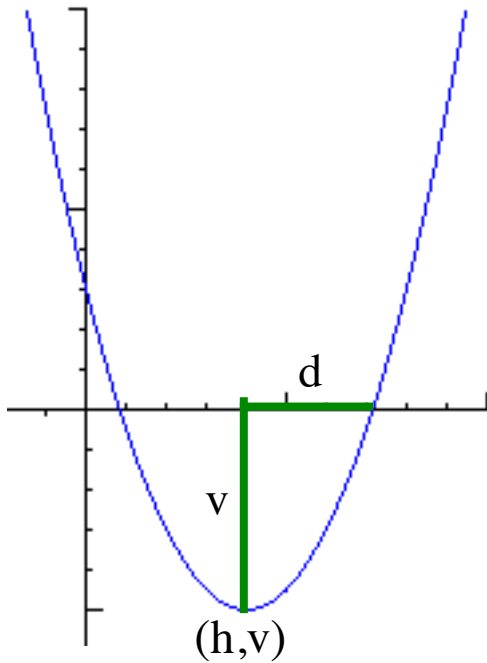


A Graphical Approach to the Quadratic Formula

This is an approach to the quadratic formula based on moving parabolas.

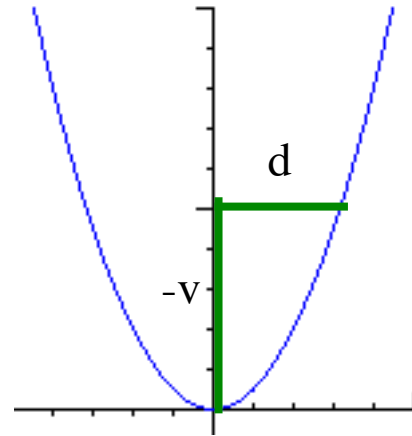
The solutions to $ax^2+bx+c=0$ are the x -intercepts of $y=ax^2+bx+c$. The x -intercepts are equidistant from the axis of symmetry, at a distance we'll call d . We'll say that the coordinates of the vertex are (h,v) . Thus, the intercepts are $h \pm d$.



1. **Review:** What is h in terms of a , b , and/or c ?
2. Use the answer to #1 to find v in terms of a , b , and/or c .
3. Discuss how the existence of the x -intercepts depends on the signs of v and a . (Four cases: both positive / $a>0, v<0$ / $a<0, v>0$ / both negative)
4. Use this to find one expression in terms of a , b , and c whose sign predicts the existence of the x -intercepts.

If we find the value of d in terms of a , b , and c , we have essentially found a formula for the solutions of $ax^2+bx+c=0$

Move the parabola so its vertex is at the origin:



5. What is the formula for this parabola?
6. Explain why the length that was labeled " v " before the move is now labeled " $-v$ ".
7. Label the point $P(d, -v)$ on the graph. Write a formula for its y -coordinate in terms of its x -coordinate.
8. Solve for d . In other words, write a formula for d in terms of v .
9. Use this to prove the quadratic formula.

Notes and Answers

Prerequisite: this is best done following the lessons **Factored Form of Quadratic Equations, From Factored to Standard Form**, and **Moving Parabolas Around**. It is intended as a lesson for teachers, though it may in the end be more accessible to students than the usual proof of the quadratic formula by completing the square.

1. $h = -b/2a$

2. This is a tricky calculation. Many students are likely to need help. The result: $v = \frac{-b^2 + 4ac}{4a}$.

3 and 4. This is a way to discover or re-discover the discriminant. Basically, a and v must have opposite signs if we want to have x -intercepts. If a is positive, the parabola is a smile, and v needs to be non-positive for there to be solutions. So $b^2 - 4ac$ needs to be positive or zero. If on the other hand a is negative, the parabola is a frown, and v needs to be non-negative for there to be solutions. Again, $b^2 - 4ac$ needs to be positive or zero for there to be solutions. In short, there are solutions if and only if $b^2 - 4ac$ is non-negative. (This argument is not likely to be discovered by students. Help them out.)

5. The formula is simply $y = ax^2$, since translating a parabola does not change a , and the vertex is at the origin.

7. Thus, $-v = ad^2$

8. $d = \frac{\sqrt{b^2 - 4ac}}{2a}$.

9. The intercepts are $h \pm d = \frac{-b}{2a} \pm \frac{\sqrt{b^2 - 4ac}}{2a} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$, the quadratic formula.