**This is the correct method of installing any alloy wheel. Use a torque wrench, following correct torque value and the proper criss-cross tightening pattern to avoid stressing or distorting the wheel or hub/rotor.**

# INSTALLING ALLOY WHEELS

Let's face it: Wheel installation is rarely viewed as a topic deserving of much attention. Most shops tend to zip them off, mount and balance, and bang them back onto the vehicle. Basically, wheels are considered by many techs as components that are essentially "in the way" when performing other services such as brake or suspension system jobs.

In reality, the wheels, and their means of attachment to the vehicle, are the most important components on any vehicle. After all, if the wheels fall off, it's never a pretty picture.

In this article, we'll discuss the basics of wheel fasteners and the handling and proper installation of alloy wheels, which deserve even greater attention due to their higher cost and because of the potential for cosmetic damage.

## WHEEL FASTENERS

Instead of referring to these all-critical pieces (the only thing that

clamps the wheel to the hub) generically as "lug nuts," get into the habit of calling them "wheel fasteners," since that's an apt description of their task.

Also, although Toyota vehicles use a threaded stud (affixed to the hub) and a nut system to secure the wheels, some vehicles feature female threaded holes in their hubs and require the use of wheel bolts. This is just one reason to use the term wheel fasteners to broadly refer to any wheel-to-hub clamping system.


**Fastener sizing cards are handy to determine bolt or stud diameter (both inch and metric), as well as bolt or stud shank lengths and nut diameters.**

## CHECK FASTENER SIZE AND STYLE

Granted, when you remove an original Toyota wheel and replace the wheel using the same Toyota nuts, you won't have a nut-matching problem. However, if you're dealing with a customer's vehicle that features aftermarket wheels, or have been requested to change the wheels from OEM to aftermarket, never assume that you already have the correct style of wheel nut. Check to make sure that the thread size is correct (shank diameter and thread pitch), and make absolutely sure that the fastener's seat style matches that of the wheels. Using an incorrect seat style will prevent secure clamping of the wheel to the hub, and will certainly result in loosening during operation. Packing/shipping mistakes are always possible, so never blindly assume that what you have is correct.

Wheel fastener seat styles include 60-degree taper/conical seats, radius (also called spherical or ball) seats or mag-style straight shank with flat washers.

Make sure that the new fasteners match the seat style required by the wheels at hand. Never mismatch by using a mag/shank type fastener on a wheel intended for a conical seat, etc. Only the correct, matching type seat will provide the required wheel clamping. In the case of blind (capped/enclosed) wheel nuts, make absolutely sure that the nut does not bottom-out against the stud tip (this can occur if the nut is too short for the application) This situation will prevent full clamping force, resulting in wheel wobble and almost-certain failure of the threaded studs.

Wheel fastener threads must be clean and in good condition. Do not lubricate threads unless specifically instructed to do so by Toyota technical information specific to the vehicle being serviced. Torque values are commonly specified based on the use of dry threads. The use of lubricants will result in overclamping and possibly stretching the stud beyond its design yield point.

## UNDERSTANDING THREAD SIZE

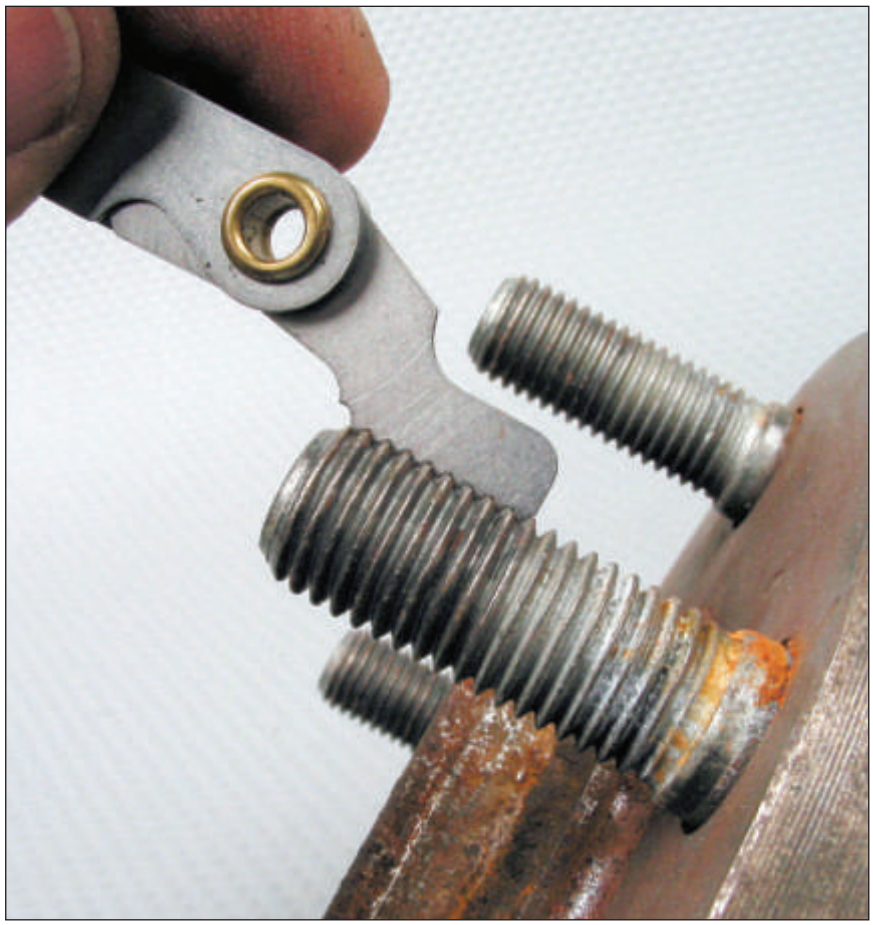
Fastener sizing involves selecting the correct diameter, thread pitch and length for proper thread engagement. Following is a basic overview.

## DIAMETER

This refers to the diameter of the threaded section of the fastener (outer diameter of a bolt shank or stud; or inner diameter of a nut's threaded hole).

Threaded fastener size is referred to with a series of three numbers, which indicate thread diameter, thread pitch and shank length, in that order. For example, a 1/2 x 20 x 4 indicates a bolt or stud that features a 1/2-inch diameter shank, a thread pitch of 20 (20 threads per inch) and a shank length of four inches. If the fastener is metric, the numbers refer to the same dimensional areas, but are indicated using metric dimensions. For example, a 14 x 1.5 x 45 refers to a 14mm

## INSTALLING ALLOY WHEELS



**Thread pitch gauges (available in both inch and metric formats) provide an easy and accurate method of determining the wheel stud thread pitch, eliminating any guesswork.**

thread diameter, a thread pitch of 1.5mm and a thread length of 45mm.

A common mistake some folks make is to incorrectly identify nut or bolt sizes, confusing hex head size with thread size. The size of the fastener (thread area diameter) refers to the diameter of the threaded area (threaded hole in a nut or threaded shank on a stud or bolt). The wrench size required to service the fastener does not indicate fastener size. The width of the hex head (let's say a nut requires a 3/4-inch or 19mm socket) has no bearing whatsoever on fastener size. For example, if the threaded area is 12mm in diameter, the nut or stud is a 12mm size, not a 19mm (referring to the size of socket required). When sizing any fastener, ignore the service end (hex head). It's only the diameter of the thread area that indicates the fastener's size.

### THREAD PITCH

All Toyota vehicles feature metric wheel fasteners. However, simply to provide a better understanding of threaded fasteners, we'll offer an overview of both "inch" and metric formats.

When using inch format, the thread pitch number indicates the number of threads along a one-inch length of the shank. For example, a 1/2-inch x 20 wheel stud is 1/2-inch in diameter, and has a thread count of 20 threads per inch of shank length.

When using a metric format, the first number indicates the thread shank diameter in millimeters (12mm, 14mm, etc.). However, metric thread pitch numbers indicate the distance between threads. For example, a thread pitch of 1.25 indicates that the distance between two adjacent threads is 1.25mm. If the thread pitch is 1.50, the distance between threads is 1.5mm. The last number of a stud or bolt size indicates length. A size of 14mm x 1.5 x 35, for example, indicates a stud or bolt that is 14mm in diameter, a thread pitch of 1.5mm and a shank length of 35mm.

In inch format, the higher the pitch number, the "finer" the threads (more threads per inch of shank length). Using a 1/2-inch diameter fastener as an example, a thread pitch of 13 is "coarse," while a thread pitch of 20 is considered "fine." Using a 1/4-inch diameter fastener as an example, a thread pitch of 20 is considered coarse, while a 28 pitch is considered fine. Basically, in inch format, each fastener thread diameter size offers two choices — coarse or fine. With regard to wheel fasteners, the threads are always "fine." As compared to coarse threads, this provides increased bolt strength and potential clamping load. If a wheel fastener is 7/16-inch diameter, the thread pitch will be 20. If 1/2-inch diameter, thread pitch will be 20. If 9/16-inch diameter, thread pitch will be 18. In metric format, the

higher the number, the more "coarse" the thread pitch. For example, a 1.0 pitch is "very fine," a 1.25 pitch is "medium fine," a 1.5 pitch is "medium" and a 1.75 pitch is "coarse." Metric wheel fasteners will commonly either feature a 1.25 or 1.5 thread pitch, regardless of thread diameter.

## LENGTH

The amount of thread engagement between the stud and nut (or wheel bolt to hub) is critical. At the minimum, thread engagement length must be equal to or greater than the diameter of the fastener. In other words, if the stud is 12mm in diameter, the nut must engage onto the stud by at least 12mm. If not, either a longer stud or longer nut must be used (if a longer nut is needed, the nut must protrude further through the wheel hole to meet the stud). Use of longer nuts is possible when the nut features an extended shank that offers greater thread length. This will vary depending on nut style. If this isn't feasible, a longer stud must be used.

When using wheel bolts or capped (enclosed) nuts, care must be taken to avoid bottoming the bolt or nut. For example, if the stud offers one inch of exposed length for nut engagement, but the threaded hole in the nut is only 3/4-inch deep, the nut will bottom-out on the stud and will not clamp the wheel against the hub.

In order to accurately identify the thread diameter, pitch and length of any wheel fastener, you can handle this by obtaining a total of three readily available tools: a combination bolt/nut sizing card (these are hard plastic and are available to cover both inch and metric sizes) and two thread pitch gauges (one inch and one metric). That's all you need to quickly and accurately read any wheel bolt or nut without any guesswork.

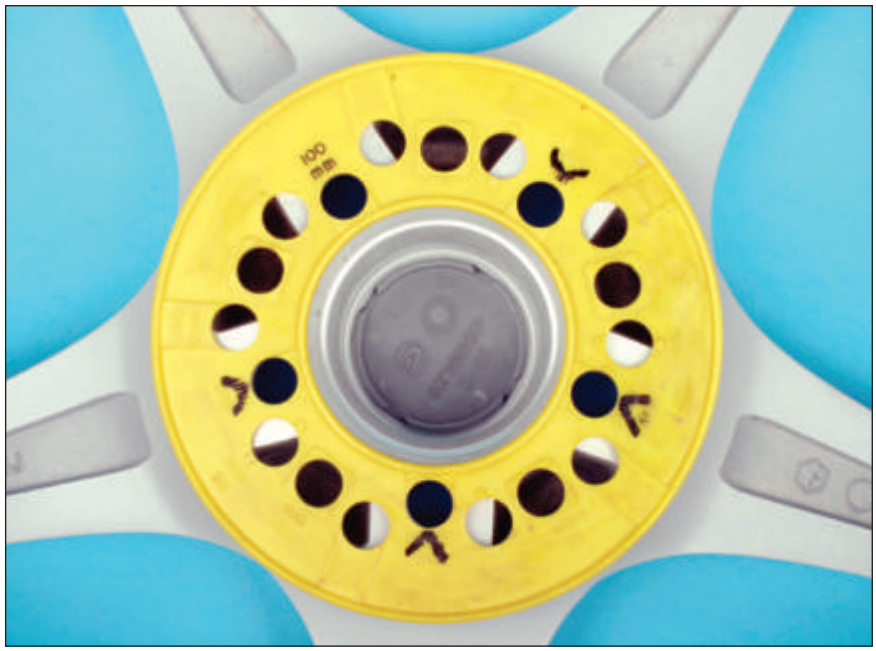
## BOLT CIRCLE

The term "bolt circle" or "bolt pattern" refers to the diameter of the circle formed by the wheel or hub fastener mounting locations. Toyota models use bolt circles of 100mm (3.93 inches), 114.3mm (4.5 inches) and 139.7mm (5.5 inches). A designation of 4x100 indicates a wheel with four bolt holes, with the holes positioned to create a 100mm circle (when measured through the centerline of all holes). A wheel designation of 5x114.3 indicates a five-bolt wheel that provides a bolt circle of 114.3mm (4.5 inches).

If you want to manually measure a bolt circle, here are some easy methods:

1. With a four-bolt or six-bolt pattern, measure from the center of one stud (at the hub) or wheel hole, to the center of an opposing stud or wheel hole.
2. With a five-bolt pattern, orient the hub or wheel to place one fastener location at 12-o'clock. Measure from the center of the 12-o'clock location to a horizontal line drawn across the bottom of the two bottom studs or wheel holes.

Bolt circle information is usually provided on the wheel (look at the rear of the wheel, the information should be stamped or cast on the

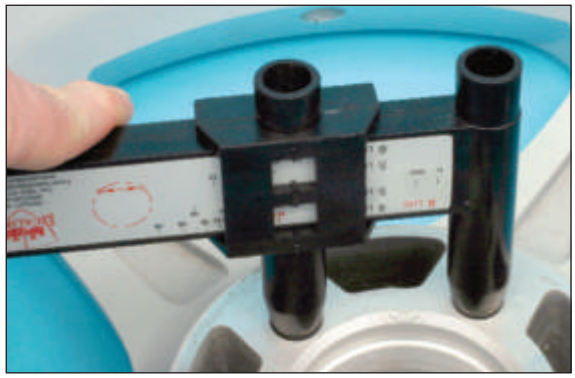


**A plastic sizing disc provides multiple holes, each labeled for bolt circle reference. Simply align the disc onto the wheel (or onto the hub studs) until all of the hub or wheel holes align on the disc, and read the numbers on the disc to identify the bolt circle. For illustrative purposes, we've marked the holes that align to the wheel shown here. Note the numbers that we've highlighted in black (at upper left of disc), noting that this wheel features a 100mm bolt circle.**

# INSTALLING ALLOY WHEELS

wheel's center section, likely on the rear of a wheel spoke).

Checking a hub or wheel bolt pattern can also be performed with the aid of specialty tools. A bolt circle reference "disc" (these are available in all bolt circle sizes) offers multiple hole patterns, with each hole labeled. Simply drop the disc onto a hub (or place on the rear mounting surface of the wheel) until all holes align. Note which holes align (per the hole labels). Another method involves the use of a specialty sliding caliper type tool. Insert the two tapered pins of the tool into two adjacent wheel holes and note the reading on the tool's gauge.



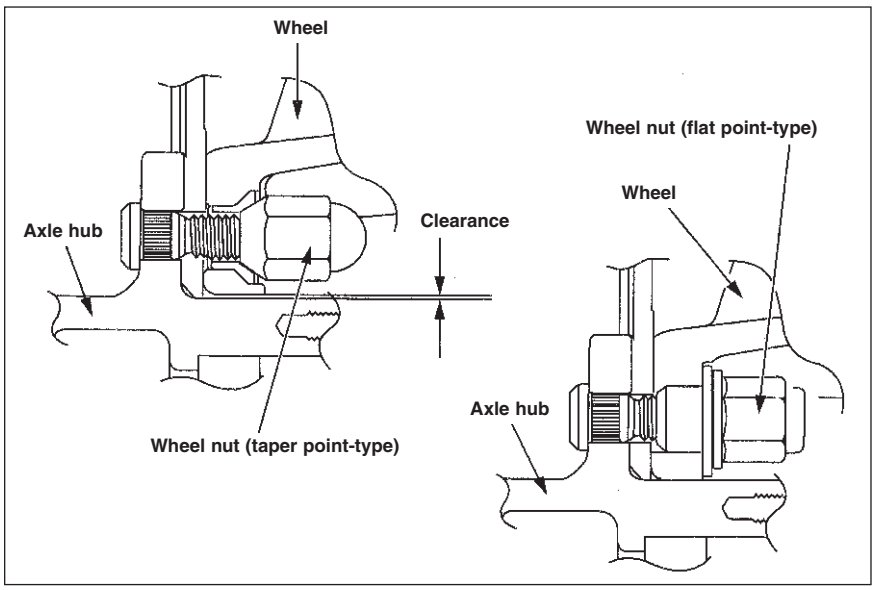
**This handy caliper-style tool can be used to quickly determine bolt circle. Insert both pins into adjacent holes and read the gauge.**

## WHEEL NUT SEAT STYLES

The contact area between the fastener and the wheel is referred to as the "seat." This is the surface area where the fastener actually contacts the wheel and where clamping pressure is applied when the fastener is tightened. It is absolutely vital that the seat style of the fastener matches the seat style of the wheel's fastener hole entry. The use of incorrect seat styles, even though thread pitch and thread diameter may be correct, can easily result in wheel damage during tightening, and fastener loosening during vehicle operation. If the fasteners loosen, the wheel will "wobble" as it moves in relation to the hub. Eventually, this movement, or play, will ruin the wheel's fasteners holes, resulting in either breaking the wheel or complete loss of the tire/wheel assembly.

Do not confuse the style or shape of the fastener head with the shape of the fastener's seat. If a wheel nut features a radiused head (rounded head), some folks may call this an "acorn" nut. However, others will interpret the term "acorn" as a radiused or ball-style fastener seat. Always make sure that you clearly understand the terminology for seat styles.

The majority of Toyota wheels require the use of conical (also called tapered) seat-style nuts. However, citing the 1999-2001 Avalon, Camry, Solara and Sienna models as examples, two different accessory wheels were offered. Style 1 (wheel part number PT351-00990) features a conical seat, while Style 2 (wheel part number PT351-00991) features a flat-seat ("mag") style nut. Each wheel requires the use of a specific style nut. Attempting to use a conical-style nut on a wheel that features flat seats (or using a flat-seat nut on a wheel that features conical seats) will result in both wheel damage and certain loosening.




**Two types of wheel nuts are used with Toyota wheels. Some alloy wheels use shank type (mag) wheel nuts that feature flat mounting bosses. Steel wheels use tapered (conical) wheel nuts. The two styles are not interchangeable.**

## AN EXPLANATION OF WHEEL NUT SEAT STYLES

The most commonly employed seat styles include conical, radius and flat ("mag"). These terms refer to the shape of the seat (where the

# INSTALLING ALLOY WHEELS

**Shown here are two conical/tapered nuts (two at left); and two ball/radius fasteners at the right. Note that the two conical nuts feature different engagement lengths. The nut at the far left terminates at the bottom of the tapered seat while the nut to its right features a slight extension below the conical seat area. The extended nut (second from left) may be required for a thicker alloy wheel, in order to achieve proper thread engagement to the stud. Pay strict attention to both seat style and proper thread engagement!**

fastener contacts the entry of the fastener hole in the wheel.

## CONICAL

Conical seats are also called "tapered" or "cone" seats. All three terms refer to a seat that features an angled seat wall, where the dimension of the taper is largest at the top, under the head, and tapers to a smaller diameter where the angle meets the rear face of the nut (or adjacent to the threaded shank on a wheel bolt). The most common angle of taper is 60 degrees. The male taper nestles into a tapered relief pocket at the fastener hole entrance.

## RADIUS

Radius seats are also called "ball" seats, with good reason. The rear of the nut (or base of the head on a wheel bolt) is rounded into a ball shape. It's like a ball that is cut in half, with only the radius remaining. The male ball seat fastener contacts the wheel's female radiused ball relief.

## MAG (FLAT SEAT)

The term "mag" refers to a fastener that features a flat contact at the wheel (usually including a thick flat washer). The generic term "mag" is a holdover from the early days of custom wheels, when magnesium was sometimes used to make lightweight racing wheels. The mag style nut also features a smooth outer-walled shank that serves to help center the wheel (the shank drops through the wheel hole, serving as a guide pin to center the wheel's hole over the hub's threaded stud). The shank length varies depending on wheel thickness and stud length. When using a capped nut (where the female threaded hole does not pass all the way through the nut), it's important to pay attention to thread engagement length.

## FASTENER TORQUE

When tightening any wheel fasteners, we need to consider the degree of tightening in order to achieve proper clamping load. In addition, we need to consider the tightening sequence, or pattern, to assure that clamping loads are evenly distributed across the hub contact area.

Threaded fasteners, by design, are intended to stretch slightly when fully tightened to specification. This

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**Any busy shop should have their torque wrenches periodically re-calibrated in order to maintain accuracy and consistency.**

creates a preload, which is what serves to clamp the wheel securely to the hub. If undertightened, the nut (or bolt) can gradually loosen, and we all know the consequences of that. If overtightened, the stud or bolt can exceed its "elastic" range, and can permanently stretch (fatigue), which destroys its ability to provide clamping load. If this happens, the stud or bolt can either loosen on its own or can break during operation. Especially when dealing with today's lightweight alloy wheels and sometimes light (and thin) rotor mounting faces, severe wheel vibrations under braking can occur if wheels are improperly or unevenly tightened.

## REASONS TO NOT USE AN IMPACT GUN ON ALLOY WHEELS

An impact gun (especially when installing wheels) can wreak havoc on alloy wheels. Fastener damage can occur as a result of a socket banging against a nut's chrome plating. If aftermarket spline-drive "tuner" nuts are used, the narrow splines can be burred. Probably the biggest area of concern is inaccurate and/or excessive clamping loads, which can distort the wheel and its mated hub/rotor, leading to vibration complaints. Additional wheel cosmetic damage can result if socket-to-fastener recess is minimal, or if a thick-walled socket is used that minimizes clearance, the outer wall of the socket can abrade against the wheel's nut recess.

If the socket is dirty, abrasive damage to both the fastener and wheel are possible. In addition, excessive tightening can cause the nut or bolt seat to pound into the aluminum wheel's seat pocket, displacing the aluminum (gouging/deforming the alloy). This can lead to eventual fastener loosening, since the seat base integrity has been deformed or reduced. Excessive tightening can also stress the wheel stud, permanently stretching the threaded shank

**While the use of a torque wrench is preferred for tightening an alloy wheel, if an impact gun must be used, be sure to employ torque sticks, which feature a pre-set torsional limiting range to prevent over-tightening.**

beyond its elastic point, weakening the stud considerably. When this happens, the stud may eventually break or allow the nut to loosen.

## WHEEL FASTENER TORQUE VALUES

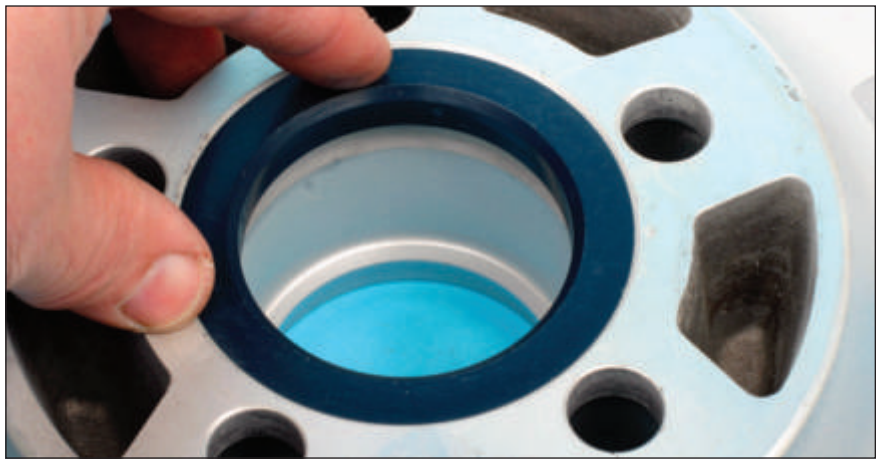
Always refer to the Toyota tightening specifications for proper wheel fastener torque values. Listed here is a broad generalization of torque values, based on fastener size, for example only.

| Vehicle | Torque |
|---|---|
| RAV4 | 76 ft-lbs (103N-m) |
| MR2 | 76 ft-lbs (103N-m) |
| Avalon | 76 ft-lbs (103N-m) |
| Camry | 76 ft-lbs (103N-m) |
| Solara | 76 ft-lbs (103N-m) |
| Celica | 76 ft-lbs (103N-m) |
| Echo | 76 ft-lbs (103N-m) |
| Scion tC | 76 ft-lbs (103N-m) |
| Prius | 76 ft-lbs (103N-m) |
| Sienna | 76 ft-lbs (103N-m) |
| Highlander | 76 ft-lbs (103N-m) |
| Scion xB | 76 ft-lbs (103N-m) |
| Scion xA | 76 ft-lbs (103N-m) |
| Corolla | 76 ft-lbs (103N-m) |
| Matrix | 76 ft-lbs (103N-m) |
| 4Runner | 83 ft-lbs (110 N-m) |
| Tacoma | 83 ft-lbs (110 N-m) |
| Tundra | 83 ft-lbs (110 N-m) |
| Sequioa | 83 ft-lbs (110 N-m) |
| Land Cruiser | 97 ft-lbs (131 N-m) |

## TORQUE WRENCHES PREFERRED

While the use of a calibrated torque wrench is always preferred for wheel fastener tightening, an option (if your shop decides that it simply must use an air gun) involves the use of "torque sticks," which are available individually or in sets.

Each tool is essentially a short torsion bar with a 1/2-inch drive at one end and a hex socket at the other end. Using this tool on the air gun allows you to pneumatically tighten the wheel fastener to within a theoretically acceptable range. Each "stick" is color coded and labeled in terms of its hex size and its torque range. When the stick is subjected to its pre-set torque range, the center section of the tool begins to twist (similar to a torsion bar spring), theoretically preventing tightening the fastener beyond that pre-set range. If you can't convince your shop to take the time to use a torque wrench, at the very least be sure to use a torque stick.



**If the customer brings in aftermarket wheels, pay attention to the hubcentric fit of the wheel's center hole to the hub's center flange lip. Since the vast majority of Toyota vehicles use a hubcentric fit, make sure that the wheel closely centers itself at the hub. Some aftermarket wheels may be made to fit a variety of vehicles, in which case the wheel's center hole may be larger than is required for proper fit. In these cases, hubcentric adapter rings will be needed. Here a hubcentric ring is installed onto an aftermarket wheel. The inside diameter of this ring will match the required size for the customer's Toyota vehicle.**

## CHECK WHEEL CENTERING

Wheels are designed to center onto the vehicle hubs by one of two methods: lug-centricity or hub-centricity.

A lug-centric wheel relies on centering via the fastener locations only. As the lug nuts (or wheel bolts) are tightened, the wheel is centered onto the hub, guided by the wheel studs and the seating of the wheel nuts. This requires precise location of both wheel bolt holes and the fastener locations on the hub.

A hub-centric wheel is centered onto the hub via the fit of the wheel center hole at the hub face. The hub face will feature a center lip that engages into a recess on the wheel's hub face. Hub-centric designs more precisely locate the wheel onto the hub, to minimize the chance for installed-radial-runout. All later-model Toyota wheels and hubs are designed for hub-centric fitments. However, some earlier Toyotas (1989 and older) may feature lug-centric designs, wherein the wheel is centered onto the hub as the wheel nuts are tightened.

It's important to recognize which type of centering you have. If the hub design calls for a hub-centric

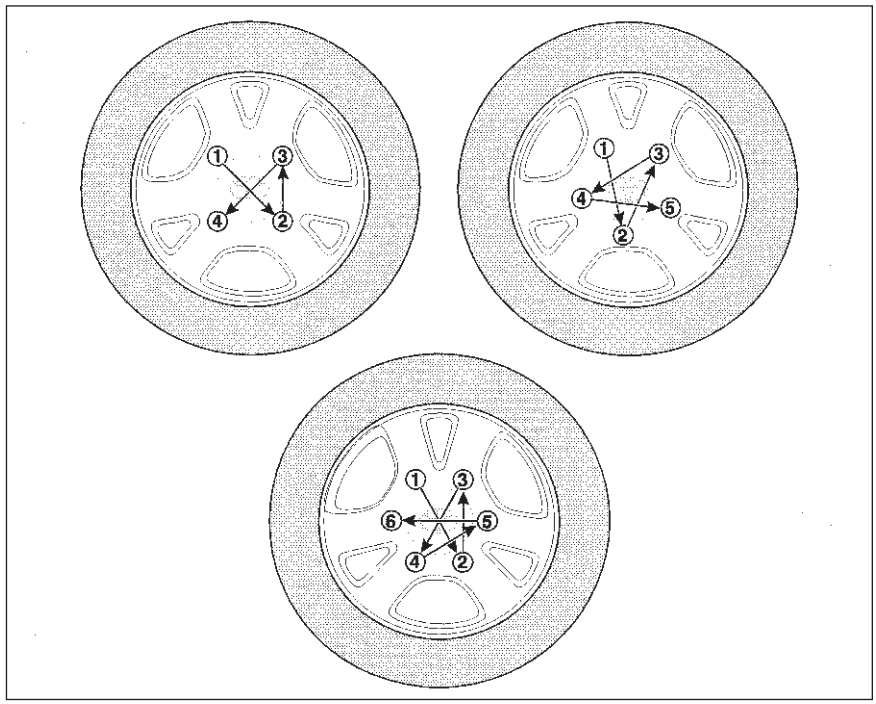
# INSTALLING ALLOY WHEELS

mounting, take a close look at both the wheel's hub face and the vehicle's hub face itself. In the case of Toyota wheels, the wheel centering hole is precisely machined to fit the hub center flange lip.

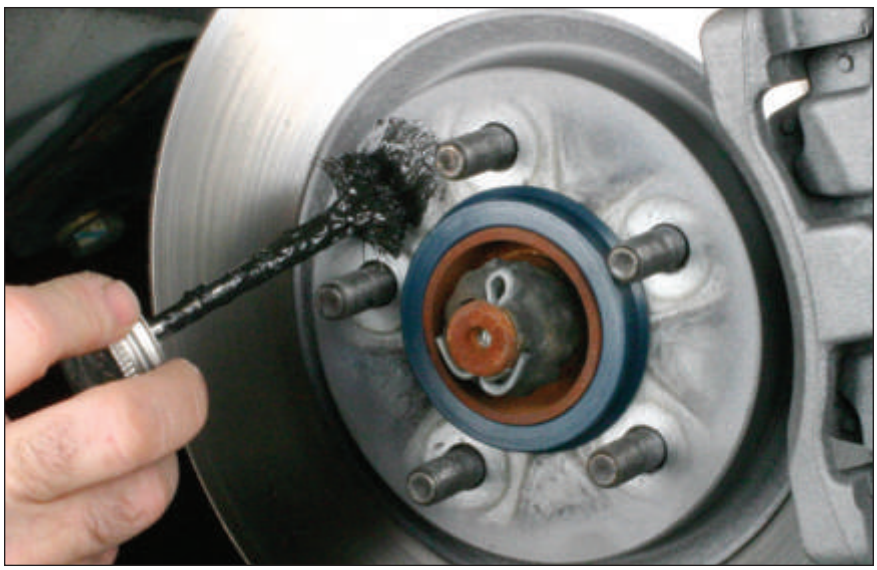
If an aftermarket alloy wheel is to be used, a hub-centric ring adapter may be required in order to attain a proper fit, since the aftermarket wheel may feature a larger center hole (which makes the wheel adaptable to various hub center fitments).

When adapter rings have been used on the vehicle in the past, it is possible that an old adapter ring has stuck to the hub. If this ring is not the correct size for the wheel being installed, the wheel may not be able to seat flush against the hub. This is sometimes easy to miss, so always check the hub face flange diameter and the diameter of the wheel's hub face to make sure they match before installing the wheels.

The wheel must fit flush against the hub, and the wheel must be centered on the hub. If the wheel requires rings and none are used, you'll have an off-center installation.




**Always follow the proper torque sequence and torque values when installing the wheels. The objective when tightening is to evenly spread the clamping loads across the bolt circle pattern, to avoid isolated and excessive loading. Failure to follow the correct tightening sequence can lead to distortion of the wheel and hub/rotor.**



**A corrosive (electrolysis) reaction can occur between an alloy wheel and a steel hub, resulting in future wheel removal difficulty. To avoid this, first clean the hub and wheel, and apply a thin coating of a high-temperature anti-seize paste onto the hub surface.**

Caution, if wheel spacers are used, make sure they don't effect the wheel track and/or the number of threads on the wheel studs. If old rings are stuck to the hub, but the new wheels don't need them, or if you try to double-up old rings that are stuck to the hub and new rings on the wheels, the wheels won't mate flush to the hub, which will cause severe axial runout. Always check closely.

NOTE: If the aftermarket wheels that the customer has chosen include hubcentric ring adapters (these may be either aluminum or plastic), be sure to use them. Even if you feel that the fasteners will center the wheel, the rings provide a closer-tolerance fit to the hub center and will allow you to better center the wheel during fastener tightening.

# INSTALLING ALLOY WHEELS

## TIGHTENING SEQUENCE

Always install ANY wheel by tightening the fasteners in a criss-cross pattern in order to provide even clamping loads. Uneven tightening can easily result in a distorted hub or wheel, leading to vibration complaints and brake pedal-bounce complaints.

## AFTERMARKET WHEELS

If the customer has requested a change to aftermarket wheels and/or oversized tires that he or she has provided, it's important to verify wheel and tire clearance.

After mounting one tire/wheel, test fit the assembly onto the vehicle. With the vehicle on the lift, check for clearance between fender, suspension and brake components with the tire/wheel in a straight ahead position and during full turns (lock-to-lock) in each direction. This is especially important when an upgrade has been performed where tire section width and/or wheel offset and backspace has changed (as compared to original Toyota specifications). Next, lower the vehicle in order to compress the suspension, and repeat the clearance inspection (have a helper bounce the vehicle as well, to further inspect for clearance issues). It's better to discover an interference problem at this point as compared to after all four wheels/tires have been mounted, balanced and installed.

NOTE: If the wheels have been supplied by the customer, be sure to check the wheel's rated load range. This is especially important if the customer has selected a passenger car wheel for a truck or SUV application. The wheel's load range should be visible somewhere on the wheel surface (rim or rear of the center section). Use of an alloy wheel that is not designed to support the weight of the vehicle at hand is to be avoided, since the risk of wheel failure is possible.

## TIPS:

• Two styles of center caps (if used) includes the type that pops into place from the outside of the center, and the type that is inserted from behind the wheel hub face. If the caps are to be inserted from the rear, make sure that the cap flange matches the wheel's center hole chamfer and is below the wheel's mounting surface. If the cap protrudes beyond the mounting surface, this will create an obstruction that won't allow flush seating of the wheel to the hub. This will result in false torque value readings and can cause an axial runout condition.

• To avoid corrosion that may cause an alloy wheel to "stick" to a steel or iron hub, apply a very thin coating of an anti-seize paste to the hub face where the wheel makes contact. Don't apply too much, as any excess can sling out as a result of centrifugal force and can contaminate the wheel face or brake surfaces. A thin coating of this compound will make it easy to remove the wheels in the future, preventing electrolysis (corrosive reaction between aluminum and steel). Don't apply lubricant to fastener threads, since fastener torque specification values are based on the use of clean, dry threads. By lubricating the threads with a slippery substance, inaccurate (usually too high) torque values may be obtained.


**If the customer has aftermarket wheels, check to verify that the wheel load rating is proper for the weight of the vehicle. Never install a wheel that is underrated for the vehicle at hand.**

• After installing a set of custom wheels onto the customer's vehicle, place one-wheel's set of original Toyota nuts in a Ziploc bag and store this in the vehicle (in the original Toyota vehicle tool kit, next to the spare tire or jack, etc.). If the customer ever needs to install the original Toyota spare wheel/tire in an emergency, he or she will have the correct fasteners, since the fasteners that are used with the aftermarket wheels may differ in length or style from the OE. Also, the vehicle-equipped Toyota lug wrench might not fit the new fasteners, as the aftermarket nut hex size may differ from those used by Toyota.

• This brings up a point well worth mentioning. If the aftermarket fastener hex size differs from the Toyota nut size (let's say for example that the Toyota nuts require a 19mm wrench, but the aftermarket fasteners might require an 18mm or 11/16-inch wrench), be sure to advise the customer of the need to carry an appropriate-sized socket and breaker bar to allow the aftermarket wheel to be removed during a roadside tire change. ★