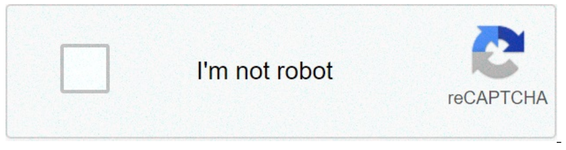

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Minute of angle calculator metric

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I would prefer to use MOA/MOA, but there aren't enough of those around. 1 "click" with a 1/4 MOA scope (1/4 MOA true) = .26175inch (4 "clicks = 1.047 inch at 100 yards). 1"click" with a .1mil scope = 0.36 inch (3 "clicks" = 1.08 inch" at 100 yards) If your scope is truly .25in/click at 100 yards, it is .12 inches in error/click... 10 clicks is 1.2 inches in error. Just things to consider… How accurate is your ability to judge distance? If it is only off by +/- a yard, how much does an inch or so here or there matter?Finding MOA calibrated reticles has only recently been in "vogue"... Most American shooters are grounded in the older imperial units of the inch, foot and yard. The metric system was presented as an aside, not really emphasized and little used. But engineers and scientific types are wed to the metric system. Nowadays speedometer dials are in miles per hour and kilometers per hour while our food container labels are in ounces and liters or ounces and gram for weight. Eventually the metric system will be fully incorporated in the American way of life. Metallic Silhouette Shooting Until that happens most shooting sports use feet per second for velocity, distance in yards and bullet weight in grains with 7000 grains to the pound. One area where metrics are used are in metallic silhouette shooting, it being an import from Mexico and all. Except for a few caliber designations we are free from metrics. Minute of Angle (MOA) Calculator Mils and MOA are systems used by shooters and the military to measure angles, and the MOA is a measurement of inherent accuracy. MOA is minute of angle. An angle, like the hour is divided into minutes and seconds. One MOA is angle width at one hundred yards of about one inch (1.047 inches). So, at 200 yards the width is 2 inches and 300 yards at 3 inches and so one, 1 inch per every one hundred yards. At a thousand yards a 1 MOA group would measure about 10 inches in diameter. MOA is a measure of accuracy and precision. Incidentally good target rifles can shoot to sub MOA groups and even sub half MOA or 30 second groups. Milliradian Explained The US military and NATO use 6400 mils to a full 360-degree circle. But the term mil, is short for a milliradian. A radian is the angle subtended that is equal to the radius. This is the calculus unit used to calculate angles. It is equal to 180/π or rounds off to about 5.30 degrees. There are 2π radian in a circle or 6.28 radian to 360 degrees. A milliradian is 1/1000 of a radian leaving us with 6283.18 milliradians in a circle. An inconvenient number to do math with. So, by agreement 6400 radian was used, about a 2%, actually it is only 1.82%, acceptable for most practicable purposes. Milliradian Distance Calculator The mil is used to sight artillery and for navigation. Most military compasses have an inner ring below the degree ring marked in mils. But mils are handy, they can be used to determine range by a shooter and are used by snipers. Mils have a unique property, on mile equals 1 unit at a 1000 unit. One-foot arc at 1000 feet, 1-yard arc at 1000 yards, etcetera. Many a precision rifle scope are marked in miles and are accurate at one magnification. Take a human in summer clothing he is about 22 inches wide on average. The scope is marked in 1 mil dots. If a man is about between two dots wide how far is he? Range = 1000 x target width/mils Range = 1000 x 22 = 22,000 (inches)/2 = 11,000 inches or 11,000 / 36 = 305.6 yards. A mule deer averages between 31 – 42 inches at the shoulders, nose-to-tail length of 3.9 to 6.9 feet. A fully mature mule deer buck will have eight points including the brow tines. Let's say it looks like a mature eight point buck, and we will use an average height of 36 inches at the shoulder. Range = 1000 x 1/3.5 mils, the converted the inches to yards so our answer will be in yards. Range = 1000/3.5 = 285.7 yards. Mils and MOA's are handy. There is about 3.6 inches to a mile at 100 yards. Some principles to think about. Author: Calculator Academy Team Last Updated: August 4, 2021 Enter the total angle into the calculator to determine the MOA as well as the total spread. MOA Formula The following formulas are used to calculate the MOA and spread respectively. MOA = A / 60 S = MOA * D / 100 Where MOA is the minute of angleS is the total spread (inches) D is the total horizontal distance (yards) MOA Definition MOA is short for minute of angle and is used to describe 1/60th of a degree. MOA Example How to calculate MOA? First, determine the absolute angle. Measure the total angle in degrees. Next, calculate the MOA. Calculate the minute of angle using the formula above. FAQ What is a MOA? A minute of angle is described as 1/60th of a degree. This term is often used in fields such as shooting and archery. What is spread? Spread is the amount of vertical distance an angle causes at a certain horizontal distance. For example, 1 MOA at 100 yards is approximately 1″ of vertical spread, while at 200 yards it's close to 2″ of vertical spread. A minute of arc (MOA)1, arcminute, or minute arc, is a unit of angular measurement equal to 1/60 of one degree. MOA – Minute of Angle In shooting circles, Minute of Angle, or MOA represents approximately one inch at 100 yards.2 Many modern rifle scopes are set up to adjust in half or quarter MOA increments, also know as 'clicks'. Therefore, if you know the distance of the target (100 yards) and your point of impact is 3″ high and 1.5″ of where you intended the shot to go, then you need to adjust your scope 3 MOA down, and 1.5 MOA right. This makes adjustments on the scope easy, enabling you to dial quickly in the scope to your intended point of impact. It is worth noting; that scopes can be calibrated in true MOA, or in Shooters MOA (SMOA) – which is a true 1 inch at 100 yards. While this may not make a whole lot of difference at shorter ranges – at longer ranges the difference compounds – if adjusting over 20 MOA, this could add up to over an inch difference. Significant if you are looking for a first shot hit. Firearm accuracy Manufacturers will often express the accuracy of their firearm in MOA. For example, a 1 MOA rifle should be capable, under ideal conditions, of shooting on average, 1-inch groups at 100 yards. This discounts shooter error – and often also defines a particular ammunition that needs to be used. It also often only refers to a group of 3 to 5 shots. It is often suggested that larger groups should be utilised to measure this. Many modern rifles are capable of 'sub-moa grouping' – it has become the defacto standard for marketing a precision rifle. But we live in a metric world True. Though many people have adapted to the MOA standard, another system, the MilRad lives in the metric world. A MilRad is equal to one 1000th of the target range. This is laid out in a circle around the shooters position, with the target range as the radius. Which means, 2 x π x 1000. Therefore 1 MOA = 0.2908 MilRad. Adjusting one Milrad up at 100 metres will result in an offset of 100 mm. The markings on a reticle that mark MilRads are called MilDots. Such a reticle is called a MilDot Reticle. Mixed systems What is most important is that no matter what system you decide to use is ensuring that the reticle measurements (if it has them) and your turret adjustments are the same. For example, if your reticle gives measurements in MOA, don't get turrets with MilRad adjustments. You are just asking for confusion. If you are mathematically inclined, go for it – but converting from imperial to metric while estimating wind and range and hoping the animal doesn't wander off could be a bit much. Why a manufacturer even allows you to purchase them this way I am not sure. But it is possible, so pay attention when buying. What system should I use? Depends. While MOA inherently has finer adjustments what MilRAD it makes sense to stick with what system you are already familiar with. I.e. if you were to estimate a distance to an object, would it be in metres or feet? What do your shooting buddies already shoot? It might make sense to keep it the same so you can easily communicate back and forth. Already own a rangefinder? What is it set up to return information in? By keeping the system the same you reduce the amount of conversion you have to do. Buckle in, because I'm about to talk nerdy to you. This post is all about the two most common marksmanship measurement systems, how to use them, and which one you should use.Be warned, I will be dropping some math on you. I'll be gentle, though.Angular MeasurementThe first thing you need to let go of is thinking in terms of linear measurement. Both of these systems are methods of measuring angles. More specifically, we are measuring the angles from the sighting device to a target. We then use these angles to estimate linear measurement.U.S. Marine Corps Photo by Cpl. Matthew CallahanWhat kind of things do we use these angles for?Measuring the distance to targetDetermining the size of a targetDialing the amount of drop for a bullet at a distanceAdjusting the impact of a bullet due to windThose last two points aren't actually measuring anything. Sure, you could turn those angular adjustments into a linear value, like saying the bullet will drop 14 inches at 400 yards, but it's ultimately not all that useful for you in actual marksmanship.But let's step back. What do I mean when I say we are thinking in terms of angles?It All Comes Back to the CircleThe easiest way to imagine this is with a compass. If you remember geometry from back in the day, you recall that there are 360 degrees in a circle. Our compass also has 360 degrees, represented as tic marks.You probably remember using protractors in school. These devices helped you measure the angles of two joining lines in degrees. Using a protractor to measure an angle. Courtesy of Lfahlberg via Creative Commons LicenseIf you look at this animation, the angle is 115 degrees. We can do all sorts of geometry to figure out the distance between the ends of each green line. But the real trick is being able to change the length of those lines and quickly recalculate the third leg of the triangle.Here is a visual version of what I'm talking about.The red line in this diagram is the important part. The distance represented by the red line is an example of measuring the size of a target, drop due to gravity, or the push of wind. We can calculate that regardless of how long the green legs are, or how far the red line is from the center of the circle.Everything relies on the geometry of arcs, which is a key element of shooting.Minutes of AngleHere's where things get more complicated.The distance between two adjacent degree markers is very small. If you drew lines one degree apart, things diverge pretty slowly. Using the circle diagram above, imagine a dotted line from the center of the circle to the center of the red line, that would be 10 feet.At that distance, the red line would only be two inches long.If we extend the dotted line all the way out to 100 yards, the red line grows to about five feet long. It's over 50 feet long at 1000 yards.Well, now you see the conundrum. For marksmanship, a full degree of divergence is simply too large to be useful. We need to further divide that degree. Like a clock, we divide that degree into 60 evenly distributed minutes of angle. Doing the MathLet's assume our target is 100 yards away. I'm setting my scientific calculator to degree mode. I'll press "tangent," then input 1/60 and multiply it by 100. Multiply that result by 36 to convert from yards to inches.Tangent(1/60) * 100 * 36 = 1.047″1 MOA = 1.047″ at 100 yards, or 10.47″ at 1000 yards.This is a much more useful accuracy measurement and is easy to convert in your head. A lot of shooters just round it off to 1 inch. In the past, you might have seen optics marked with IPHY, which means "Inches Per Hundred Yards." This is a bit more old-school but represented a rounding of 1.047″ to just 1″ in the optic. I don't see optics that still use IPHY, but we often still talk like it. The Army even still teaches it.Depiction of a minute of angle found in Army TC 3-22.9Using MOA with RiflesHistorically, rifle sights that adjusted in 1 MOA increments were very common. Both the M1 Garand and the M14 had irons that adjusted for both elevation and windage in 1 MOA increments. The M16A2 rear sight was the same, at least for elevation.To get even more accurate, we can further subdivide those minutes of angle into 60 seconds of angle. Whereas a minute of angle is 1/60th of a degree, a second of angle is a mere 1/3600th of a degree.A single second of a degree is a bit too fine for practical use, so we machine our optics and sights to jump several seconds at a time. The most common are 30 seconds and 15 seconds per click, otherwise known as 1/2 MOA and 1/4 MOA.MilliradiansSo far, I've talked only about taking the 360 degrees of a circle and dividing it into smaller segments. But there is another way to measure circles beside degrees.A radian is a way to measure the arc of a circle. Specifically, a single radian (shown as rad) is a segment of the circumference of a circle equivalent to the radius (shown as r) of the circle. Half of the circle is π*r, and the whole circle is 2π*r.This graphic shows it better than I explain it:This animation, courtesy of Lucas V. Barbosa, demonstrates radiansWhen we talk about milliradians, we are taking 1/1000th of a single radian. We often abbreviate milliradian as MRAD or mil. Riflescopes that used this measurement system often had dots spaced at MRAD intervals, we call these mil-dots.Doing the MathLet's do some back-of-the-napkin math to figure out some distance equivalents.Once again, let's assume our target is 100 yards away.I'm going to set my scientific calculator to radian mode and press "tangent." Then I'll multiply .001, for 1/1000th, by 100, the distance to the target.Next, multiply that result by 36, which converts my result from yards to inches.Tangent(.001)*100*36 = 3.6000012″That's the dirty way of saying that one MRAD is about 3.6 inches at 100 yards. It's not exact, just like one minute of angle isn't a perfect 1″, but it's close enough to work with.The convenient part about this is that if you multiply that by 10, it's 36 inches at 1000 yards. One milliradian equals one yard at 1000 yards. A six-foot object at 1000 yards measures two mils tall.Here's the neat thing about mils, though: the system doesn't care what linear measurement you use. Angle math is funny like that. Let's use 100 meters instead, and multiply by 10 to get centimeters.Tangent(.001)*100*10 = 10.00335 cmWith this, you see that one mil equals about 10 centimeters at 100 meters away. Or, alternatively, 1 meter at a distance of 1000 meters.Tangent(.001)*1000 = 1 mArmy TC 3-22.9 depiction of a single MRAD diverging over distance. Note that the inch equivalents are rounding up by quite a bit.All this is well and good, but let's look back at that 3.6″ at 100 yards number. That's too coarse for good accuracy out of a rifle. But, like with MOA, we subdivide MRAD. Most commonly, we make adjustments in 1/10th of an MRAD per click, or .36″ per click at 100 yards.Milliradians vs Minutes of Angle for MarksmanshipArmy TC 3-22.9 comparison of mils and degrees. Of note here is that the Army says there are 6400 mils in a circle. That is actually wrong, as there are actually 6283 mils in a circle. The Army rounds up to make artillery math simpler. You'll find that a lot of the numbers in this discussion aren't exact, but close enough for illustration.There's a common misconception among American shooters that MRAD is a metric-based system and MOA is imperial-based. I understand where that comes from since meters and centimeters work so cleanly with the MRAD system. In reality, that's a happy coincidence of using a system based on multiplying or dividing by 10.The same math worked to show that one mil equals one yard at 1000 yards. The complicating factor is that one yard contains 36 inches, which isn't easily divisible.Another way to look at this is ratios. A milliradian work on a 1:1000 ratio. If something is 1 inch tall and measures 1 mil in your optic, then it's 1000 inches away. If it's 1 yard tall, it's 1000 yards away.1 angstrom measures 1 mil tall in the scope, then it's 1000 angstroms away. Mils are 1:1000, always.MOA works on a ratio of 1:3438So which is better? Well, that depends on your point of view.Adjustment IncrementsThe most common adjustment interval for an MRAD-based sighting system is 1/10th of a mil per click. At 100 yards, that's .36″ or just under 1 centimeter.The most common adjustment for MOA-based sighting systems is 1/4 MOA per click. At 100 yards, that's .25″ per click of adjustment. I've seen some optics that go even finer than that, offering 1/8 MOA per click.If you're looking purely from a precision perspective, then Minutes of angle win here because they are a finer adjustment method. But that doesn't tell the whole story, there's more to this math than adjusting your scope.Mils vs MOA for RangingOne of the classic "killer features" for both milliradians and minutes of angle is the ability to use them for determining range and holdover. Now, using your reticle to determine range is a bit of an old-school skill, especially in an era of affordable laser rangefinders. But I find the math interesting, so let's go there.By reversing the tangent formulas I presented earlier, you can use the known size of a target and what it measures within your scope to find the range to the target.MOA FormulasThese formulas are used for determining the range to the target using MOA reticles. You can shift the numbers around using algebra to determine other points, though.Something important to note for each of these. The multiplier number is often rounded. The first one, for finding yards given inches, says to multiply by 100. A lot of people use 95.5 as the multiplier number instead, which is closer to the actual value of 95.28. Here's the thing, though: yes, precision in the math is important. Rounding errors are still errors that compound over distance. These deviations become very significant at very long range. But at practical distances most people tend to shoot, it's within the natural deviation of the rifle and ammunition accuracy anyway.You'll notice the 3438 and 34.38 on these last two. Recall that that's the ratio I mentioned earlier with minutes of angle 1:3438. You're seeing it come up because those last two use the metric system and it's nice round 10-based numbers.The random 87.3 you see on the second formula comes from converting inches to meters. It's the result of dividing 3438 by 39.37, the number of inches in a meter.Milliradian FormulasThese formulas do the same thing but utilize a mil-based reticle for the measurement. Again, a lot of these multiplier numbers are rounded and you see some oddball numbers coming from the imperial system. The 27.8 comes from dividing 1000 by 36, for 36 inches per yard. The 25.4 comes from dividing 1000 by 39.37, the number of inches per meter.TakeawaysOk, I'm done with the math for now. The takeaway here is that mils are significantly easier to do the math with, especially if you're combining it with the metric system that works in powers of 10. That said, I highly doubt any serious shooter would ever be whipping out a calculator in the field to run these formulas. If they didn't have a laser rangefinder, then a tool like the Mildot Master makes short work of it.The ability to correctly range a target is vital to actually hitting the target. The Precision Rifle Blog did a study where they gauged the importance of correct ranging on distant targets and the results are clear. Even a little ranging error will cause a miss, and using your reticle to range a target introduces far more margin of error.Mils vs MOA for CommunicationThis is where the distinction between linear measurement and angular measurement gets important. Let's say you take three shots at a target placed 650 yards away. You hit the paper, but miss the x ring a little high and right. Your shooting buddy is looking through a spotting scope to give you a correction. There are three ways to communicate this:"You need to come down a little lower and to the left.""I think you should come down twelve inches and adjust ten inches to the left .""Adjust down .5 mil and left .4 mil"When it comes to precision shooting, the first method is almost useless. So let's ignore that one.The second method at least has numbers in it. How the spotter would actually know to come down twelve inches a to the left ten inches is another story. But assuming he's right, we could figure it out in our head using some rounding. At 650 yards, 1 MOA is roughly 6 inches. So you figure that you need to come down 2 MOA and left 1.75.With that method, you'd be closer. But the rounding errors are starting to add up. That rough 6 inches is actually 6.8 inches, so your actual adjustment is less than you thought. What happens if you don't actually know the distance to the target? Well, then you're back to option number one.The third method is ideal, though. Your spotter looks at the target with his reticle and measures the offset of the shots as he sees it. The linear measurement doesn't matter, because you already have the angle. If the spotter says to move .5 mil, then you simply dial .5 mil of adjustment on your optic.So Which is Easier?In practice, either an MRAD-based scope or MOA-based scope will work the same way. Both the spotter and the shooter can measure the required adjustment and communicate.So, for me, it comes down to the numbers involved.Look at this ballistic chart I compiled for a Berger 175gr .308 projectile firing at 2650 FPS.Compare the mil numbers and MOA numbers for both drop and windage. Both represent the same amount of linear drop at each distance. When you consider that milliradian-based scopes adjust in .1 increments, it's very easy to identify how many clicks of adjustment you need for each of those distances.For MOA, you're dealing with larger numbers as well as rounding errors. Most MOA scopes adjust in .25 MOA increment. If I said you need to come down 17.9 MOA, is that closer to 17.75 or 18 MOA?You also have to do more math in your head. How many clicks is 32.7 MOA?For mils, how many clicks is 13 mils?They're the same amount, 130. How much longer did it take you to figure that out with MOA?MRAD takes it here for ease of use.MOA vs Mil-dot OpticsI'm not going to spend a lot of time here. The truth is that both systems work well for optics. Look at these reticles designated EBR-2C by Vortex Optics. Both of these are perfectly usable. That is, as long as the turret of the optic work in the same system as the reticle.Up until fairly recently, a lot of American rifle scopes had mil-dot reticles but MOA turret adjustment. We call that mil/MOA. There is no good reason to do that to yourself.To work with ths, it requires more math. You need a conversion factor of 3.43, which is the rounded version of 3438 divided by 1000 (the two ratios representative of each system).Put it this way:Scenario #1: You take a shot and watch the impact in the reticle, measuring it as 1.8 mils high. To convert that into minutes of angle, you multiply 1.8 x 3.43 and get 6.174 MOA. Divide 6.174 by .25 (MOA per click), and get 24.696. Now you adjust the elevation turret 24 or 25 clicks. Scenario #2: You're now using a mil/mil scope and take another shot. You measure the impact as 2.3 mils to the right. Move the decimal one place to the right (the result of multiplying by 10) and you get 23. Adjust the elevation turret 23 clicks.Scenario #3: Someone handed you a MOA/MOA optic. You fire and measure the impact as 17.9 MOA low. Divide 17.9 by .25 and you get 71.6. Adjust the elevation turret 72 clicks.Which of those is the most convenient?Whichever system you choose, buy a scope with matching reticle and turret sub-tensions.Wrapping UpHopefully you now have a good understanding of these two angular measurement systems. This was a lot of fairly technical information, with plenty of math.The takeaway I want you to have is that when it comes to mils vs MOA, neither system is absolutely superior to the other. They both have their perks depending on what you need to do with it.Minutes of Angle are an easy way to teach someone the basics if you're sticking to the imperial system, but it does end up being more difficult to work with later on. A minute of angle is a more precise unit of measurement when you're trying to squeeze maximum accuracy.Milliradians are super convenient to use with the 10-based metric system. It also works with inches and yards with a little bit of math. The real benefit to MRAD is that it's faster to communicate and make adjustments. The 10-based math makes calculations significantly quicker.The final thing to keep in mind is that it's not all about you. Consider what those around you are also using. If you are shooting PRS matches and get teamed with a bunch of guys using mil-based optics, it's going to be much easier to communicate if you're using the same.Otherwise, you'll be doing lots of math to translate between the two systems.Over to YouSo which system between milliradians and minutes of angle is your preference? Let me know in the comments.

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