \text{ or } x = -\dfrac{11}{6}$

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Quadratic Equations
Exercise C, Question 1

Question:

Complete the square for the expression:

$x^2 + 4x$

Solution:

$$= (x+2)^2 - 4$$

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Quadratic Equations
Exercise C, Question 2

Question:

Complete the square for the expression:

$x^2 - 6x$

Solution:

$$= (x - 3)^2 - 9$$

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Quadratic Equations
Exercise C, Question 3

Question:

Complete the square for the expression:

$x^2 - 16x$

Solution:

$$= (x - 8)^2 - 64$$

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Quadratic Equations
Exercise C, Question 4

Question:

Complete the square for the expression:

$x^2 + x$

Solution:

$$= \left(x + \frac{1}{2} \right)^2 - \frac{1}{4}$$

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Quadratic Equations
Exercise C, Question 5

Question:

Complete the square for the expression:

$x^2 - 14x$

Solution:

$$= (x - 7)^2 - 49$$

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Quadratic Equations
Exercise C, Question 6

Question:

Complete the square for the expression:

$2x^2 + 16x$

Solution:

$= 2 (x^2 + 8x)$
$= 2 [(x + 4)^2 - 16]$
$= 2 (x + 4)^2 - 32$

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Quadratic Equations
Exercise C, Question 7

Question:

Complete the square for the expression:

$3x^2 - 24x$

Solution:

$= 3 (x^2 - 8x)$
$= 3 [(x - 4)^2 - 16]$
$= 3 (x - 4)^2 - 48$

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Quadratic Equations
Exercise C, Question 8

Question:

Complete the square for the expression:

$2x^2 - 4x$

Solution:

$= 2 \left(x^2 - 2x \right)$
$= 2 \left[\left(x - 1 \right)^2 - 1 \right]$
$= 2 \left(x - 1 \right)^2 - 2$

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Quadratic Equations
Exercise C, Question 9

Question:

Complete the square for the expression:

$5x^2 + 20x$

Solution:

$= 5 \, (\, x^2 + 4x \,)$
$= 5 \, [\, (\, x + 2 \,)^2 - 4 \,]$
$= 5 \, (\, x + 2 \,)^2 - 20$

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Quadratic Equations
Exercise C, Question 10

Question:

Complete the square for the expression:

$2x^2 - 5x$

Solution:

$$= 2\left(x^2 - \frac{5}{2}x\right)$$

$$= 2\left[\left(x - \frac{5}{4}\right)^2 - \frac{25}{16}\right]$$

$$= 2\left(x - \frac{5}{4}\right)^2 - \frac{25}{8}$$

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Quadratic Equations
Exercise C, Question 11

Question:

Complete the square for the expression:

$3x^2 + 9x$

Solution:

$$= 3 \left(x^2 + 3x \right)$$

$$= 3 \left[\left(x + \frac{3}{2} \right)^2 - \frac{9}{4} \right]$$

$$= 3 \left(x + \frac{3}{2} \right)^2 - \frac{27}{4}$$

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Quadratic Equations
Exercise C, Question 12

Question:

Complete the square for the expression:

$3x^2 - x$

Solution:

$$= 3 \left(x^2 - \frac{1}{3}x \right)$$

$$= 3 \left[\left(x - \frac{1}{6} \right)^2 - \frac{1}{36} \right]$$

$$= 3 \left(x - \frac{1}{6} \right)^2 - \frac{3}{36}$$

$$= 3 \left(x - \frac{1}{6} \right)^2 - \frac{1}{12}$$

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Quadratic Equations
Exercise D, Question 1

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$x^2 + 6x + 1 = 0$

Solution:

$x^2 + 6x = -1$
$(x + 3)^2 - 9 = -1$
$(x + 3)^2 = -1 + 9$
$(x + 3)^2 = 8$
$x + 3 = \pm \sqrt{8}$
$x = -3 \pm \sqrt{8}$
$x = -3 \pm \sqrt{2}\sqrt{4}$
$x = -3 \pm 2\sqrt{2}$
So $x = -3 + 2\sqrt{2}$ or $x = -3 - 2\sqrt{2}$

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Quadratic Equations
Exercise D, Question 2

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$x^2 + 12x + 3 = 0$

Solution:

$x^2 + 12x = -3$
$(x + 6)^2 - 36 = -3$
$(x + 6)^2 = 33$
$x + 6 = \pm \sqrt{33}$
$x = -6 \pm \sqrt{33}$
So $x = -6 + \sqrt{33}$ or $x = -6 - \sqrt{33}$

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Quadratic Equations
Exercise D, Question 3

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$x^2 - 10x = 5$

Solution:

$(x - 5)^2 - 25 = 5$
$(x - 5)^2 = 5 + 25$
$(x - 5)^2 = 30$
$x - 5 = \pm \sqrt{30}$
$x = 5 \pm \sqrt{30}$
So $x = 5 + \sqrt{30}$ or $x = 5 - \sqrt{30}$

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Quadratic Equations
Exercise D, Question 4

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$x^2 + 4x - 2 = 0$

Solution:

$x^2 + 4x = 2$
$(x + 2)^2 - 4 = 2$
$(x + 2)^2 = 6$
$x + 2 = \pm \sqrt{6}$
So $x = -2 + \sqrt{6}$ or $x = -2 - \sqrt{6}$

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Quadratic Equations
Exercise D, Question 5

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$x^2 - 3x - 5 = 0$

Solution:

$x^2 - 3x = 5$

$\left(x - \dfrac{3}{2} \right)^2 - \dfrac{9}{4} = 5$

$\left(x - \dfrac{3}{2} \right)^2 = 5 + \dfrac{9}{4}$

$\left(x - \dfrac{3}{2} \right)^2 = \dfrac{29}{4}$

$x - \dfrac{3}{2} = \pm \dfrac{\sqrt{29}}{2}$

$x = \dfrac{3}{2} \pm \dfrac{\sqrt{29}}{2}$

So $x = \dfrac{3 + \sqrt{29}}{2}$ or $x = \dfrac{3 - \sqrt{29}}{2}$

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Quadratic Equations
Exercise D, Question 6

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$2x^2 - 7 = 4x$

Solution:

$2x^2 - 4x = 7$

$x^2 - 2x = \dfrac{7}{2}$

$(x - 1)^2 - 1 = \dfrac{7}{2}$

$(x - 1)^2 = \dfrac{9}{2}$

$x - 1 = \pm \dfrac{3}{\sqrt{2}}$

$x = 1 \pm \dfrac{3}{\sqrt{2}}$

$x = 1 \pm \dfrac{3\sqrt{2}}{2}$

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Quadratic Equations
Exercise D, Question 7

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$4x^2 - x = 8$

Solution:

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

$\left(x - \frac{1}{8} \right)^2 - \frac{1}{64} = 2$

$\left(x - \frac{1}{8} \right)^2 = 2 + \frac{1}{64}$

$\left(x - \frac{1}{8} \right)^2 = \frac{129}{64}$

$x - \frac{1}{8} = \pm \frac{\sqrt{129}}{8}$

$x = \frac{1}{8} \pm \frac{\sqrt{129}}{8}$

So $x = \frac{1 + \sqrt{129}}{8}$ or $x = \frac{1 - \sqrt{129}}{8}$

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Quadratic Equations
Exercise D, Question 8

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$10 = 3x - x^2$

Solution:

$x^2 - 3x = -10$

$\left(x - \dfrac{3}{2} \right)^2 - \dfrac{9}{4} = -10$

$\left(x - \dfrac{3}{2} \right)^2 = -\dfrac{31}{4}$

No real roots as RHS is negative.

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Quadratic Equations
Exercise D, Question 9

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$15 - 6x - 2x^2 = 0$

Solution:

$2x^2 + 6x = 15$

$x^2 + 3x = \dfrac{15}{2}$

$\left(x + \dfrac{3}{2} \right)^2 - \dfrac{9}{4} = \dfrac{15}{2}$

$\left(x + \dfrac{3}{2} \right)^2 = \dfrac{39}{4}$

$x + \dfrac{3}{2} = \pm \dfrac{\sqrt{39}}{2}$

$x = -\dfrac{3}{2} \pm \dfrac{\sqrt{39}}{2}$

So $x = -\dfrac{3}{2} + \dfrac{\sqrt{39}}{2}$ or $x = -\dfrac{3}{2} - \dfrac{\sqrt{39}}{2}$

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Quadratic Equations
Exercise D, Question 10

Question:

Solve the quadratic equation by completing the square (remember to leave your answer in surd form):

$5x^2 + 8x - 2 = 0$

Solution:

$x^2 + \dfrac{8}{5}x = \dfrac{2}{5}$

$\left(x + \dfrac{4}{5} \right)^2 - \dfrac{16}{25} = \dfrac{2}{5}$

$\left(x + \dfrac{4}{5} \right)^2 = \dfrac{26}{25}$

$x + \dfrac{4}{5} = \pm \dfrac{\sqrt{26}}{5}$

$x = -\dfrac{4}{5} \pm \dfrac{\sqrt{26}}{5}$

So $x = \dfrac{-4 + \sqrt{26}}{5}$ or $x = \dfrac{-4 - \sqrt{26}}{5}$

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Quadratic Equations
Exercise E, Question 1

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

$x^2 + 3x + 1 = 0$

Solution:

$$x = \frac{-3 \pm \sqrt{3^2 - 4(1)(1)}}{2 \times 1}$$

$$x = \frac{-3 \pm \sqrt{9 - 4}}{2}$$

$$x = \frac{-3 \pm \sqrt{5}}{2}$$

Then $x = \frac{-3 + \sqrt{5}}{2}$ or $x = \frac{-3 - \sqrt{5}}{2}$

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Quadratic Equations
Exercise E, Question 2

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

$x^2 - 3x - 2 = 0$

Solution:

$$x = \frac{-(-3) \pm \sqrt{(-3)^2 - 4(1)(-2)}}{2 \times 1}$$

$$x = \frac{+3 \pm \sqrt{9 + 8}}{2}$$

$$x = \frac{3 \pm \sqrt{17}}{2}$$

Then $x = \dfrac{3 + \sqrt{17}}{2}$ or $x = \dfrac{3 - \sqrt{17}}{2}$

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Quadratic Equations
Exercise E, Question 3

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

$x^2 + 6x + 6 = 0$

Solution:

$$x = \frac{-6 \pm \sqrt{(6)^2 - 4(1)(6)}}{2 \times 1}$$

$$x = \frac{-6 \pm \sqrt{36 - 24}}{2}$$

$$x = \frac{-6 \pm \sqrt{12}}{2}$$

$$x = \frac{-6 \pm 2\sqrt{3}}{2}$$

$$x = -3 \pm \sqrt{3}$$

Then $x = -3 + \sqrt{3}$ or $x = -3 - \sqrt{3}$

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Quadratic Equations
Exercise E, Question 4

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

$x^2 - 5x - 2 = 0$

Solution:

$$x = \frac{-(-5) \pm \sqrt{(-5)^2 - 4(1)(-2)}}{2 \times 1}$$

$$x = \frac{+5 \pm \sqrt{25 + 8}}{2}$$

$$x = \frac{5 \pm \sqrt{33}}{2}$$

Then $x = \frac{5 + \sqrt{33}}{2}$ or $x = \frac{5 - \sqrt{33}}{2}$

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Quadratic Equations
Exercise E, Question 5

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

$3x^2 + 10x - 2 = 0$

Solution:

$$x = \frac{-10 \pm \sqrt{10^2 - 4(3)(-2)}}{2 \times 3}$$

$$x = \frac{-10 \pm \sqrt{100 + 24}}{6}$$

$$x = \frac{-10 \pm \sqrt{124}}{6}$$

$$x = \frac{-10 \pm 2\sqrt{31}}{6}$$

Then $x = \dfrac{-5 + \sqrt{31}}{3}$ or $x = \dfrac{-5 - \sqrt{31}}{3}$

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Quadratic Equations
Exercise E, Question 6

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

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

Solution:

$$x = \frac{-(-4) \pm \sqrt{(-4)^2 - 4(4)(-1)}}{2 \times 4}$$

$$x = \frac{+4 \pm \sqrt{16 + 16}}{8}$$

$$x = \frac{4 \pm \sqrt{32}}{8}$$

$$x = \frac{4 \pm 4\sqrt{2}}{8}$$

Then $x = \dfrac{1 + \sqrt{2}}{2}$ or $x = \dfrac{1 - \sqrt{2}}{2}$

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Quadratic Equations
Exercise E, Question 7

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

$7x^2 + 9x + 1 = 0$

Solution:

$$x = \frac{-9 \pm \sqrt{9^2 - 4\,(\,7\,)\,(\,1\,)}}{2 \times 7}$$

$$x = \frac{-9 \pm \sqrt{81 - 28}}{14}$$

$$x = \frac{-9 \pm \sqrt{53}}{14}$$

Then $x = \dfrac{-9 + \sqrt{53}}{14}$ or $x = \dfrac{-9 - \sqrt{53}}{14}$

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Quadratic Equations
Exercise E, Question 8

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

$5x^2 + 4x - 3 = 0$

Solution:

$$x = \frac{-4 \pm \sqrt{4^2 - 4(5)(-3)}}{2 \times 5}$$

$$x = \frac{-4 \pm \sqrt{16 + 60}}{10}$$

$$x = \frac{-4 \pm \sqrt{76}}{10}$$

$$x = \frac{-4 \pm 2\sqrt{19}}{10}$$

Then $x = \dfrac{-2 + \sqrt{19}}{5}$ or $x = \dfrac{-2 - \sqrt{19}}{5}$

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Quadratic Equations
Exercise E, Question 9

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

$4x^2 - 7x = 2$

Solution:

$4x^2 - 7x - 2 = 0$

$$x = \frac{-(-7) \pm \sqrt{(-7)^2 - 4(4)(-2)}}{2 \times 4}$$

$$x = \frac{+7 \pm \sqrt{49 + 32}}{8}$$

$$x = \frac{7 \pm \sqrt{81}}{8}$$

$$x = \frac{7 \pm 9}{8}$$

Then $x = 2$ or $x = -\frac{1}{4}$

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Quadratic Equations
Exercise E, Question 10

Question:

Solve the following quadratic equation by using the formula, giving the solution in surd form. Simplify your answer:

$11x^2 + 2x - 7 = 0$

Solution:

$x = \dfrac{-2 \pm \sqrt{2^2 - 4(11)(-7)}}{2 \times 11}$

$x = \dfrac{-2 \pm \sqrt{4 + 308}}{22}$

$x = \dfrac{-2 \pm \sqrt{312}}{22}$

$x = \dfrac{-2 \pm 2\sqrt{78}}{22}$

$x = \dfrac{-1 \pm \sqrt{78}}{11}$

Then $x = \dfrac{-1 + \sqrt{78}}{11}$ or $x = \dfrac{-1 - \sqrt{78}}{11}$

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Quadratic Equations
Exercise F, Question 1

Question:

Sketch the graphs of the following equations:

(a) $y = x^2 + 3x + 2$

(b) $y = x^2 - 3x + 10$

(c) $y = x^2 + 2x - 15$

(d) $y = 2x^2 + 7x + 3$

(e) $y = 2x^2 + x - 3$

(f) $y = 6x^2 - 19x + 10$

(g) $y = 3x^2 - 2x - 5$

(h) $y = 3x^2 - 13x$

(i) $y = -x^2 + 6x + 7$

(j) $y = 4 - 7x - 2x^2$

Solution:

(a) $a > 0$ so graph is a $\cup$ shape.
$b^2 = 9, 4ac = 8$
$b^2 > 4ac$, so there are two different roots of the equation $y = 0$.
When $y = 0$,
$(x + 2)(x + 1) = 0$
$x = -2$ or $x = -1$
So crossing points are $(-2, 0)$ and $(-1, 0)$.
When $x = 0$, $y = 2$, so $(0, 2)$ is a crossing point.
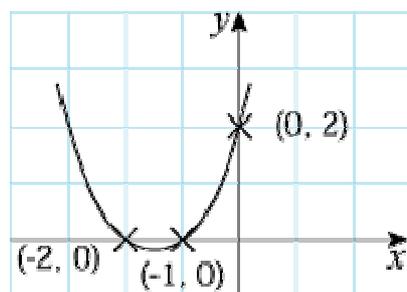
(b) $a > 0$ so graph is a $\cup$ shape.
$b^2 = 9, 4ac = 40$
$b^2 < 4ac$, so there are no real roots of the equation $y = 0$.
So there are no crossing points at $y = 0$.
When $x = 0$, $y = 10$, so crossing point is $(0, 10)$.
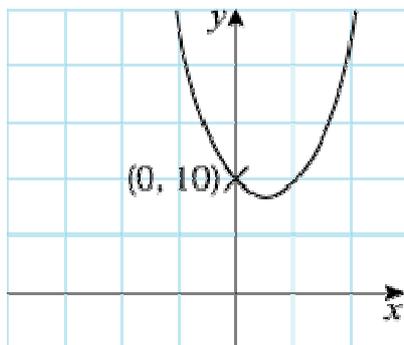
(c) $a > 0$ so graph is a ∪ shape.

$b^2 = 4, 4ac = -60$
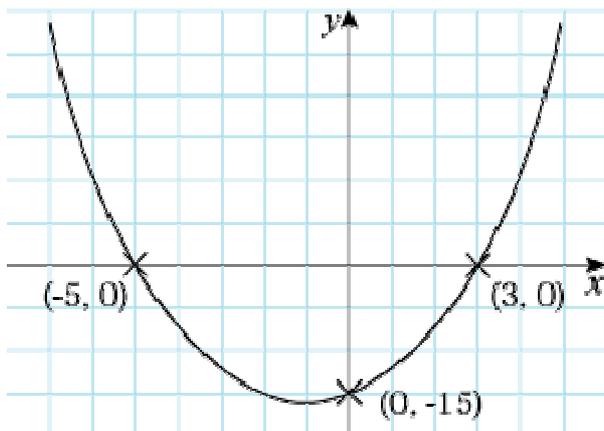
$b^2 > 4ac$, so two different roots of $y = 0$.

When $y = 0$,

$0 = (x + 5)(x - 3)$

$x = -5$ or $x = 3$

So crossing points are $(-5, 0)$ and $(3, 0)$.

When $x = 0, y = -15$, so crossing point is $(0, -15)$.

(d) $a > 0$ so graph is a ∪ shape.

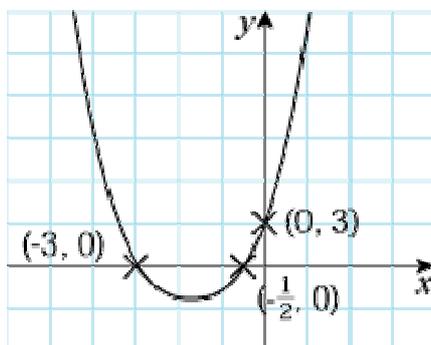$b^2 = 49, 4ac = 24$

$b^2 > 4ac$, so two different roots of $y = 0$.

When $y = 0$,

$0 = (2x + 1)(x + 3)$

$x = -\frac{1}{2}$ or $x = -3$

So crossing points are $\left(-\frac{1}{2}, 0\right)$ and $(-3, 0)$.

When $x = 0, y = 3$, so crossing point is $(0, 3)$.

(e) $a > 0$ so graph is a $\cup$ shape.

$b^2 = 1, 4ac = -24$

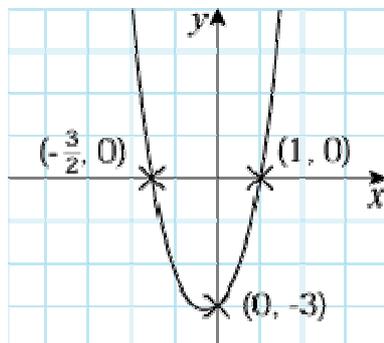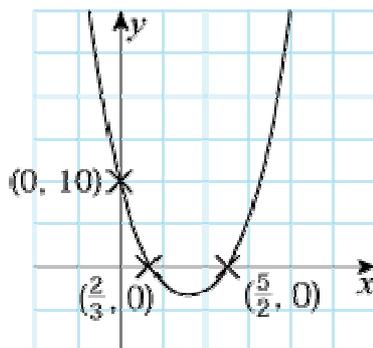$b^2 > 4ac$, so two different roots of $y = 0$.

When $y = 0$,

$0 = (2x + 3)(x - 1)$

$x = -\frac{3}{2}$ or $x = 1$

So crossing points are $\left(-\frac{3}{2}, 0 \right)$ and $(1, 0)$.

When $x = 0$, $y = -3$, so crossing point is $(0, -3)$.

(f) $a > 0$ so graph is a $\cup$ shape.

$b^2 = 361, 4ac = 240$

$b^2 > 4ac$, so two different roots of $y = 0$.

When $y = 0$,

$0 = (3x - 2)(2x - 5)$

$x = \frac{2}{3}$ or $x = \frac{5}{2}$

So crossing points are $\left(\frac{2}{3}, 0 \right)$ and $\left(\frac{5}{2}, 0 \right)$.

When $x = 0$, $y = 10$, so crossing point is $(0, 10)$.

(g) $a >$ so graph is a $\cup$ shape.

$b^2 = 4, 4ac = -60$
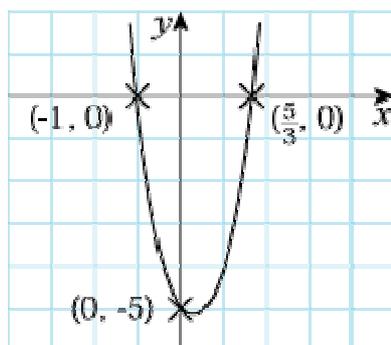
$b^2 > 4ac$, so two different roots of $y = 0$.

When $y = 0$,

$0 = (3x - 5)(x + 1)$

$x = \frac{5}{3}$ or $x = -1$

So crossing points are $\left(\frac{5}{3} , 0 \right)$ and $(-1 , 0)$.

When $x = 0$, $y = -5$, so crossing point is $(0 , -5)$.

(h) $a > 0$ so graph is a $\cup$ shape.

$b^2 = 169$, $4ac = 0$
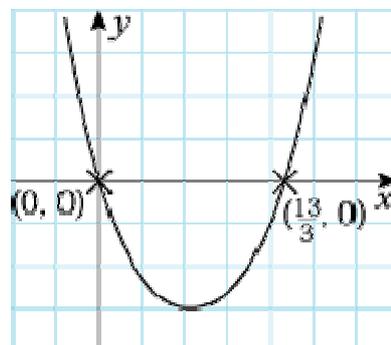
$b^2 > 4ac$, so two different roots of $y = 0$.

When $y = 0$,

$0 = x (3x - 13)$

$x = 0$ or $x = \frac{13}{3}$

So crossing points are $(0 , 0)$ and $\left(\frac{13}{3} , 0 \right)$.

When $x = 0$, $y = 0$, so crossing point is $(0 , 0)$.

(i) $a < 0$ so graph is a $\cap$ shape.

$b^2 = 36$, $4ac = -28$
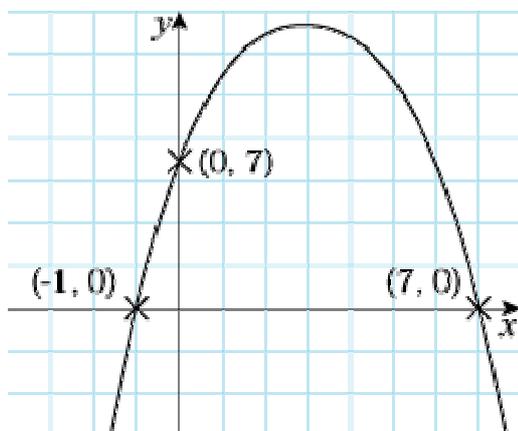
$b^2 > 4ac$, so two different roots of $y = 0$.

When $y = 0$,

$0 = (7 - x) (1 + x)$

$x = 7$ or $x = -1$

So crossing points are $(7 , 0)$ and $(-1 , 0)$.

When $x = 0$, $y = 7$, so crossing point is $(0 , 7)$.

(j) $a < 0$ so graph is a $\cap$ shape.
$b^2 = 49$, $4ac = -32$
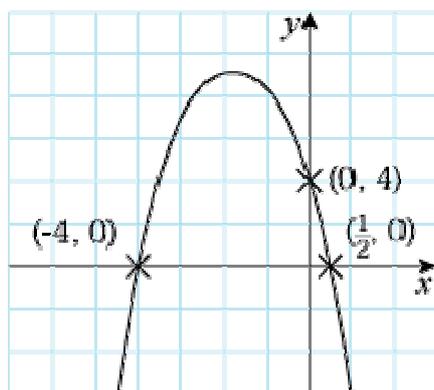$b^2 > 4ac$, so two different roots of $y = 0$.
When $y = 0$,
$0 = (1 - 2x)(4 + x)$
$x = \dfrac{1}{2}$ or $x = -4$

So crossing points are $\left(\dfrac{1}{2}, 0 \right)$ and $(-4, 0)$.

When $x = 0$, $y = 4$, so crossing point is $(0, 4)$.

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Quadratic Equations
Exercise F, Question 2

Question:

Find the values of k for which $x^2 + kx + 4 = 0$ has equal roots.

Solution:

$x^2 + kx + 4 = 0$ has equal roots if
$b^2 = 4ac$
i.e.
$k^2 = 4 \times 1 \times 4 = 16 \quad \Rightarrow \quad k = \pm 4$

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Quadratic Equations
Exercise F, Question 3

Question:

Find the values of k for which $kx^2 + 8x + k = 0$ has equal roots.

Solution:

$kx^2 + 8x + k = 0$ has equal roots if
$b^2 = 4ac$
i.e.
$8^2 = 4 \times k \times k = 4k^2$
So $k^2 = \dfrac{64}{4} = 16 \quad \Rightarrow \quad k = \pm 4$

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Quadratic Equations
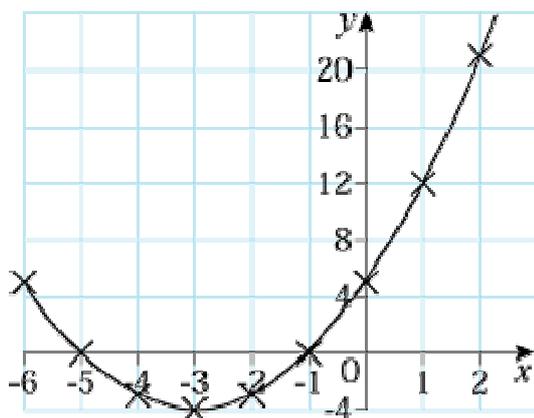**Exercise G, Question 1**

Question:

Draw the graphs with the following equations, choosing appropriate values for x. For each graph write down the equation of the line of symmetry.

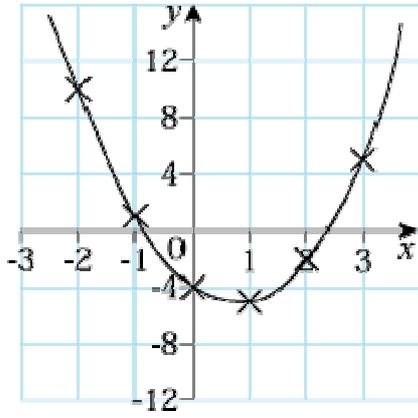(a) $y = x^2 + 6x + 5$

(b) $y = 2x^2 - 3x - 4$

Solution:

	x	-6	-5	-4	-3	-2	-1	0	1	2
	x^2	36	25	16	9	4	1	0	1	4
(a)	$+6x$	-36	-30	-24	-18	-12	-6	0	$+6$	$+12$
	$+5$	$+5$	$+5$	$+5$	$+5$	$+5$	$+5$	$+5$	$+5$	$+5$
	y	5	0	-3	-4	-3	0	5	12	21

$x = -3$ is line of symmetry.

	x	-2	-1	0	1	2	3
	$2x^2$	8	2	0	2	8	18
(b)	$-3x$	$+6$	$+3$	0	-3	-6	-9
	-4	-4	-4	-4	-4	-4	-4
	y	10	1	-4	-5	-2	5

$x = \dfrac{3}{4}$ is line of symmetry.

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Quadratic Equations
Exercise G, Question 2

Question:

Solve the following equations:

(a) $y^2 + 3y + 2 = 0$

(b) $3x^2 + 13x - 10 = 0$

(c) $5x^2 - 10x = 4x + 3$

(d) $(2x - 5)^2 = 7$

Solution:

(a) $(y + 1)(y + 2) = 0$
$y = -1$ or $y = -2$

(b) $(3x - 2)(x + 5) = 0$
$x = \dfrac{2}{3}$ or $x = -5$

(c) $5x^2 - 14x - 3 = 0$
$(5x + 1)(x - 3) = 0$
$x = -\dfrac{1}{5}$ or $x = 3$

(d) $2x - 5 = \pm \sqrt{7}$
$2x = \pm \sqrt{7} + 5$
$x = \dfrac{5 \pm \sqrt{7}}{2}$

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Quadratic Equations
Exercise G, Question 3

Question:

Solve the following equations by:

(i) Completing the square.

(ii) Using the formula.

(a) $x^2 + 5x + 2 = 0$

(b) $x^2 - 4x - 3 = 0$

(c) $5x^2 + 3x - 1 = 0$

(d) $3x^2 - 5x = 4$

Solution:

(a) (i) $x^2 + 5x = -2$

$$\left(x + \frac{5}{2} \right)^2 - \frac{25}{4} = -2$$

$$\left(x + \frac{5}{2} \right)^2 = \frac{17}{4}$$

$$x + \frac{5}{2} = \pm \frac{\sqrt{17}}{2}$$

$$x = \frac{-5 \pm \sqrt{17}}{2}$$

(ii) $x = \dfrac{-5 \pm \sqrt{5^2 - 4(1)(2)}}{2}$

$$x = \frac{-5 \pm \sqrt{25 - 8}}{2}$$

$$x = \frac{-5 \pm \sqrt{17}}{2}$$

(b)(i) $x^2 - 4x = 3$
$(x - 2)^2 - 4 = 3$
$(x - 2)^2 = 7$
$x - 2 = \pm \sqrt{7}$
$x = 2 \pm \sqrt{7}$

(ii) $x = \dfrac{-(-4) \pm \sqrt{16 - 4(1)(-3)}}{2}$

$$x = \frac{+4 \pm \sqrt{16 + 12}}{2}$$

$$x = \frac{4 \pm \sqrt{4 \times 7}}{2}$$

$x = \dfrac{4 \pm 2\sqrt{7}}{2}$

$x = 2 \pm \sqrt{7}$

(c) (i) $5x^2 + 3x = 1$

$5\left(x^2 + \dfrac{3}{5}x \right) = 1$

$5\left[\left(x + \dfrac{3}{10} \right)^2 - \dfrac{9}{100} \right] = 1$

$\left(x + \dfrac{3}{10} \right)^2 - \dfrac{9}{100} = \dfrac{1}{5}$

$\left(x + \dfrac{3}{10} \right)^2 = \dfrac{29}{100}$

$x + \dfrac{3}{10} = \pm \dfrac{\sqrt{29}}{10}$

$x = \dfrac{-3 \pm \sqrt{29}}{10}$

(ii) $x = \dfrac{-3 \pm \sqrt{9 - 4(5)(-1)}}{10}$

$x = \dfrac{-3 \pm \sqrt{29}}{10}$

(d)(i) $3\left(x^2 - \dfrac{5}{3}x \right) = 4$

$3\left[\left(x - \dfrac{5}{6} \right)^2 - \dfrac{25}{36} \right] = 4$

$\left(x - \dfrac{5}{6} \right)^2 - \dfrac{25}{36} = \dfrac{4}{3}$

$\left(x - \dfrac{5}{6} \right)^2 = \dfrac{73}{36}$

$x - \dfrac{5}{6} = \pm \dfrac{\sqrt{73}}{6}$

$x = \dfrac{5 \pm \sqrt{73}}{6}$

(ii) $x = \dfrac{-(-5) \pm \sqrt{25 - 4(3)(-4)}}{6}$

$x = \dfrac{+5 \pm \sqrt{25 + 48}}{6}$

$x = \dfrac{5 \pm \sqrt{73}}{6}$

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Quadratic Equations
Exercise G, Question 4

Question:

Sketch graphs of the following equations:

(a) $y = x^2 + 5x + 4$

(b) $y = 2x^2 + x - 3$

(c) $y = 6 - 10x - 4x^2$

(d) $y = 15x - 2x^2$

Solution:

(a) $a > 0$ so   ∪   shape
$b^2 = 25, 4ac = 16$
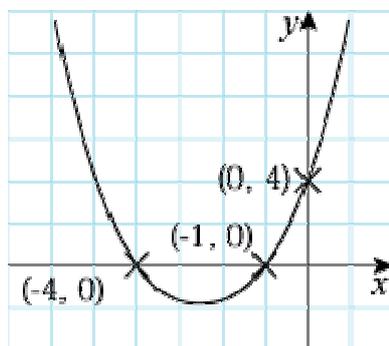$b^2 > 4ac$, so two different roots of $y = 0$.
$y = 0 \quad \Rightarrow \quad 0 = (x + 1)(x + 4)$
$x = -1$ or $x = -4$
So x-axis crossing points are $(-1, 0)$ and $(-4, 0)$.
$x = 0 \quad \Rightarrow \quad y = 4$ So y-axis crossing point is $(0, 4)$.
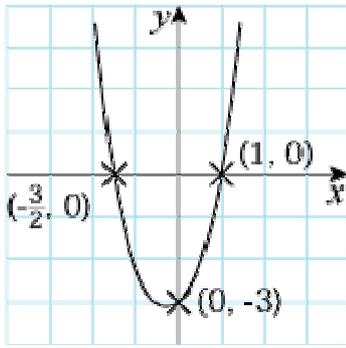

(b) $a > 0$ So   ∪   shape
$b^2 = 1, 4ac = -24$
$b^2 > 4ac$, so two different roots of $y = 0$.
$y = 0 \quad \Rightarrow \quad 0 = (2x + 3)(x - 1)$

$x = -\frac{3}{2}$ or $x = 1$

So x-axis crossing points are $\left(-\frac{3}{2}, 0 \right)$ and $(1, 0)$.

$x = 0 \quad \Rightarrow \quad y = -3$ so y-axis crossing point in $(0, -3)$.
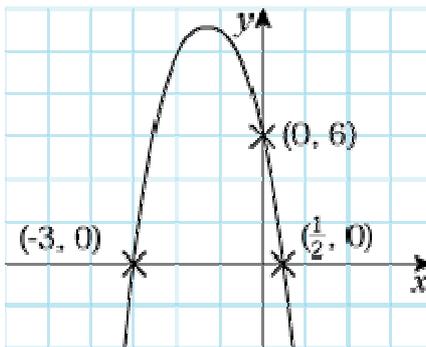
(c) $a < 0$ So $\cap$ shape

$b^2 = 100, 4ac = -96$

$b^2 > 4ac$, so two different roots of $y = 0$.

$y = 0 \Rightarrow 0 = (1 - 2x)(6 + 2x)$

$x = \frac{1}{2}$ or $x = -3$

So x-axis crossing points are $\left(\frac{1}{2}, 0 \right)$ and $(-3, 0)$.

$x = 0 \Rightarrow y = 6$ so y-axis crossing point is $(0, 6)$.
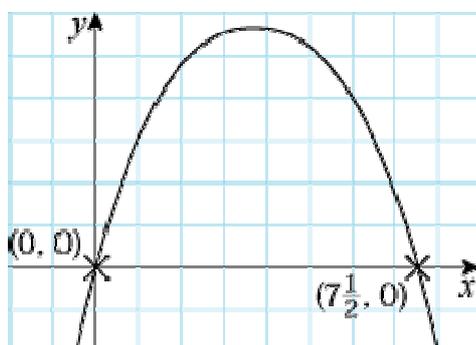

(d) $a < 0$ so $\cap$ shape

$b^2 = 225, 4ac = 0$

$b^2 > 4ac$, so two different roots of $y = 0$.

$y = 0 \Rightarrow 0 = x(15 - 2x)$

$x = 0$ or $x = 7\frac{1}{2}$

So x-axis crossing points are $(0, 0)$ and $\left(7\frac{1}{2}, 0 \right)$.

$x = 0 \Rightarrow y = 0$ So y-axis crossing point is $(0, 0)$.

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Quadratic Equations
Exercise G, Question 5

Question:

Given that for all values of x :

$3x^2 + 12x + 5 = p \left(x + q \right)^2 + r$

(a) Find the values of p, q and r.

(b) Solve the equation $3x^2 + 12x + 5 = 0$. **[E]**

Solution:

(a) $3x^2 + 12x + 5 = p \left(x^2 + 2qx + q^2 \right) + r$
$3x^2 + 12x + 5 = px^2 + 2pqx + pq^2 + r$
Comparing x^2 : $p = 3$ ①
Comparing x : $2pq = 12$ ②
Comparing constants : $pq^2 + r = 5$ ③
Substitute ① into ②:
$2 \times 3q = 12$
$q = 2$
Substitute $p = 3$ and $q = 2$ into ③:
$3 \times 2^2 + r = 5$
$12 + r = 5$
$r = -7$
So $p = 3, q = 2, r = -7$

(b) $3x^2 + 12x + 5 = 0$
$\Rightarrow \quad 3 \left(x + 2 \right)^2 - 7 = 0$
$\Rightarrow \quad 3 \left(x + 2 \right)^2 = 7$
$\Rightarrow \quad \left(x + 2 \right)^2 = \dfrac{7}{3}$
$\Rightarrow \quad x + 2 = \pm \sqrt{\dfrac{7}{3}}$
So $x = -2 \pm \sqrt{\dfrac{7}{3}}$

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Quadratic Equations
Exercise G, Question 6

Question:

Find, as surds, the roots of the equation

$2(x+1)(x-4) - (x-2)^2 = 0$

Solution:

$2(x^2 - 3x - 4) - (x^2 - 4x + 4) = 0$
$2x^2 - 6x - 8 - x^2 + 4x - 4 = 0$
$x^2 - 2x - 12 = 0$
$x = \dfrac{-(-2) \pm \sqrt{4 - 4(1)(-12)}}{2}$

$x = \dfrac{+2 \pm \sqrt{52}}{2}$

$x = \dfrac{2 \pm \sqrt{4 \times 13}}{2}$

$x = \dfrac{2 \pm 2\sqrt{13}}{2}$

$x = 1 \pm \sqrt{13}$

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Quadratic Equations
Exercise G, Question 7

Question:

Use algebra to solve $(x-1)(x+2) = 18$. **[E]**

Solution:

$x^2 + x - 2 = 18$
$x^2 + x - 20 = 0$
$(x+5)(x-4) = 0$
$x = -5$ or $x = 4$