ATV Maintenance

- **ATV Maintenance Schedules and Service Intervals**
  ATV Maintenance Schedules and Service Intervals How to plan regular service for your ATV Key steps for creating a seasonal ATV maintenance plan Essential fluids to change in your ATV and when to change them How often to replace filters on different types of ATVs Checklist for pre-ride inspections to avoid mechanical issues Signs that your ATV is due for professional servicing Understanding the difference between hours and mileage intervals How to prepare your ATV for long term storage Tips for keeping an accurate ATV maintenance log Why seasonal tune ups improve ATV reliability How to schedule preventative maintenance before major trips Common maintenance tasks to extend the life of your ATV
- **Diagnosing and Troubleshooting Common ATV Issues**
  Diagnosing and Troubleshooting Common ATV Issues How to identify the cause of engine stalling in an ATV Steps to troubleshoot electrical problems in your ATV Why your ATV may lose power under load and how to fix it Simple checks to find the cause of poor ATV acceleration What to do when your ATV struggles to start in cold weather Understanding common overheating problems in ATVs How to track down unusual noises in your ATV drivetrain Signs of brake system issues in your ATV How to tell if your ATV has a slipping CVT belt Techniques for testing fuel delivery problems in ATVs How to spot early signs of bearing or bushing wear Finding the source of vibration while riding an ATV
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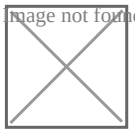
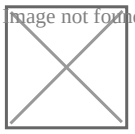
All-Terrain Vehicles (ATVs) are robust machines designed to handle rough terrains and challenging conditions. Battery checks keep your ATV starting reliably **judson outdoor power & atv** LoJack. However, like any mechanical device, regular maintenance is essential to ensure their longevity and optimal performance. By adhering to a routine of common maintenance tasks, ATV owners can significantly extend the life of their vehicles while ensuring safety and reliability during use.

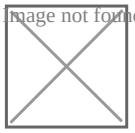
First and foremost, one of the most critical maintenance tasks is regular oil changes. The engine oil in an ATV serves as a lubricant and coolant, reducing friction between moving parts and preventing overheating. Over time, oil can break down or become contaminated with debris, which can lead to decreased engine efficiency and potential damage. Most manufacturers recommend changing the engine oil every 100 hours of operation or annually, whichever comes first. Additionally, checking the oil level before each ride ensures that it remains within the recommended range.



Another vital aspect of ATV maintenance is tire care. Tires are the only point of contact between the vehicle and the ground, making their condition crucial for safety and performance. Regularly inspecting tires for signs of wear, such as cracks or bald spots, can prevent unexpected blowouts or loss of traction. Maintaining proper tire pressure is equally important; underinflated tires can lead to excessive wear and reduced fuel efficiency, while overinflated tires may compromise handling and increase the risk of punctures.



The air filter plays a significant role in keeping an ATVs engine running smoothly by preventing dirt and debris from entering the combustion chamber. A clogged air filter can restrict airflow, leading to decreased performance and potential engine damage. Owners should inspect the air filter regularly-typically every 25 hours of operation-and replace it when necessary. Cleaning reusable filters according to manufacturer guidelines can also help maintain optimal engine health.



Brakes are another critical component requiring regular attention. Inspecting brake pads for wear and ensuring that brake fluid levels are adequate can prevent catastrophic failures that could result in accidents. Many experts suggest checking brakes at least once per season or more frequently if riding in particularly harsh conditions.

In addition to these core maintenance tasks, there are several other areas that ATV owners should monitor regularly:

- **Battery Maintenance:** Keeping terminals clean and free from corrosion helps ensure reliable starting power.
- **Cooling System:** For liquid-cooled ATVs, checking coolant levels and inspecting hoses for leaks or damage is essential.
- **Drive Belt:** Inspecting drive belts for signs of wear or cracking helps prevent sudden failures during operation.
- **Chassis Lubrication:** Applying grease to suspension components reduces friction and prevents premature wear.

By incorporating these common maintenance tasks into a regular schedule, ATV owners can not only extend the lifespan of their vehicles but also enhance their overall riding experience. Well-maintained ATVs tend to perform better, consume less fuel, and require fewer costly repairs over time. Moreover, diligent upkeep contributes significantly to rider safety by minimizing the risk of mechanical failures on challenging trails.

In conclusion, caring for an ATV goes beyond mere enjoyment; its about responsibility towards ones investment in this versatile machine capable of thrilling adventures across diverse landscapes. Through consistent attention to detail-from routine oil changes to meticulous tire inspections-ATV enthusiasts uphold not just their vehicles durability but also their commitment towards safe recreational pursuits amidst nature's rugged beauty.

About tire

For other uses, see Tire (disambiguation).
"Rubber tires" redirects here. For the film, see Rubber Tires.

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Assorted new automotive road tires, showing a variety of tread patterns.

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Tractor tires have substantial ribs and voids for traction in soft terrain.

A **tire** (North American English) or **tyre** (Commonwealth English) is a ring-shaped component that surrounds a wheel's rim to transfer a vehicle's load from the axle through the wheel to the ground and to provide traction on the surface over which the wheel travels. Most tires, such as those for automobiles and bicycles, are pneumatically inflated structures, providing a flexible cushion that absorbs shock as the tire rolls over rough features on the surface. Tires provide a footprint, called a contact patch, designed to match the vehicle's weight and the bearing on the surface that it rolls over by exerting a pressure that will avoid deforming the surface.

The materials of modern **pneumatic tires** are synthetic rubber,[1] natural rubber, fabric, and wire, along with carbon black and other chemical compounds. They consist of a tread and a body. The tread provides traction while the body provides containment for a quantity of compressed air. Before rubber was developed, tires were metal bands fitted around wooden wheels to hold the wheel together under load and to prevent wear and tear. Early rubber tires were solid (not pneumatic). Pneumatic tires are used on many vehicles, including cars, bicycles, motorcycles,

buses, trucks, heavy equipment, and aircraft. Metal tires are used on locomotives and railcars, and solid rubber (or other polymers) tires are also used in various non-automotive applications, such as casters, carts, lawnmowers, and wheelbarrows.

Unmaintained tires can lead to severe hazards for vehicles and people, ranging from flat tires making the vehicle inoperable to blowouts, where tires explode during operation and possibly damage vehicles and injure people. The manufacture of tires is often highly regulated for this reason. Because of the widespread use of tires for motor vehicles, tire waste is a substantial portion of global waste. There is a need for tire recycling through mechanical recycling and reuse, such as for crumb rubber and other tire-derived aggregate, and pyrolysis for chemical reuse, such as for tire-derived fuel. If not recycled properly or burned, waste tires release toxic chemicals into the environment. Moreover, the regular use of tires produces micro-plastic particles that contain these chemicals that both enter the environment and affect human health.[2]

Etymology and spelling

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The word *tire* is a short form of *attire*, from the idea that a wheel with a tire is a dressed wheel.[3][4]

Tyre is the oldest spelling,[5] and both *tyre* and *tire* were used during the 15th and 16th centuries. During the 17th and 18th centuries, *tire* became more common in print. The spelling *tyre* did not reappear until the 1840s when the English began shrink-fitting railway car wheels with malleable iron. Nevertheless, many publishers continued using *tire*. *The Times* newspaper in London was still using *tire* as late as 1905.[6] The spelling *tyre* began to be commonly used in the 19th century for pneumatic tires in the UK. The 1911 edition of the *Encyclopædia Britannica* states that *"The spelling 'tyre' is not now accepted by the best English authorities, and is unrecognized in the US"*,[7] while Fowler's *Modern English Usage* of 1926 describes that "there is nothing to be said for 'tyre', which is etymologically wrong, as well as needlessly divergent from our own [sc. British] older & the present American usage".[8] However, over the 20th century, *tyre* became established as the standard British spelling.[4]

History

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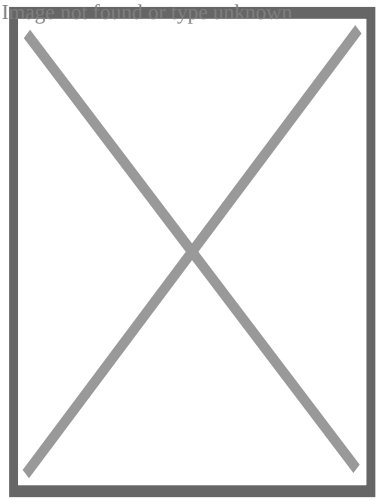

John Boyd Dunlop on a bicycle, c. 1915

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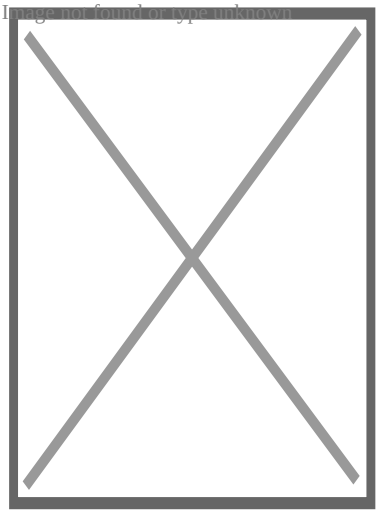

Factory workers making tires, 1918

The earliest tires were bands of leather in Sumer,[9] then iron (later steel) placed on wooden wheels used on carts and wagons. A skilled worker, known as a wheelwright, would cause the tire to expand by heating it in a forge fire, placing it over the wheel, and quenching it, causing the metal to contract back to its original size to fit tightly on the wheel.

The first patent for what appears to be a standard pneumatic tire appeared in 1847 and was lodged by Scottish inventor Robert William Thomson.[10] However, this idea never went into production. The first practical pneumatic tire was made in 1888 on May Street, Belfast, by Scots-born John Boyd Dunlop, owner of one of Ireland's most prosperous veterinary practices. It was an effort to prevent the headaches of his 10-year-old son Johnnie while riding his tricycle on rough pavements. His doctor, John, later Sir John Fagan, had prescribed cycling as an exercise for the boy and was a regular visitor. Fagan participated in designing the first pneumatic tires. Cyclist Willie Hume demonstrated the supremacy of Dunlop's tires in 1889, winning the tire's first-ever races in Ireland and then England.[11][12] In Dunlop's tire patent specification dated 31 October 1888, his interest is only in its use in cycles and light vehicles. In September 1890, he was made aware of an earlier development, but the company kept the information to itself.[13] In 1892, Dunlop's patent was declared invalid because of the prior art by forgotten fellow Scot Robert William Thomson of

London (patents London 1845, France 1846, USA 1847). However, Dunlop is credited with "realizing rubber could withstand the wear and tear of being a tire while retaining its resilience".[14] John Boyd Dunlop and Harvey du Cros worked through the ensuing considerable difficulties. They employed inventor Charles Kingston Welch and acquired other rights and patents, which allowed them some limited protection of their Pneumatic Tyre business's position. Pneumatic Tyre would become Dunlop Rubber and Dunlop Tyres. The development of this technology hinged on myriad engineering advances, including the vulcanization of natural rubber using sulfur, as well as the development of the "clincher" rim for holding the tire in place laterally on the wheel rim.

Synthetic rubbers were invented in the laboratories of Bayer in the 1920s.[15] Rubber shortages in the United Kingdom during WWII prompted research on alternatives to rubber tires with suggestions including leather, compressed asbestos, rayon, felt, bristles, and paper.[16]

In 1946, Michelin developed the radial tire method of construction. Michelin had bought the bankrupt Citroën automobile company in 1934 to utilize this new technology. Because of its superiority in handling and fuel economy,[17] use of this technology quickly spread throughout Europe and Asia.[18] In the US, the outdated bias-ply tire construction persisted until the Ford Motor Company adopted radial tires in the early 1970s,[19] following a 1968 article in an influential American magazine, *Consumer Reports*, highlighting the superiority of radial construction.[20][21] The US tire industry lost its market share to Japanese and European manufacturers,[22] which bought out US companies.[23]

Applications

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Tires may be classified according to the type of vehicle they serve. They may be distinguished by the load they carry and by their application, e.g. to a motor vehicle, aircraft, or bicycle.

Automotive

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Light–medium duty

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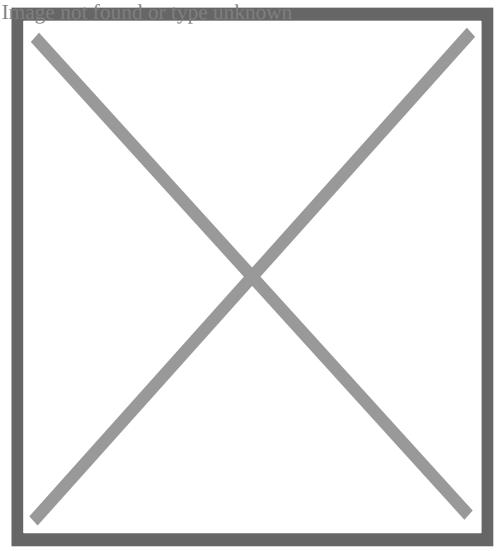

Studded winter tire

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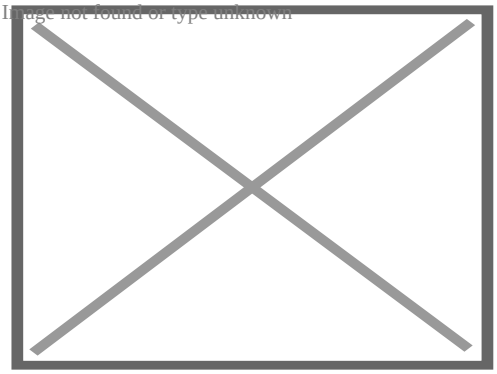

A winter tire without studs, showing tread pattern designed to compact snow in the gaps.[24]

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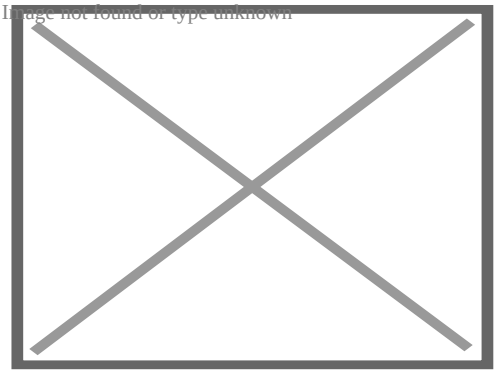

High-performance rally tires

Light-duty tires for passenger vehicles carry loads in the range of 250 to 500 kilograms (550 to 1,100 lb) on the drive wheel. Light-to-medium duty trucks and vans carry loads in the range of 500 to 1,500 kilograms (1,100 to 3,300 lb) on the drive wheel.[25] They are differentiated by speed rating for different vehicles, including (starting from the lowest speed to the highest): winter tires, light truck tires, entry-level car tires, sedans and vans, sport sedans, and high-performance cars.[26] Apart from road tires, there are special categories:

- Snow tires are designed for use on snow and ice. They have a tread design with larger gaps than those on summer tires, increasing traction on snow and ice. Such tires that have passed a specific winter traction performance test are entitled to display a "Three-Peak Mountain Snow Flake" symbol on their sidewalls. Tires designed for winter conditions are optimized to drive at temperatures below 7 °C (45 °F). Some snow tires have metal or ceramic studs that protrude from the tire to increase traction on hard-packed snow or ice. Studs abrade dry pavement, causing dust and creating wear in the wheel path.[27] Regulations that require the use of snow tires or permit the use of studs vary by country in Asia and Europe, and by state or province in North America.
- All-season tires are typically rated for mud and snow (M+S). These tires have tread gaps that are smaller than snow tires and larger than conventional tires. They are quieter than snow tires on clear roads, but less capable on snow or ice.[28]
- All-terrain tires are designed to have adequate traction off-road, yet have benign handling and noise characteristics for highway driving.[29] Such tires are rated better on snow and rain than street tires and "good" on ice, rock, and sand.[30]
- Mud-terrain tires have a deeper, more open tread for good grip in mud, than all-terrain tires, but perform less well on pavement.[31]
- High-performance tires are rated for speeds up to 270 kilometres per hour (168 mph) and ultra-high-performance tires are rated for speeds up to 299 kilometres per hour (186 mph), but have harsher ride characteristics and durability.[32]
- Electric vehicles have unique demands on tires due to the combination of weight (resulting in new load index), higher torque, and requirements for lower rolling resistance.[33]

Other types of light-duty automotive tires include run-flat tires and race car tires:

- Run-flat tires eliminates the need for a spare tire because they can be traveled on at a reduced speed in the event of a puncture, using a stiff sidewall to prevent damage to the tire rim.[34] Vehicles without run-flat tires rely on a spare tire, which may be a compact tire, to replace a damaged tire.[34]
- Race car tires come in three main categories, *DOT* (street-legal), *slick*, and *rain*. Race car tires are designed to maximize cornering and acceleration friction at the expense of longevity. Racing slicks have no tread to maximize contact with the pavement and rain tires have channels to eject water to avoid hydroplaning.[35]

Heavy duty

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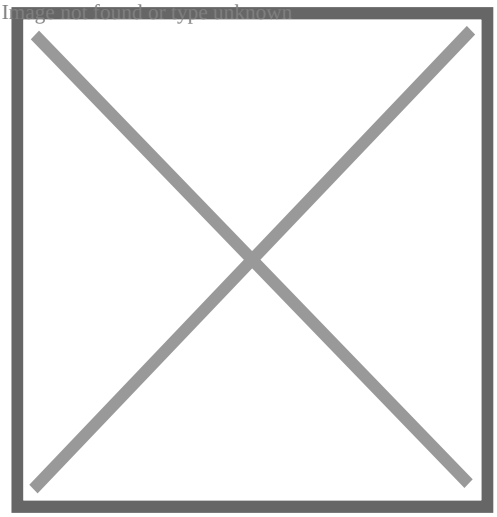

Off-road tires under transport

Heavy-duty tires for large trucks and buses come in a variety of profiles and carry loads in the range of 1,800 to 2,500 kilograms (4,000 to 5,500 lb) on the drive wheel.[25] These are typically mounted in tandem on the drive axle.[34]

- Truck tires come in a variety of profiles that include "low profile" with a section height that is 70 to 45% of the tread width, "wide-base" for heavy vehicles, and a "super-single" tire that has the same total contact pressure as a dual-mounted tire combination.[34]
- Off-road tires are used on construction vehicles, agricultural and forestry equipment, and other applications that take place on soft terrain. The category also includes machinery that travels over hardened surfaces at industrial sites, ports, and airports.[36] Tires designed for soft terrain have a deep, wide tread to provide traction in loose dirt, mud, sand, or gravel.[37]

Other

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Aircraft, bicycles, and a variety of industrial applications have distinct design requirements.

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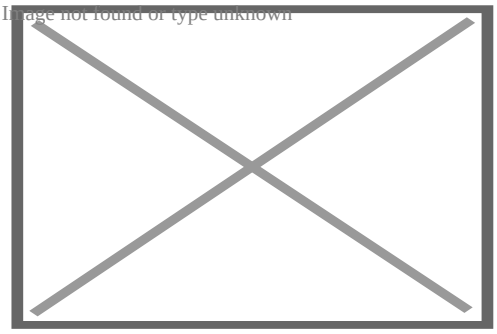

Tires on the wheels of a bogie on a Boeing 777

- Aircraft tires are designed for landing on paved surfaces and rely on their landing gear to absorb the shock of landing. To conserve the weight and space required, they are typically small in proportion to the vehicle that they support. Most are radial-ply construction. They are designed for a peak load when the aircraft is stationary, although side loads upon landing are an important factor.[38] Although hydroplaning is a concern for aircraft tires, they typically have radial grooves and no lateral grooves or sipes.[39] Some light aircraft employ large-diameter, low-pressure tundra tires for landing on unprepared surfaces in wilderness areas.[40]
- Bicycle tires may be designed for riding on roads or over unimproved terrain and may be mounted on vehicles with more than two wheels. There are three main types: *clincher*, *wired* and *tubular*.[41] Most bicycle tires are *clincher* and have a bead that presses against the wheel rim. An inner tube provides the air pressure and the contact pressure between the bead and wheel rim.[42]
- Industrial tires support such vehicles as forklifts, tractors, excavators, road rollers, and bucket loaders. Those used on smooth surfaces have a smooth tread, whereas those used on soft surfaces typically have large tread features.[43] Some industrial tires are solid or filled with foam.[44]
- Motorcycle tires provide traction, resisting wear, absorbing surface irregularities, and allow the motorcycle to turn via countersteering. The two tires' contact with the ground affects safety, braking, fuel economy, noise, and rider comfort.[45][*self-published source?*]

Construction types

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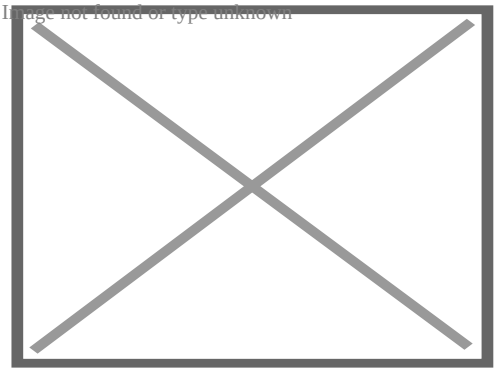

A cross-section of a tire showing ply orientations

Tire construction spans pneumatic tires used on cars, trucks, and aircraft, but also includes non-automotive applications with slow-moving, light-duty, or railroad applications, which may have non-pneumatic tires.

Automotive

[edit]

Following the 1968 *Consumer Reports* announcement of the superiority of the radial design, radial tires began an inexorable climb in market share, reaching 100% of the North American market in the 1980s.[20] Radial tire technology is now the standard design for essentially all automotive tires, but other methods have been used.[26]

Radial (or radial-ply) tire construction utilizes body ply cords extending straight across the tread from bead to bead—so that the cords are laid at approximately right angles to the centerline of the tread, and parallel to one another—as well as stabilizer belts directly beneath the tread. The plies are generally made of nylon, polyester, or steel, and the belts of steel, fiberglass, or Kevlar.[46][47] The tire's footprint, wider than a bias tire's, and flexible sidewalls provide a better grip in turns, and its circumferential belts stabilize it. The advantages of this construction over that of a bias tire are many, including longer tread life, better steering control, lower rolling resistance, improved fuel economy, more uniform wear, higher heat resistance, fewer blowouts, and a steadier, more comfortable ride at speed. Disadvantages, besides a higher cost than that of bias tires, are a harder ride at low speeds and generally worse performance on rough terrain.[48][49][26] Radial tires are also seldom seen in diameters of greater than 42 inches, as such tires are difficult to make.[50]

Bias tire (bias-ply, or cross-ply) construction utilizes body ply cords that extend diagonally from bead to bead, usually at angles in the range of 30 to 40 degrees from the direction of travel.[51] Successive plies are laid at opposing angles, forming a crisscross pattern to which the tread is applied. Such a design is resistant to sidewall deformation and punctures (and to punctures' expansion, or "torque splitting") and therefore durable in severe use.[52] Since the tread and sidewalls share their casing plies, the tire body flexes as a whole, providing the main advantage of this construction, better traction and smoother motion on uneven surfaces, with a greater tendency to conform to rocky ground and throw off mud and clay, especially because the rubber is usually of a softer compound than that used on radial tires. However, this conformity increases a bias tire's rolling resistance, and its stiffness allows less control, traction, and comfort at higher speeds, while shear between its overlapping plies causes friction that generates heat.[48][53][54][26] Still, bias tires benefit from simpler structure and so cost less than like-size radials, and they remain in use on heavy equipment and off-road vehicles, although the earthmoving market has shifted to radials.[26][55]

A belted bias tire starts with two or more bias plies to which stabilizer belts are bonded directly beneath the tread. This construction provides a smoother ride that is similar to the bias tire, while lessening rolling resistance because the belts increase tread stiffness. The design was introduced by Armstrong, while Goodyear made it popular with the "Polyglas" trademark tire featuring a polyester carcass with belts of fiberglass.[56] The "belted" tire starts two main plies of polyester, rayon, or nylon annealed as in conventional tires, and then placed on top are circumferential belts at different angles that improve performance compared to non-belted bias tires. The belts may be fiberglass or steel.[56]

Other

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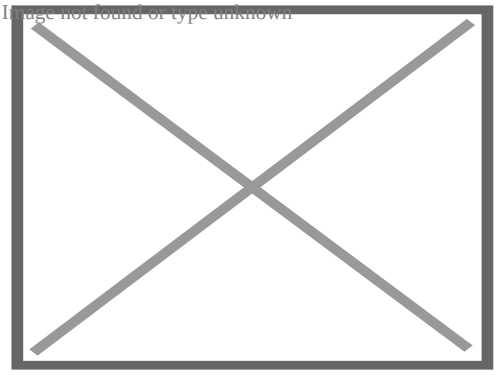

Airless tire

Tubeless tires are pneumatic tires that do not require a separate inner tube.

Semi-pneumatic tires have a hollow center, but they are not pressurized. They are lightweight, low-cost, puncture-proof, and provide cushioning.[57] These tires often come as a complete assembly with the wheel and even integral ball bearings. They are used on lawn mowers, wheelchairs, and wheelbarrows. They can also be rugged, typically used in industrial applications,[58] and are designed to not pull off their rim under use.

An airless tire is a non-pneumatic tire that is not supported by air pressure. They are most commonly used on small vehicles, such as golf carts, and on utility vehicles in situations where the risk of puncture is high, such as on construction equipment. Many tires used in industrial and commercial applications are non-pneumatic, and are manufactured from solid rubber and plastic compounds via molding operations. Solid tires include those used for lawnmowers, skateboards, golf carts, scooters, and many types of light industrial vehicles, carts, and trailers. One of the most common applications for solid tires is for material handling equipment (forklifts). Such tires are installed utilizing a hydraulic tire press.

Wooden wheels for horse-drawn vehicles usually have a wrought iron tire. This construction was extended to wagons on horse-drawn tramways, rolling on granite setts or cast iron rails.

The wheels of some railway engines and older types of rolling stock are fitted with railway tires to prevent the need to replace the entirety of a wheel. The tire, usually made of steel, surrounds the wheel and is primarily held in place by interference fit.

Aircraft tires may operate at pressures that exceed 1,400 kilopascals (14 bar; 200 psi).[59] Some aircraft tires are inflated with nitrogen to "eliminate the possibility of a chemical reaction between atmospheric oxygen and volatile gases from the tire inner liner producing a tire explosion".[60]

Manufacturing

[edit]
Main article: Tire manufacturing

Pneumatic tires are manufactured in about 450 tire factories around the world. Tire production starts with bulk raw materials such as rubber, carbon black, and chemicals and produces numerous specialized components that are assembled and cured. Many kinds of rubber are used, the most common being styrene-butadiene copolymer.[61]

Forecasts for the global automotive tire market indicate continued growth through 2027. Estimates put the value of worldwide sales volume around $126 billion in 2022, it is expected to reach the value of over $176 billion by 2027.[62] Production of tires is also experiencing growth. In 2015, the US manufactured almost 170 million tires.[63] Over 2.5 billion tires are manufactured annually, making the tire industry a major consumer of natural rubber. It was estimated that for 2019 onwards, at least 3 billion tires would be sold globally every year.[64] However, other estimates put worldwide tire production of 2,268 million in 2021 and is predicted to reach 2,665 million tires by 2027.[65]

As of 2011, the top three tire manufacturing companies by revenue were Bridgestone (manufacturing 190 million tires), Michelin (184 million), Goodyear (181 million); they were followed by Continental, and Pirelli.[66][67] The Lego group produced over 318 million toy tires in 2011 and was recognized by Guinness World Records as having the highest annual production of tires by any manufacturer.[68][69]

Components

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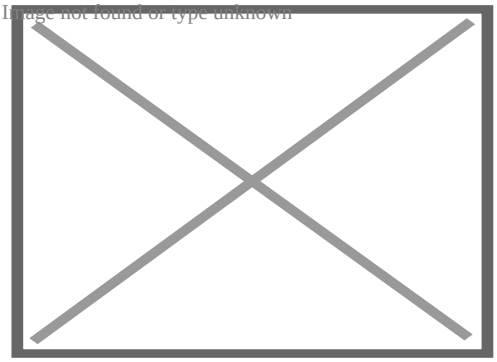
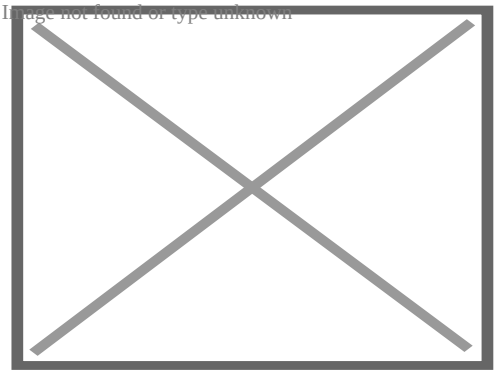
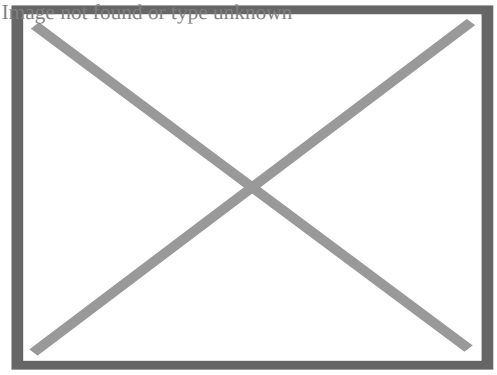


Components of a radial tire



Mountain bicycle tires with an open-lug pattern for grip in soft soil



Absence of grooves maximizes dry-pavement friction on a set of slick Formula One tires

A tire comprises several components: the tread, bead, sidewall, shoulder, and ply.

Tread

[edit]

The tread is the part of the tire that comes in contact with the road surface. The portion that is in contact with the road at a given instant in time is the contact patch. The tread is a thick rubber, or rubber/composite compound formulated to provide an appropriate level of traction that does not wear away too quickly.[70]

The tread pattern is characterized by a system of circumferential grooves, lateral sipes, and slots for road tires[26] or a system of lugs and voids for tires designed for soft terrain or snow. Grooves run circumferentially around the tire and are needed to channel away water. Lugs are that portion of the tread design that contacts the road surface. Grooves, sipes, and slots allow tires to evacuate water.

The design of treads and the interaction of specific tire types with the roadway surface affects roadway noise, a source of noise pollution emanating from moving vehicles. These sound intensities increase with higher vehicle speeds.[71] Tires treads may incorporate a variety of distances between slots (*pitch lengths*) to minimize noise levels at discrete frequencies. Sipes are slits cut across the tire, usually perpendicular to the grooves, which allow the water from the grooves to escape sideways and mitigate hydroplaning.[26]

Different tread designs address a variety of driving conditions. As the ratio of tire tread area to groove area increases, so does tire friction on dry pavement, as seen on Formula One tires, some of which have no grooves. High-performance tires often have smaller void areas to provide more rubber in contact with the road for higher traction, but may be compounded with softer rubber that provides better traction, but wears quickly.[72] Mud and snow (M&S) tires employ larger and deeper slots to engage mud and snow.[26] Snow tires have still larger and deeper slots that compact snow and create shear strength within the compacted snow to improve braking and cornering performance.[73]

Wear bars (or wear indicators) are raised features located at the bottom of the tread grooves that indicate the tire has reached its wear limit. When the tread lugs are worn to the point that the wear bars connect across the lugs, the tires are fully worn and should be taken out of service, typically at a remaining tread depth of 1.6 millimetres (0.063 in).[74]

Other

[edit]

The tire bead is the part of the tire that contacts the rim on the wheel. This essential component is constructed with robust steel cables encased in durable, specially formulated rubber designed to resist stretching. The precision of the bead's fit is crucial, as it seals the tire against the wheel, maintaining air pressure integrity and preventing any loss of air. The bead's design ensures a secure, non-slip connection, preventing the tire from rotating independently from the wheel during vehicle motion. Additionally, the interplay between the bead's dimensions and the wheel's width significantly influences the vehicle's steering responsiveness and stability, as it helps to maintain the tire's intended shape and contact with the road.

The sidewall is that part of the tire, or bicycle tire, that bridges between the tread and bead. The sidewall is largely rubber but reinforced with fabric or steel cords that provide for tensile strength and flexibility. The sidewall contains air pressure and transmits the torque applied by the drive axle to the tread to create traction but supports little of the weight of the vehicle, as is clear from the total collapse of the tire when punctured.

Sidewalls are molded with manufacturer-specific detail, government-mandated warning labels, and other consumer information.[75][76]

Sidewall may also have sometimes decorative ornamentation that includes whitewall or red-line inserts as well as tire lettering.[77]

The shoulder is that part of the tire at the edge of the tread as it makes the transition to the sidewall.[78]

Plies are layers of relatively inextensible cords embedded in the rubber[79] to hold its shape by preventing the rubber from stretching in response to the internal pressure. The orientations of the plies play a large role in the performance of the tire and are one of the main ways that tires are categorized.[80]

Blems

[edit]

Blem (short for "blemished") is a term used for a tire that failed inspection during manufacturing - but only for superficial/cosmetic/aesthetic reasons. For example, a tire with white painted lettering which is smudged or incomplete might be classified as a "blem". Blem tires are fully functional and generally carry the same warranty as flawless tires - but are sold at a discount.[81]

Materials

[edit]

The materials of modern pneumatic tires can be divided into two groups, the cords that make up the ply and the elastomer which encases them.

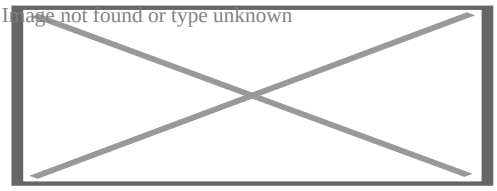
Cords

[edit]

The cords, which form the ply and bead and provide the tensile strength necessary to contain the inflation pressure, can be composed of steel, natural fibers such as cotton or silk, or synthetic fibers such as nylon or kevlar. Good adhesion between the cords and the rubber is important. To achieve this the steel cords are coated in a thin layer of brass,[82] various additives will also be added to the rubber to improve binding, such as resorcinol/HMMM mixtures.

Elastomer

[edit]



About 50% of tires use the Styrene-butadiene copolymer as a primary ingredient[15]

The elastomer, which forms the tread and encases the cords to protect them from abrasion and hold them in place, is a key component of pneumatic tire design. It can be composed of various composites of rubber material – the most common being styrene-butadiene copolymer – with other chemical compounds such as silica and carbon black.

Optimizing rolling resistance in the elastomer material is a key challenge for reducing fuel consumption in the transportation sector. It is estimated that passenger vehicles consume approximately 5~15% of their fuel to overcome rolling resistance, while the estimate is understood to be higher for heavy trucks.[83] However, there can be a trade-off between rolling resistance and

wet traction and grip, based on the viscoelastic properties of the rubber compound. A low dissipation factor, which is often written as the tangent of the phase angle delta (tan(?)), reduces rolling resistance, whereas a high tan(?) can improve wet traction and grip. Fortunately, this tradeoff is not inherent: rolling resistance is affected by tan(?) at low frequencies (on the order of 100 Hz) whereas the improvement in traction comes from high tan(?) at much higher frequencies. Historically, direct measurement of tan(?) at high frequencies was difficult, and it became common to instead use measured low-frequency tan(?) at a low temperature (0 °C) as a predictor of wet traction because of its correlation to high-frequency tan(?). For rolling resistance, tan(?) value at 60 °C is directly relevant and often used as a predictor of low rolling resistance. [84] [31]

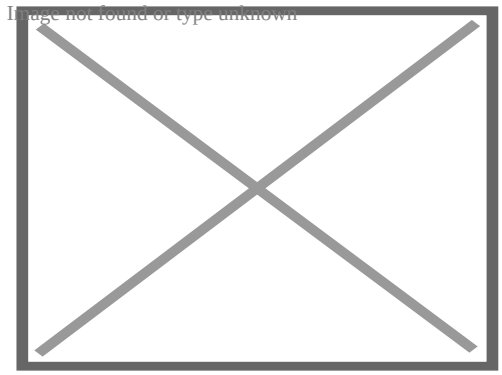
Designing an elastomer material that can achieve both high wet traction and low rolling resistance is key in achieving safety and fuel efficiency in the transportation sector. More recent research has found that compounds using dual-phase fillers exhibit a poor correlation between low-temperature tan(?) and wet traction, indicating an opportunity to circumvent the tradeoff assumed in the traditional approach. New approaches to understanding wet traction incorporate consideration of the effect of water lubrication on the interactions between surfaces and have pointed the way to developing compounds that can provide high wet traction and low rolling resistance. [85]

The most common elastomer material used today is a styrene-butadiene copolymer. It combines the properties of polybutadiene, which is a highly rubbery polymer (*Tg* = -100 °C) having high hysteresis and thus offering good wet grip properties, with the properties of polystyrene, which is a glassy polymer (*Tg* = 100 °C) having low hysteresis and thus offering low rolling resistance in addition to wear resistance. Therefore, the ratio of the two monomers in the styrene-butadiene copolymer is considered key in determining the glass transition temperature of the material, which is correlated to its grip and resistance properties.[86]

Non-exhaust emissions of particulate matter, generated by the wearing down of brakes, clutches, tires, and road surfaces, as well as by the suspension of road dust, constitute a little-known but rising share of emissions from road traffic and significantly harm public health.[87]

On the wheel

[edit]
Main articles: Wheel, Bicycle wheel, and Motorcycle wheel



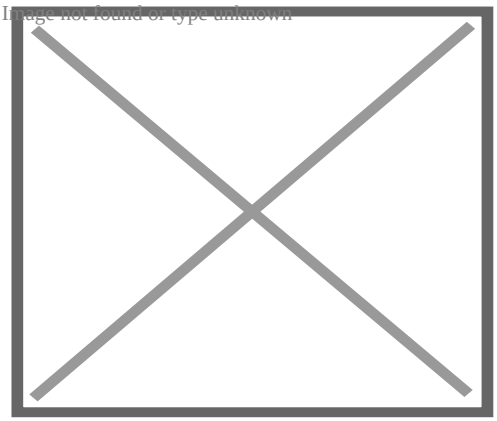
A bicycle inner tube with valve stem

Associated components of tires include the wheel on which it is mounted, the valve stem through which air is introduced, and, for some tires, an inner tube that provides the airtight means for maintaining tire pressure.

- *Wheel*: Pneumatic tires are mounted onto wheels that most often have integral rims on their outer edges to hold the tire. Automotive wheels are typically made from pressed and welded steel, or a composite of lightweight metal alloys, such as aluminum or magnesium. There are two aspects to how pneumatic tires support the rim of the wheel on which they are mounted.[88] First, the tension in the cords pull on the bead uniformly around the wheel, except where it is reduced above the contact patch.[89] Second, the bead transfers that net force to the rim.[90][89] Tires are mounted on the wheel by forcing its beads into the channel formed by the wheel's inner and outer rims.[91][92]
- *Valve stem*: Pneumatic tires receive their air through a valve stem—a tube made of metal or rubber, with a check valve, typically a Schrader valve on automobiles and most bicycle tires, or a Presta valve on high-performance bicycles. They mount directly to the rim, in the case of tubeless tires, or are an integral part of the inner tube. Most modern passenger vehicles are now required to have a tire pressure monitoring system which usually consists of a valve stem attached to an electronic module.[34]
- *Inner tube*: Most bicycle tires, many motorcycle tires, and many tires for large vehicles such as buses, heavy trucks, and tractors are designed for use with inner tubes. Inner tubes are torus-shaped balloons made from an impermeable material, such as soft, elastic synthetic rubber, to prevent air leakage. The inner tubes are inserted into the tire and inflated to retain air pressure. Large inner tubes can be reused for other purposes, such as swimming and rafting (see swim ring), tubing (recreation), sledding, and skitching. Purpose-built inflatable tori are also manufactured for these uses, offering a choice of colors, fabric covering, handles, decks, and other accessories, and eliminating the protruding valve stem.

Performance characteristics

[edit]



Tire performance envelope by Goodyear

The interactions of a tire with the pavement are complex. A commonly used (empirical) model of tire properties is Pacejka's "Magic Formula".[93] Some are explained below, alphabetically, by section.

Dynamics

[edit]

- *Balance*: Wheel-tire combinations require an even distribution of mass around their circumferences to maintain tire balance, while turning at speed. Tires are checked at the point of manufacture for excessive static imbalance and dynamic imbalance using automatic tire balance machines. Tires are checked again in the auto assembly plant or tire retail shop after mounting the tire to the wheel. Assemblies that exhibit excessive imbalance are corrected by applying balance weights to the wheels to counteract the tire/wheel imbalance. An alternative method to tire balancing is the use of internal tire balancing agents. These agents take advantage of centrifugal force and inertia to counteract the tire imbalance.[94] To facilitate proper balancing, most high-performance tire manufacturers place red and yellow marks on the sidewalls to enable the best possible match-mounting of the tire/wheel assembly. There are two methods of match-mounting high-performance tire-to-wheel assemblies using these red (uniformity) or yellow (weight) marks.[95]
- *Centrifugal growth*: A tire rotating at higher speeds tends to develop a larger diameter, due to centrifugal forces that force the tread rubber away from the axis of rotation. This may cause speedometer error. As the tire diameter grows, the tire width decreases. This centrifugal growth can cause rubbing of the tire against the vehicle at high speeds. Motorcycle tires are often designed with reinforcements aimed at minimizing centrifugal growth.[26]
- *Pneumatic trail*: Pneumatic trail of a tire is the trail-like effect generated by compliant tires rolling on a hard surface and subject to side loads, as in a turn. More technically, it is the distance that the resultant force of side-slip occurs behind the geometric center of the contact patch.[96]
- *Slip angle*: Slip angle or sideslip angle is the angle between a rolling wheel's actual direction of travel and the direction towards which it is pointing (i.e., the angle of the vector sum of wheel translational velocity v_i and sideslip velocity v_i).[26]
- *Relaxation length*: Relaxation length is the delay between when a slip angle is introduced and when the cornering force reaches its steady-state value.[26]
- *Spring rate*: Vertical stiffness, or spring rate, is the ratio of vertical force to vertical deflection of the tire, and it contributes to the overall suspension performance of the vehicle. In general, the spring rate increases with inflation pressure.[97]
- *Stopping distance*: Performance-oriented tires have a tread pattern and rubber compounds designed to grip the road surface, and so usually have a slightly shorter stopping distance. However, specific braking tests are necessary for data beyond generalizations.[26]

Forces

[edit]

- *Camber thrust*: Camber thrust and camber force are the force generated perpendicular to the direction of travel of a rolling tire due to its camber angle and finite contact patch.[26]
- *Circle of forces*: The circle of forces, traction circle, friction circle, or friction ellipse is a useful way to think about the dynamic interaction between a vehicle's tire and the road surface.[98]
- *Contact patch*: The contact patch, or footprint, of the tire, is the area of the tread that is in contact with the road surface. This area transmits forces between the tire and the road via friction. The length-to-width ratio of the contact patch affects steering and cornering behavior.[26]
- *Cornering force*: Cornering force or side force is the lateral (i.e. parallel to the road surface) force produced by a vehicle tire during cornering.[26]
- *Dry traction*: Dry traction is the measure of the tire's ability to deliver traction, or grip, under dry conditions. Dry traction is a function of the tackiness of the rubber compound.[26]
- *Force variation*: The tire tread and sidewall elements undergo deformation and recovery as they enter and exit the footprint. Since the rubber is elastomeric, it is deformed during this cycle. As the rubber deforms and recovers, it imparts cyclical forces into the vehicle. These variations are collectively referred to as tire uniformity. Tire uniformity is characterized by radial force variation (RFV), lateral force variation (LFV), and tangential force variation. Radial and lateral force variation is measured on a force variation machine at the end of the manufacturing process. Tires outside the specified limits for RFV and LFV are rejected. Geometric parameters, including radial runout, lateral runout, and sidewall bulge, are measured using a tire uniformity machine at the tire factory at the end of the manufacturing process as a quality check.[26]
- *Rolling resistance*: Rolling resistance is the resistance to rolling caused by deformation of the tire in contact with the road surface. As the tire rolls, the tread enters the contact area and is deformed flat to conform to the roadway. The energy required to make the deformation depends on the inflation pressure, rotating speed, and numerous physical properties of the tire structure, such as spring force and stiffness. Tire makers seek lower rolling resistance tire constructions to improve fuel economy in cars and especially trucks, where rolling resistance accounts for a high proportion of fuel consumption. Pneumatic tires also have a much lower rolling resistance than solid tires. Because the internal air pressure acts in all directions, a pneumatic tire is able to "absorb" bumps in the road as it rolls over them without experiencing a reaction force opposite to the direction of travel, as is the case with a solid (or foam-filled) tire.[26]
- *Self aligning torque*: Self-aligning torque, also known as the aligning torque, SAT or Mz, is the torque that a tire creates as it rolls along that tends to steer it, i.e. rotate it around its vertical axis.[26]
- *Wet traction*: Wet traction is the tire's traction, or grip, under wet conditions. Wet traction is improved by the tread design's ability to channel water out of the tire footprint and reduce hydroplaning. However, tires with a circular cross-section, such as those found on racing bicycles, when properly inflated have a sufficiently small footprint to not be susceptible to hydroplaning. For such tires, it is observed that fully slick tires will give superior traction on both wet and dry pavement.[99]

Load

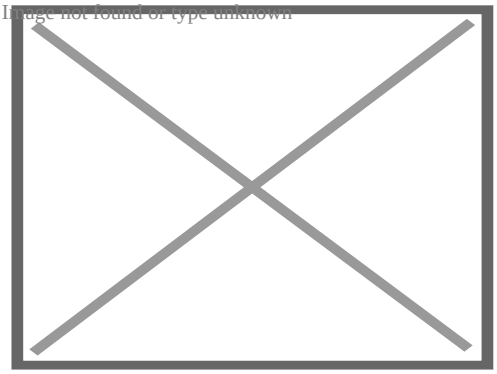
[edit]

- *Load sensitivity*: Load sensitivity is the behavior of tires under load. Conventional pneumatic tires do not behave as classical friction theory would suggest. Namely, the load sensitivity of most real tires in their typical operating range is such that the coefficient of friction decreases as the vertical load, Fz, increases.[26]
- *Work load*: The work load of a tire is monitored so that it is not put under undue stress, which may lead to its premature failure.[100] Work load is measured in *Ton Kilometer Per Hour* (TKPH). The measurement's appellation and units are the same. The recent shortage and increasing cost of tires for heavy equipment has made TKPH an important parameter in tire selection and equipment maintenance for the mining industry. For this reason, manufacturers of tires for large earth-moving and mining vehicles assign TKPH ratings to their tires based on their size, construction, tread type, and rubber compound.[101][102] The rating is based on the weight and speed that the tire can handle without overheating and causing it to deteriorate prematurely. The equivalent measure used in the United States is *Ton Mile Per Hour* (TMPH).

Wear

[edit]
See also: Rubber pollution and Road wear

Tire wear is a major source of rubber pollution. A concern hereby is that vehicle tire wear pollution is unregulated, unlike exhaust emissions.[103]

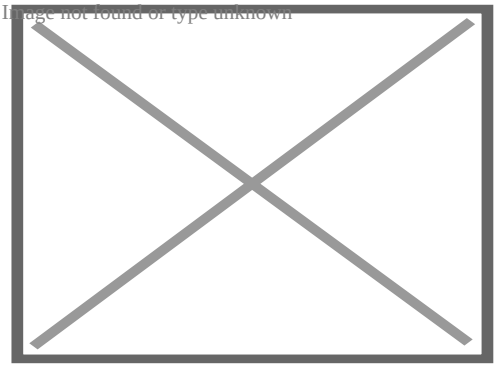


Tire showing uneven tread wear to the point of exposing the casing

Tread wear

This occurs through normal contact with roads or terrain; there are several types of abnormal tread wear. Poor wheel alignment can cause excessive wear of the innermost or outermost ribs. Gravel roads, rocky terrain, and other rough terrain cause accelerated wear. Over-

inflation above the sidewall maximum can cause excessive wear to the center of the tread. Modern tires have steel belts built in to prevent this. Under-inflation causes excessive wear to the outer ribs. Unbalanced wheels can cause uneven tire wear, as the rotation may not be perfectly circular. Tire manufacturers and car companies have mutually established standards for tread wear testing that include measurement parameters for tread loss profile, lug count, and heel-toe wear.[26]



Wear bar and tread wear indicator on the snow tire tread

Tread wear indicators (**T.W.I.**)

Raised bars in the tread channels, which indicate that the tread is becoming worn and therefore unsafe. Indicators have been required on all new tires since 1968 in the US.[104] In many countries the Highway Code forbids driving on public roads when the contact surface is flush with any of these bars - this is often defined when the groove depth is approximately 1.5 or 1.6 mm (2/32 inch). TWI can also be used to refer to small arrows or icons on the tire sidewall, indicating the location of the raised wear bars.

Damage by aging

Tire aging or "thermo-oxidative degradation" can be caused by time, ambient and operating temperatures, partial pressure of O2 in a tire, flex fatigue, or construction and compounding characteristics. For example, prolonged UV exposure leads to rubber's chemicals warping, potentially causing dry rot. Various storage methods may slow the aging process, but will not eliminate tire degradation.[105]

Sizes, codes, standards, and regulatory agencies

[edit]

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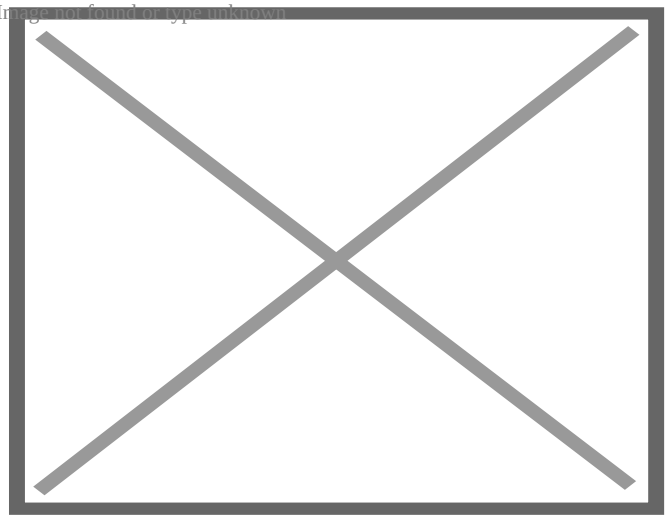

Tire identification diagram with tire codes

Further information: Tire code

Automotive tires have a variety of identifying markings molded onto the sidewall as a tire code. They denote size, rating, and other information pertinent to that individual tire.

Americas

[edit]

The National Highway and Traffic Safety Administration (NHTSA) is a U.S. government body within the Department of Transportation (DOT) tasked with regulating automotive safety in the United States.[106] NHTSA established the Uniform Tire Quality Grading System (UTQG), is a system for comparing the performance of tires according to the Code of Federal Regulations 49 CFR 575.104; it requires labeling of tires for tread wear, traction, and temperature. The DOT Code is an alphanumeric character sequence molded into the sidewall of the tire and allows the identification of the tire and its age. The code is mandated by the U.S. Department of Transportation[106] but is used worldwide.[107] The DOT Code is also useful in identifying tires subject to product recall[108] or at end of life due to age. The *Tire and Rim Association* (T&RA) is a voluntary U.S. standards organization that promotes the interchangeability of tires, rims, and allied parts. Of particular interest, they publish key tire dimensions, rim contour dimensions, tire valve dimension standards, and load/inflation standards.

The National Institute of Metrology Standardization and Industrial Quality (INMETRO) is the Brazilian federal body responsible for automotive wheel and tire certification.[109]

Europe

[edit]

The European Tyre and Rim Technical Organisation (ETRTO) is the European standards organization "to establish engineering dimensions, load/pressure characteristics and operating guidelines".[110] All tires sold for road use in Europe after July 1997 must carry an E-mark. The mark itself is either an upper case "E" or lower case "e" – followed by a number in a circle or rectangle, followed by a further number. An (upper case) "E" indicates that the tire is certified to comply with the dimensional, performance, and marking requirements of ECE regulation 30. A (lowercase) "e" indicates that the tire is certified to comply with the dimensional, performance, and marking requirements of Directive 92/23/EEC. The number in the circle or rectangle denotes the country code of the government that granted the type approval. The last number outside the circle or rectangle is the number of the type approval certificate issued for that particular tire size and type.[111]

The British Rubber Manufacturers Association (BRMA) recommended practice, issued June 2001, states, "BRMA members strongly recommend that unused tires should not be put into service if they are over six years old and that all tires should be replaced ten years from the date of their manufacture."[112]

Asia

[edit]

The Japanese Automobile Tire Manufacturers Association (JATMA) is the Japanese standards organization for tires, rims, and valves.[113] It performs similar functions as the T&RA and ETRTO.

The China Compulsory Certification (CCC) is a mandatory certification system concerning product safety in China that went into effect in August 2002. The CCC certification system is operated by the State General Administration for Quality Supervision and Inspection and Quarantine of the People's Republic of China (AQSIQ) and the Certification and Accreditation Administration of the People's Republic of China (CNCA).[114]

Maintenance

[edit]

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A tire repair shop in Niger

To maintain tire health, several actions are appropriate, tire rotation, wheel alignment, and, sometimes, retreading the tire.

- *Rotation*: Tires may exhibit irregular wear patterns once installed on a vehicle and partially worn. Front-wheel drive vehicles tend to wear the front tires at a greater rate compared to the rear tires. Tire rotation is moving the tires to different car positions, such as front-to-rear, in order to even out the wear, with the objective of extending the life of the tire.[115]
- *Alignment*: Wheel alignment helps prevent wear due to rotation in a direction other than the path of the vehicle. When mounted on the vehicle, the wheel and tire may not be perfectly aligned to the direction of travel, and therefore may exhibit irregular wear. If the discrepancy in alignment is large, then the irregular wear will become substantial if left uncorrected. Wheel alignment is the procedure for checking and correcting this condition through adjustment of camber, caster, and toe angles. The adjustment of the angles should be done as per the OEM specifications.[116]

Inflation

[edit]

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Rolling resistance as a function of tire inflation

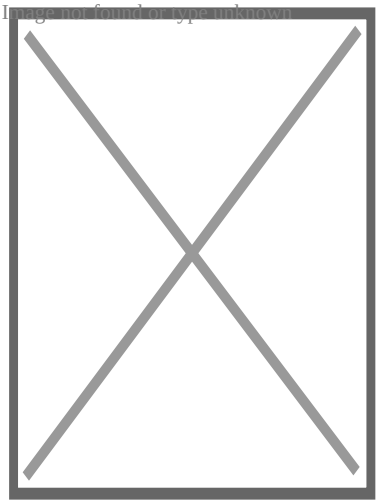
Inflation is key to proper wear and rolling resistance of pneumatic tires. Many vehicles have monitoring systems to assure proper inflation. Most passenger cars are advised to maintain a tire

pressure within the range of 220 to 240 kilopascals (32 to 35 psi) when the tires are not warmed by driving.[117][118]

- *Specification*— Vehicle manufacturers provide tire specifications, including a recommended cold inflation pressure, to ensure safe operation within the designated load rating and vehicle loading capacity. While many tires feature a maximum pressure rating stamped on them, passenger vehicles and light trucks typically include inflation guidance on a decal located just inside the driver's door and in the vehicle owner's handbook.[119]
- *Ground contact*: The tire contact patch is readily changed by both over- and underinflation. Overinflation may increase the wear on the center contact patch, and underinflation will cause a concave tread, resulting in less center contact, though the overall contact patch will still be larger.[120] Most modern tires will wear evenly at high tire pressures, but will degrade prematurely if underinflated. Increased tire pressure may decrease rolling resistance, and may also result in shorter stopping distances[121] If tire pressure is too low, the tire contact patch is greatly increased. This increases rolling resistance, tire flexing, and friction between the road and the tire. Under-inflation can lead to tire overheating, premature tread wear, and tread separation in severe cases.[122]
- *Monitoring*: Tire pressure monitoring systems (TPMS) are electronic systems that monitor the tire pressures on individual wheels on a vehicle and alert the driver when the pressure goes below a warning limit. There are several types of designs to monitor tire pressure. Some actually measure the air pressure, and some make indirect measurements, such as gauging when the relative size of the tire changes due to lower air pressure.

Hazards

[edit]



Tire bubble

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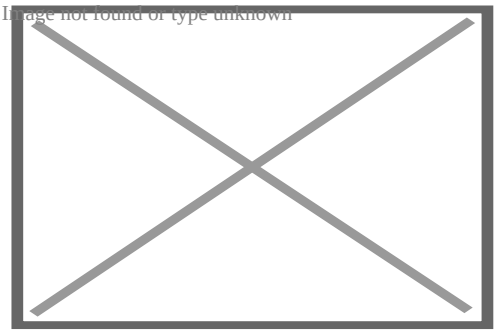

Tire showing weather-cracking over long-term exposure to the weather

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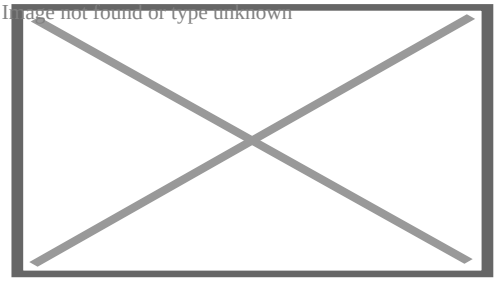


A flat tire on a passenger car

Tire hazards may occur from failure of the tire, itself, or from loss of traction on the surface over which it is rolling. Structural failures of a tire can result in flat tires or more dangerous blowouts. Some of these failures can be caused by manufacture error and may lead to recalls, such as the widespread Firestone tire failures on Ford vehicles that lead to the Firestone and Ford tire controversy in the 1990s.

Tire failure

[edit]

Tires may fail for any of a variety of reasons, including:[123]

- *Belt separation* which may be belt-to-belt, tread and belt, or separation of the edge of the belt. Belt-to-belt separation may occur having the tire deflect too much, from high pavement temperatures, road hazard impacts, or other causes that have to do with maintenance and storage.

- *Non-belt separations* include those at the tire tread, in the bead area, in the lower sidewall, between reinforcing plies, and of the reinforcing steel or fabric materials.
- Other types of failure include run-flat damage, chemical degradation, cracking, indentations and bulges.

Vehicle operation failures

[edit]

- *Melting rubber*: As tire rubber compounds heat, owing to the friction of stopping, cornering, or accelerating, they may begin to melt, lubricate the tire-road contact area, and become deposited on the pavement. This effect is stronger with increased ambient temperature.[26]
- *Hydroplaning*: Motor vehicles or aircraft tires passing over a wet pavement may lose contact with sufficient speed or water depth for a given tread design. In this case, the tire contact area is riding on a film of water and loses the friction needed for braking or cornering and begins to *hydroplane* (or *aquaplane*). Hydroplaning may occur as *dynamic hydroplaning* where standing water is present with a depth of at least 3 millimetres (0.12 in) above the texture of the pavement and speed is sustained above a threshold level. It may also occur as *viscous hydroplaning* whereby tire rubber melts for a brief interval and causes slippage. This may leave deposits of rubber on a runway as airplanes land.[124] Dynamic hydroplaning causes decreased friction and contact with increased tire speed.[125]
- *Snow*: The degree to which a tire can maintain traction in snow depends on its ability to compact snow, which material then develops strength against slippage along a shear plane parallel to the contact area of the tire on the ground.[126] At the same time, the bottom of the tire treads compress the snow on which they are bearing, also creating friction. The process of compacting snow within the treads requires it to be expelled in time for the tread to compact snow anew on the next rotation. The compaction/contact process works both in the direction of travel for propulsion and braking, but also laterally for cornering.[73]
- *Ice*: Ice is typically close to its melting point when a tire travels over it. This, combined with a smooth texture, promotes a low coefficient of friction and reduced traction during braking, cornering or acceleration.[26]
- *Soft ground*: Soil can become lubricated with water, which reduces its ability to maintain shear strength when a tire tries to apply force in acceleration, braking, or cornering. Dry sand also has low shear strength, owing to poor cohesiveness among sand particles.[127]

Health impacts

[edit]
Further information: Rubber pollution

Tires contain a number of trace toxic chemicals including heavy metals and chemical agents used to increase the durability of the tires.[2] These typically include polycyclic aromatic hydrocarbon, benzothiazoles, isoprene and heavy metals such as zinc and lead.[2]

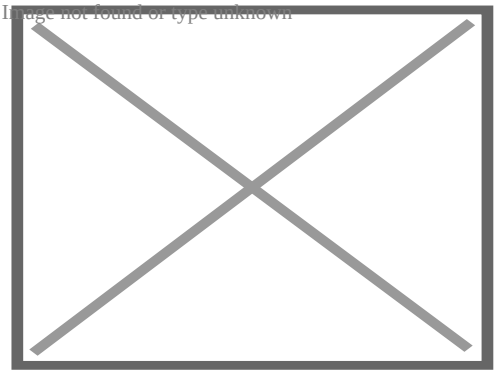
As tires are used for vehicle operations, the natural wear of the tire leaves microfine particles equivalent to PM0.1, PM2.5, and PM10 as tire residue.[2] This residue accumulates near roadways and vehicle use areas, but also will travel into the environment through surface runoff.[2] Both humans and animals are exposed to these chemicals at the sites of accumulation (i.e. walking on

the road surface) and through bioaccumulation in natural environments and foodchains.[2] A 2023 literature review from Imperial College London, warned of both the toxic chemicals and microplastics produced from tire wear as having potential widespread serious environmental and health consequences.[2]

Moreover, burning of tires releases these chemicals as air pollutants that can harm first responders and leaves toxic residues that endanger local communities.[128]

End of use

[edit]
Main article: Tire recycling

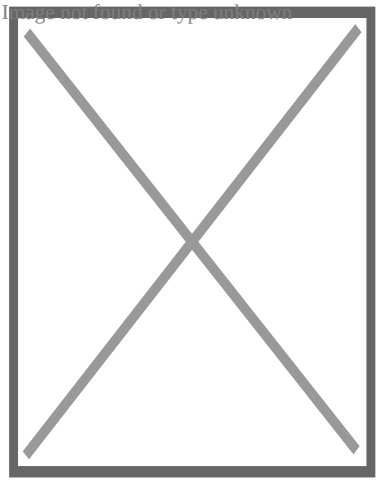


Tires recycled into water tanks on the roof in Cherchen, Xinjiang

Once tires are discarded, they are considered scrap tires. Scrap tires are often re-used for things from bumper car barriers to weights to hold down tarps. Tires are not desired at landfills, due to their large volumes and 75% void space, which quickly consumes valuable space. Rubber tires are likely to contain some traces of heavy metals or other serious pollutants, but these are tightly bonded within the actual rubber compound so they are unlikely to be hazardous unless the tire structure is seriously damaged by fire or strong chemicals.[129] Some facilities are permitted to recycle scrap tires by chipping and processing them into new products or selling the material to licensed power plants for fuel. Some tires may also be retreaded for re-use.

Environmental issues

[edit]


Toxic fumes emerging from a fire at a tire dump.

Americans generate about 285 million scrap tires per year.[130] Many states regulate the number of scrap tires that can be held at any site out of concern with dumping, fire hazards, and mosquitoes. In the past, millions of tires were simply discarded into open fields. Outdoor tire heaps create breeding grounds for mosquitoes, which are a nuisance and may spread disease, since the tires often hold water inside and remain warm enough for mosquito breeding. It also creates a fire hazard. Tires very seldom catch fire inadvertently, requiring a temperature of 400 °C (752 °F) to combust,[131] but once burning in a mass are hard to extinguish, for a large tire pile is a lot of fuel, and water used to douse fires does not adequately penetrate or cool burning tires. Some tire fires have burned for months, sometimes liquefying and releasing hydrocarbons and other contaminants to the ground and even groundwater, and black smoke, an air pollutant that is a hazard to downwind properties, to the air.

The use of scrap tire chips for landscaping has become controversial because of the leaching of metals and other contaminants from the tire pieces. Zinc is concentrated (up to 2% by weight) to levels high enough to be highly toxic to aquatic life and plants.[132] Of particular concern is evidence that some of the compounds that leach from tires into the water contain hormone disruptors and cause liver lesions.[133]

Tires are a major source of microplastic pollution, found in a 2020 study to contribute 78% of the total mass of microplastics found in the ocean.[134][135] The commonly used compound 6PPD-quinone, found entering stormwater runoff via tire-wear particles, has been identified as toxic to coho salmon, brook trout, and rainbow trout.[136]

Retreading

[edit]
Main article: retread

Tires that are fully worn can be retreaded, re-manufactured to replace the worn tread.[137] This is known as retreading or recapping, a process of buffing away the worn tread and applying a new

tread.[138] There are two main processes used for retreading tires, called mold-cure and pre-cure methods. Both processes start with the inspection of the tire, followed by non-destructive inspection method such as shearography[139] to locate non-visible damage and embedded debris and nails. Some casings are repaired and some are discarded. Tires can be retreaded multiple times if the casing is in usable condition. Tires used for short delivery vehicles are retreaded more than long haul tires over the life of the tire body. Casings fit for retreading have the old tread buffed away to prepare for retreading.[140]

During the retreading process, retread technicians must ensure the casing is in the best condition possible to minimize the possibility of a casing failure. Casings with problems such as capped tread, tread separation, irreparable cuts, corroded belts or sidewall damage, or any run-flat or skidded tires, will be rejected. The mold cure method involves the application of raw rubber on the previously buffed and prepared casing, which is later cured in matrices. During the curing period, vulcanization takes place, and the raw rubber bonds to the casing, taking the tread shape of the matrix. On the other hand, the pre-cure method involves the application of a ready-made tread band on the buffed and prepared casing, which later is cured in an autoclave so that vulcanization can occur.[140]

Recycling

[edit]

Tires can be recycled into, among other things, the hot melt asphalt, typically as crumb rubber modifier—recycled asphalt pavement (CRM—RAP),[141][142] and as an aggregate in portland cement concrete.[143] Shredded tires can create rubber mulch on playgrounds to diminish fall injuries.[144] There are some "green" buildings that are being made both private and public buildings that are made from old tires.[145]

The tire pyrolysis method for recycling used tires is a technique that heats whole or shredded tires in a reactor vessel containing an oxygen-free atmosphere and a heat source. In the reactor, the rubber is softened after which the rubber polymers continuously break down into smaller molecules.

Other uses

[edit]

Other downstream uses have been developed for worn-out tires, including:

- *Building elements*: Tires filled with earth have been used as garden containers[146] house foundations,[147] bullet-proof walls[148] and to prevent soil erosion in flood plains.[149] Tire walls are a common feature of motor racing circuits for safety.

- *Recreational equipment*: Used tires are employed as exercise equipment for athletic programs such as American football.[150] One classic conditioning drill that hones players' speed and agility is the "Tire Run" where tires are laid out side by side, with each tire on the left a few inches ahead of the tire on the right in a zigzag pattern. Athletes then run through the tire pattern by stepping in the center of each tire. The drill forces athletes to lift their feet above the ground higher than normal to avoid tripping on the tires.[151] Old tires are sometimes converted into a swing for play.[152]
- *Burning tires as protest*: Protestors, worldwide, have burned tires to create black smoke.[153][154]
- Necklacing is the use of tires to kill people, typically by lynch mobs. A tire is soaked in gasoline, placed around the victim's neck, and set on fire.

Children on a tire swing

- Image not found or type unknown

Children on a tire swing
Burning tires in protest

- Image not found or type unknown

Burning tires in protest

See also

[edit]

- Dry steering
- List of auto parts
- List of inflatable manufactured goods
- Off-road tire
- Outline of tires
- Rubber-tyred metro
- Rubber-tyred trams
- Shinosaur

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Look up ***inner tube***, ***tire***, or ***tyre*** in Wiktionary, the free dictionary.

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- National Highway Traffic Safety Adm "Tire Safety" Brochure (Archived 28 October 2020 at the Wayback Machine)
- U.S. government tire rating and maintenance site

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Tires

Types

- Tubeless tire
- Radial tire
- Low rolling resistance tire
- Run-flat tire
- Michelin PAX System
- Airless tire
- Tweel
- Rain tyre
- Snow tire
- All-terrain tire
- Bar grip
- Knobby tire
- Large tire
- Mud-terrain tire
- Paddle tire
- Orange oil tires
- Whitewall tire
- Aircraft tire
- Tundra tire
- Bicycle tire
- Tubular tire
- Lego tire
- Motorcycle tyre
- Tractor tire
- Racing slick
- Formula One tyres
- Spare tire
- Continental tire

Components

- Bead
- Beadlock
- Tread
- Siping (rubber)
- Valve stem
  - Dunlop valve
  - Presta valve
  - Schrader valve

Attributes	○ Camber thrust ○ Circle of forces ○ Cold inflation pressure ○ Contact patch ○ Cornering force ○ Ground pressure ○ Pacejka's Magic Formula ○ Pneumatic trail ○ Relaxation length ○ Rolling resistance ○ Self aligning torque ○ Slip angle ○ Steering ratio ○ Tire balance ○ Tire load sensitivity ○ Tire uniformity ○ Lateral Force Variation ○ Radial Force Variation ○ Traction (engineering) ○ Treadwear rating
Behaviors	○ Aquaplaning ○ Groove wander ○ Slip (vehicle dynamics) ○ Tramlining
Maintenance	○ Tire maintenance ○ Tire rotation ○ Bicycle pump ○ Central Tire Inflation System ○ Tire mousse ○ Tire-pressure monitoring system ○ Tire-pressure gauge ○ Direct TPMS ○ Bead breaker ○ Tire changer ○ Tire manipulator ○ Tire iron

Life cycle

- Tire manufacturing
- List of tire companies
- Retread
- Waste tires
- Tire recycling
- Tire fire
- Blowout
- Flat tire
- Ozone cracking

Organizations

- European Tyre and Rim Technical Organisation
- Tire Society
- Tire Science and Technology

Identification

- Tire code
- Plus sizing
- Tire label
- Uniform Tire Quality Grading (UTQG)

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Rubber

Chemical types

- Latex
- Natural rubber
- Synthetic rubber
  - Butyl rubber
  - Chloroprene rubber
  - EPDM rubber
  - Nitrile rubber
  - Silicone rubber
  - Styrene-butadiene

Mechanical types

- Cold rubber
- Foam rubber
- Crumb rubber
  - Micronized rubber powder

Additives

- Biodegradable additives
- Filler (materials)
- Plasticizer
- Polymer additive
- Polymer stabilizers

Rubber processing

- Rubber tapping
- Rubber technology
- Vulcanization

Industry

- Bridgestone
- Dunlop
- Goodyear Tire and Rubber Company
- Michelin
- Rubber Board
- Rubber industry in Malaysia
  - Rubber Industry Smallholders Development Authority
- Rubber Manufacturers Association
- United States Rubber Company
- List of tire companies

Products

- Rubber band
- Rubber mulch
- Rubberized asphalt
- Tires
  - codes

Waste

- Airfield rubber removal
- Rubber pollution
  - Dioxins
  - Environmental hazards
  - Great Pacific Garbage Patch
  - Persistent organic pollutant
- Tire-derived fuel
- Tire recycling

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Automotive handling

Main topics	○ Car handling ○ Center of mass ○ Downforce ○ Drifting ○ Electronic Stability Control ○ Fishtailing ○ Inboard brake ○ Oversteer ○ Steering ○ Suspension ○ Tire / Tyre ○ Transaxle ○ Understeer ○ Unsprung mass ○ Vehicle dynamics ○ Weight transfer
Spring types	○ Coil ○ Leaf ○ Pneumatic ○ Torsion

Suspension types	**Dependent**	○ Beam axle ○ De Dion tube
	Semi-independent	○ Twist beam
	Independent	○ Double wishbone (Jaguar IRS) ○ Dubonnet ○ MacPherson strut (Chapman strut) ○ Multi-link ○ Sliding pillar ○ Swing axle ○ Trailing arm (Semi-trailing arm)

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Powertrain

Part of the Automobile series

Automotive engine	○ Diesel engine ○ Electric ○ Fuel cell ○ Hybrid (Plug-in hybrid) ○ Internal combustion engine ○ Petrol engine ○ Steam engine

Transmission

- Automatic transmission
- Chain drive
- Direct-drive
- Clutch
- Constant-velocity joint
- Continuously variable transmission
- Coupling
- Differential
- Direct-shift gearbox
- Drive shaft
- Dual-clutch transmission
- Drive wheel
- Automated manual transmission
- Electrorheological clutch
- Epicyclic gearing
- Fluid coupling
- Friction drive
- Gearshift
- Giubo
- Hotchkiss drive
- Limited-slip differential
- Locking differential
- Manual transmission
- Manumatic
- Parking pawl
- Park-by-wire
- Preselector gearbox
- Semi-automatic transmission
- Shift-by-wire
- Torque converter
- Transaxle
- Transfer box
- Transmission control unit
- Universal joint

Wheels and tires	○ Wheel hub assembly
	○ Wheel
	  ○ Rim
	  ○ Alloy wheel
	  ○ Hubcap
	○ Tire
	  ○ Off-road
	  ○ Racing slick
	  ○ Radial
	  ○ Rain
	  ○ Run-flat
	  ○ Snow
	  ○ Spare
	  ○ Tubeless

Hybrid	○ Electric motor ○ Hybrid vehicle drivetrain ○ Electric generator ○ Alternator

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Automotive design

Part of a series of articles on cars

Body	Framework	○ Backbone chassis
		○ Beltline
		○ Body-on-frame
		○ Bumper
		  ○ Dagmar
		○ Cabrio coach
		○ Chassis
		○ Continental tire
		○ Crumple zone
		○ Fender
		  ○ ponton
		  ○ skirts
		○ Grille
		○ Hood
		  ○ scoop
		  ○ shaker
		○ Monocoque
		○ Overhang
		○ Pillar
		○ Platform
		○ Quarter panel
		○ Roof
		  ○ rack
		○ Spoiler
		○ Stressed member engine
		○ Subframe
		○ Tonneau
		○ Trunk lid

	Compartments	○ Hood/bonnet ○ Trunk/boot/dickie
	Doors	○ Butterfly ○ Canopy ○ Gull-wing ○ Scissor ○ Sliding ○ Suicide ○ Swan
	Glass	○ Glass run channel ○ Greenhouse ○ Opera window ○ Power window ○ Quarter glass ○ Sunroof ○ Windshield/windscreen

	Lighting	○ Automotive light bulb types
		○ Daytime running lamp
		○ Headlamp
		  ○ hidden
		  ○ high-intensity discharge
		  ○ sealed beam
		  ○ trafficators

Exterior equipment	Other elements	○ Horn ○ Side-view mirror ○ power ○ Tow hitch ○ Window deflector
	Legal	○ Registration plate ○ vanity plate ○ Theft ○ Vehicle identification number (VIN)

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Other	○ Yale LUX

About Roadster (car)

This article is about a style of automobile. For other uses of the terms, see Roadster (disambiguation) and Spyder (disambiguation).

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2016 Mazda MX-5

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1931 Ford Model A roadster

A **roadster** (also **spider**, **spyder**) is an open two-seat car with emphasis on sporting appearance or character.[1][2] Initially an American term for a two-seat car with no weather protection, its usage has spread internationally and has evolved to include two-seat convertibles.

The roadster was also a style of racing car driven in United States Auto Club (USAC) Championship Racing, including the Indianapolis 500, in the 1950s and 1960s. This type of racing car was superseded by rear-mid-engine cars.

Etymology

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Early roadster competing for the Vanderbilt Cup

The term "roadster" originates in the United States, where it was used in the 19th century to describe a horse suitable for travelling.[3][4] By the end of the century, the definition had expanded to include bicycles and tricycles.[5] In 1916, the United States Society of Automobile Engineers defined a roadster as: "an open car seating two or three. It may have additional seats on running boards or in rear deck."[6] Since it has a single row of seats, the main seat for the driver and passenger was usually further back in the chassis than it would have been in a touring car.[4][7]: 258 Roadsters usually had a hooded dashboard.[7]: 257

In the United Kingdom, historically, the preferred terms were "open two-seater" and "two-seat tourer".[8][9] Since the 1950s, the term "roadster" has also been increasingly used in the United Kingdom. It is noted that the optional 4-seat variant of the Morgan Roadster would not be technically considered a roadster.[*citation needed*]

The term "spider" or "spyder," sometimes used in names for convertible models, is said to come from before the automobile era. Some 19th-century lightweight horse-drawn phaetons had a small body and large wooden wheels with thin spokes; they were nicknamed "spiders" because of their appearance; the nickname was transferred to sports cars, although they did not look similar.[10]

In 1962, Chevrolet introduced the *Monza Spyder*, a turbocharged version of its Corvair compact, available as a convertible or coupe. Although not a true 2 passenger vehicle, it featured upgraded suspension and other equipment to classify it as a "sporty car."

History

[edit]

Auto racing began with the first earnest contests in 1894 in Europe, and in 1895 in the United States. Some of the earliest race cars were purpose-built or stripped for the greatest speed, with minimal or no bodywork at all, leading to a body style aptly named 'speedster'. The cut-down speedster body-style really took form in the 1900s. After removing most of the body (and fenders), an empty platform on the ladder-frame chassis was mounted with one or two seats, a gas tank, and spare tyres.[11]

American manufacturers Mercer and Stutz started offering ready-made racing speedsters, intentionally built to be driven to race(-track), raced, and driven back by their owner – essentially the first track day cars.[11]

- 1890s to 1920s speedsters
- Ransom Olds' 1896/1897 "Pirate" racer was one of the first speedsters.

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Ransom Olds'
1896/1897 "Pirate" racer
was one of the first
speedsters.

- Barney Oldfield and Henry Ford with Oldfield's 999 speedster, 1902

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Barney Oldfield and Henry Ford with Oldfield's 999 speedster, 1902

- 1909 model T speedster – announced winner of the 1909 Ocean to Ocean race, disqualified becaus

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1909 model T speedster – announced winner of the 1909 Ocean to Ocean race, disqualified because of an engine change

1910 Mercer 35R Raceabout (1912 specimen)

-

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1910 Mercer 35R Raceabout (1912 specimen)

The 1912 Stutz Bear Cat / Bearcat, (1914 shown), available doorless through 1916

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The 1912 Stutz Bear Cat / Bearcat, (1914 shown), available doorless through 1916

The immediate predecessor to the roadster was the runabout, a body style with a single row of seats and no doors, windshield, or other weather protection. Another predecessor was the touring car, similar in body style to the modern roadster except for its multiple rows of seats. By the 1920s roadsters were appointed similarly to touring cars, with doors, windshields, simple folding tops, and side curtains.[4]

Roadster bodies were offered on automobiles of all sizes and classes, from mass-produced cars like the Ford Model T and the Austin 7 to extremely expensive cars like the Cadillac V-16, the Duesenberg Model J and Bugatti Royale.

- 1920s to 1950s roadsters

- 1926 Ford Model T roadster

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1926 Ford Model T
roadster
1932 Duesenberg J Murphy-bodied roadster

-

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1932 Duesenberg J
Murphy-bodied roadster
1937 Delahaye 135MS roadster

-

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1937 Delahaye 135MS
roadster
- 1949 MG TC open two-seater marketed in USA as a roadster

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1949 MG TC open two-
seater marketed in USA
as a roadster

By the 1970s "roadster" could be applied to any two-seater car of sporting appearance or character.[12] In response to market demand they were manufactured as well-equipped as convertibles[13] with side windows that retracted into the doors. Popular models through the 1960s and 1970s were the Alfa Romeo Spider, MGB and Triumph TR4.

- 1950s to 1980s roadsters

1973 MGB

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  1973 MGB
- Alfa Romeo Spider

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Alfa Romeo Spider

- 1983 Mercedes-Benz 380SL

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1983 Mercedes-Benz 380SL
1987 Cadillac Allanté

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  1987 Cadillac Allanté

The highest selling roadster is the Mazda MX-5, which was introduced in 1989.[14][15][16] The early style of roadster with minimal weather protection is still in production by several low-volume manufacturers and fabricators, including the windowless Morgan Roadster, the doorless Caterham 7 and the bodyless Ariel Atom.

- 1990s to present day roadsters
  BMW Z3

- Image not found or type unknown
  BMW Z3

- Pontiac Solstice

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Pontiac Solstice
Mazda MX-5

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Mazda MX-5
Porsche Boxster

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Porsche Boxster
- MG Cyberster

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MG Cyberster

IndyCar roadster layout

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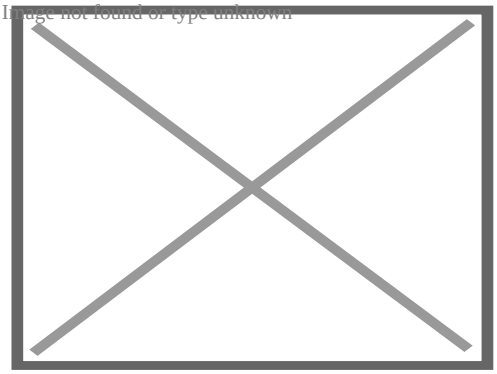

1957 Kurtis Indy roadster

The term *roadster* was used to describe a style of racing cars competing in the AAA/USAC Championship Cars series (the IndyCar equivalents of the time) from 1952 to 1969. The roadster

engine and drive shaft are offset from the centerline of the car. This allows the driver to sit lower in the chassis and facilitates a weight offset which is beneficial on oval tracks.[17]

One story of why this type of racing car is referred to as a "roadster" is that a team was preparing a new car for the Indianapolis 500. They had it covered in a corner of their shop. If they were asked about their car they would try and obscure its importance by saying that it was just their (hot rod) "roadster". After the Indianapolis racer was made public, the "roadster" name was still attached to it.[*citation needed*]

Frank Kurtis built the first roadster to race and entered it in the 1952 Indianapolis 500. It was driven by Bill Vukovich who led for most of the race until a steering failure eliminated him. The Howard Keck owned team with Vukovich driving went on to win the 1953 and 1954 contests with the same car. Bob Sweikert won the 1955 500 in a Kurtis after Vukovich was killed while leading. A. J. Watson,[18] George Salih and Quinn Epperly were other notable roadster constructors. Watson-built roadsters won in 1956, 1959 – 1964 though the 1961 and 1963 winners were actually close copies built from Watson designs. The 1957 and 1958 winner was the same car built by Salih with help by Epperly built with a unique placement of the engine in a 'lay down' mounting so the cylinders were nearly horizontal instead of vertical as traditional design dictated.[19] This gave a slightly lower center of mass and a lower profile.

Roadsters continued to race until the late 1960s, although they became increasingly uncompetitive against the new rear-engined racing cars. The last roadster to complete the full race distance was in 1965, when Gordon Johncock finished fifth in the Wienberger Homes Watson car. The last roadster to make the race was built and driven by Jim Hurtubise in the 1968 race and dropped out early.[20]

Some pavement midget roadsters were built and raced into the early 1970s but never were dominant.[21]

See also

[edit]

- Barchetta, a related two-seater body style designed primarily for racing
- Convertible, the general term to describe vehicles with retractable roofs and retractable side windows
- Roadster utility
- Tonneau cover, a protective cover for the seats in an open car

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Car design

Classification	**By size**	○ Micro ○ Kei ○ Subcompact ○ Supermini ○ Family ○ Compact ○ Mid-size ○ Full-size
	Custom	○ Baja Bug ○ Hot rod ○ Lead sled ○ Lowrider ○ Sandrail ○ T-bucket
	Luxury	○ Compact executive ○ Executive ○ Personal
	Minivan / MPV	○ Compact ○ Leisure ○ Mini
	SUV	○ Compact ○ Crossover (CUV) ○ Mini ○ Coupe SUV
	Sports	○ Grand tourer ○ Hot hatch ○ Muscle ○ Pony ○ Sport compact ○ Sports sedan ○ Super ○ Go-kart
	Other	○ Antique ○ Classic ○ Economy ○ Ute ○ Van ○ Vintage car

Body styles

- 2+2
- Baquet
- Barchetta
- Berlinetta
- Brougham
- Cabrio coach
- Cab over
- Cabriolet / Convertible / Drophead coupe
- Coupe
- Coupé de Ville / Sedanca de Ville
- Coupé utility
- Fastback
- Hardtop
- Hatchback
- Kammback
- Landaulet
- Liftback
- Limousine
- Microvan
- Minibus
- Multi-stop truck
- Notchback
- Panel van
- Phaeton
- Pickup truck
- Quad coupé
- Retractable hardtop
- Roadster / Spider / Spyder
- Runabout
- Saloon / Sedan
- Sedan delivery/Panel van
- Shooting brake
- Station wagon
- Targa top
- Torpedo
- Touring
- Town (Coupé de Ville)
- T-top
- Vis-à-vis

Specialized vehicles	○ All-terrain vehicle ○ Amphibious ○ Connected ○ Driverless (autonomous) ○ Dune buggy ○ Go-kart ○ Gyrocar ○ Pedal car ○ Personal rapid transit ○ Police car ○ Flying car ○ Taxicab ○ Tow truck ○ Voiturette
Propulsion	○ Alternative fuel ○ Autogas ○ Biodiesel ○ Biofuel ○ Biogasoline ○ Biogas ○ Compressed natural gas ○ Diesel ○ Electric (battery ○ NEV) ○ Ethanol (E85) ○ Fossil fuel ○ Fuel cell ○ Fuel gas ○ Natural gas ○ Gasoline / petrol (direct injection) ○ Homogeneous charge compression ignition ○ Hybrid (plug-in) ○ Hydrogen ○ Internal combustion ○ Liquid nitrogen ○ Liquified petroleum gas ○ Steam

Drive wheels	○ Front-wheel ○ Rear-wheel ○ Two-wheel ○ Four-wheel ○ Six-wheel ○ Eight-wheel ○ Ten-wheel ○ Twelve-wheel
Engine position	○ Front ○ Mid ○ Rear
Layout (engine / drive)	○ Front-front ○ Front mid-front ○ Rear-front ○ Front-rear ○ Rear mid-rear ○ Rear-rear ○ Front-four-wheel ○ Mid-four-wheel ○ Rear-four-wheel ○ Dual motor-four-wheel ○ Individual wheel drive
Engine configuration (internal combustion)	○ Boxer ○ Flat ○ Four-stroke ○ H-block ○ Reciprocating ○ Single-cylinder ○ Straight ○ Two-stroke ○ V (Vee) ○ W engine ○ Wankel

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- **Category**
- **Template:EC car classification**

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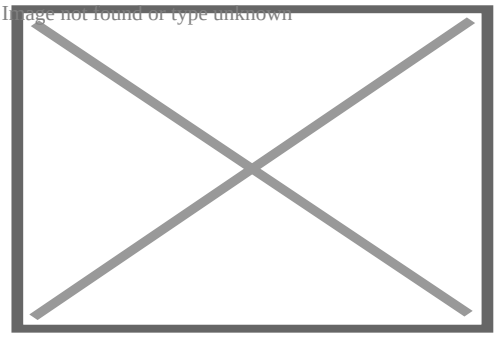

Campagna T-Rex

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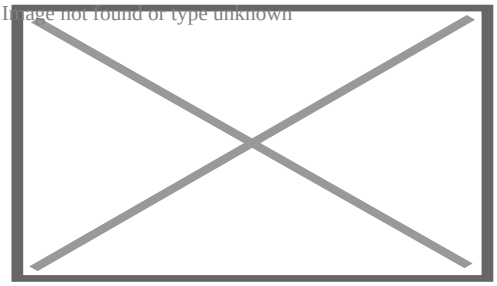

1932 Morgan Aero 2-Seater Sports

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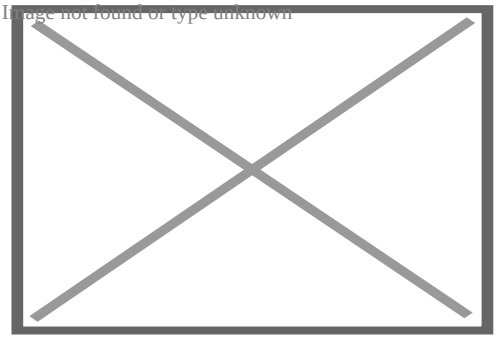

Fuldamobil three-wheeler (Postwar-era Germany)

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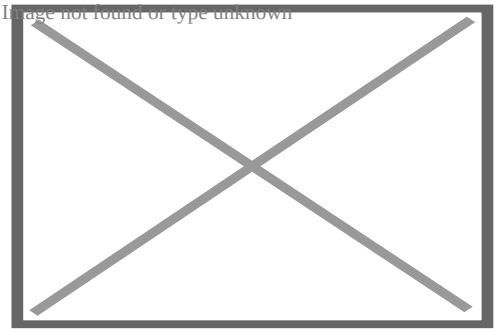

Tricycle truck in Poland (Gorzów Wlkp)

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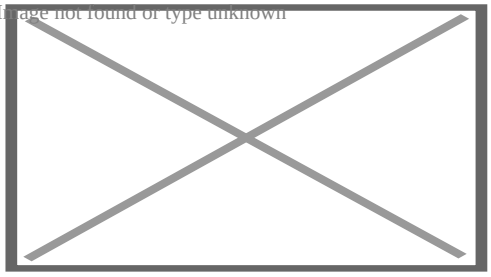

Trihawk, a tadpole-type trike manufactured in California, United States during the 1980s

A **three-wheeler** is a vehicle with three wheels. Some are motorized tricycles, which may be legally classed as motorcycles, while others are tricycles without a motor, some of which are human-powered vehicles and animal-powered vehicles.

Overview

[edit]

Many three-wheelers which exist in the form of motorcycle-based machines are often called trikes and often have the front single wheel and mechanics similar to that of a motorcycle and the rear axle similar to that of a car. Often such vehicles are owner-constructed using a portion of a rear-engine, rear-drive Volkswagen Beetle in combination with a motorcycle front end. Other trikes include All-terrain vehicles that are specially constructed for off-road use.

Three-wheelers can have either one wheel at the back and two at the front (2F1R), (for example: Morgan Motor Company) or one wheel at the front and two at the back (1F2R) (such as the Reliant Robin). Due to better safety when braking, an increasingly popular form is the front-steering "tadpole" or "reverse trike" sometimes with front drive but usually with rear drive. A variant on the 'one at the front' layout was the Scott Sociable, which resembled a four-wheeler with a front wheel missing.[1]

Three-wheelers, including some cyclecars, bubble cars and microcars, are built for economic and legal reasons: in the UK for tax advantages, or in the US to take advantage of lower safety regulations, being classed as motorcycles. As a result of their light construction and potential better streamlining, three-wheeled cars are usually less expensive to operate.[*citation needed*]

Some inexpensive three-wheelers have been designed specifically to improve mobility for disabled people.[2]

Three-wheeler transport vehicles known as auto rickshaws are a common means of public transportation in many countries in the world, and are an essential form of urban transport in many developing countries such as India and the Philippines.

History

[edit]

Early automotive pioneer Karl Benz developed a number of three-wheeled models.[3] One of these, the Benz Patent Motorwagen,[4] is regarded as the first purpose-built automobile. It was made in 1885.

In 1896, John Henry Knight showed a tri-car at The Great Exhibition.[3]

In 1897, Edward Butler made the Butler Petrol Cycle, another three-wheeled car.

A Conti 6 hp Tri-car competed in (but did not complete) a 1907 Peking to Paris race sponsored by a French newspaper, *Le Matin*.[5]

- 1885 Benz Patent Motorwagen

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1885 Benz Patent Motorwagen

- Goliath pickup truck at a meeting for vintage cars in the 1990s

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Goliath pickup truck at a meeting for vintage cars in the 1990s
Davis D-2 Divan, at the National Automotive and Truck Museum, Auburn, Indiana, United States

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Davis D-2 Divan, at the National Automotive and Truck Museum, Auburn, Indiana, United States

Davis 494, at the National Automotive and Truck Museum, Auburn, Indiana, USA

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  Davis 494, at the National Automotive and Truck Museum, Auburn, Indiana, USA
  Velorex was a manufacturing cooperative in Solnice, Czechoslovakia, formed in 1936 to satisfy dem
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  Velorex was a manufacturing cooperative in Solnice, Czechoslovakia, formed in 1936 to satisfy demand for small, inexpensive city cars.
  Mazda T2000 truck 1957–1974, length 6.08 m, width 1.84 m, max speed 100 km/h
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  Mazda T2000 truck 1957–1974, length 6.08 m, width 1.84 m, max speed 100 km/h
  An early Daihatsu Midget, which would serve as the basis for auto rickshaws that proliferate across S
- Image not found or type unknown
  An early Daihatsu Midget, which would serve as the basis for auto rickshaws that

proliferate across
South and
Southeast Asia
- Reliant Robin 3-wheeler car.

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Reliant Robin 3-wheeler
car.
2016 Pembleton Supersports

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2016 Pembleton
Supersports

Configurations

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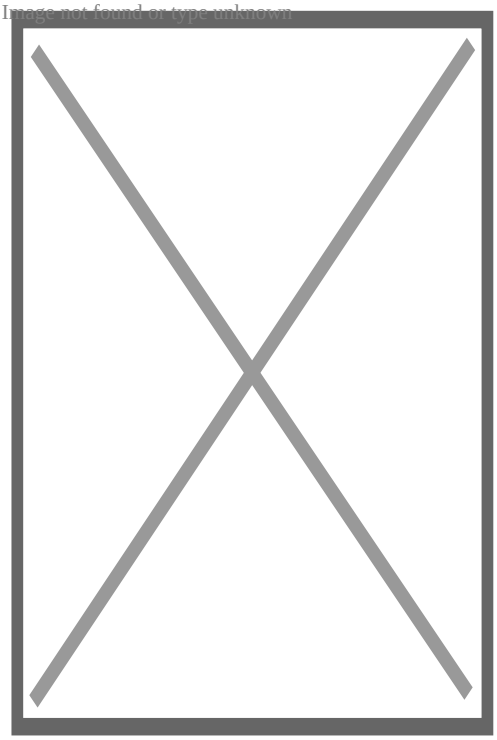

Diagram comparing delta and tadpole layouts

Two front

[edit]

A configuration of two wheels in the front and one wheel at the back presents two advantages: it has improved aerodynamics, and that it readily enables the use of a small lightweight motorcycle powerplant and rear wheel. This approach was used by the Messerschmitt KR200 and BMW Isetta. Alternatively, a more conventional front-engine, front wheel drive layout as is common in four-wheeled cars can be used, with subsequent advantages for transversal stability (the center of mass is further to the front) and traction (two driven wheels instead of one). Some vehicles have a front engine driving the single rear wheel, similar to the rear engine driving the rear wheel. The wheel must support acceleration loads as well as lateral forces when in a turn, and loss of traction can be a challenge.

A new tadpole configuration has been proposed with a rear engine driving the front wheels. This concept (Dragonfly Three Wheeler[6]) claims both stability and traction (two driven wheels), as well as a unique driving experience.

With two wheels in the front (the "tadpole" form or "reverse trike") the vehicle is far more stable in braking turns, but remains more prone to overturning in normal turns compared to an equivalent four-wheeled vehicle, unless the center of mass is lower and/or further forward. Motorcycle-derived designs suffer from most of the weight being toward the rear of the vehicle.[*citation needed*]

For lower wind resistance (which increases fuel efficiency), a teardrop shape is often used.[*citation needed*] A teardrop is wide and round at the front, tapering at the back. The three-wheel configuration allows the two front wheels to create the wide round surface of the vehicle. The single rear wheel allows the vehicle to taper at the back. Examples include the Aptera (solar electric vehicle) and Myers Motors NmG.

Two rear

[edit]

Having one wheel in front and two in the rear for power reduces the cost of the steering mechanism but greatly decreases lateral stability when cornering while braking.

When the single wheel is in the front (the "delta" form, as in a child's pedal tricycle), the vehicle is inherently unstable in a braking turn, as the combined tipping forces at the center of mass from turning and braking can rapidly extend beyond the triangle formed by the contact patches of the wheels. This type, if not tipped, also has a greater tendency to spin out ("swap ends") when handled roughly.[*citation needed*]

Lateral stability[7]

[edit]

The disadvantage of a three-wheel configuration is that lateral stability is lower than with a four-wheeled vehicle.

With any vehicle, an imaginary line can be projected from the vehicles centre of mass to the ground, representing the force exerted on the vehicle by its mass. With the vehicle stationary, the line will be vertical. As the vehicle accelerates, that imaginary line tilts backward, remaining anchored to the centre of mass the point at which the line intersects the ground moves backward. As you brake it moves forward, with cornering it moves sideward. Should the point at which this line intersects the ground move outside of the boundary formed by connecting the tyre contact patches together (a rectangle for a four-wheeled car, or a triangle for a trike) then the vehicle will tip and eventually fall over. This is true for any vehicle.

With all vehicles it is critical that the vehicle should be engineered to slide before this point of instability is reached.

This can be achieved in several ways:

- by placing the center of mass closer to the ground
- by placing the center of mass closer to the axle with two wheels (for three wheelers)
- by increasing the track width
- by limiting the grip provided by the tyres, such that the vehicle loses adhesion before it starts to tip.
- By tilting some or all of the vehicle as it corners.

In the case of a three-wheeled ATV, tipping may be avoided by the rider leaning into turns.

Tilting option

[edit]
Main article: Tilting three-wheeler

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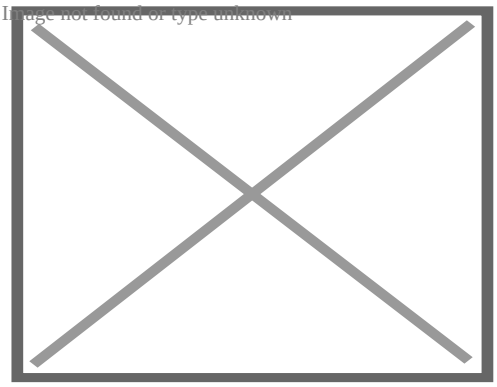

Tripendo recumbent tricycle, a tilting three-wheeler

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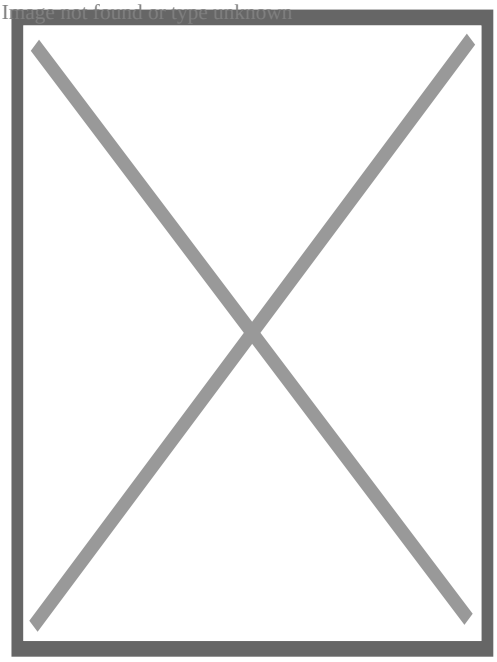


Vandenbrink Carver

To improve stability some three-wheelers are designed to tilt while cornering like a motorcyclist would do. The tilt may be controlled manually, mechanically or by computer.

A tilting three-wheeler's body or wheels, or both, tilt in the direction of the turn. Such vehicles can corner safely even with a narrow track.

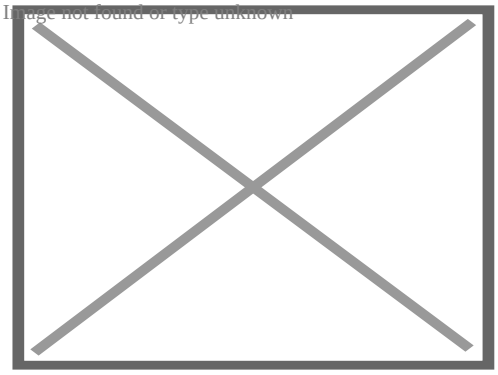
Some tilting three-wheelers could be considered to be forms of feet forward motorcycles or cabin motorcycles or both.

Electric three wheelers

[edit]
Main article: Electric vehicle. See also: Electric tricycle (disambiguation)

Battery-powered three wheelers

[edit]



Toyota i-Road, a three-wheeled battery powered personal mobility vehicle

Main articles: Battery electric vehicle and Electric rickshaw

Three-wheeled battery powered designs include:

- Aptera (solar electric vehicle)
- Arcimoto
- CityEl
- Commuter Cars Tango
- Cree SAM
- ElectraMeccanica SOLO
- Myers Motors NmG (formerly Corbin Sparrow)
- Nobe GT100
- Toyota i-Road
- Triac
- Vanderhall Edison 2
- ZAP Xebra
- EWheels EW 36(mobility scooter)

Solar-powered three wheelers

[edit]
Main article: Solar vehicle

Here are three notable examples of solar-powered three wheelers; two race cars, the Infinium and the Sky Ace TIGA, and a vehicle planned for production, the Aptera.

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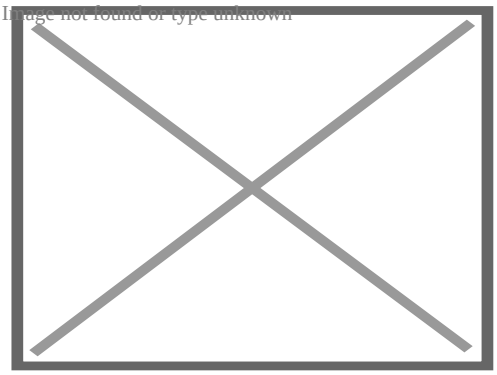

Infinium, winner of 2010 American Solar Challenge

The Infinium, built by the University of Michigan Solar Car Team, came in 3rd place in the 2009 World Solar Challenge held in Australia, and won the 2010 American Solar Challenge.

Ashiya University's Sky Ace TIGA achieved 91.332 kilometres per hour (56.751 mph) at Shimojishima Airport, in Miyakojima, Okinawa, Japan, to win the Guinness World Record, on 20 August 2014.[8] It took the record from another three-wheeler, Sunswift IV, designed and built at the University of New South Wales in Australia,[9] by a margin of almost 3 km/h.

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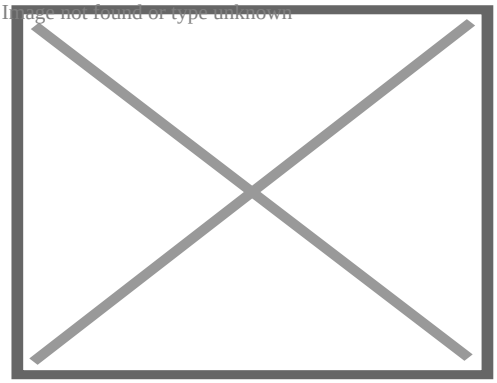
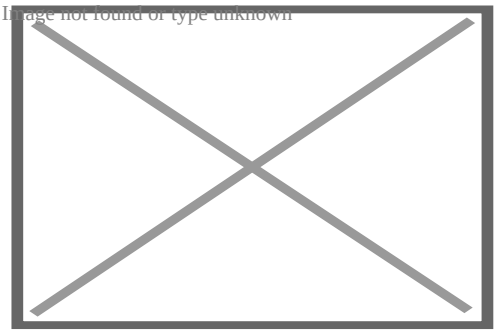


Solar panels on the hood, roof, dashboard and hatch of the Aptera EV

The Aptera solar electric vehicle[10] uses a tadpole layout and is being designed to have a top speed of over 100 mph. The Aptera uses 42 KW in-wheel electric motors[11] and can be ordered with two (front-wheel drive) or three (all-wheel drive) motors. The Aptera's roof and dashboard, and optionally its hood and hatch, are fitted with solar panels, with the full compliment being designed to add a range of up to 40 miles per day and 11,000 miles per year in the sunniest climates. First customer availability is planned for before the end of 2024.[12]

Steam-powered three wheelers

[edit]



Cugnot's *fardier à vapeur*, as preserved at the Musée des Arts et Métiers, Paris, France

Main articles: Steam tricycle and Steamroller

The world's first full-size self-propelled land vehicle was a three-wheeler. French Army Captain Nicolas-Joseph Cugnot's 1770 *fardier à vapeur* (steam dray), a steam tricycle with a top speed of around 3 km/h (2 mph), was intended for hauling artillery.[13]

Another of the earliest preserved examples is the Long steam tricycle, built by George A. Long around 1880 and patented in 1883,[14][15] now on display at the Smithsonian Institution.

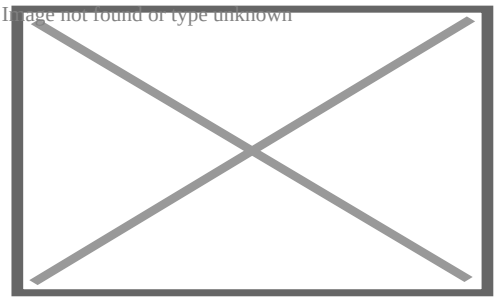
Wind-powered three wheelers

[edit]

The Whike is a recumbent tricycle with a sail, made in the Netherlands.

All-terrain vehicles

[edit]
Further information: All-terrain vehicle § Three-wheeled ATVs



Honda, Suzuki and Yamaha all-terrain vehicles

Due to the incidence of injuries and deaths related to their use, a 10-year ban, entirely voluntary for manufacturers, was placed on the sale of new three-wheeled all-terrain vehicles in the United States in January 1988.[*citation needed*] More injuries were sustained by riders by not applying a proper riding technique, and lack of wearing proper safety gear such as helmets and riding boots. In a search conducted by the Consumer Product Safety Commission, it was determined that "no inherent flaw was found in the three wheel design".[*citation needed*]

Registration

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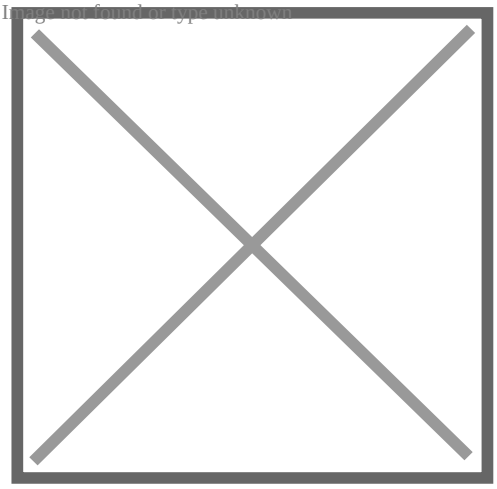

Bond Bug at Silverstone

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The examples and perspective in this section **may not represent a worldwide view of the subject**. You may improve this section, discuss the issue on the talk page, or create a new section, as appropriate. *(October 2015) (Learn how and when to remove this message)*

In the U.S, the National Highway Traffic Safety Administration defines and regulates three-wheeled vehicles as motorcycles.[16] However, in 2015 a bill was introduced in Congress that would prevent some three wheeled vehicles from being classified as motorcycles in the United States, instead creating a new classification for "autocycles".[17][18]

Driver's license and registration requirements vary on a state-by-state basis. Some states require drivers of three wheeled vehicles to have a motorcycle license and register the vehicle as a motorcycle. Some states, including Virginia, Kansas, and Indiana, classify some three wheeled vehicles as autocycles. Virginia defines an autocycle as "a three-wheeled motor vehicle that has a steering wheel and seating that does not require the operator to straddle or sit astride and is manufactured to comply with federal safety requirements for motorcycles."[19] Indiana defines it as "a three (3) wheeled motor vehicle in which the operator and passenger ride in a completely or partially enclosed seating area that is equipped with:(1) a rollcage or roll hoops; (2) safety belts for each occupant; and (3) antilock brakes;and is designed to be controlled with a steering wheel and pedals."[20] In other jurisdictions, such as British Columbia, Canada, and Connecticut, a three-wheeled vehicle with an enclosed passenger compartment or partially enclosed seat is considered an automobile.[*citation needed*]

Examples

[edit]

Two front wheels

[edit]

Name	Country	Years manufactured	Comments
Léon Bollée Voiturette	France	1895–?	
TriPodCars[21] Tripod 1	Australia	2012–?	400 kg Reverse Trike, Bandit 1250, ZX14R (200+ hp) and EV
Berkeley Cars Berkeley T60	England	1959	
Egg	Switzerland	1896–99	
Advance 6 hp air-cooled Tri Car and 9 hp water-cooled Tri Car[22]	England	1902–12	
Humber Tricar[23][24]	England	1904	
Riley Olympia Tricar [25]	England	1904	[26]
Mars Carette[27]	England	1904–05	Mars Motors Co existed in Finchley, London, White and Poppe water-cooled engine, Single-cylinder, 3.3 kW
Lagonda Tricar[28]	England	1904–07	total production: 69 cars
Anglian	England	1905–07	
Armadale	England	1906–07	
Ranger Cub	England	1970–1980	Reverse Trike/Tadpole, A-Series engine 848-1275cc
Morgan V-Twin and F-Series	England	1911–39, 1932–52	Morgan Super Sports 2-Seater 1937
American Tri-Car	United States	1912	
Birmingham Small Arms Company Three Wheeler	England	1929–36	1100cc engine[29]
Zaschka	Germany	1929	Folding three-wheeler: Zaschka Three-wheeler 1929
Dymaxion car	United States	1933	Concept car designed by Buckminster Fuller
Mathis VEL 333	France	1946	3 seats, flat-twin front engine, aluminium body, production less than 10 units

Fend Flitzer	Germany	1948 - 1951	1 seat, Messerschmitt kabinenroller precursor, production about 250 units
1951 Hoffmann	Germany	1951	2 seats, aluminium body, engine mounted on the rear wheel steering pivot
Velorex Oskar and other models	Czechoslovakia	1951–71	Originally with leather bodies
Isetta	UK	1957–62	Three-wheeled version of the Isetta built in the UK to take advantage of tax and licensing regulations
Scootacar	UK	1957–64	
Messerschmitt KR175	Germany	1953–55	
Messerschmitt KR200	Germany	1955–64	
Peel P50	Isle of Man	1963–64	Smallest production car ever built
HM Vehicles Free-way	United States	1979–82	
Campagna T-Rex	Canada	1996–present	
Malone Car Company F1000|Skunk SS|TAZR	United Kingdom	1999–present	High-power internal combustion and pure electric versions released November 2010
Cree SAM	Switzerland	2001	Electric, only 80 produced
Myers Motors NmG ("No more Gas")	United States	2006–present	Single-occupant all-electric plug-in
BRP Can-Am Spyder RoadsterCan-Am Spyder Roadster	Canada	2007–present	The Can-Am Spyder is a three-wheeled motorcycle manufactured by Bombardier Recreational Products.
Brudeli 645L	Norway	2008–	
Moonbeam	United States	2008–present	100 mpg DIY, fabric-covered car based on parts from two Honda 150cc motorscooters[30]
Triac	United States	2009–2011	Electric, never entered production
XR-3 Hybrid	United States	Plans–2008, Kit–2009	Front 3-cylinder diesel (125 mpg), rear electric 40 mile range (220 mpg when used as a hybrid)[31]
Aptera (solar electric vehicle)	United States	2022 planned	Solar-powered Electric
Triton Trike	United States	2000–present	Gas-powered, 42+ mpg, front-wheel drive, custom builds and kits available

Nobe GT100	Estonia & United States	2021 planned	Electric, powered at all 3 wheels
Polaris Slingshot	United States	2015–present	
Vanderhall Laguna Roadster	United States	2016–2018	Exotic Auto-cycle, mono-aluminum chassis, carbon fiber body, 200 HP, 1550 pounds dry weight, side-by-side seating, fwd. 1.4 liter turbo GM power plant. 6 speed Automatic with paddle shift option. Manufactured by Vanderhall Motor Works in Provo, Utah U.S.A
Vanderhall Venice	United States	2017–present	The mainstay of the Vanderhall line up, the Venice brings the soul of roadster motoring while extending effortless performance in kind.[32]
Vanderhall Carmel	United States	2020–present	The Vanderhall Carmel brings more luxury and convenience to the Carmel lineup. With provisions to accommodate a removable capshade, the Carmel promises additional class and comfort for your journey.[33]
Vanderhall Edison	United States	2020–present	The Edison2: A fully electric roadster that combines refined and eye-catching design while maintaining classic, elegant lines. Unplug and play has been redefined [34]
Elio Motors	Shreveport, LA, United States	Awaiting funding	Two passenger fully enclosed cockpit with car controls
Girfalco Azkarra	Canada	2017	All-electric two-passenger three-wheeled vehicle, possibly the quickest three-wheeler
Go3Wheeler	United States	2014	single person three wheeler
Corbin Sparrow			
Piaggio MP3			
Tri-Magnum	United States		Tilting 3-wheeler capable of seating two people.[35]
Volkswagen GX3			
Morgan 3-Wheeler	England	2012–present	The power train is a 1983cc ‘V-twin’ fuel injected engine mated to a Mazda 5 speed (and reverse) gearbox
Fuel Vapours Alé	Canada	2005–present	Prototype. Gets 92 mpg.
Arcimoto FUV	United States	2019–present	Two passenger all-electric, 102 mile range City
Fiberfab Scarab STM	United States	1976	Kit car with canopy door manufactured by Fiberfab

Bricklin 3EV	United States	Planned	Two passenger electric vehicle from Malcolm Bricklin.[36]

Two rear wheels

[edit]

Name	Country	Years manufactured	Comments
Apino	Brazil	unknown	Mini Truck
Benz Patent Motorwagen	Germany	1886–93	
Eco-Fueler	USA	2009–2011	2 seater built in Oregon.[37]
La Va Bon Train	France	1904–10	50–100 believed built
Davis D-2 Divan	United States	1947–48	about 13–17 built, including the 494, a Jeep-like military vehicle[38]
Scammell Scarab	England	1948–67	
Autoette	United States	1948–70	
Daihatsu Bee	Japan	1951–1952	
Daihatsu Midget	Japan	1957–72	
Mazda T-2000	Japan	1957–74	
Mazda K360	Japan	1959–69	
Mazda T600	Japan	1959–71	
Kia K-360	South Korea	1962–1973	Kia's first truck (OEM Mazda K-360)
Kia T-1500	South Korea	1963–?	1484 cc, 60 hp, four cylinder and a maximum load of 1.5 tons. (OEM Mazda T-1500)
Kia T-600	South Korea	1969–1974	577cc, 20 HP and 500 kg load. Top speed of 75 km/h. 7726 produced (OEM Mazda T-600)
Kia T-2000	South Korea	1967–1981	1985 cc, 81 hp, four cylinder and a maximum load of 2 tons. 15952 produced (OEM Mazda T-2000)
Piaggio Ape	Italy	1948–present	
Electra-King	United States	1964?–1980s?	Two-seater electric car[39]
Bond 875	England	1965–70	
Bond Bug	England	1970–74	

Reliant Robin	England	1973–81, 1989–2002	
Reliant Regal	England	1953–1973	An example of this vehicle is the iconic van belonging to Del Boy and Rodney Trotter in the long-running BBC sitcom Only Fools and Horses, though it is often incorrectly referred to as a Reliant Robin.
GM Lean Machine[40][41]	United States	1980s	Tilt, concept car[42]
TriVette	United States	1974–1976	
Twike	Germany	1995–present	Electric-human-power hybrid, developed in Switzerland
ZAP Xebra	United States	2006–2009	electric power
eTuk	United States	2014–	re-designed tuk tuk for the US Market, including an all-electric motor[43]
Snyder ST600-c	United States	2011–2012	Imported by Snyder Technologies / Wildfire Motors, this is a rebrand of the Fulu Motors ?????, Fulu Jinjunma in English. Referred to as the 09 golden horse internally.
Carver	Netherlands	2007–2009	Tilt
CityEl	Denmark		Mini-El, City-El
CLEVER			
Harley-Davidson Servi-Car	United States	1932-1973[44]	
Harley-Davidson Tri Glide	United States	since 2009	

See also

[edit]

- Four-wheeler

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[edit]

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41.606342917118, -87.909382977642
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41.588263444146, -87.97398929193
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41.619926653045, -87.892455610928
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Frequently Asked Questions

How often should I change the engine oil in my ATV?

You should change the engine oil in your ATV every 100 hours of operation or at least once a year, whichever comes first.

What is the recommended tire pressure for my ATV?

The recommended tire pressure for your ATV can be found in the owners manual, but it typically ranges between 3 to 7 PSI, depending on the model and tire type.

How frequently should I clean and lubricate the drive chain on my ATV?

Clean and lubricate the drive chain on your ATV after every ride or at least once a week if you use it regularly to prevent wear and tear.

When should I replace the air filter in my ATV?

Replace the air filter in your ATV every 25 hours of operation or more frequently if you ride in dusty conditions to maintain optimal engine performance.

How often should I check and adjust the brake system on my ATV?

Check and adjust the brake system on your ATV before every ride to ensure proper function and safety, and perform a thorough inspection every 100 hours or annually.

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