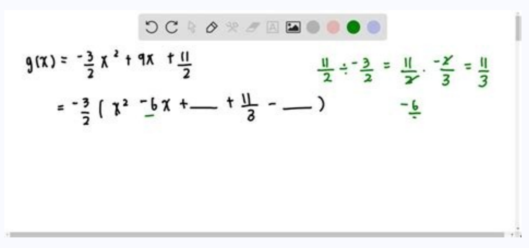
Complete the square to vertex form worksheet

Continue

WRITE IN VERTEX FORM

$$y = x^2 + 12x + 32$$
$$y - 32 = x^2 + 12x$$
$$y - 32 + 36 = x^2 + 12x + 36$$
$$y + 4 = x^2 + 12x + 36$$
$$y + 4 = (x+6)(x+6)$$
$$y + 4 = (x+6)^2$$
$$y = (x+6)^2 - 4$$

Vertex: $(-6, -4)$



Completing the Square: *Deriving the Quadratic Formula*

Quadratic Formula

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

$$ax^2 + bx + c = 0$$

Solve for x (by completing the square):

separate the variable: $ax^2 + bx \quad + c = 0$

change lead coefficient to 1 (factor out the 'a'): $a(x^2 + \frac{b}{a}x \quad) \quad + c = 0$

complete the square by adding $\left(\frac{\frac{b}{a}}{2}\right)^2$: $a(x^2 + \frac{b}{a}x + \frac{b^2}{4a^2}) \quad + c = 0 + \frac{b^2}{4a}$

Since we added $a\left(\frac{b}{4a^2}\right)$ on the left side, we add $\frac{b^2}{4a}$ to the right side...

$$a(x + \frac{b}{2a})(x + \frac{b}{2a}) + c = 0 + \frac{b^2}{4a}$$

Factor

$$a(x + \frac{b}{2a})^2 + c = 0 + \frac{b^2}{4a}$$

Isolate the binomial

$$a(x + \frac{b}{2a})^2 = \frac{b^2}{4a} - c$$

$$a(x + \frac{b}{2a})^2 = \frac{b^2}{4a} - \frac{4a^2c}{4a}$$

$$\frac{a}{(a)}(x + \frac{b}{2a})^2 = \frac{b^2 - 4a^2c}{4a\,(a)}$$

Square root both sides

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

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

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

Comparison: Example $x^2 + 5x - 12 = 0$

Completing the square:

$$x^2 + 5x - 12 = 0$$
$$x^2 + 5x + \frac{25}{4} = 12 + \frac{25}{4}$$
$$(x + \frac{5}{2})^2 = \frac{73}{4}$$
$$x + \frac{5}{2} = \pm\sqrt{\frac{73}{4}}$$
$$x = -\frac{5}{2} \pm \frac{\sqrt{73}}{2}$$

Quadratic Formula:

a = 1
b = 5
c = −12

$$x = \frac{-(5) \pm \sqrt{(5)^2 - 4(1)(-12)}}{2(1)}$$

$$x = \frac{-5 \pm \sqrt{73}}{2}$$

1)

Determine the vertex of the quadratic function. In order to do this, complete the square.

a) Function: $6x^2 + 96x + 374$

Factor out the leading coefficient 6: $\_\_(x^2 + \_\_x) + \_\_$

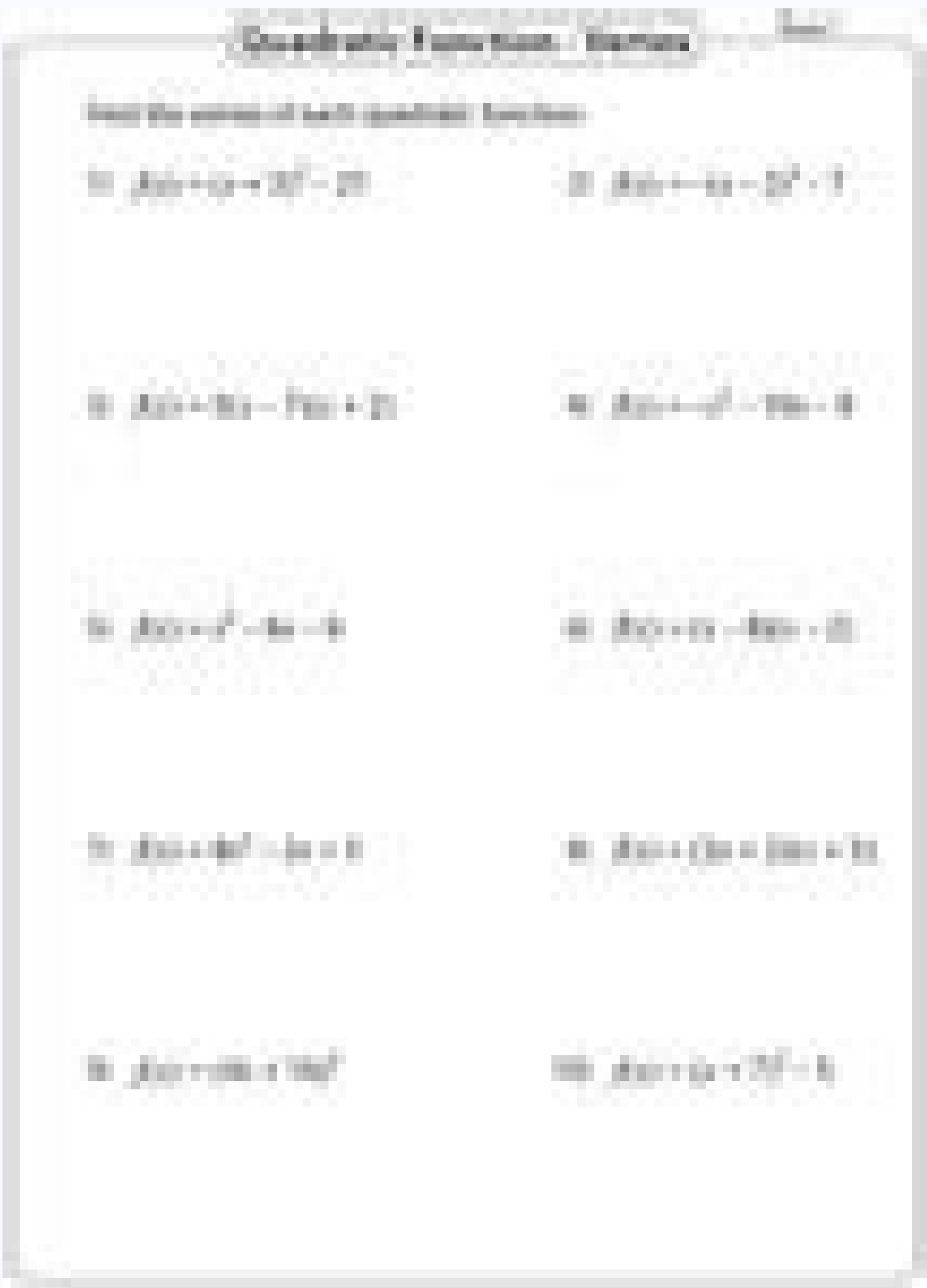
Complete the square: $\_\_(x^2 + \_\_x + \_\_ - \_\_) + \_\_$

Form square: $\_\_((x + \_\_)^2 - \_\_) + \_\_$

Multiply out: $\_\_(x + \_\_)^2 - \_\_ + \_\_$

Convert to vertex form: $\_\_(x + \_\_)^2 - \_\_$

Vertex: $(\_\_ | \_\_)$



Completing the square vertex form worksheet.

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The sum of the angles in a convex quadrilateral add up to 360°. Add the angles in each set and figure out which sets of angles satisfy the angle sum property of quadrilaterals and form a quadrilateral. Algebra in Quadrilaterals | Solve for 'x' The measure of one of the angles of the quadrilateral is offered as an algebraic expression. Add up the angles and equate with 360°. Solve for 'x' to complete the worksheet. Find the Indicated Angles | Solve for 'x' - Level 1 Determine the measure of the indicated angles in a quadrilateral; two of whose angles are depicted as algebraic expressions. Simplify the expressions, find 'x' and compute the measure of the unknown angle(s). Special Quadrilaterals | Vertex Angles The congruent parts are marked and the measures of one or two angles of the special quadrilaterals are provided. Apply relevant properties to find the measure of the indicated vertex angles of quadrilaterals. Special Quadrilaterals | Diagonal The diagonals bisecting the vertex angles of the special quadrilaterals are depicted and the congruent parts are marked in this array of high school worksheets. Use appropriate quadrilateral properties to find the specified angle(s). Angles in Special Quadrilaterals | Vertex Angles Featured here are special quadrilaterals, providing two angle measures, of which one is an algebraic expression. Apply relevant angle properties to form an equation with the given angles and solve for 'x'. Angles in Special Quadrilaterals | Diagonal Each pdf worksheet comprises eight special quadrilaterals with diagonals. Using appropriate quadrilateral properties, equate the algebraic expression with the given angle and solve for 'x'. Angles in Special Quadrilaterals | Mixed Review This bundle of printable revision worksheets encompasses quadrilaterals with angle measures offered as algebraic expressions. Equate the expressions applying relevant theorems and solve for 'x'. Use the value of 'x' to determine the measure of the indicated angle(s). Here is everything you need to know about completing the square for GCSE maths (Edexcel, AQA and OCR). You'll learn how to recognise a perfect square, complete the square on algebraic expressions, and tackle more difficult problems with the coefficient of x2 ≠ 1. You will also learn how to solve quadratic equations by completing the square, and how the completed square form links to graphs of quadratic equations. Look out for completing the square worksheets and exam questions at the end. A quadratic expression like x2 + 4x + 4 is called a perfect square. This is because it factorises to give (x + 2)(x+ 2), which can also be written as (x + 2)2. We can see this idea diagrammatically as follows: Most quadratic expressions are not perfect squares, and cannot be written in this form as a single squared bracket. When we complete the square, we try to fit the expression to the closest possible perfect square, with a little bit added or subtracted to make things work. Some expressions will have an 'extra' amount over from a perfect square, such as: So we would write this expression in completed square form as: Some expressions will be 'missing' an amount to make a perfect square, such as: So we would write this expression in completed square form as: While it's easy to see this using diagrams for quadratic expressions with small coefficients, we need a better method for expressions with larger coefficients. You may have noticed already that we divide the coefficient of x by 2 in order to work out the nearest perfect square. Completing the square is a really useful method for solving quadratic equations; the quadratic formula for solving quadratic equations is based on it and can be derived by completing the square. The completed square form of a quadratic expression is also really useful for identifying key points of quadratic functions, such as the maximum or minimum of a quadratic parabola (also called the vertex), without having to draw a graph. You can see this in the examples below. You may sometimes see an expression in the form (x + a) referred to as a binomial. In order to complete the square: Find the closest perfect square by dividing the coefficient of x by 2.Expand the perfect square expression.Compare the constant term in the perfect square to the original expression, and adjust as needed. Get your free completing the square worksheet of 20+ questions and answers. Includes reasoning and applied questions. DOWNLOAD FREE x Get your free completing the square worksheet of 20+ questions and answers. Includes reasoning and applied questions. DOWNLOAD FREE Complete the square for the expression Find the closest perfect square by dividing the coefficient of x by 2. The coefficient of x is 8, so when we divide this by 2, we get 4. The closest perfect square is: 2 Expand the perfect square expression. \[(x + 4)^{2} = x^{2} + 8x + 16\] 3 Compare the constant term in the perfect square to the original expression, and adjust as needed. These match (because our example was a perfect square), so we don't need to make any adjustment. The answer in complete square form is Graphically This graph shows the curve The minimum value of y occurs when the bracket equals 0. This happens when x = −4. If we substitute x = −4, we get: \[y = (-4 + 4)^{2} = 0^{2} = 0\] So the coordinates of the vertex, which is a minimum point, are (−4, 0). Complete the square for the expression Find the closest perfect square by dividing the coefficient of x by 2. The coefficient of x is 6, so when we divide this by 2, we get 3. The closest perfect square is Expand the perfect square expression. \[(x + 3)^{2} = x^{2} + 6x + 9\] Compare the constant term in the perfect square to the original expression, and adjust as needed. In order to make the constant term correct, we need to add 8, because 9 + 8 = 17. The answer in complete square form is Graphically This graph shows the curve The minimum value of y occurs when the bracket equals 0. This happens when x = −3. If we substitute x = −3, we get: \[y = (-3 + 3)^{2} + 8 = 0^{2} + 8 = 8\] So the coordinates of the vertex, which is a minimum point, are (−3, 8). As a little shortcut, the y value is just whatever number is on its own outside the bracket, and the x value is the opposite sign of the number inside the bracket. Complete the square for the expression Find the closest perfect square by dividing the coefficient of x by 2. The coefficient of x is 2, so when we divide this by 2, we get 1. The closest perfect square is Expand the perfect square expression. \[(x + 1)^{2} = x^{2} + 2x + 1\] Compare the constant term in the perfect square to the original expression, and adjust as needed. In order to make the constant term correct, we need to subtract 6, because 1 − 6 = −15. The answer in complete square form is Graphically This graph shows the curve The minimum value of y occurs when the bracket equals 0. This happens when x = −1. If we substitute x = −1, we get: \[y = (-1 + 1)^{2} – 6 = 0^{2} – 6 = -6\] So the coordinates of the vertex, which is a minimum point, are (−1, −6). This is really straightforward – just remember that your perfect square bracket will need subtraction rather than addition in the middle. Complete the square for the expression Find the closest perfect square by dividing the coefficient of x by 2. The coefficient of x is −10, so when we divide this by 2, we get −5. The closest perfect square is Expand the perfect square expression. \[(x – 5)^{2} = x^{2} – 10x + 25\] Compare the constant term in the perfect square to the original expression, and adjust as needed. In order to make the constant term correct, we need to subtract 8, because 25 − 8 = 17. The answer in complete square form is Graphically This graph shows the curve The minimum value of y occurs when the bracket equals 0. This happens when x = −5. If we substitute x = 5, we get: \[y = (5 – 5)^{2} – 8 = 0^{2} – 8 = -8\] So the coordinates of the vertex, which is a minimum point, are (5, −8). Complete the square for the expression Find the closest perfect square by dividing the coefficient of xby 2. The coefficient of x is 3, so when we divide this by 2, we get It can be tempting to use decimals, but fractions are much easier, particularly as completing the square is more likely to be examined on a non-calculator paper at GCSE. The closest perfect square is \[\left(x + \frac{3}{2}\right)^{2}\] Expand the perfect square expression. \[\left(x + \frac{3}{2}\right)^{2} = x^{2} + 3 x + \frac{9}{4}\] Compare the constant term in the perfect square to the original expression, and adjust as needed. It can be useful to think of 4 as the improper fraction this makes it easier to work out the adjustment. In order to make the constant term correct, we need to add because \[\frac{9}{4} + \frac{7}{4} = \frac{16}{4} = 4\] The answer in complete square form is \[\left(x+\frac{3}{2}\right)^{2}+\frac{7}{4}\] Graphically This graph shows the curve The minimum value of y occurs when the bracket equals 0. This happens when If we substitute we get: \[y=\left(\frac{-3}{2}+\frac{3}{2}\right)^{2}+\frac{7}{4}=0^{2}+\frac{7}{4}=\frac{7}{4}\] So the coordinates of the vertex, which is a minimum point, are \[\left(\frac{-3}{2}, \frac{7}{4}\right)\] If the coefficient of x2 is not 1, we must first factorise to get an expression where the coefficient of x2 is 1. If the expression involves the term ax2, then we take out a factor of a. Factorise.Complete the square on the expression inside the brackets: find the closest perfect square by dividing the coefficient of x by 2.Expand the perfect square expression.Compare the constant term in the perfect square to the original expression, and adjust as needed.Multiply out the factorised value. Complete the square for the expression We take out the common factor of 2, so the expression becomes \[2\left(x^{2} + 4 x-5\right)\] then complete the square on the expression inside the bracket. Find the closest perfect square by dividing the coefficient of x by 2. The coefficient of x is 4, so when we divide this by 2, we get 2. The closest perfect square is Expand the perfect square expression. Compare the constant term in the perfect square to the original expression, and adjust as needed. In order to make the constant term correct, we need to subtract 9, because 4 − 9 = −5. So the expression in complete square form is Multiply out the factorised value. Don't forget to deal with the factor of 2 that we removed at the start. So the expression: \[2\left(x^{2}+4 x-5\right)\] in complete square form is: \[2\left((x+2)^{2}-9\right)\] Finally, expand out to give a final answer: Graphically This graph shows the curve The minimum value of y occurs when the bracket equals 0. This happens when x = −2. If we substitute x = −2, we get: \[y=2(x+2)^{2}-18=0^{2}-18=-18\] So the coordinates of the vertex, which is a minimum point, are (−2, −18). Note: we can also complete the square for expressions with a negative x2 coefficient in the same way, by taking out a negative factor in the first step. For example, would be written as: \[-\left(x^{2}-5 x+3\right)\] and then completed as in Example 5. Some quadratic equations can be solved by factorising, but most require either completing the square or the quadratic formula – in fact, the quadratic formula is derived from completing the square (see worksheet). In order to solve quadratic equations using complete the square: Make sure the equation is rearranged so that the right hand side equals 0 (if necessary).Complete the square on the left hand side.Rearrange and solve the resulting equation for x. Solve the quadratic equation Make sure the equation is rearranged so that the right hand side equals 0 (if necessary). RHS already equals 0 here, so no need to do anything. Complete the square on the left hand side. \[x^{2}+6x+3=(x+3)^{2}-6\] Rearrange and solve the resulting equation for x. \[\begin{aligned} (x+3)^{2}-6&=0 \\\\ (x+3)^{2}&=6 \\\\ x+3&=\pm \sqrt{6} \\\\ x&=-3 \pm \sqrt{6} \end{aligned} \] We have two solutions to the equation: \[x=-3+\sqrt{6} \\\\ x=-3-\sqrt{6} \] It is really important to remember the ± sign when square-rooting, as most quadratic equations you're asked to solve at GCSE have two solutions or roots. Sometimes, there will be one repeated root. In most cases, your answer should be left in surd form (with the square root sign in), not converted to a decimal. Solve the quadratic equation Make sure the equation is rearranged so that the right hand side equals 0 (if necessary). Rearrange by adding 5 and 2x to both sides of the equation to give Complete the square on the left hand side. Remember to take out a common factor of 2 first. \[\begin{aligned} 2 x^{2}+12 x+5 &=2\left[x^{2}+6 x+\frac{5}{2}\right] \\\\ &=2\left[(x+3)^{2}-\frac{13}{2}\right] \\\\ &=2(x+3)^{2}-13 \end{aligned} \] Rearrange and solve the resulting equation for x. \begin{aligned} 2(x+3)^{2}-13&=0 \\\\ 2(x+3)^{2}&=13 \\\\ (x+3)^{2}&=\frac{13}{2} \\\\ x+3&=\pm \sqrt{\frac{13}{2}} \\\\ x&=-3 \pm \sqrt{\frac{13}{2}} \end{aligned} We have two solutions to the equation: \[x=-3+\sqrt{\frac{13}{2}} \\\\ x=-3-\sqrt{\frac{13}{2}} \] Incorrect sign in the middle of the perfect square bracket The sign will always be the same sign as the coefficient of x. Errors with fraction arithmetic In particular, remember to square the numerator and denominator when squaring a fraction. Going the wrong way when working out the adjustment Remember to always work out how you get from the perfect square to the expression in the question. Forgetting the ± sign when using the completing the square method to solve quadratics Check carefully to make sure you haven't lost one of your solutions! Practice completing the square questions Half the coefficient of x is 6 so it is (x+6)^{2} . Expanding (x+6)^{2}. gives us x^{2}+12x+36 so we do not need to add or subtract anything. Half the coefficient of x is 3 so it is (x+3)^{2} . Expanding (x+3)^{2} gives us x^{2}+6x+9 so we need to subtract 7 which gives us (x+3)^{2} -7 . =(x+\frac{5}{2})^{2}+\frac{23}{4} =(x-\frac{5}{2})^{2}+\frac{73}{4} =(x-\frac{5}{2})^{2}+\frac{23}{4} Half the coefficient of x is \frac{5}{2} so it is (x-\frac{5}{2})^{2} . Expanding (x-\frac{5}{2})^{2} gives us x^{2}-5x+\frac{25}{4} . We need +12 , which is the same as + \frac{48}{4} so we need to add \frac{23}{4} . Therefore the answer is (x-\frac{5}{2})^{2} + \frac{23}{4} . We must first take a factor of -2 out to get -2(x^{2}+2x-7) . We then need to complete the square for x^{2}+2x-7 . This gives us (x+1)^{2}-8 . So the final answer is -2[(x+1)^{2}-8]=-2(x+1)^{2}+16 . We need to start by completing the square. This gives us y=(x-3)^{2}-8 . We can then see that the minimum point is when   (x-3) = 0 so x=3 . Substituting this in gives us y=0^{2}-8=-8. . Therefore the minimum point is (3, -8) . Completing the square gives us (x+4)^{2}-13 . Therefore we need to solve: \begin{aligned} (x+4)^{2}-13&=0\\\\ (x+4)^{2}&=13\\\\ x+4&=\pm \sqrt{13}\\\\ x&= -4 \pm \sqrt{13} \end{aligned} Completing the square GCSE questions 1. x^{2}+12x+19   can be written in the form (x+a)^{2}+b   where a   and b   are integers. Work out the values of a   and b . (2 marks) 2. (a)   x^{2}-6x+7   can be written in the form (x+a)^{2}+b   where a   and b   are integers. Work out the values of a   and b . (b)   Hence, or otherwise, solve the equation x^{2}-6x+7=0 Give your answers in surd form. (4 marks) (a) a = −3 (1) b = −2 (1) (b) x = 3 + \sqrt{2} (1) x = 3 − \sqrt{2} (1) 3. (a) 3x^{2}+12x-18   can be written in the form a(x+b)^{2}+c   where a   and b   are integers. Work out the values of a, b   and c . (b)   Hence, or otherwise, find the coordinates of the turning point of the graph of y=3x^{2}+12x-18 (4 marks) (a) a = 3 (1) b = 2 (1) c = −30 (1) (b) (−2, −30) (1) You have now learned how to: Complete the square for a quadratic expressionSolve quadratic equations by completing the squareIdentify turning points by completing the square Quadratic graphsFunctions in algebra Prepare your KS4 students for maths GCSEs success with Third Space Learning. Weekly online one to one GCSE maths revision lessons delivered by expert maths tutors. Find out more about our GCSE maths revision programme. We use essential and non-essential cookies to improve the experience on our website. Please read our Cookies Policy for information on how we use cookies and how to manage or change your cookie settings.AcceptPrivacy & Cookies Policy

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