Complex number multiplication polar form

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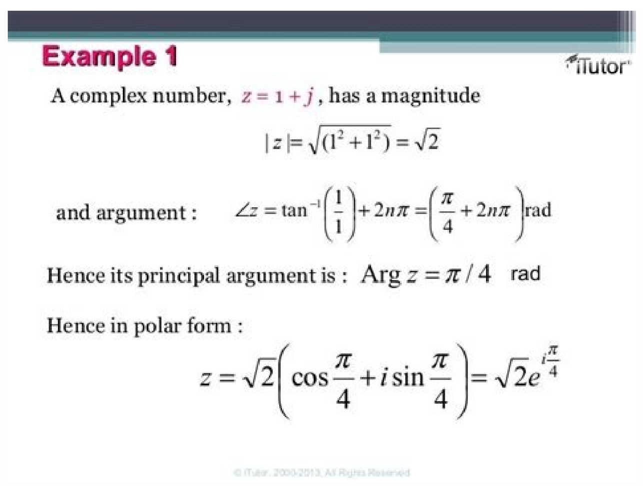

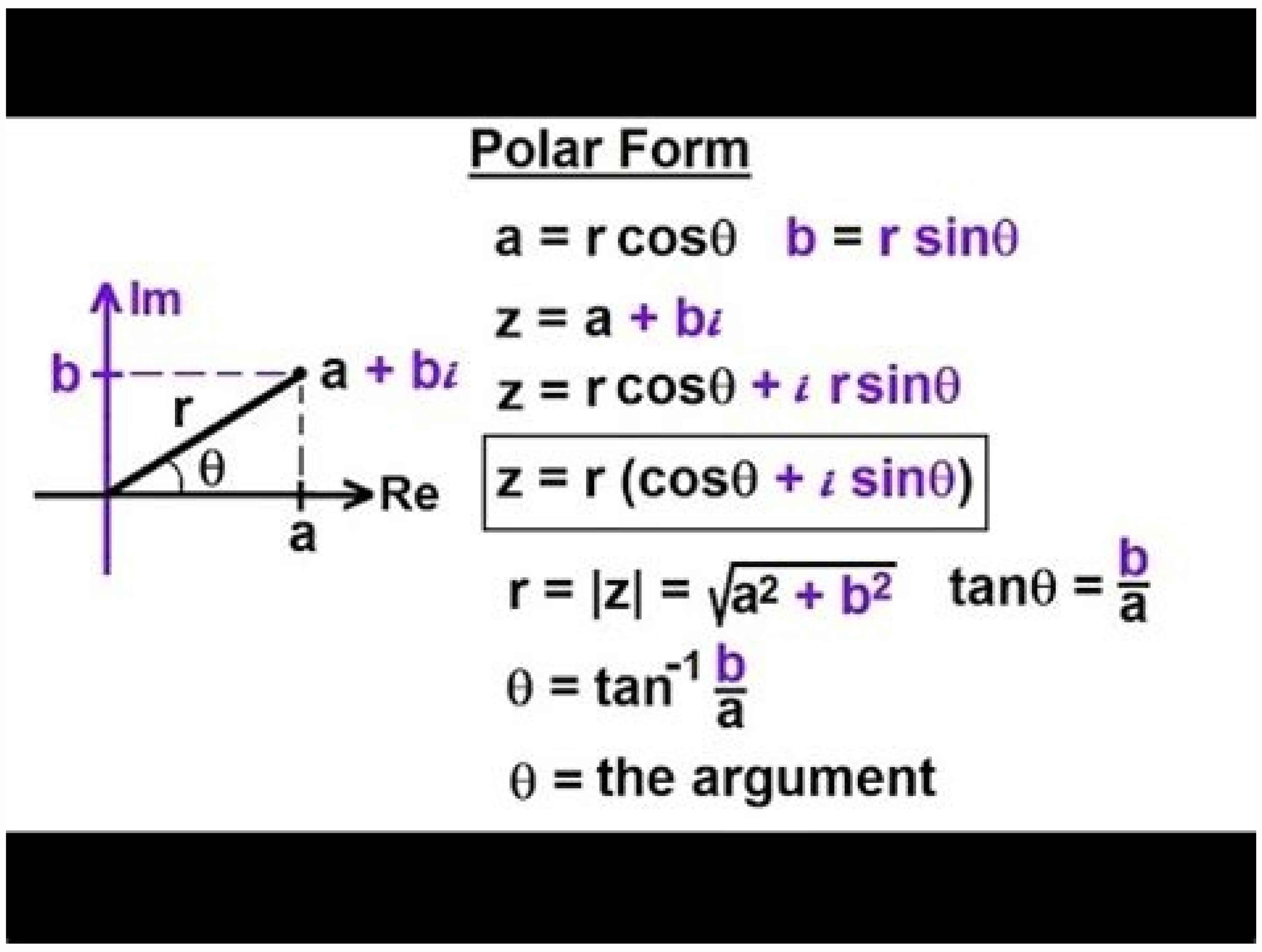

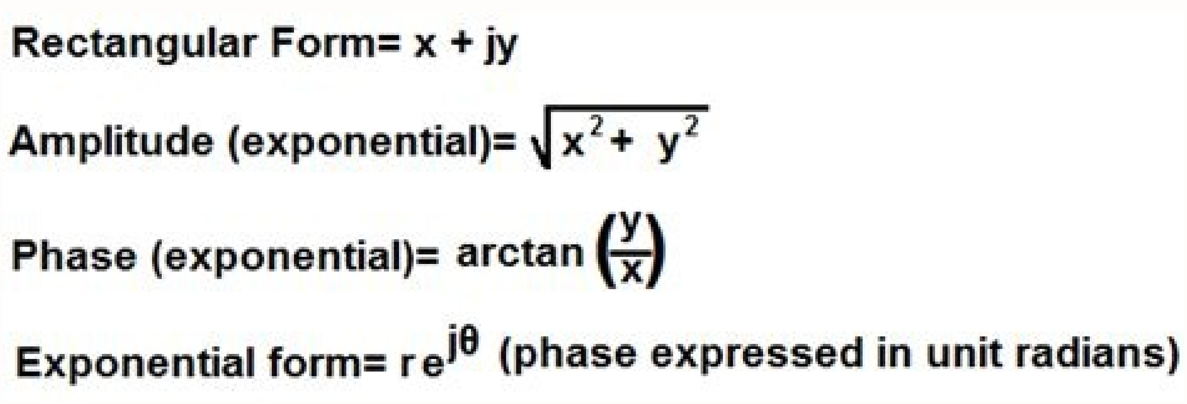

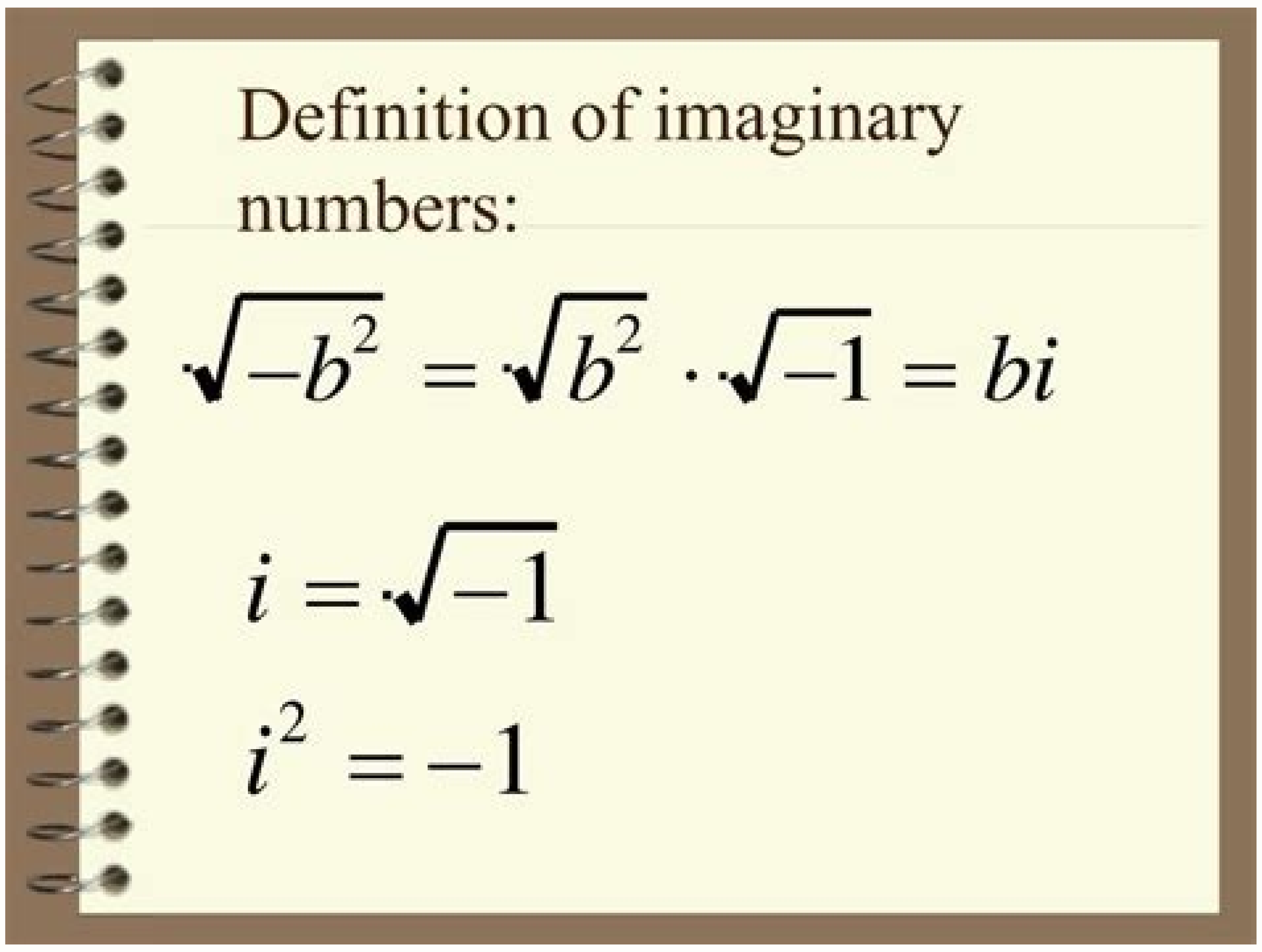

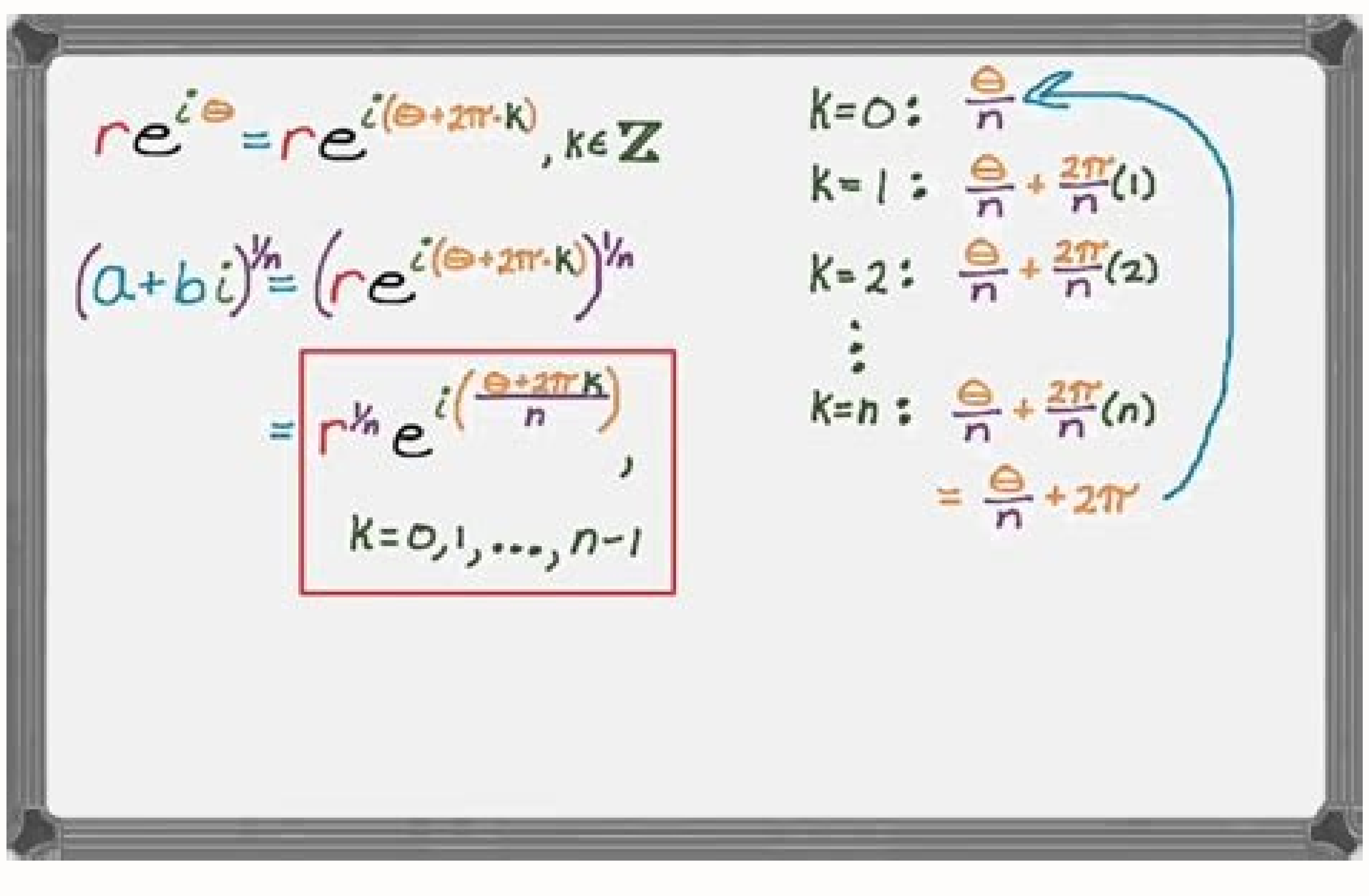

What is polar form complex numbers. Complex number polar form multiplication calculator. Can you add complex numbers in polar form. How to write a complex number in polar form.

Multiplying complex numbers is a fundamental operation on complex numbers where two or more complex numbers are multiplied. It is a complex operation as compared to the addition and subtraction of complex numbers. A complex number is of the form a + ib, where i is an imaginary number and a, b are real numbers. The working mechanism of the multiplication of complex numbers is similar to the multiplication of binomials using the distributive property. Let us understand the concept of multiplying complex numbers using the distributive property, its formula, multiplication of a real number, and purely imaginary number with complex numbers. We will also explore squaring complex numbers along with some solved examples for a better understanding. What is Multiplication Of Complex Numbers? Multiplication of complex numbers is a process of the multiplication of two or more complex numbers using the distributive property. Mathematically, if we have two complex numbers z = a + ib and w = c + id, then multiplication of complex numbers z and w is written as zw = (a + ib) (c + id). We use the distributive property of multiplication to find the product of complex numbers. Multiplication Of Complex Numbers Formula Multiplying complex numbers is similar to multiplying polynomials. We use the following polynomial identity to solve the multiplication of complex numbers: (a+b)(c+d) = ac + ad + bc + bd. The formula for multiplying complex numbers is given as: (a + ib) (c + id) = ac + iad + ibc + i2bd ⇒ (a + ib) (c + id) = (ac - bd) + i(ad + bc) [Because i2 = -1] Multiplication Of Complex Numbers in Polar Form A complex number in polar form is written as z = r (cos θ + i sin θ), where r is the modulus of the complex number and θ is its argument. Now, the formula for multiplying complex numbers z1 = r1 (cos θ1 + i sin θ1) and z2 = r2 (cos θ2 + i sin θ2) in polar form is given as: z1z2 = [r1 (cos θ1 + i sin θ1)] [r2 (cos θ2 + i sin θ2)] = r1 r2 (cos θ1 cos θ2 + i cos θ1 sin θ2 + i sin θ1 cos θ2 + i2 sin θ1 sin θ2) = r1 r2 (cos θ1 cos θ2 + i cos θ1 sin θ2 + i sin θ1 cos θ2 - sin θ1 sin θ2) {Because i2 = -1} = r1 r2 [cos θ1 cos θ2 - sin θ1 sin θ2 + i (cos θ1 sin θ2 + sin θ1 cos θ2)] = r1 r2 [cos (θ1 + θ2) + i sin (θ1 + θ2)] {Because cos a cos b - sin a sin b = cos (a + b) and sin a cos b + sin b cos a = sin (a + b)} Hence the formula for multiplying complex numbers in polar form is [r1 (cos θ1 + i sin θ1)] [r2 (cos θ2 + i sin θ2)] = r1 r2 [cos (θ1 + θ2) + i sin (θ1 + θ2)] Multiplication Of Complex Numbers with Purely Real and Imaginary Numbers We know that the formula for multiplying complex numbers is (a + ib) (c + id) = (ac - bd) + i(ad + bc). If we have b = 0, then the two complex numbers are 'a' and 'c + id'. The formula to multiply a complex number with a real number becomes a (c + id) = ac + iad. For example, we multiply 2 with 1 + 3i as: 2 × (1 + 3i) = 2 + 6i Now, if we multiply a purely imaginary number of the form bi with a complex number, then the formula becomes (bi) (c + id) = ibc - bd. For example, if we multiply a complex number 2 + 3i with -5i, we have: (-5i) (2 + 3i) = -10i -15i2 = -10i + 15 Squaring Complex Numbers As we know that the formula for the multiplication of complex numbers is (a + ib) (c + id) = (ac - bd) + i(ad + bc). If we have a + ib = c + id, then we have a = c and b = d, i.e., we multiply the same complex number with itself. So, the formula for multiplying a complex number with itself becomes: (a + ib) (a + ib) = (a.a - b.b) + i(ab + ba) = (a2 - b2) + i 2ab For example, square the complex number 3 - 7i. We have (3 - 7i)2 = (32 - (-7)2) + i 2 × 3 × (-7) = (9 - 49) - 42i = -40 - 42i Multiplicative Inverse Of Complex Numbers The multiplicative inverse of a complex number on multiplying with the given complex number results in the multiplicative identity of 1. The multiplicative inverse of the complex number z = a + ib is z-1 = \(\dfrac{\bar z}{|z|^2}\). Here \(\bar z \) = a - ib , and |z| = \(\sqrt {a^2 + b^2}\). z.z-1 = 1 z-1 = |z| = \(\dfrac{\bar z}{|z|^2}\) For finding the multiplicative inverse of a complex number we need the conjugate of the complex number and the modulus of the complex number. The conjugate of the complex number is \(\bar z\) = a - ib, and the modulus of the complex number is |z| = \(\sqrt {a^2 + b^2}\). Let us take a simple example of finding the multiplicative inverse of a complex number z = 3 + 4i. For this complex number the conjugate complex number is \(\bar z \) = 3 - 4i, and the modulus of the complex number is |z| = \(\sqrt {3^2 + 4^2}\) = 5. And the multiplicative inverse is z-1 = \(\dfrac{3 - 4i}{5}\) = 3/5 - 4i/5. Important Notes on Multiplying Complex Numbers Multiplication of complex numbers in cartesian form: (a + ib) (c + id) = (ac - bd) + i(ad + bc) Multiplication of complex numbers in polar form: [r1 (cos θ1 + i sin θ1)] [r2 (cos θ2 + i sin θ2)] = r1 r2 [cos (θ1 + θ2) + i sin (θ1 + θ2)] Squaring Complex Number: (a + ib)2 = (a2 - b2) + i 2ab Topics Related to Multiplication of Complex Numbers Example 1: Multiply complex numbers z = 3 − 2i and w = − 4 + 3i. Solution: For multiplying complex numbers z and w, we will use the formula (a + ib) (c + id) = (ac - bd) + i(ad + bc). Here a = 3, b = -2, c = -4, d = 3 (3 − 2i) (− 4 + 3i) = [3 × (-4) - (-2) × 3) + i(3 × 3 + (-2) × (-4)) = (-12 + 6) + i (9 + 8) = -6 + 17i Answer: (3 − 2i) (− 4 + 3i) = -6 + 17i Example 2: Find the square of the complex number (-4 + 6i). Solution: To find the square of a complex number, we will use the formula (a + ib)2 = (a2 - b2) + i 2ab. Here, a = -4 and b = 6 (-4 + 6i)2 = ((-4)2 - 62) + i 2 × (-4) × 6 = (16 - 36) - 48i = -20 - 48i Answer: (-4 + 6i)2 = -20 - 48i Example 3: Multiply complex numbers z = 2 (cos 15° + i sin 15°) and w = 5 (cos 15° + i sin 15°). Solution: For multiplying complex numbers in polar form, we will use the formula [r1 (cos θ1 + i sin θ1)] [r2 (cos θ2 + i sin θ2)] = r1 r2 [cos (θ1 + θ2) + i sin (θ1 + θ2)]. Here, r1 = 2 and r2 = 5, θ1 = 15°, θ2 = 15° zw = [2 (cos 15° + i sin 15°)] × [5 (cos 15° + i sin 15°)] = 10 [cos (15° + 15°) + i sin (15° + 15°)] = 10 (cos 30° + i sin 30°) = 10 (√3/2 + i (1/2)) = (10/2) (√3 + i) = 5√3 + 5i Answer: [2 (cos 15° + i sin 15°)] × [5 (cos 15° + i sin 15°)] = 5√3 + 5i View Answer > go to slidego to slidego to slide Great learning in high school using simple cues Indulging in rote learning, you are likely to forget concepts. With Cuemath, you will learn visually and be surprised by the outcomes. Book a Free Trial Class FAQs on Multiplying Complex Numbers Multiplication of complex numbers is a process of the multiplication of two or more complex numbers using the distributive property. Mathematically, if we have two complex numbers z = a + ib and w = c + id, then multiplication of complex numbers z and w is written as zw = (a + ib) (c + id). What is Multiplication Of Complex Numbers Formula? The formula for multiplying complex numbers is: (a + ib) (c + id) = (ac - bd) + i(ad + bc). What are the Steps for Multiplication Of Complex Numbers? The steps for multiplying complex numbers are: Step 1: Apply the distributive property and multiply each term of the first complex number with each term of the second complex number. Step 2: Simplify i2 = -1 Step 3: Combine real parts and imaginary parts and simplify them to get the product. How Do You Multiplication Of Complex Numbers in Polar Form? The formula for multiplying complex numbers in polar form is z1 = r1 (cos θ1 + i sin θ1) and z2 = r2 (cos θ2 + i sin θ2) in polar form is given as [r1 (cos θ1 + i sin θ1)] [r2 (cos θ2 + i sin θ2)] = r1 r2 [cos (θ1 + θ2) + i sin (θ1 + θ2)]. What Happens When You Multiply Two Imaginary Numbers? When two purely imaginary numbers are multiplied, then the product is a real number. If we have two purely imaginary complex numbers ai and bi, then their product is (ai) (bi) = i2 ab = -ab. What Is The Multiplicative Inverse Of Complex Number? The multiplicative inverse of a complex number z = a + ib is z-1 = \(\dfrac{\bar z}{|z|^2}\). Here the complex conjugate \(\bar z \) = a - ib, and is the conjugate of the given complex number , and |z| = \(\sqrt {a^2 + b^2}\) is the conjugate of the complex number. How Do You Do Multiplication Of Complex Numbers? Two complex numbers are multiplied in following manner: (a + ib) (c + id) = ac + iad + ibc + i2bd ⇒ (a + ib) (c + id) = (ac - bd) + i(ad + bc) [Because i2 = -1] Now, we just substitute the values of a, b, c, d in the above formula. How Is Multiplication Of Complex Numbers Related to Multiplying Two Binomials? The working mechanism of the multiplication of complex numbers is similar to the multiplication of binomialshe distributive property. Just like we multiply two binomials (a + bx) (c + dx) = ac + (ad + bc) x + bd x2. In case of complex numbers, x takes the value of i. What is the Multiplication of Complex Numbers with a Real Number? Multiplying complex numbers with real numbers is evaluated as a(c + id) = ac + i ad which is a complex number. It turns out to be super easy to multiply complex numbers in polar form. Just multiply the magnitudes r, and add the angles, using the fact that (cos(x) + i sin(x)) (cos(y) + i sin(y)) = cos(x+y) + i sin(x+y). BTW, this is a great way to remember the angle addition identities. If you're seeing this message, it means we're having trouble loading external resources on our website. If you're behind a web filter, please make sure that the domains *.kastatic.org and *.kasandbox.org are unblocked. In order to continue enjoying our site, we ask that you confirm your identity as a human. Thank you very much for your cooperation. A Complex Number is a combination of a Real Number and an Imaginary Number: A Real Number is the type of number we use every day. Examples: 12.38, ½, 0, −2000 An Imaginary Number, when squared gives a negative result: The "unit" imaginary number when squared equals −1 i2 = −1 Examples: 5i, −3.6i, i/2, 500i 3.6 + 4i (real part is 3.6, imaginary part is 4i) −0.02 + 1.2i (real part is −0.02, imaginary part is 1.2i) 25 − 0.3i (real part is 25, imaginary part is −0.3i) Either part can be zero: 0 + 2i (no real part, imaginary part is 2i) same as 2i 4 + 0i (real part is 4, no imaginary part) same as 4 Multiplying To multiply complex numbers: Each part of the first complex number gets multiplied by each part of the second complex number Just use "FOIL", which stands for "Firsts, Outers, Inners, Lasts" (see Binomial Multiplication for more details): Firsts: a × c Outers: a × di Inners: bi × c Lasts: bi × di (a+bi)(c+di) = ac + adi + bci + bdi2 Like this: (3 + 2i)(1 + 7i) = 3×1 + 3×7i + 2i×1+ 2i×7i = 3 + 21i + 2i + 14i2 = 3 + 21i + 2i − 14 (because i2 = −1) = −11 + 23i Here is another example: (1 + i)2= (1 + i)(1 + i) = 1×1 + 1×i + 1×i + i2 = 1 + 2i − 1 (because i2 = −1) = 0 + 2i But There is a Quicker Way! Use this rule: (a+bi)(c+di) = (ac−bd) + (ad+bc)i (3 + 2i)(1 + 7i) = (3×1 − 2×7) + (3×7 + 2×1)i = −11 + 23i Why Does That Rule Work? It is just the "FOIL" method after a little work: (a+bi)(c+di) = ac + adi + bci + bdi2 FOIL method = ac + adi + bci − bd (because i2=−1) = (ac − bd) + (ad + bc)i (gathering like terms) And there you have the (ac − bd) + (ad + bc)i pattern. This rule is certainly faster, but if you forget it, just remember the FOIL method. Now let's see what multiplication looks like on the Complex Plane. The Complex Plane This is the complex plane: It is a plane for complex numbers! We can plot a complex number like 3 + 4i : It is placed 3 units along (the real axis), and 4 units up (the imaginary axis). Multiplying By i Let's multiply it by i: (3 + 4i) x i = 3i + 4i2 Which simplifies to (because i2 = −1): −4 + 3i And here is the cool thing ... it's the same as rotating by a right angle (90° or π/2) Was that just a weird coincidence? Let's try multiplying by i again: (−4 + 3i) x i = −4i + 3i2 = −3 − 4i and again: (−3 − 4i) x i = −3i − 4i2 = 4 − 3i and again: (4 − 3i) x i = 4i − 3i2 = 3 + 4i Well, isn't that stunning? Each time it rotates by a right angle, until it ends up where it started. Let's try it on the number 1: 1 × i = i i × i = −1 −1 × i = −i −i × i = 1 Back to 1 again! Each time a right angle rotation. Choose your own complex number and try that for yourself, it is good practice. Let's look more closely at angles now. Polar Form Our friendly complex number 3 + 4i : Here it is again, but in polar form: (distance and angle) So the complex number 3 + 4i can also be shown as distance (5) and angle (0.927 radians). How do we do the conversions? We can do a Cartesian to Polar conversion: r = √(x2 + y2) = √(32 + 42) = √25 = 5 θ = tan-1 (y/x) = tan-1 (4/3) = 0.927 (to 3 decimals) We can also take Polar coordinates and convert them to Cartesian coordinates: x = r × cos(θ) = 5 × cos(0.927) = 5 × 0.6002... = 3 (close enough) y = r × sin(θ) = 5 × sin(0.927) = 5 × 0.7998... = 4 (close enough) In fact, a common way to write a complex number in Polar form is x + iy = r cos θ + i r sin θ = r(cos θ + i sin θ) And "cos θ + i sin θ" is often shortened to "cis θ", so: x + iy = r cis θ cis is just shorthand for cos θ + i sin θ So we can write: 3 + 4i = 5 cis 0.927 In some subjects, like electronics, "cis" is used a lot! Now For Some More Multiplication Let's try another multiplication: (1+i) (3+i) =1(3+i) + i(3+i) =3 + i + 3i + i2 =3 + 4i − 1 =2 + 4i And here is the result on the Complex Plane: But it is more interesting to see those numbers in Polar Form: Convert 1+i to Polar: r = √(12 + 12) = √2 θ = tan-1 (1/1) = 0.785 (to 3 decimals) Convert 3+i to Polar: r = √(32 + 12) = √10 θ = tan-1 (1/3) = 0.322 (to 3 decimals) Convert 2+4i to Polar: r = √(22 + 42) = √20 θ = tan-1 (4/2) = 1.107 (to 3 decimals) Have a look at the r values for a minute. Are they related somehow? And what about the θ values? Here is that multiplication in one line (using "cis"): (√2 cis 0.785) × (√10 cis 0.322) = √20 cis 1.107 This is the interesting thing: √2 x √10 = √20 0.785 + 0.322 = 1.107 So: The magnitudes get multiplied. And the angles get added. When multiplying in Polar Form: multiply the magnitudes, add the angles. And that is why multiplying by i rotates by a right angle: i has a magnitude of 1 and forms a right angle on the complex plane Squaring To square a complex number, multiply it by itself: multiply the magnitudes: magnitude × magnitude = magnitude2 add the angles: angle + angle = 2 , so we double them. Result: square the magnitudes, double the angle. Example: Let us square 1 + 2i: (1 + 2i)(1 + 2i) = 1 + 4i + 4i2 = −3 + 4i On the diagram the angle looks to be (and is!) doubled. Also: The magnitude of (1+2i) = √(12 + 22) = √5 The magnitude of (−3+4i) = √(32 + 42) = √25 = 5 So the magnitude got squared, too. In general, a complex number like: r(cos θ + i sin θ) When squared becomes: r2(cos 2θ + i sin 2θ) (the magnitude r gets squared and the angle θ gets doubled.) Or in the shorter "cis" notation: (r cis θ)2 = r2 cis 2θ De Moivre's Formula And the mathematician Abraham de Moivre found it works for any integer exponent n: [r(cos θ + i sin θ)]n = rn(cos nθ + i sin nθ) (the magnitude becomes rn the angle becomes nθ.) Or in the shorter "cis" notation: (r cis θ)n = rn cis nθ Example: What is (1+i)6 Convert 1+i to Polar: r = √(12 + 12) = √2 θ = tan-1 (1/1) = π/4 In "cis" notation: 1+i = √2 cis π/4 Now, with an exponent of 6, r becomes r6, θ becomes 6θ: (√2 cis π/4)6 = (√2)6 cis 6π/4 = 8 cis 3π/2 The magnitude is now 8, and the angle is 3π/2 (=270°) Which is also 0−8i (see diagram) Summary Use "FOIL" to multiply complex numbers, Or use the formula: (a+bi)(c+di) = (ac−bd) + (ad+bc)i Or use polar form and then multiply the magnitudes and add the angles. De Moivre's Formula can be used for integer exponents: [r(cos θ + i sin θ)]n = rn(cos nθ + i sin nθ) Polar form r cos θ + i r sin θ is often shortened to r cis θ Copyright © 2020 MathsIsFun.com

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