

Solutionbank C1

Edexcel Modular Mathematics for AS and A-Level

Equations and inequalities

Exercise A, Question 1

Question:

Solve these simultaneous equations by elimination:

$$\begin{aligned}2x - y &= 6 \\4x + 3y &= 22\end{aligned}$$

Solution:

$$\begin{aligned}6x - 3y &= 18 \\4x + 3y &= 22\end{aligned}$$

Add:

$$10x = 40$$

$$x = 4$$

Substitute into $2x - y = 6$:

$$8 - y = 6$$

$$y = 2$$

So solution is $x = 4, y = 2$

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Exercise A, Question 2

Question:

Solve these simultaneous equations by elimination:

$$\begin{aligned}7x + 3y &= 16 \\2x + 9y &= 29\end{aligned}$$

Solution:

$$\begin{aligned}21x + 9y &= 48 \\2x + 9y &= 29\end{aligned}$$

Subtract:

$$19x = 19$$

$$x = 1$$

Substitute into $7x + 3y = 16$:

$$7 + 3y = 16$$

$$3y = 9$$

$$y = 3$$

So solution is $x = 1, y = 3$

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Exercise A, Question 3

Question:

Solve these simultaneous equations by elimination:

$$\begin{aligned}5x + 2y &= 6 \\3x - 10y &= 26\end{aligned}$$

Solution:

$$\begin{aligned}25x + 10y &= 30 \\3x - 10y &= 26 \\ \text{Add:} & \\28x &= 56 \\x &= 2 \\ \text{Substitute into } 5x + 2y = 6: & \\10 + 2y &= 6 \\2y &= -4 \\y &= -2 \\ \text{So solution is } x = 2, y = -2 & \end{aligned}$$

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Exercise A, Question 4

Question:

Solve these simultaneous equations by elimination:

$$\begin{aligned}2x - y &= 12 \\6x + 2y &= 21\end{aligned}$$

Solution:

$$\begin{aligned}4x - 2y &= 24 \\6x + 2y &= 21\end{aligned}$$

Add:

$$10x = 45$$

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

Substitute into $2x - y = 12$:

$$9 - y = 12$$

$$-y = 3$$

$$y = -3$$

So solution is $x = 4 \frac{1}{2}, y = -3$

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Exercise A, Question 5

Question:

Solve these simultaneous equations by elimination:

$$\begin{aligned}3x - 2y &= -6 \\6x + 3y &= 2\end{aligned}$$

Solution:

$$\begin{aligned}6x - 4y &= -12 \\6x + 3y &= 2\end{aligned}$$

Subtract:

$$\begin{aligned}-7y &= -14 \\y &= 2\end{aligned}$$

Substitute into $3x - 2y = -6$:

$$\begin{aligned}3x - 4 &= -6 \\3x &= -2\end{aligned}$$

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

So solution is $x = -\frac{2}{3}, y = 2$

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Exercise A, Question 6

Question:

Solve these simultaneous equations by elimination:

$$3x + 8y = 33$$

$$6x = 3 + 5y$$

Solution:

$$6x + 16y = 66$$

$$6x = 3 + 5y$$

$$6x + 16y = 66$$

$$6x - 5y = 3$$

Subtract:

$$21y = 63$$

$$y = 3$$

Substitute into $3x + 8y = 33$:

$$3x + 24 = 33$$

$$3x = 9$$

$$x = 3$$

So solution is $x = 3, y = 3$

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Exercise B, Question 1

Question:

Solve these simultaneous equations by substitution:

$$\begin{aligned}x + 3y &= 11 \\4x - 7y &= 6\end{aligned}$$

Solution:

$$\begin{aligned}x &= 11 - 3y \\ \text{Substitute into } 4x - 7y &= 6: \\ 4(11 - 3y) - 7y &= 6 \\ 44 - 12y - 7y &= 6 \\ -19y &= -38 \\ y &= 2 \\ \text{Substitute into } x = 11 - 3y: \\ x &= 11 - 6 \\ x &= 5 \\ \text{So solution is } x = 5, y = 2\end{aligned}$$

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Exercise B, Question 2

Question:

Solve these simultaneous equations by substitution:

$$\begin{aligned}4x - 3y &= 40 \\ 2x + y &= 5\end{aligned}$$

Solution:

$$\begin{aligned}y &= 5 - 2x \\ \text{Substitute into } 4x - 3y &= 40: \\ 4x - 3(5 - 2x) &= 40 \\ 4x - 15 + 6x &= 40 \\ 10x &= 55\end{aligned}$$

$$x = 5 \frac{1}{2}$$

$$\begin{aligned}\text{Substitute into } y &= 5 - 2x: \\ y &= 5 - 11 \\ y &= -6\end{aligned}$$

So solution is $x = 5 \frac{1}{2}, y = -6$

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Exercise B, Question 3

Question:

Solve these simultaneous equations by substitution:

$$\begin{aligned}3x - y &= 7 \\10x + 3y &= -2\end{aligned}$$

Solution:

$$\begin{aligned}-y &= 7 - 3x \\y &= 3x - 7\end{aligned}$$

Substitute into $10x + 3y = -2$:

$$\begin{aligned}10x + 3(3x - 7) &= -2 \\10x + 9x - 21 &= -2 \\19x &= 19 \\x &= 1\end{aligned}$$

Substitute into $y = 3x - 7$:

$$\begin{aligned}y &= 3 - 7 \\y &= -4\end{aligned}$$

So solution is $x = 1, y = -4$

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Equations and inequalities

Exercise B, Question 4

Question:

Solve these simultaneous equations by substitution:

$$\begin{aligned}2y &= 2x - 3 \\ 3y &= x - 1\end{aligned}$$

Solution:

$$\begin{aligned}x &= 3y + 1 \\ \text{Substitute into } 2y &= 2x - 3: \\ 2y &= 2(3y + 1) - 3 \\ 2y &= 6y + 2 - 3 \\ -4y &= -1\end{aligned}$$

$$y = \frac{1}{4}$$

Substitute into $x = 3y + 1$:

$$x = \frac{3}{4} + 1$$

$$x = 1\frac{3}{4}$$

So solution is $x = 1\frac{3}{4}$, $y = \frac{1}{4}$

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Equations and inequalities

Exercise C, Question 1

Question:

Solve the simultaneous equations:

(a) $x + y = 11$
 $xy = 30$

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

(c) $y = 3x$
 $2y^2 - xy = 15$

(d) $x + y = 9$
 $x^2 - 3xy + 2y^2 = 0$

(e) $3a + b = 8$
 $3a^2 + b^2 = 28$

(f) $2u + v = 7$
 $uv = 6$

Solution:

(a) $y = 11 - x$
 Substitute into $xy = 30$:
 $x(11 - x) = 30$
 $11x - x^2 = 30$
 $0 = x^2 - 11x + 30$
 $0 = (x - 5)(x - 6)$
 $x = 5$ or $x = 6$
 Substitute into $y = 11 - x$:
 when $x = 5$, $y = 11 - 5 = 6$
 when $x = 6$, $y = 11 - 6 = 5$
 Solutions are $x = 5$, $y = 6$ and $x = 6$, $y = 5$

(b) $y = 1 - 2x$
 Substitute into $x^2 + y^2 = 1$:
 $x^2 + (1 - 2x)^2 = 1$
 $x^2 + 1 - 4x + 4x^2 = 1$
 $5x^2 - 4x = 0$
 $x(5x - 4) = 0$
 $x = 0$ or $x = \frac{4}{5}$
 Substitute into $y = 1 - 2x$:
 when $x = 0$, $y = 1$
 when $x = \frac{4}{5}$, $y = 1 - \frac{8}{5} = -\frac{3}{5}$

Solutions are $x = 0$, $y = 1$ and $x = \frac{4}{5}$, $y = -\frac{3}{5}$

(c) $y = 3x$
 Substitute into $2y^2 - xy = 15$:

$$2(3x)^2 - x(3x) = 15$$

$$18x^2 - 3x^2 = 15$$

$$15x^2 = 15$$

$$x^2 = 1$$

$$x = -1 \text{ or } x = 1$$

Substitute into $y = 3x$:

$$\text{when } x = -1, y = -3$$

$$\text{when } x = 1, y = 3$$

Solutions are $x = -1, y = -3$ and $x = 1, y = 3$

$$(d) x = 9 - y$$

Substitute into $x^2 - 3xy + 2y^2 = 0$:

$$(9 - y)^2 - 3y(9 - y) + 2y^2 = 0$$

$$81 - 18y + y^2 - 27y + 3y^2 + 2y^2 = 0$$

$$6y^2 - 45y + 81 = 0$$

Divide by 3:

$$2y^2 - 15y + 27 = 0$$

$$(2y - 9)(y - 3) = 0$$

$$y = \frac{9}{2} \text{ or } y = 3$$

Substitute into $x = 9 - y$:

$$\text{when } y = \frac{9}{2}, x = 9 - \frac{9}{2} = \frac{9}{2}$$

$$\text{when } y = 3, x = 9 - 3 = 6$$

Solutions are $x = 4\frac{1}{2}, y = 4\frac{1}{2}$ and $x = 6, y = 3$

$$(e) b = 8 - 3a$$

Substitute into $3a^2 + b^2 = 28$:

$$3a^2 + (8 - 3a)^2 = 28$$

$$3a^2 + 64 - 48a + 9a^2 = 28$$

$$12a^2 - 48a + 36 = 0$$

Divide by 12:

$$a^2 - 4a + 3 = 0$$

$$(a - 1)(a - 3) = 0$$

$$a = 1 \text{ or } a = 3$$

Substitute into $b = 8 - 3a$:

$$\text{when } a = 1, b = 8 - 3 = 5$$

$$\text{when } a = 3, b = 8 - 9 = -1$$

Solutions are $a = 1, b = 5$ and $a = 3, b = -1$

$$(f) v = 7 - 2u$$

Substitute into $uv = 6$:

$$u(7 - 2u) = 6$$

$$7u - 2u^2 = 6$$

$$0 = 2u^2 - 7u + 6$$

$$0 = (2u - 3)(u - 2)$$

$$u = \frac{3}{2} \text{ or } u = 2$$

Substitute into $v = 7 - 2u$:

$$\text{when } u = \frac{3}{2}, v = 7 - 3 = 4$$

$$\text{when } u = 2, v = 7 - 4 = 3$$

Solutions are $u = \frac{3}{2}, v = 4$ and $u = 2, v = 3$

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Exercise C, Question 2

Question:

Find the coordinates of the points at which the line with equation $y = x - 4$ intersects the curve with equation $y^2 = 2x^2 - 17$.

Solution:

$$y = x - 4$$

Substitute into $y^2 = 2x^2 - 17$:

$$(x - 4)^2 = 2x^2 - 17$$

$$x^2 - 8x + 16 = 2x^2 - 17$$

$$0 = x^2 + 8x - 33$$

$$0 = (x + 11)(x - 3)$$

$$x = -11 \text{ or } x = 3$$

Substitute into $y = x - 4$:

$$\text{when } x = -11, y = -11 - 4 = -15$$

$$\text{when } x = 3, y = 3 - 4 = -1$$

Intersection points: $(-11, -15)$ and $(3, -1)$

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Equations and inequalities

Exercise C, Question 3

Question:

Find the coordinates of the points at which the line with equation $y = 3x - 1$ intersects the curve with equation $y^2 - xy = 15$.

Solution:

$$y = 3x - 1$$

Substitute into $y^2 - xy = 15$:

$$(3x - 1)^2 - x(3x - 1) = 15$$

$$9x^2 - 6x + 1 - 3x^2 + x = 15$$

$$6x^2 - 5x - 14 = 0$$

$$(6x + 7)(x - 2) = 0$$

$$x = -\frac{7}{6} \text{ or } x = 2$$

Substitute into $y = 3x - 1$:

$$\text{when } x = -\frac{7}{6}, y = -\frac{21}{6} - 1 = -\frac{9}{2}$$

$$\text{when } x = 2, y = 6 - 1 = 5$$

Intersection points: $\left(-1\frac{1}{6}, -4\frac{1}{2}\right)$ and $(2, 5)$

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Equations and inequalities

Exercise C, Question 4

Question:

Solve the simultaneous equations:

$$(a) \begin{aligned} 3x + 2y &= 7 \\ x^2 + y &= 8 \end{aligned}$$

$$(b) \begin{aligned} 2x + 2y &= 7 \\ x^2 - 4y^2 &= 8 \end{aligned}$$

Solution:

$$(a) \begin{aligned} 2y &= 7 - 3x \\ y &= \frac{1}{2}(7 - 3x) \end{aligned}$$

Substitute into $x^2 + y = 8$:

$$x^2 + \frac{1}{2}(7 - 3x) = 8$$

Multiply by 2:

$$\begin{aligned} 2x^2 + (7 - 3x) &= 16 \\ 2x^2 - 3x - 9 &= 0 \\ (2x + 3)(x - 3) &= 0 \end{aligned}$$

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

$$\text{Substitute into } y = \frac{1}{2} \left(7 - 3x \right) :$$

$$\text{when } x = -\frac{3}{2}, y = \frac{1}{2} \left(7 + \frac{9}{2} \right) = \frac{23}{4}$$

$$\text{when } x = 3, y = \frac{1}{2} \left(7 - 9 \right) = -1$$

Solutions are $x = -1\frac{1}{2}, y = 5\frac{3}{4}$ and $x = 3, y = -1$

$$(b) 2x = 7 - 2y$$

$$x = \frac{1}{2} \left(7 - 2y \right)$$

Substitute into $x^2 - 4y^2 = 8$:

$$\left[\frac{1}{2} \left(7 - 2y \right) \right]^2 - 4y^2 = 8$$

$$\frac{1}{4} (7 - 2y)^2 - 4y^2 = 8$$

Multiply by 4:

$$\begin{aligned} (7 - 2y)^2 - 16y^2 &= 32 \\ 49 - 28y + 4y^2 - 16y^2 &= 32 \\ 0 &= 12y^2 + 28y - 17 \\ 0 &= (6y + 17)(2y - 1) \end{aligned}$$

$$y = -\frac{17}{6} \text{ or } y = \frac{1}{2}$$

Substitute into $x = \frac{1}{2} \left(7 - 2y \right)$:

$$\text{when } y = -\frac{17}{6}, x = \frac{1}{2} \left(7 + \frac{17}{3} \right) = \frac{19}{3}$$

$$\text{when } y = \frac{1}{2}, x = \frac{1}{2} \left(7 - 1 \right) = 3$$

Solutions are $x = 6\frac{1}{3}, y = -2\frac{5}{6}$ and $x = 3, y = \frac{1}{2}$

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Equations and inequalities

Exercise C, Question 5

Question:

Solve the simultaneous equations, giving your answers in their simplest surd form:

(a) $x - y = 6$
 $xy = 4$

(b) $2x + 3y = 13$
 $x^2 + y^2 = 78$

Solution:

(a) $x = 6 + y$

Substitute into $xy = 4$:

$$y(6 + y) = 4$$

$$6y + y^2 = 4$$

$$y^2 + 6y - 4 = 0$$

$$a = 1, b = 6, c = -4$$

$$y = \frac{-b \pm \sqrt{(b^2 - 4ac)}}{2a} = \frac{-6 \pm \sqrt{(36 + 16)}}{2} = \frac{-6 \pm \sqrt{52}}{2}$$

$$\sqrt{52} = \sqrt{(4 \times 13)} = \sqrt{4} \sqrt{13} = 2\sqrt{13}$$

$$y = \frac{-6 \pm 2\sqrt{13}}{2} = -3 \pm \sqrt{13}$$

Substitute into $x = 6 + y$:

when $y = -3 - \sqrt{13}$, $x = 6 - 3 - \sqrt{13} = 3 - \sqrt{13}$

when $y = -3 + \sqrt{13}$, $x = 6 - 3 + \sqrt{13} = 3 + \sqrt{13}$

Solutions are $x = 3 - \sqrt{13}$, $y = -3 - \sqrt{13}$ and $x = 3 + \sqrt{13}$, $y = -3 + \sqrt{13}$

(b) $2x = 13 - 3y$

$$x = \frac{1}{2} (13 - 3y)$$

Substitute into $x^2 + y^2 = 78$:

$$\left[\frac{1}{2} (13 - 3y) \right]^2 + y^2 = 78$$

$$\frac{1}{4} (13 - 3y)^2 + y^2 = 78$$

Multiply by 4:

$$(13 - 3y)^2 + 4y^2 = 312$$

$$169 - 78y + 9y^2 + 4y^2 = 312$$

$$13y^2 - 78y - 143 = 0$$

Divide by 13:

$$y^2 - 6y - 11 = 0$$

$$a = 1, b = -6, c = -11$$

$$y = \frac{-b \pm \sqrt{(b^2 - 4ac)}}{2a} = \frac{6 \pm \sqrt{(36 + 44)}}{2} = \frac{6 \pm \sqrt{80}}{2}$$

$$\sqrt{80} = \sqrt{(16 \times 5)} = \sqrt{16} \sqrt{5} = 4\sqrt{5}$$

$$y = \frac{6 \pm 4\sqrt{5}}{2} = 3 \pm 2\sqrt{5}$$

Substitute into $x = \frac{1}{2} (13 - 3y)$:

$$\text{when } y = 3 - 2\sqrt{5}, x = \frac{1}{2} \left[13 - 3(3 - 2\sqrt{5}) \right] = \frac{1}{2} \left[13 - 9 + 6\sqrt{5} \right] = 2 + 3\sqrt{5}$$

$$\text{when } y = 3 + 2\sqrt{5}, x = \frac{1}{2} \left[13 - 3(3 + 2\sqrt{5}) \right] = \frac{1}{2} \left[13 - 9 - 6\sqrt{5} \right] = 2 - 3\sqrt{5}$$

Solutions are $x = 2 - 3\sqrt{5}, y = 3 + 2\sqrt{5}$ and $x = 2 + 3\sqrt{5}, y = 3 - 2\sqrt{5}$

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Equations and inequalities

Exercise D, Question 1

Question:

Find the set of values of x for which:

(a) $2x - 3 < 5$

(b) $5x + 4 \geq 39$

(c) $6x - 3 > 2x + 7$

(d) $5x + 6 \leq -12 - x$

(e) $15 - x > 4$

(f) $21 - 2x > 8 + 3x$

(g) $1 + x < 25 + 3x$

(h) $7x - 7 < 7 - 7x$

(i) $5 - 0.5x \geq 1$

(j) $5x + 4 > 12 - 2x$

Solution:

(a) $2x < 5 + 3$

$$2x < 8$$

$$x < 4$$

(b) $5x \geq 39 - 4$

$$5x \geq 35$$

$$x \geq 7$$

(c) $6x - 2x > 7 + 3$

$$4x > 10$$

$$x > 2\frac{1}{2}$$

(d) $5x + x \leq -12 - 6$

$$6x \leq -18$$

$$x \leq -3$$

(e) $-x > 4 - 15$

$$-x > -11$$

$$x < 11$$

(f) $21 - 8 > 3x + 2x$

$$13 > 5x$$

$$5x < 13$$

$$x < 2\frac{3}{5}$$

$$\begin{aligned} \text{(g)} \quad x - 3x &< 25 - 1 \\ -2x &< 24 \\ x &> -12 \end{aligned}$$

$$\begin{aligned} \text{(h)} \quad 7x + 7x &< 7 + 7 \\ 14x &< 14 \\ x &< 1 \end{aligned}$$

$$\begin{aligned} \text{(i)} \quad -0.5x &\geq 1 - 5 \\ -0.5x &\geq -4 \\ x &\leq 8 \end{aligned}$$

$$\begin{aligned} \text{(j)} \quad 5x + 2x &> 12 - 4 \\ 7x &> 8 \\ x &> 1 \frac{1}{7} \end{aligned}$$

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Equations and inequalities

Exercise D, Question 2

Question:

Find the set of values of x for which:

(a) $2(x - 3) \geq 0$

(b) $8(1 - x) > x - 1$

(c) $3(x + 7) \leq 8 - x$

(d) $2(x - 3) - (x + 12) < 0$

(e) $1 + 11(2 - x) < 10(x - 4)$

(f) $2(x - 5) \geq 3(4 - x)$

(g) $12x - 3(x - 3) < 45$

(h) $x - 2(5 + 2x) < 11$

(i) $x(x - 4) \geq x^2 + 2$

(j) $x(5 - x) \geq 3 + x - x^2$

Solution:

(a) $2x - 6 \geq 0$
 $2x \geq 6$
 $x \geq 3$

(b) $8 - 8x > x - 1$
 $8 + 1 > x + 8x$
 $9 > 9x$
 $1 > x$
 $x < 1$

(c) $3x + 21 \leq 8 - x$
 $3x + x \leq 8 - 21$
 $4x \leq -13$
 $x \leq -3\frac{1}{4}$

(d) $2x - 6 - x - 12 < 0$
 $2x - x < 6 + 12$
 $x < 18$

(e) $1 + 22 - 11x < 10x - 40$
 $1 + 22 + 40 < 10x + 11x$
 $63 < 21x$
 $3 < x$
 $x > 3$

(f) $2x - 10 \geq 12 - 3x$

$$2x + 3x \geq 12 + 10$$

$$5x \geq 22$$

$$x \geq 4 \frac{2}{5}$$

$$(g) 12x - 3x + 9 < 45$$

$$12x - 3x < 45 - 9$$

$$9x < 36$$

$$x < 4$$

$$(h) x - 10 - 4x < 11$$

$$x - 4x < 11 + 10$$

$$-3x < 21$$

$$x > -7$$

$$(i) x^2 - 4x \geq x^2 + 2$$

$$x^2 - x^2 - 4x \geq 2$$

$$-4x \geq 2$$

$$x \leq -\frac{1}{2}$$

$$(j) 5x - x^2 \geq 3 + x - x^2$$

$$5x - x - x^2 + x^2 \geq 3$$

$$4x \geq 3$$

$$x \geq \frac{3}{4}$$

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Exercise D, Question 3

Question:

Find the set of values of x for which:

(a) $3(x - 2) > x - 4$ and $4x + 12 > 2x + 17$

(b) $2x - 5 < x - 1$ and $7(x + 1) > 23 - x$

(c) $2x - 3 > 2$ and $3(x + 2) < 12 + x$

(d) $15 - x < 2(11 - x)$ and $5(3x - 1) > 12x + 19$

(e) $3x + 8 \leq 20$ and $2(3x - 7) \geq x + 6$

Solution:

(a) $3x - 6 > x - 4$

$$3x - x > -4 + 6$$

$$2x > 2$$

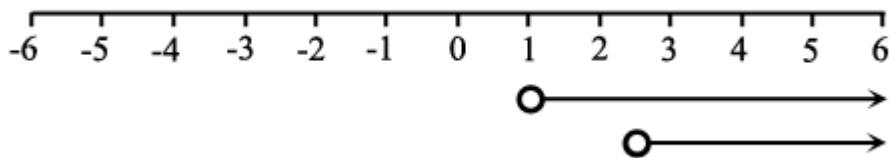
$$x > 1$$

$$4x + 12 > 2x + 17$$

$$4x - 2x > 17 - 12$$

$$2x > 5$$

$$x > 2\frac{1}{2}$$



So the required set of values is $x > 2\frac{1}{2}$

(b) $2x - x < -1 + 5$

$$x < 4$$

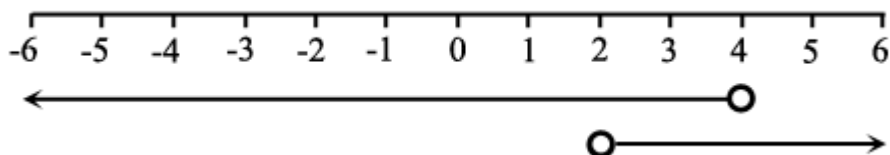
$$7(x + 1) > 23 - x$$

$$7x + 7 > 23 - x$$

$$7x + x > 23 - 7$$

$$8x > 16$$

$$x > 2$$



So the required set of values is $2 < x < 4$

$$(c) 2x > 2 + 3$$

$$2x > 5$$

$$x > 2\frac{1}{2}$$

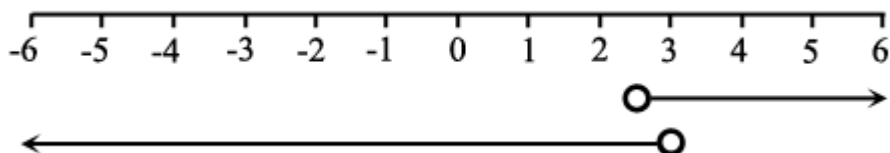
$$3(x + 2) < 12 + x$$

$$3x + 6 < 12 + x$$

$$3x - x < 12 - 6$$

$$2x < 6$$

$$x < 3$$



So the required set of values is $2\frac{1}{2} < x < 3$

$$(d) 15 - x < 22 - 2x$$

$$-x + 2x < 22 - 15$$

$$x < 7$$

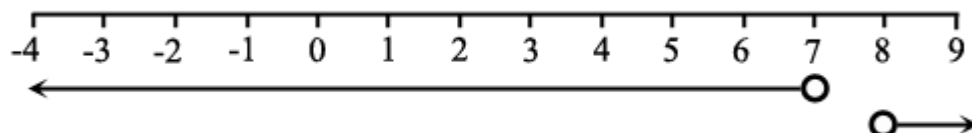
$$5(3x - 1) > 12x + 19$$

$$15x - 5 > 12x + 19$$

$$15x - 12x > 19 + 5$$

$$3x > 24$$

$$x > 8$$



There are no values satisfying both inequalities.

$$(e) 3x \leq 20 - 8$$

$$3x \leq 12$$

$$x \leq 4$$

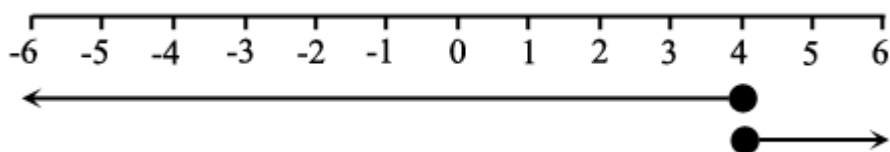
$$2(3x - 7) \geq x + 6$$

$$6x - 14 \geq x + 6$$

$$6x - x \geq 6 + 14$$

$$5x \geq 20$$

$$x \geq 4$$



There is just one value, $x = 4$.

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Equations and inequalities

Exercise E, Question 1

Question:

Find the set of values of x for which:

(a) $x^2 - 11x + 24 < 0$

(b) $12 - x - x^2 > 0$

(c) $x^2 - 3x - 10 > 0$

(d) $x^2 + 7x + 12 \geq 0$

(e) $7 + 13x - 2x^2 > 0$

(f) $10 + x - 2x^2 < 0$

(g) $4x^2 - 8x + 3 \leq 0$

(h) $-2 + 7x - 3x^2 < 0$

(i) $x^2 - 9 < 0$

(j) $6x^2 + 11x - 10 > 0$

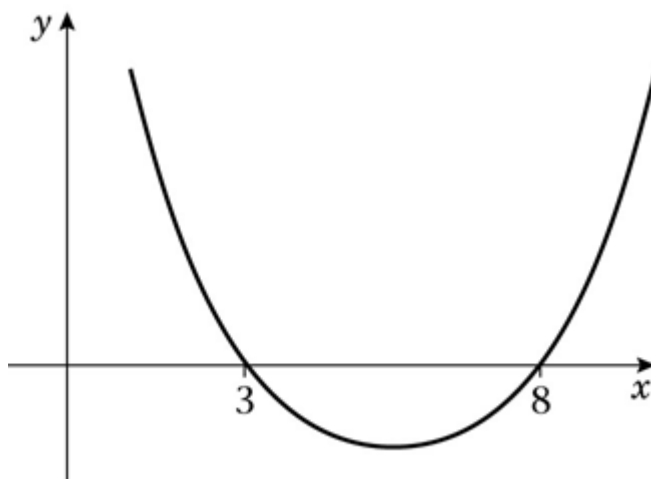
(k) $x^2 - 5x > 0$

(l) $2x^2 + 3x \leq 0$

Solution:

(a) $x^2 - 11x + 24 = 0$
 $(x - 3)(x - 8) = 0$
 $x = 3, x = 8$

Sketch of $y = x^2 - 11x + 24$:



$$x^2 - 11x + 24 < 0 \text{ when } 3 < x < 8$$

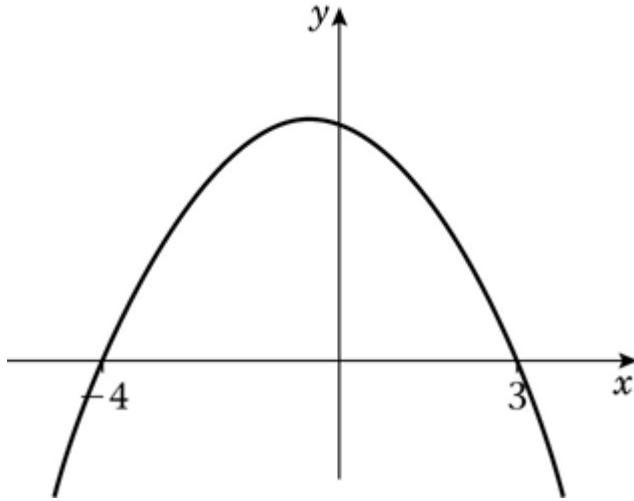
$$(b) 12 - x - x^2 = 0$$

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

$$0 = (x + 4)(x - 3)$$

$$x = -4, x = 3$$

Sketch of $y = 12 - x - x^2$:



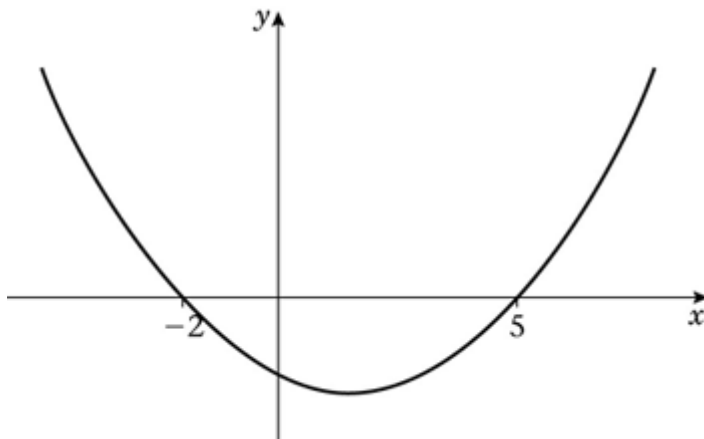
$$12 - x - x^2 > 0 \text{ when } -4 < x < 3$$

$$(c) x^2 - 3x - 10 = 0$$

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

$$x = -2, x = 5$$

Sketch of $y = x^2 - 3x - 10$:



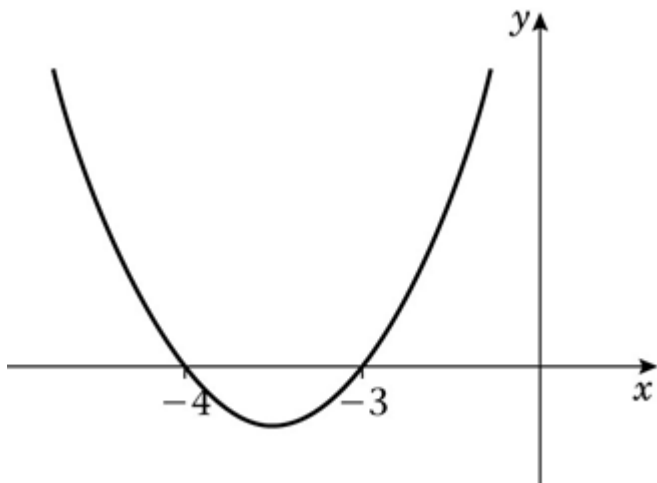
$$x^2 - 3x - 10 > 0 \text{ when } x < -2 \text{ or } x > 5$$

$$(d) x^2 + 7x + 12 = 0$$

$$(x + 4)(x + 3) = 0$$

$$x = -4, x = -3$$

Sketch of $y = x^2 + 7x + 12$:



$$x^2 + 7x + 12 \geq 0 \text{ when } x \leq -4 \text{ or } x \geq -3$$

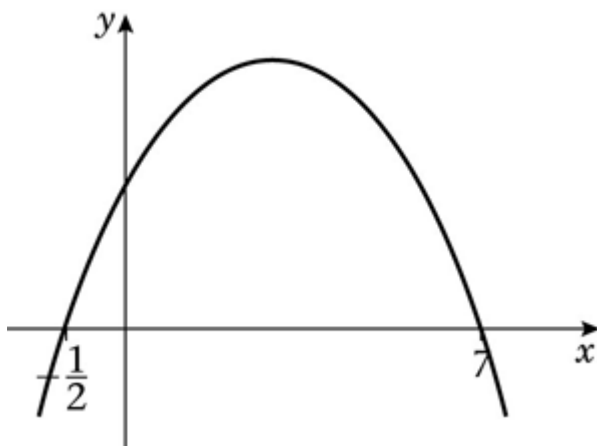
$$(e) 7 + 13x - 2x^2 = 0$$

$$2x^2 - 13x - 7 = 0$$

$$(2x + 1)(x - 7) = 0$$

$$x = -\frac{1}{2}, x = 7$$

Sketch of $y = 7 + 13x - 2x^2$:



$$7 + 13x - 2x^2 > 0 \text{ when } -\frac{1}{2} < x < 7$$

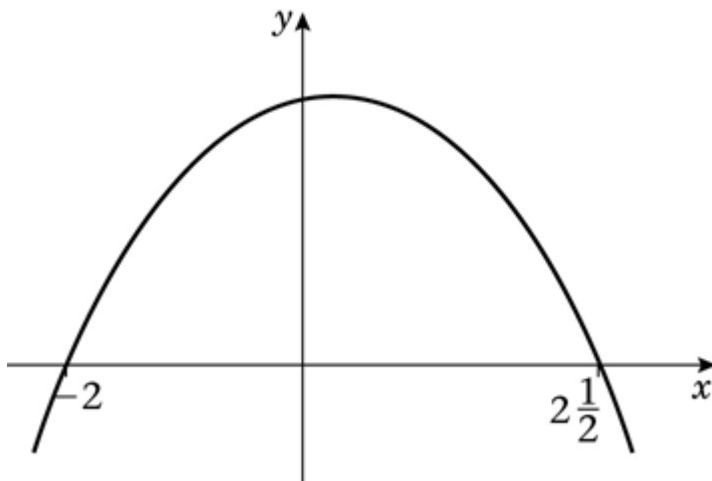
$$(f) 10 + x - 2x^2 = 0$$

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

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

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

Sketch of $y = 10 + x - 2x^2$:

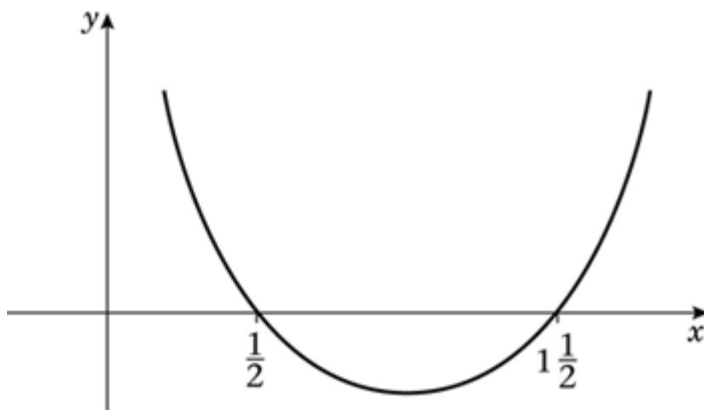


$$10 + x - 2x^2 < 0 \text{ when } x < -2 \text{ or } x > 2\frac{1}{2}$$

$$\begin{aligned} \text{(g) } 4x^2 - 8x + 3 &= 0 \\ (2x - 1)(2x - 3) &= 0 \end{aligned}$$

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

Sketch of $y = 4x^2 - 8x + 3$:

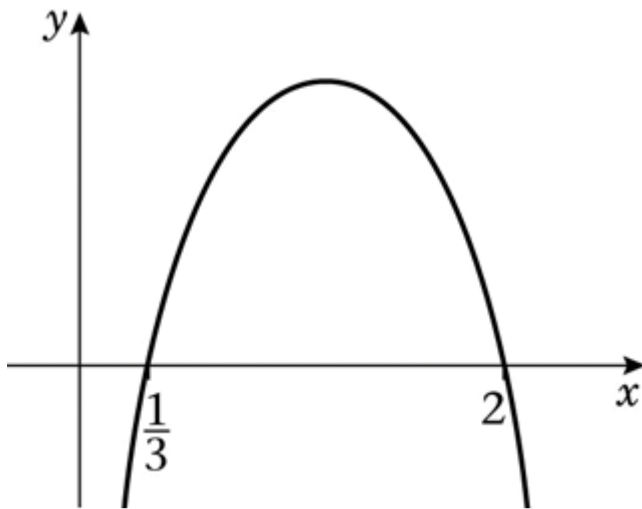


$$4x^2 - 8x + 3 \leq 0 \text{ when } \frac{1}{2} \leq x \leq 1\frac{1}{2}$$

$$\begin{aligned} \text{(h) } -2 + 7x - 3x^2 &= 0 \\ 3x^2 - 7x + 2 &= 0 \\ (3x - 1)(x - 2) &= 0 \end{aligned}$$

$$x = \frac{1}{3}, x = 2$$

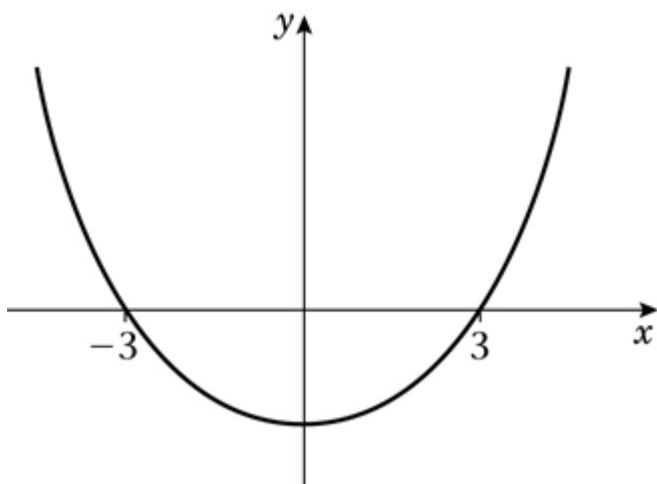
Sketch of $y = -2 + 7x - 3x^2$:



$$-2 + 7x - 3x^2 < 0 \text{ when } x < \frac{1}{3} \text{ or } x > 2$$

$$\begin{aligned} \text{(i) } x^2 - 9 &= 0 \\ (x + 3)(x - 3) &= 0 \\ x &= -3, x = 3 \end{aligned}$$

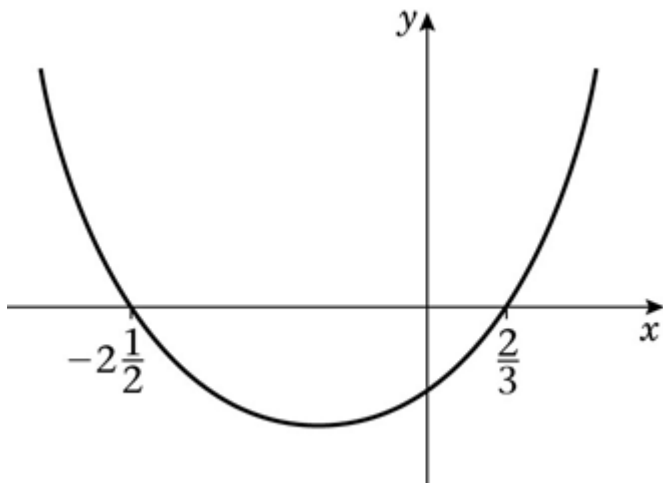
Sketch of $y = x^2 - 9$:



$$x^2 - 9 < 0 \text{ when } -3 < x < 3$$

$$\begin{aligned} \text{(j) } 6x^2 + 11x - 10 &= 0 \\ (3x - 2)(2x + 5) &= 0 \\ x &= \frac{2}{3}, x = -2\frac{1}{2} \end{aligned}$$

Sketch of $y = 6x^2 + 11x - 10$:



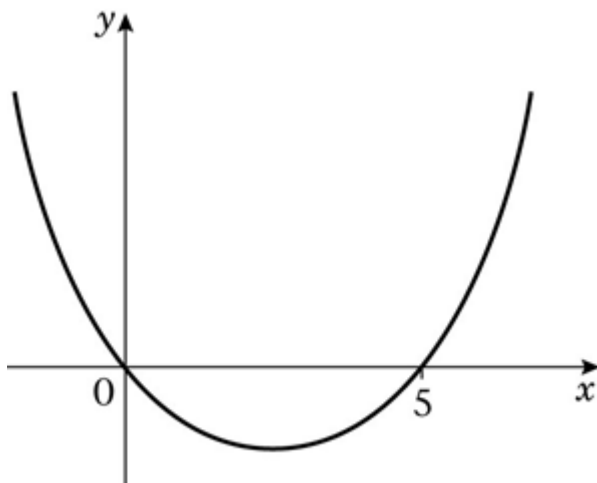
$$6x^2 + 11x - 10 > 0 \text{ when } x < -2\frac{1}{2} \text{ or } x > \frac{2}{3}$$

$$(k) x^2 - 5x = 0$$

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

$$x = 0, x = 5$$

Sketch of $y = x^2 - 5x$:



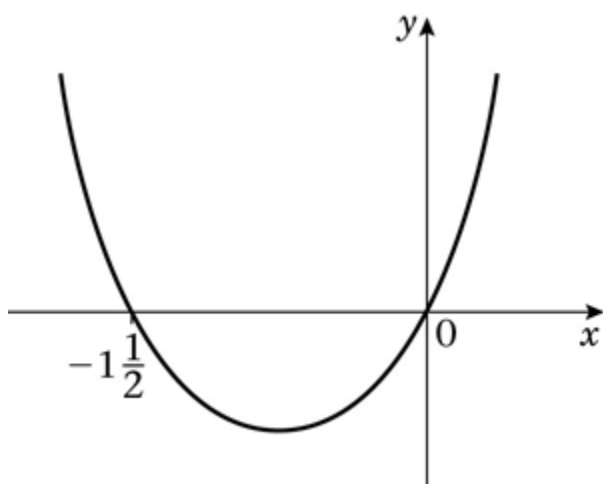
$$x^2 - 5x > 0 \text{ when } x < 0 \text{ or } x > 5$$

$$(l) 2x^2 + 3x = 0$$

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

$$x = 0, x = -1\frac{1}{2}$$

Sketch of $y = 2x^2 + 3x$:



$$2x^2 + 3x \leq 0 \text{ when } -1\frac{1}{2} \leq x \leq 0$$

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Edexcel Modular Mathematics for AS and A-Level

Equations and inequalities

Exercise E, Question 2

Question:

Find the set of values of x for which:

(a) $x^2 < 10 - 3x$

(b) $11 < x^2 + 10$

(c) $x(3 - 2x) > 1$

(d) $x(x + 11) < 3(1 - x^2)$

Solution:

(a) $x^2 = 10 - 3x$

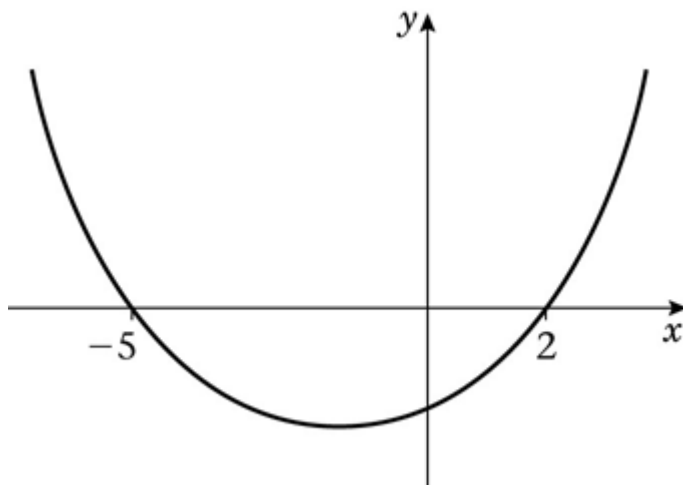
$$x^2 + 3x - 10 = 0$$

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

$$x = -5, x = 2$$

$$x^2 < 10 - 3x \Rightarrow x^2 + 3x - 10 < 0$$

Sketch of $y = x^2 + 3x - 10$:



$$x^2 + 3x - 10 < 0 \text{ when } -5 < x < 2$$

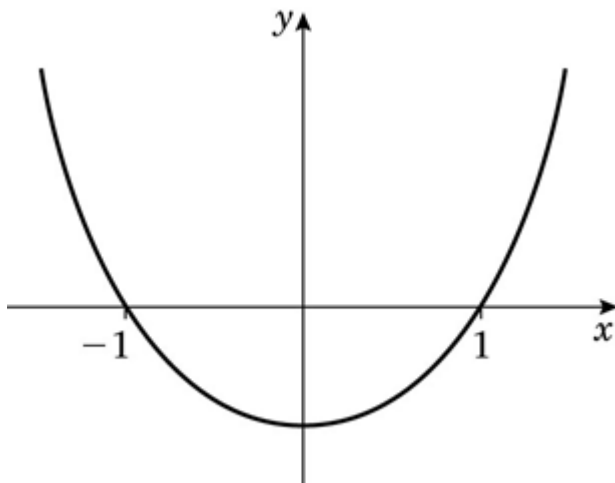
(b) $11 = x^2 + 10$

$$x^2 = 1$$

$$x = -1, x = 1$$

$$11 < x^2 + 10 \Rightarrow 0 < x^2 + 10 - 11 \Rightarrow x^2 - 1 > 0$$

Sketch of $y = x^2 - 1$:



$x^2 - 1 > 0$ when $x < -1$ or $x > 1$

$$(c) x(3 - 2x) = 1$$

$$3x - 2x^2 = 1$$

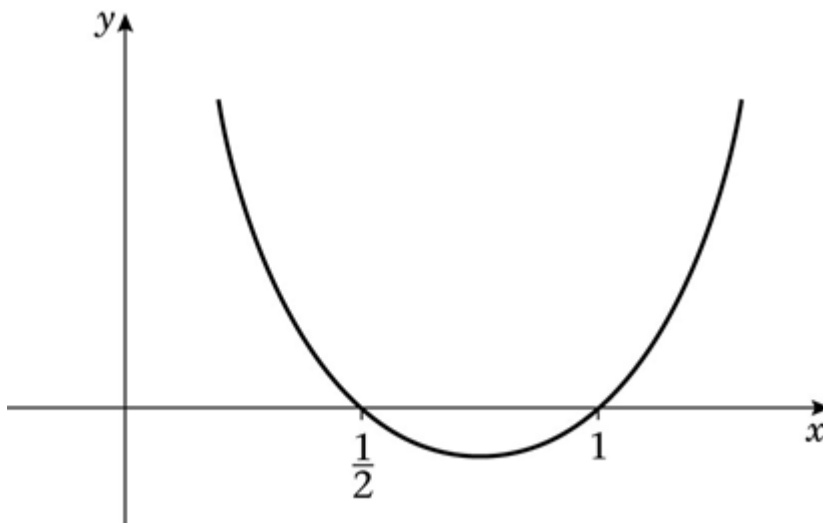
$$0 = 2x^2 - 3x + 1$$

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

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

$$x(3 - 2x) > 1 \Rightarrow -2x^2 + 3x - 1 > 0 \Rightarrow 2x^2 - 3x + 1 < 0$$

Sketch of $y = 2x^2 - 3x + 1$:



$2x^2 - 3x + 1 < 0$ when $\frac{1}{2} < x < 1$

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

$$x^2 + 11x = 3 - 3x^2$$

$$x^2 + 3x^2 + 11x - 3 = 0$$

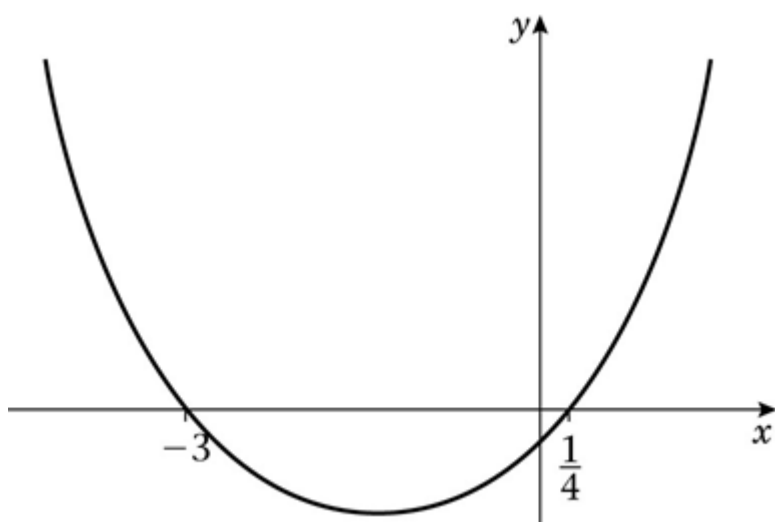
$$4x^2 + 11x - 3 = 0$$

$$(4x - 1)(x + 3) = 0$$

$$x = \frac{1}{4}, x = -3$$

$$x(x + 11) < 3(1 - x^2) \Rightarrow 4x^2 + 11x - 3 < 0$$

Sketch of $y = 4x^2 + 11x - 3$:



$$4x^2 + 11x - 3 < 0 \text{ when } -3 < x < \frac{1}{4}$$

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Edexcel Modular Mathematics for AS and A-Level

Equations and inequalities

Exercise E, Question 3

Question:

Find the set of values of x for which:

(a) $x^2 - 7x + 10 < 0$ and $3x + 5 < 17$

(b) $x^2 - x - 6 > 0$ and $10 - 2x < 5$

(c) $4x^2 - 3x - 1 < 0$ and $4(x + 2) < 15 - (x + 7)$

(d) $2x^2 - x - 1 < 0$ and $14 < 3x - 2$

(e) $x^2 - x - 12 > 0$ and $3x + 17 > 2$

(f) $x^2 - 2x - 3 < 0$ and $x^2 - 3x + 2 > 0$

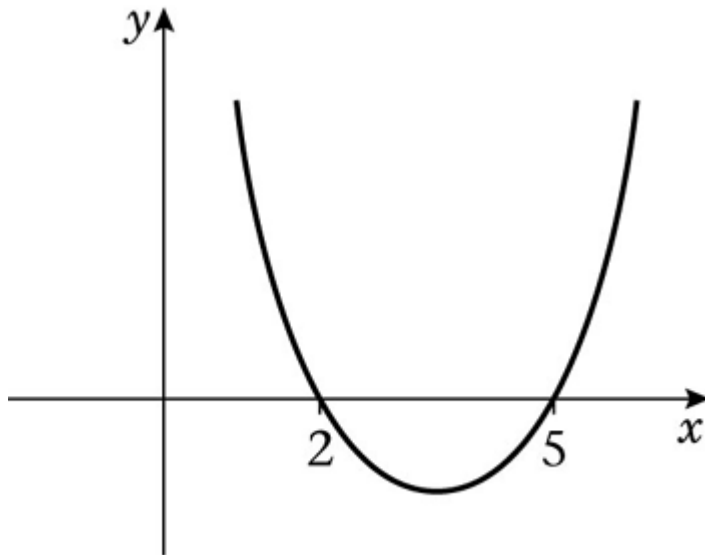
Solution:

(a) $x^2 - 7x + 10 = 0$

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

$x = 2, x = 5$

Sketch of $y = x^2 - 7x + 10$:



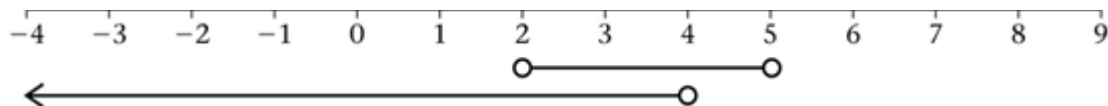
$x^2 - 7x + 10 < 0$ when $2 < x < 5$.

$3x + 5 < 17$

$3x < 17 - 5$

$3x < 12$

$x < 4$



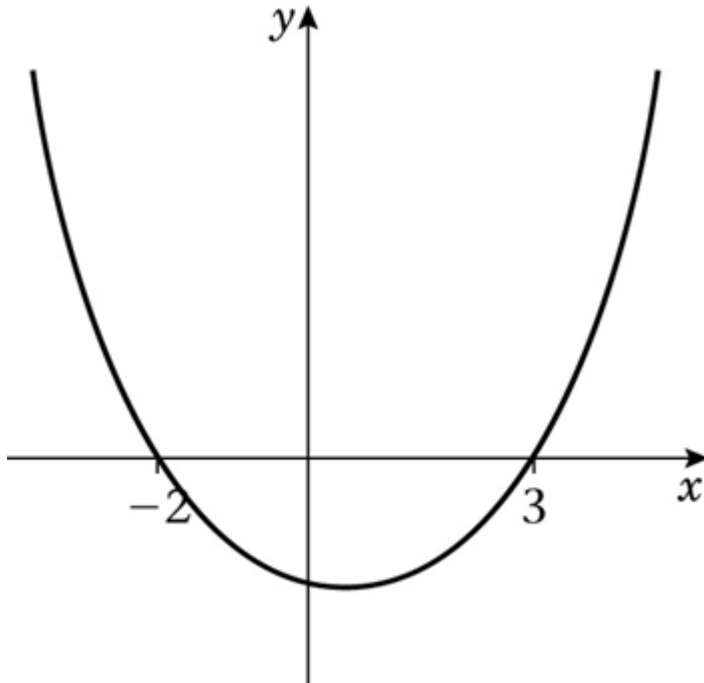
Intersection is $2 < x < 4$.

$$(b) x^2 - x - 6 = 0$$

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

$$x = -2, x = 3$$

Sketch of $y = x^2 - x - 6$:



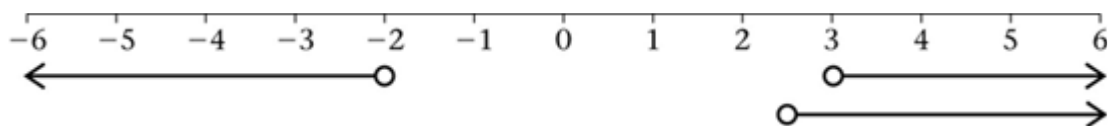
$$x^2 - x - 6 > 0 \text{ when } x < -2 \text{ or } x > 3$$

$$10 - 2x < 5$$

$$-2x < 5 - 10$$

$$-2x < -5$$

$$x > 2\frac{1}{2}$$



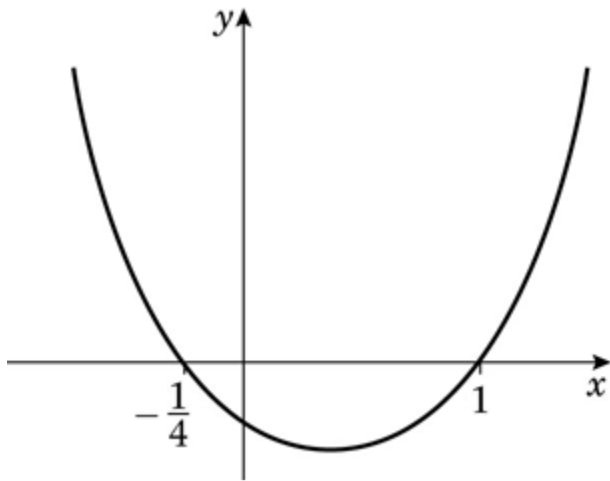
Intersection is $x > 3$.

$$(c) 4x^2 - 3x - 1 = 0$$

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

$$x = -\frac{1}{4}, x = 1$$

Sketch of $y = 4x^2 - 3x - 1$:



$$4x^2 - 3x - 1 < 0 \text{ when } -\frac{1}{4} < x < 1$$

$$4(x + 2) < 15 - (x + 7)$$

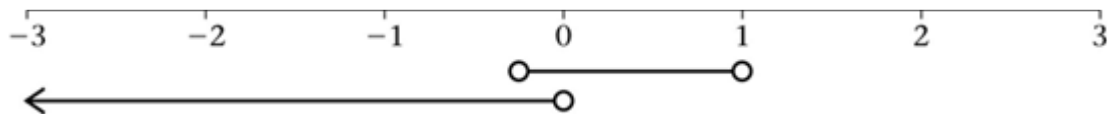
$$4x + 8 < 15 - x - 7$$

$$4x + 8 < 8 - x$$

$$4x + x < 8 - 8$$

$$5x < 0$$

$$x < 0$$



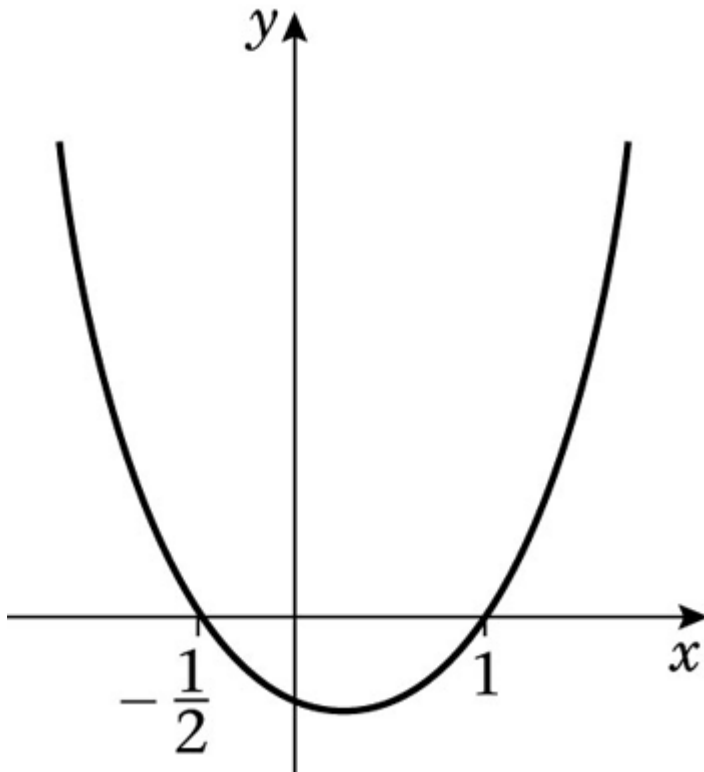
$$\text{Intersection is } -\frac{1}{4} < x < 0$$

$$(d) 2x^2 - x - 1 = 0$$

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

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

Sketch of $y = 2x^2 - x - 1$:



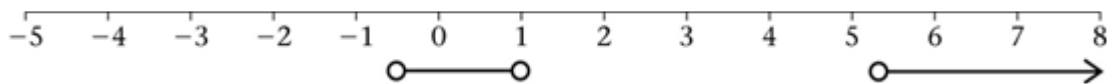
$$2x^2 - x - 1 < 0 \text{ when } -\frac{1}{2} < x < 1$$

$$14 < 3x - 2$$

$$14 + 2 < 3x$$

$$3x > 16$$

$$x > 5\frac{1}{3}$$



No intersection.

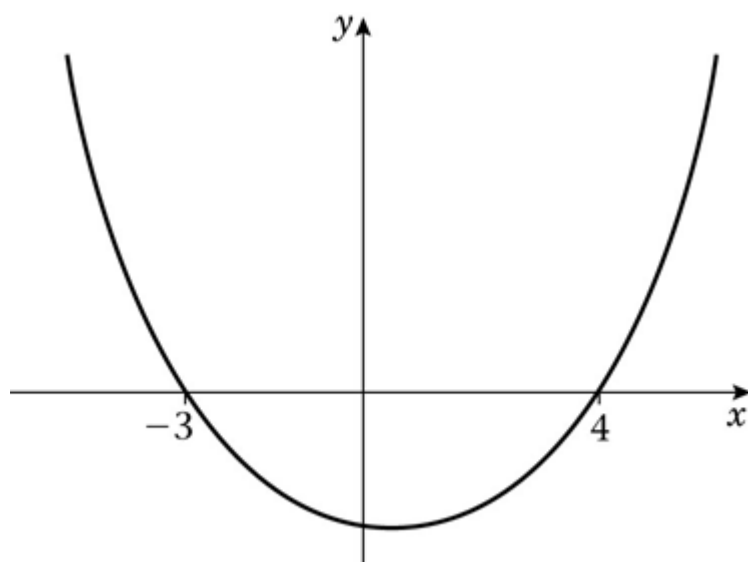
There are no values of x for which both inequalities are true.

$$(e) x^2 - x - 12 = 0$$

$$(x + 3)(x - 4) = 0$$

$$x = -3, x = 4$$

Sketch of $y = x^2 - x - 12$:



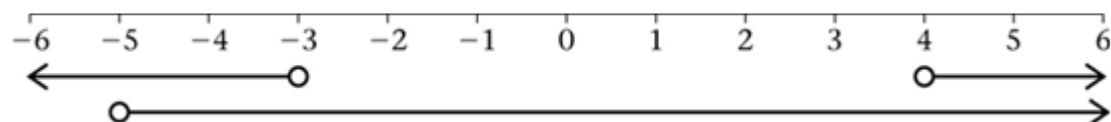
$$x^2 - x - 12 > 0 \text{ when } x < -3 \text{ or } x > 4$$

$$3x + 17 > 2$$

$$3x > 2 - 17$$

$$3x > -15$$

$$x > -5$$



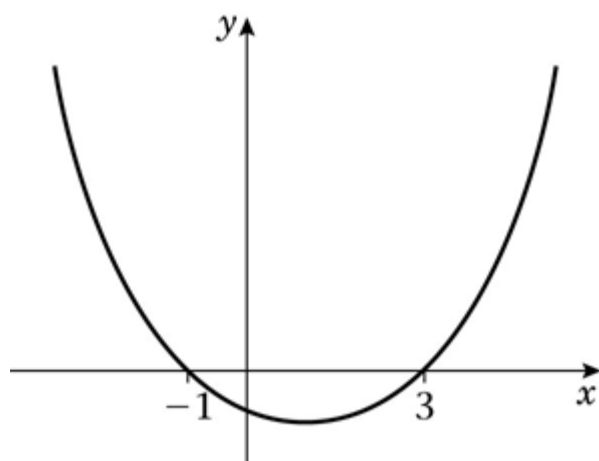
Intersection is $-5 < x < -3, x > 4$.

$$(f) x^2 - 2x - 3 = 0$$

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

$$x = -1, x = 3$$

Sketch of $y = x^2 - 2x - 3$:



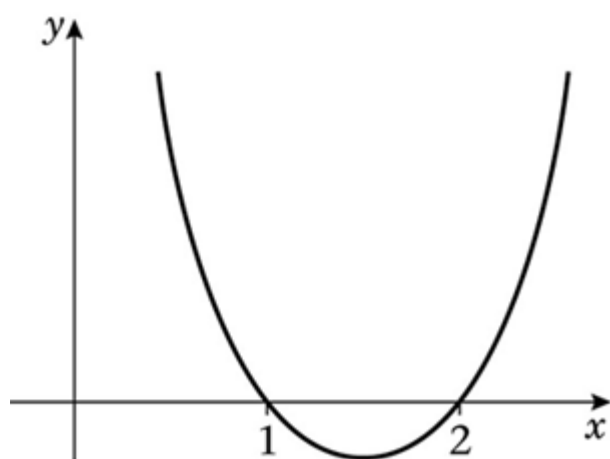
$$x^2 - 2x - 3 < 0 \text{ when } -1 < x < 3$$

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

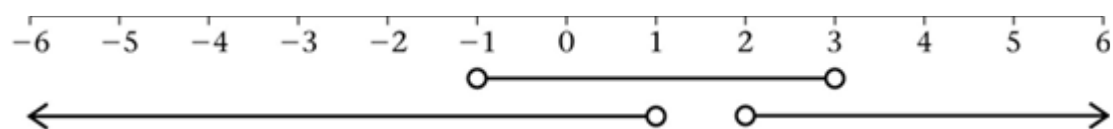
$$(x - 1)(x - 2) = 0$$

$$x = 1, x = 2$$

Sketch of $y = x^2 - 3x + 2$:



$$x^2 - 3x + 2 > 0 \text{ when } x < 1 \text{ or } x > 2$$



Intersection is $-1 < x < 1, 2 < x < 3$.

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Edexcel Modular Mathematics for AS and A-Level

Equations and inequalities

Exercise E, Question 4

Question:

- (a) Find the range of values of k for which the equation $x^2 - kx + (k + 3) = 0$ has no real roots.
- (b) Find the range of values of p for which the roots of the equation $px^2 + px - 2 = 0$ are real.

Solution:

(a) $a = 1, b = -k, c = k + 3$
 $b^2 - 4ac < 0$ for no real roots, so
 $k^2 - 4(k + 3) < 0$
 $k^2 - 4k - 12 < 0$
 $(k - 6)(k + 2) < 0$
 $-2 < k < 6$

(b) $a = p, b = p, c = -2$
 $b^2 - 4ac < 0$ for no real roots, so
 $p^2 + 8p < 0$
 $p(p + 8) < 0$
 $-8 < p < 0$

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Edexcel Modular Mathematics for AS and A-Level

Equations and inequalities

Exercise F, Question 1

Question:

Solve the simultaneous equations:

$$\begin{aligned}x + 2y &= 3 \\x^2 - 4y^2 &= -33 \quad \text{[E]}\end{aligned}$$

Solution:

$$\begin{aligned}x &= 3 - 2y \\ \text{Substitute into } x^2 - 4y^2 &= -33: \\ (3 - 2y)^2 - 4y^2 &= -33 \\ 9 - 12y + 4y^2 - 4y^2 &= -33 \\ -12y &= -33 - 9 \\ -12y &= -42 \\ y &= 3 \frac{1}{2}\end{aligned}$$

$$\begin{aligned}\text{Substitute into } x &= 3 - 2y: \\ x &= 3 - 7 = -4\end{aligned}$$

So solution is $x = -4$, $y = 3 \frac{1}{2}$

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Equations and inequalities

Exercise F, Question 2

Question:

Show that the elimination of x from the simultaneous equations:

$$x - 2y = 1$$

$$3xy - y^2 = 8$$

produces the equation

$$5y^2 + 3y - 8 = 0.$$

Solve this quadratic equation and hence find the pairs (x, y) for which the simultaneous equations are satisfied. **[E]**

Solution:

$$x = 1 + 2y$$

Substitute into $3xy - y^2 = 8$:

$$3y(1 + 2y) - y^2 = 8$$

$$3y + 6y^2 - y^2 = 8$$

$$5y^2 + 3y - 8 = 0$$

$$(5y + 8)(y - 1) = 0$$

$$y = -\frac{8}{5} \text{ or } y = 1$$

Substitute into $x = 1 + 2y$:

$$\text{when } y = -\frac{8}{5}, x = 1 - \frac{16}{5} = -\frac{11}{5}$$

$$\text{when } y = 1, x = 1 + 2 = 3$$

Solutions are $\left(-2\frac{1}{5}, -1\frac{3}{5}\right)$ and $(3, 1)$

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Edexcel Modular Mathematics for AS and A-Level

Equations and inequalities

Exercise F, Question 3

Question:

(a) Given that $3^x = 9^{y-1}$, show that $x = 2y - 2$.

(b) Solve the simultaneous equations:

$$x = 2y - 2$$

$$x^2 = y^2 + 7 \quad \text{[E]}$$

Solution:

(a) $9 = 3^2$, so $3^x = (3^2)^{y-1} \Rightarrow 3^x = 3^{2(y-1)}$

Equate powers: $x = 2(y-1) \Rightarrow x = 2y - 2$

(b) $x = 2y - 2$

Substitute into $x^2 = y^2 + 7$:

$$(2y - 2)^2 = y^2 + 7$$

$$4y^2 - 8y + 4 = y^2 + 7$$

$$4y^2 - y^2 - 8y + 4 - 7 = 0$$

$$3y^2 - 8y - 3 = 0$$

$$(3y + 1)(y - 3) = 0$$

$$y = -\frac{1}{3} \text{ or } y = 3$$

Substitute into $x = 2y - 2$:

when $y = -\frac{1}{3}$, $x = -\frac{2}{3} - 2 = -2\frac{2}{3}$

when $y = 3$, $x = 6 - 2 = 4$

Solutions are $x = -2\frac{2}{3}$, $y = -\frac{1}{3}$ and $x = 4$, $y = 3$

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Equations and inequalities

Exercise F, Question 4

Question:

Solve the simultaneous equations:

$$\begin{aligned}x + 2y &= 3 \\x^2 - 2y + 4y^2 &= 18 \quad \text{[E]}\end{aligned}$$

Solution:

$$\begin{aligned}x &= 3 - 2y \\ \text{Substitute into } x^2 - 2y + 4y^2 &= 18: \\ (3 - 2y)^2 - 2y + 4y^2 &= 18 \\ 9 - 12y + 4y^2 - 2y + 4y^2 &= 18 \\ 8y^2 - 14y + 9 - 18 &= 0 \\ 8y^2 - 14y - 9 &= 0 \\ (4y - 9)(2y + 1) &= 0 \\ y = \frac{9}{4} \text{ or } y = -\frac{1}{2}\end{aligned}$$

Substitute into $x = 3 - 2y$:

$$\text{when } y = \frac{9}{4}, x = 3 - 2 \times \frac{9}{4} = -\frac{3}{2}$$

$$\text{when } y = -\frac{1}{2}, x = 3 + 1 = 4$$

$$\text{Solutions are } x = -1\frac{1}{2}, y = 2\frac{1}{4} \text{ and } x = 4, y = -\frac{1}{2}$$

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Equations and inequalities

Exercise F, Question 5

Question:

(a) Solve the inequality $3x - 8 > x + 13$.

(b) Solve the inequality $x^2 - 5x - 14 > 0$. [E]

Solution:

(a) $3x - x > 13 + 8$

$$2x > 21$$

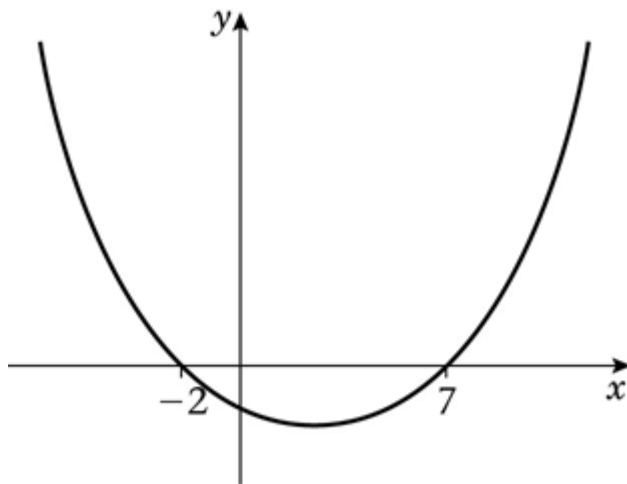
$$x > 10 \frac{1}{2}$$

(b) $x^2 - 5x - 14 = 0$

$$(x + 2)(x - 7) = 0$$

$$x = -2 \text{ or } x = 7$$

Sketch of $y = x^2 - 5x - 14$:



$$x^2 - 5x - 14 > 0 \text{ when } x < -2 \text{ or } x > 7$$

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Equations and inequalities

Exercise F, Question 6

Question:

Find the set of values of x for which $(x - 1)(x - 4) < 2(x - 4)$. [E]

Solution:

$$x^2 - 5x + 4 < 2x - 8$$

$$x^2 - 5x - 2x + 4 + 8 < 0$$

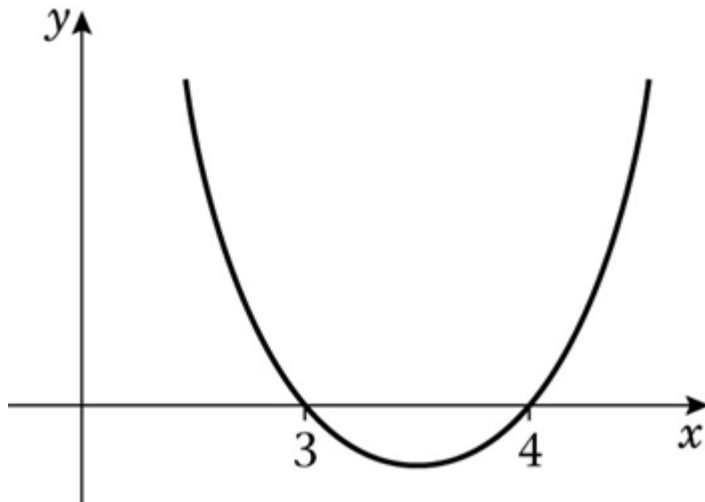
$$x^2 - 7x + 12 < 0$$

$$x^2 - 7x + 12 = 0$$

$$(x - 3)(x - 4) = 0$$

$$x = 3 \text{ or } x = 4$$

Sketch of $y = x^2 - 7x + 12$:



$$x^2 - 7x + 12 < 0 \text{ when } 3 < x < 4.$$

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Equations and inequalities

Exercise F, Question 7

Question:

(a) Use algebra to solve $(x - 1)(x + 2) = 18$.

(b) Hence, or otherwise, find the set of values of x for which $(x - 1)(x + 2) > 18$. **[E]**

Solution:

(a) $x^2 + x - 2 = 18$

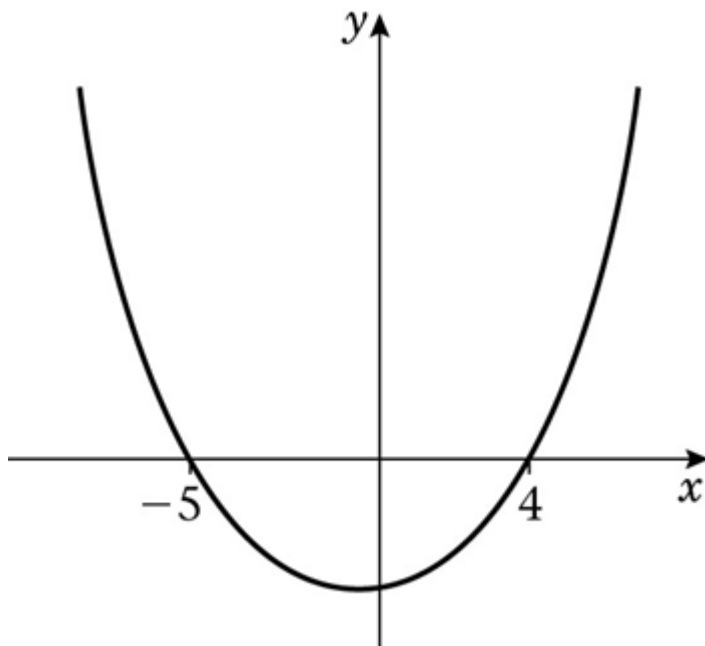
$$x^2 + x - 20 = 0$$

$$(x + 5)(x - 4) = 0$$

$$x = -5 \text{ or } x = 4$$

(b) $(x - 1)(x + 2) > 18 \Rightarrow x^2 + x - 20 > 0$

Sketch of $y = x^2 + x - 20$:



$$x^2 + x - 20 > 0 \text{ when } x < -5 \text{ or } x > 4$$

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Edexcel Modular Mathematics for AS and A-Level

Equations and inequalities

Exercise F, Question 8

Question:

Find the set of values of x for which:

(a) $6x - 7 < 2x + 3$

(b) $2x^2 - 11x + 5 < 0$

(c) both $6x - 7 < 2x + 3$ and $2x^2 - 11x + 5 < 0$. **[E]**

Solution:

(a) $6x - 2x < 3 + 7$

$4x < 10$

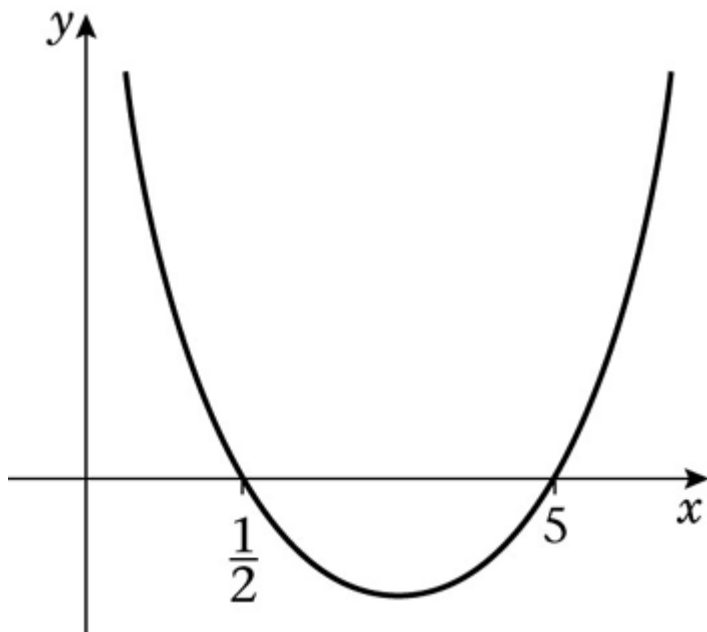
$x < 2\frac{1}{2}$

(b) $2x^2 - 11x + 5 = 0$

$(2x - 1)(x - 5) = 0$

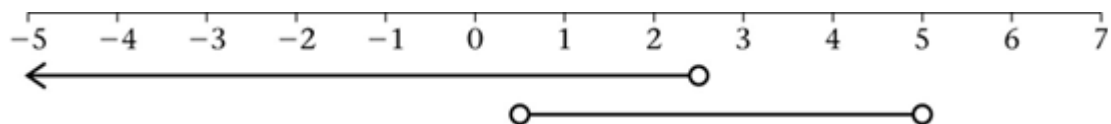
$x = \frac{1}{2}$ or $x = 5$

Sketch of $y = 2x^2 - 11x + 5$:



$2x^2 - 11x + 5 < 0$ when $\frac{1}{2} < x < 5$

(c)



Intersection is $\frac{1}{2} < x < 2\frac{1}{2}$.

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Equations and inequalities

Exercise F, Question 9

Question:

Find the values of k for which $kx^2 + 8x + 5 = 0$ has real roots.

Solution:

$$a = k, b = 8, c = 5$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

$b^2 - 4ac \geq 0$ for real roots. So

$$8^2 - 4k \times 5 \geq 0$$

$$64 - 20k \geq 0$$

$$64 \geq 20k$$

$$\frac{64}{20} \geq k$$

$$k \leq 3 \frac{1}{5}$$

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Equations and inequalities

Exercise F, Question 10

Question:

Find algebraically the set of values of x for which $(2x - 3)(x + 2) > 3(x - 2)$. [E]

Solution:

$$2x^2 + x - 6 > 3x - 6$$

$$2x^2 + x - 3x - 6 + 6 > 0$$

$$2x^2 - 2x > 0$$

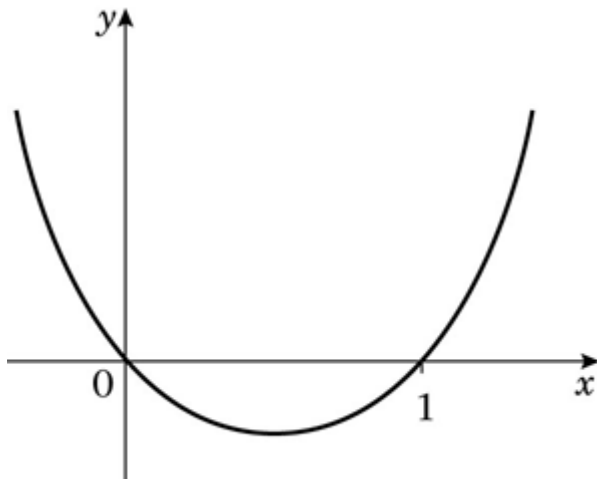
$$2x(x - 1) > 0$$

Solve the equation:

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

$$x = 0 \text{ or } x = 1$$

Sketch of $y = 2x^2 - 2x$:



$$2x^2 - 2x > 0 \text{ when } x < 0 \text{ or } x > 1$$

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Equations and inequalities

Exercise F, Question 11

Question:

(a) Find, as surds, the roots of the equation $2(x+1)(x-4) - (x-2)^2 = 0$.

(b) Hence find the set of values of x for which $2(x+1)(x-4) - (x-2)^2 > 0$. **[E]**

Solution:

$$(a) 2(x^2 - 3x - 4) - (x^2 - 4x + 4) = 0$$

$$2x^2 - 6x - 8 - x^2 + 4x - 4 = 0$$

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

$$a = 1, b = -2, c = -12$$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} :$$

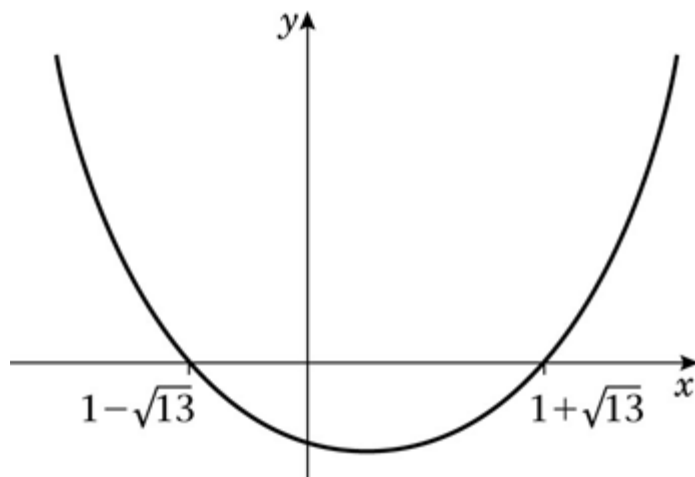
$$x = \frac{2 \pm \sqrt{(-2)^2 + 48}}{2} = \frac{2 \pm \sqrt{52}}{2}$$

$$\sqrt{52} = \sqrt{4} \sqrt{13} = 2\sqrt{13}$$

$$x = 1 + \sqrt{13} \text{ or } x = 1 - \sqrt{13}$$

$$(b) 2(x+1)(x-4) - (x-2)^2 > 0 \Rightarrow x^2 - 2x - 12 > 0$$

Sketch of $y = x^2 - 2x - 12$:



$$x^2 - 2x - 12 > 0 \text{ when } x < 1 - \sqrt{13} \text{ or } x > 1 + \sqrt{13}$$

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Edexcel Modular Mathematics for AS and A-Level

Equations and inequalities

Exercise F, Question 12

Question:

- (a) Use algebra to find the set of values of x for which $x(x - 5) > 36$.
- (b) Using your answer to part (a), find the set of values of y for which $y^2(y^2 - 5) > 36$.

Solution:

(a) $x^2 - 5x > 36$

$$x^2 - 5x - 36 > 0$$

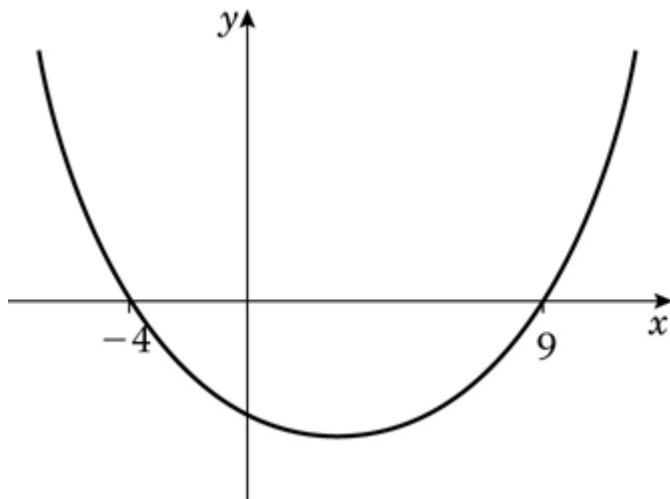
Solve the equation:

$$x^2 - 5x - 36 = 0$$

$$(x + 4)(x - 9) = 0$$

$$x = -4 \text{ or } x = 9$$

Sketch of $y = x^2 - 5x - 36$:



$$x^2 - 5x - 36 > 0 \text{ when } x < -4 \text{ or } x > 9$$

(b) Either $y^2 < -4$ or $y^2 > 9$

$y^2 < -4$ is not possible. No values.

$$y^2 > 9 \Rightarrow y > 3 \text{ or } y < -3$$

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Equations and inequalities

Exercise F, Question 13

Question:

The specification for a rectangular car park states that the length x m is to be 5 m more than the breadth. The perimeter of the car park is to be greater than 32 m.

(a) Form a linear inequality in x .

The area of the car park is to be less than 104m^2 .

(b) Form a quadratic inequality in x .

(c) By solving your inequalities, determine the set of possible values of x . **[E]**

Solution:

(a) Length is x metres, breadth is $(x - 5)$ metres.

Perimeter is $x + x + (x - 5) + (x - 5) = (4x - 10)$ metres

So $4x - 10 > 32$

(b) Area is $x(x - 5)$ m^2 .

So $x(x - 5) < 104$

(c) Linear:

$$4x - 10 > 32$$

$$4x > 32 + 10$$

$$4x > 42$$

$$x > 10 \frac{1}{2}$$

Quadratic:

$$x^2 - 5x < 104$$

$$x^2 - 5x - 104 < 0$$

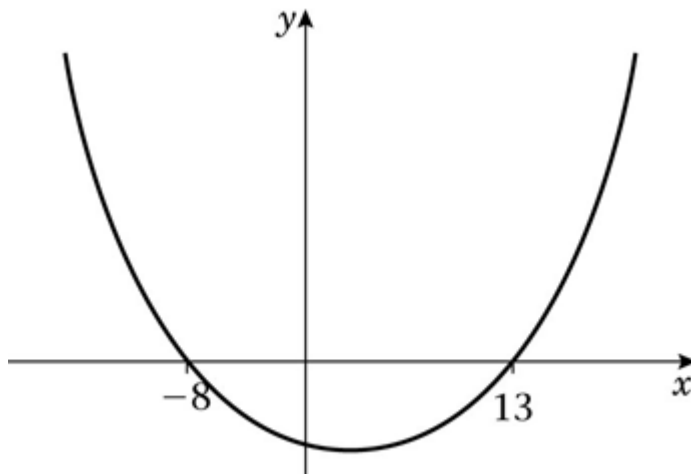
Solve the equation:

$$x^2 - 5x - 104 = 0$$

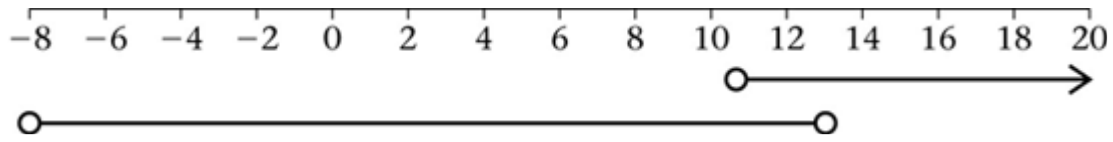
$$(x + 8)(x - 13) = 0$$

$$x = -8 \text{ or } x = 13$$

Sketch of $y = x^2 - 5x - 104$:



$$x^2 - 5x - 104 < 0 \text{ when } -8 < x < 13$$



Intersection is $10\frac{1}{2} < x < 13$.

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