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Design and Analysis of Two Wheeler Disk Brake

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Abstract

SCOPE Design and development of a front suspension system that is less complicated, less expensive, and more environmentally friendly is a goal of this project. Additionally, the project's goal is to conduct a comprehensive evaluation of the two systems, including a look at their viability in diverse riding environments around the nation. Inventive terrain An alternative front suspension system that is capable of handling and working more effectively than the standard fork system is the goal of this innovation. This also seeks to provide a system that is both simple and cost-effective. USED TOOL Simulation and model-based reasoning APPLICATION OF THE SOLIDWORKS METHOD • The design is based on the previous models that were in use and the research that was done on them. The Hub Center Steering and the double link were the subject of much research. Special joints and a big curved swing arm are required for Hub Center Steering, making it more difficult and more costly. The double mechanism was also thoroughly researched. More exact geometry was required to achieve what we were looking for in motion, which made it more difficult to get the motion we were looking for. Dynamic environments make this more challenging.

SCOPE

Project objective: The project aims at design and development of a front suspension system which should have least complexity, less material, economic and alternative to conventional fork type motorcycle suspension. The project also aims at in-depth analysis of both the systems and also the feasibility of the same under various riding conditions in the country.

INTRODUCTION

The beauty of the bicycle has always been in the simplicity and seemingly unchanging perfection of its original design — a design that has changed remarkably little in a hundred years. Truly new bicycle designs are very rare. But one that rethought the design from the ground up was the recumbent bicycle. You've probably seen at least one of these eccentric contraptions whiz by, its rider practically flat on his back. They are stable, fast, and shock the back and stress the midsection far less than traditional bikes. The only fly in the ointment is that they are complicated and start at about $1,200 for a stripped-down model.

When you look at the elaborate design of a manufactured recumbent bicycle, you'd never think you could build a better one, much less build one for almost nothing. Yet that's exactly what Jeff Setaro did. His ingenious idea is beautiful, both in its simplicity and its economy

My search for a low-cost recumbent bicycle began after reading an article on the health problems that conventional bicycle seats can cause.

TECHNOLOGY

Hard ware components:

A bicycle wheel is a wheel, most commonly a wire wheel, designed for a bicycle. A pair is often called a wheelset, especially in the context of ready built "off the shelf" performance-oriented wheels. Bicycle wheels are typically designed to fit into the frame and fork via dropouts, and hold bicycle tires.

Hub

A hub is the center part of a bicycle wheel. It consists of an axle, bearings and a hub shell. The hub shell typically has two machined metal flanges to which spokes can be attached. Hub shells can be one-piece with press-in cartridge or free bearings or, in the case of older designs, the flanges may be affixed to a separate hub shell.

Axle

The axle is attached to dropouts on the fork or the frame. The axle can attach using a: Quick release - a lever and skewer that pass through a hollow axle designed to allow for installation and removal of the wheel without any tools (found on most modern road bikes and some mountain bikes).

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Nut - the axle is threaded and protrudes past the sides of the fork/frame. (often found on track, fixed gear, single speed, BMX and inexpensive bikes) Bolt - the axle has a hole with threads cut into it and a bolt can be screwed into those threads. (found on some single speed hubs, Cannondale Lefty hubs)

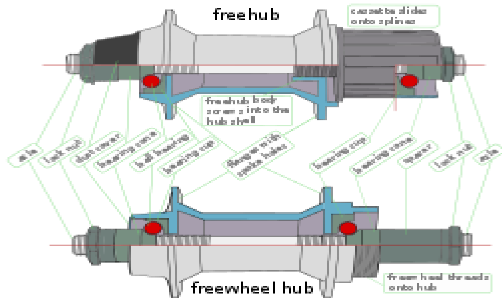
Thru axle - a removable axle with a threaded end that is inserted through a hole in one fork leg, through the hub, and then screwed into the other fork leg. Some axles have integrated cam levers that compress axle elements against the fork leg to lock it in place, while others rely on pinch bolts on the fork leg to secure it. Diameters for front thru axles include 20 mm, 15 mm, 12 mm, and 9 mm. Rear axles typically have diameters of 10 or 12 mm. Most thru axles are found on mountain bikes, although increasingly disc-braked cyclocross and road bikes are using them. Thru axles repeatably locate the wheel in the fork or frame, which is important to prevent misalignment of brake rotors when using disc brakes. Unlike other axle systems (except Lefty), the thru axle is specific to the fork or frame, not the hub. Hubs/wheels do not include axles, and the axle is generally supplied with the fork or frame. Adapters are usually available to convert wheels suitable for a larger thru axle to a smaller diameter, and to standard 9mm quick releases. This allows a degree of re-use of wheels between frames with different axle specifications.

Female axle - hollow center axle, typically 14, 15, 17, or 20 mm in diameter made of chromoly and aluminum, with two bolts thread into on either side.[2] This design can be much stronger than traditional axles, which are commonly only 8 mm, 9 mm, 9.5 mm, or 10 mm in diameter (found on higher end BMX hubs and some mountain bike hubs)

Since the 1980s, bicycles have adopted standard axle spacing: the hubs of front wheels are generally 100 mm wide fork spacing, road wheels with freehubs generally have a 130 mm wide rear wheel hub. Mountain bikes have adopted a 135 mm rear hub width which allows clearance to mount a brake disc on the hub or to decrease the wheel dish for a more durable wheel. Freeride and downhill are available with both 142 and 150 mm spacing.

Bearings

The bearings allow the hub shell (and the rest of the wheel parts) to rotate freely about the axle. Most bicycle hubs use steel or ceramic ball bearings. Some hubs use serviceable "cup and cone" bearings, whereas some use pre-assembled replaceable "cartridge" bearings.



Freehub vs freewheel hub

A "cup and cone" hub contains loose balls that contact an adjustable 'cone' that is screwed onto the axle and a 'race' that is pressed permanently into the hub shell. Both surfaces are smooth to allow the bearings to roll with little friction. This type of hub can be easily disassembled for lubrication, but it must be adjusted correctly; incorrect adjustment can lead to premature wear or failure.

In a "cartridge bearing" hub, the bearings are contained in a cartridge that is shaped like a hollow cylinder where the inner surface rotates with respect to the outer surface by the use of ball bearings. The manufacturing tolerances, as well as seal quality, can be significantly superior to loose ball bearings. The cartridge is pressed into the hub shell and the axle rests against the inner race of the cartridge. The cartridge bearing itself is generally not serviceable or adjustable; instead the entire cartridge bearing is replaced in case of wear or failure.

Gears

The rear hub has one or more methods for attaching a gear to it.

Freehub–- The mechanism that allows the rider to coast is built into the hub. Splines on the freehub body allow a single sprocket or, more commonly, a cassette containing several sprockets to be slid on. A lock ring then holds the cog(s) in place. This is the case for most modern bicycles.

Freewheel – The mechanism that allows the rider to coast is not part of the hub, it is contained in a separate freewheel body. The hub has threads that allow the freewheel body to be screwed on, and the freewheel body has threads or splines for fitting sprockets, or in the case of most single speed freewheels an integral sprocket. This style of hub was used before the freehub became practical.

Track sprocket – There is no mechanism that allows the rider to coast. There are two sets of threads on the

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hub shell. The threads are in opposite directions. The inner (clockwise) set of threads is for a track sprocket and the outer (counter-clockwise) set is for a reverse threaded lock ring. The reverse threads on the lock ring keep the sprocket from unscrewing from the hub, which is otherwise possible when slowing down.

Flip-flop hub – Both sides of the hub are threaded, allowing the wheel to be removed and reversed in order to change which gear is used. Depending on the style of threads, may be used with either a single-speed freewheel or a track sprocket.

Internal geared hub – the mechanism to provide multiple gear-ratios is contained inside the shell of the hub. Many bicycles with three-speed internally geared hubs were built in the last century. This is an extremely robust design, although for a larger number of gear ratios, it becomes heavier than more modern designs of multi-gear-ratio arrangements. Modern hubs are available from three-speed to 14 speeds or a continuously variable transmission hub, in the case of the inci.

Rim

Westwood rim as fitted to vintage roadster bicycles with rod/ stirrup brakes, today being used in contemporary "drum brake" traditional utility bicycles

The rim is commonly a metal extrusion that is butted into itself to form a hoop, though may also be a structure of carbon fiber composite, and was historically made of wood. Some wheels use both an aerodynamic carbon hoop bonded to an aluminum rim on which to mount conventional bicycle tires.

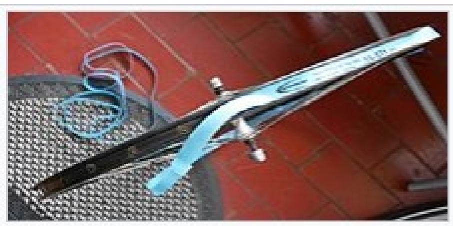
Metallic bicycle rims are now normally made of aluminium alloy, although until the 1980s most bicycle rims - with the exception of those used on racing bicycles - were made of steel[9] and thermoplastic.

Rims designed for use with rim brakes provide a smooth parallel braking surface, while rims meant for use with disc brakes or hub brakes sometimes lack this surface. The Westwood pattern rim was one of the first rim designs, and rod-actuated brakes, which press against the inside surface of the rim were designed for this rim. These rims cannot be used with caliper rim brakes.

The cross-section of a rim can have a wide range of geometry, each optimized for particular performance goals. Aerodynamics, mass and inertia, stiffness, durability, tubeless tire compatibility, brake compatibility, and cost are all considerations. If the part of the cross-section of the rim is hollow where the spokes attached, as in the Sprint rim pictured, it is described as box-section or double-wall to distinguish it from single-wall rims such as the Westwood rim pictured.[10] The double wall can make the rim stiffer. Triple-wall rims have additional reinforcement inside the box-section.

Aluminum rims are often reinforced with either single eyelets or double eyelets to distribute the stress of the spoke. A single eyelet reinforces the spoke hole much like a hollow rivet. A double eyelet is a cup that is riveted into both walls of a double-walled rim.

Clincher rims



Fitting rim tape around 26 inch wheel (MTB). Rim tape protects the bicycle wheel's inner tube from spoke holes, which will puncture the tube if exposed inside the rim.

Most bicycle rims are "clincher" rims for use with clincher tires. These tires have a wire or aramid (Kevlar or Twaron) fiber bead that interlocks with flanges in the rim. A separate airtight inner tube enclosed by the rim supports the tire carcass and maintains the bead lock. If the inner part of the rim where the inner tube fits has spoke holes, they must be covered by a rim tape or strip, usually rubber, cloth, or tough plastic, to protect the inner tube.

An advantage of this system is that the inner tube can be easily accessed in the case of a leak to be patched or replaced.

The ISO 5775-2 standard defines designations for bicycle rims. It distinguishes between

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Straight-side (SS) rims

Crochet-type (C) rims

Hooked-bead (HB) rims

Traditional clincher rims were straight-sided. Various "hook" (also called "crochet") designs emerged in the 1970s to hold the bead of the tire in place,[11][12] allowing high (6–10 bar, 80–150 psi) air pressure.

Spokes

The rim is connected to the hub by several spokes under tension. Original bicycle wheels used wooden spokes that could be loaded only in compression, modern bicycle wheels almost exclusively use spokes that can only be loaded in tension. There are a few companies making wheels with spokes that are used in both compression and tension.[16]

One end of each spoke is threaded for a specialized nut, called a nipple, which is used to connect the spoke to the rim and adjust the tension in the spoke. This is normally at the rim end. The hub end normally has a 90 degree bend to pass through the spoke hole in the hub, and a head so it does not slip through the hole.

Double-butted spokes have reduced thickness over the center section and are lighter, more elastic, and more aerodynamic than spokes of uniform thickness. *Single-butted* spokes are thicker at the hub and then taper to a thinner section all the way to the threads at the rim.[17] *Triple-butted* spokes also exist and are thickest at the hub, thinner at the threaded end, and thinnest in the middle.[18]

Apart from tubeless wheels, which do not need them, tubed bicycle wheels require rim tapes or strips, a flexible but tough liner strip (usually rubber or woven nylon or similar material) attached to the inner circumference of the wheel to cover the ends of the nipples. Otherwise, the nipple ends wear a hole in the tube causing a flat tire.

In 2007, Mavic introduced their R-Sys, a new bicycle spoke technology that allows the spokes to be loaded in both tension and compression. This technology is promised to allow for fewer spokes, lower wheel weight and inertia, increased wheel stiffness, with no loss of durability. However, in 2009 Mavic recalled R-Sys front wheels due to spoke failures leading to collapse of the entire wheel.[19]

Cross section

Spokes are usually circular in cross-section, but high-performance wheels may use spokes of flat or oval cross-section, also known as bladed, to reduce aerodynamic drag. Some spokes are hollow tubes.[17]

Material

The spokes on the vast majority of modern bicycle wheels are steel or stainless steel. Stainless steel spokes are favored by most manufacturers and riders for their durability, stiffness, damage tolerance, and ease of maintenance.[20] Spokes are also available in titanium,[20] aluminum,[21] or carbon fiber.[20]

Number of spokes

Conventional metallic bicycle wheels for single rider bikes commonly have 28, 32 or 36 spokes, while wheels on tandems have as many as 40 or 48 spokes to support the weight of an additional rider. BMX bikes commonly have 36 or 48 spoke wheels. Lowrider bicycles may have as many as144 spokes per wheel. Wheels with fewer spokes have an aerodynamic advantage, as the aerodynamic drag from the spokes is reduced. On the other hand, the reduced number of spokes results in a larger section of the rim being unsupported, necessitating stronger and often heavier rims. Some wheel designs also locate the spokes unequally into the rim, which requires a stiff rim hoop and correct tension of the spokes. Conventional wheels with spokes distributed evenly across the circumference of the rim are considered more durable and forgiving to poor maintenance. The more general trend in wheel design suggests technological advancement in rim materials may result in further reduction in the number of spokes per wheel.

Lacing

Lacing is the process of threading spokes through holes in the hub and rim[25] so that they form a spoke pattern.[26] While most manufacturers use the same lacing pattern on both left and right sides of a wheel, it is becoming increasingly common to find specialty wheels with different lacing patterns on each side. A spoke can connect the hub to the rim in a radial fashion, which creates the lightest and most aerodynamic wheel.[26] However, to efficiently transfer torque from the hub to the rim, as with driven wheels or wheels with drum or disc brakes, durability dictates that spokes be mounted at an angle to the hub flange up to a "tangential lacing pattern" to achieve maximum torque capability (but minimum vertical wheel stiffness).[26] Names for various lacing patterns

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are commonly referenced to the number of spokes that any one spoke crosses. Conventionally laced 36- or 32-spoke wheels are most commonly built as a cross-3 or a cross-2, however other cross-numbers are also possible. The angle at which the spoke interfaces the hub is not solely determined by the cross-number; as spoke count and hub diameter will lead to significantly different spoke angles. For all common tension-spoke wheels with crossed spokes, a torque applied to the hub will result in one half of the spokes - called "leading spokes" tensioned to drive the rim, while other half - "trailing spokes" are tensioned only to counteract the leading spokes. When forward torque is applied (i.e., during acceleration), the trailing spokes experience a higher tension, while leading spokes are relieved, thus forcing the rim to rotate. While braking, leading spokes tighten and trailing spokes are relieved. The wheel can thus transfer the hub torque in either direction with the least amount of change in spoke tension, allowing the wheel to stay true while torque is applied.

Wheels that are not required to transfer any significant amount of torque from the hub to the rim are often laced radially.[26] Here, the spokes leave the hub at perpendicular to the axle and go straight to the rim, without crossing any other spokes - e.g., "cross-0". This lacing pattern can not transfer torque as efficiently as tangential lacing. Thus it is generally preferred to build a crossed-spoke wheel where torque forces, whether driving or braking, issue from the hub. Where braking is concerned, the older-style caliper devices that contact the rims to apply braking force are not affected by lacing patterns in this way because braking forces are transferred from the calipers directly to the rim, then to the tires and then to the roadway. Disc brakes, however, transfer their force to the roadway via the spokes from the disc's mounting point on the hub and are therefore affected by the lacing pattern in a manner similar to that of the drive system.

Adjustment ("truing")

There are three aspects of wheel geometry which must be brought into adjustment in order to true a wheel. "Lateral truing" refers to elimination of local deviations of the rim to the left or right of center. "Vertical truing" refers to adjustments of local deviations (known as hop) of the radius, the distance from the rim to the center of the hub. "Dish" refers to the left-right centering of the plane of the rim between the lock nuts on the outside ends of the axle. This plane is itself determined as an average of local deviations in the lateral truing.[27] For most rim-brake bicycles, the dish will be symmetrical on the front wheel. However, on the rear wheel, because most bicycles accommodate a rear sprocket (or group of them), the dishing will often be asymmetrical: it will be dished at a deeper angle on the non-drive side than on the drive side.

In addition to the three geometrical aspects of truing, the overall tension of the spokes is significant to the wheel's fatigue durability, stiffness, and ability to absorb shock. Too little tension leads to a rim that is easily deformed by impact with rough terrain. Too much tension can deform the rim, making it impossible to true, and can decrease spoke life. Spoke tensiometers are tools which measure the tension in a spoke. Another common method for making rough estimates of spoke tension involves plucking the spokes and listening to the audible tone of the vibrating spoke. The optimum tension depends on the spoke length and spoke gauge (diameter). Tables are available online which list tensions for each spoke length, either in terms of absolute physical tension, or notes on the musical scale which coincide with the approximate tension to which the spoke should be tuned. In the real world, a properly trued wheel will not, in general, have a uniform tension across all spokes, due to variation among the parts from which the wheel is made.

Finally, for best, long-lasting results, spoke wind-up should be minimized. When a nipple turns, it twists the spoke at first, until there is enough torsional stress in the spoke to overcome the friction in the threads between the spoke and the nipple. This is easiest to see with bladed or ovalized spokes, but occurs in round spokes as well. If a wheel is ridden with this torsional stress left in the spokes, they may untwist and cause the wheel to become out of true. Bladed and ovalized spokes may be held straight with an appropriate tool as the nipple is turned. The common practice for minimizing wind-up in round spokes is to turn the nipple past the desired orientation by about a quarter turn, and then turn it back that quarter turn.[28]

In wheel truing, all these factors must be incrementally brought into balance against each other. A commonly recommended practice is to find the worst spot on the wheel, and bring it slightly more into true before moving on to the next worst spot on the wheel.

"Truing stands" are mechanical devices for mounting wheels and truing them. It is also possible to true a wheel while it is mounted on the bike: brake pads or some other fixed point may be used as a reference mark, however this is less accurate.

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Nipples

At one end of each spoke is a specialized nut, called a nipple, which is used to connect the spoke to the rim and adjust the tension in the spoke. The nipple is usually located at the rim end of the spoke but on some wheels is at the hub end to move its weight closer to the axis of the wheel, reducing the moment of inertia.

Until recently there were only two types of nipples: brass and aluminum (often referred to as "alloy"). Brass nipples are heavier than aluminum, but they are more durable. Aluminium nipples save weight, but they are less durable than brass and more likely to corrode.

A nipple at the rim of a wheel usually protrudes from the rim towards the center of the wheel, but in racing wheels may be internal to the rim, offering a slight aerodynamic advantage.

Nipples

Alternatives

A wheel can be formed in one piece from a material such as thermoplastic (glass-filled in this case), carbon fiber or aluminium alloy. Thermoplastic is commonly used for inexpensive BMX wheels. They have a low maximum tire pressure of 45 psi (3bars or atmospheres). Carbon fiber is typically] used for high-end aerodynamic racing wheels.

Disc wheels

Disc wheels are designed to minimize aerodynamic drag. A full disc is usually heavier than traditional spoke wheels, and can be difficult to handle when ridden with a cross wind. For this reason, international cycling organizations often ban disc wheels or limit their use to the rear wheel of a bicycle. However, international triathlon federations were (and are still) less restrictive and is what led to the wheels' initial usage growth in popularity in the 1980s.

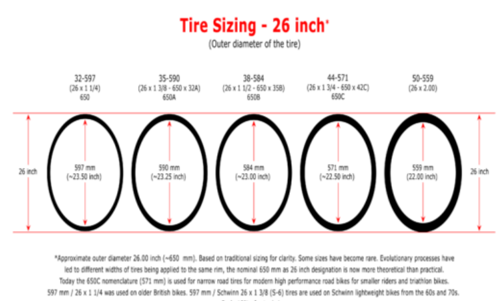
A disc wheel may simply be a fairing that clips onto a traditional, spoke wheel, addressing the drag that the spokes generate by covering them; or the disc can be integral to the wheel with no spokes inside. In the latter case carbon fiber is the material of choice. A spoke wheel with a disc cover may not be legal under UCI Union Cycliste Internationale rules because it is a non-structural fairing but are again acceptable under ITU International Triathlon Union rules.

A compromise that reduces weight and improves cross wind performance has a small number (three or four) tension-compression spokes molded integral to the rim – also typically carbon fiber.

Road/racing bicycle wheels

A Campagnolo rear wheel with "G3" triplet spoke lacing. There are 18 tangential spokes on the right side, but only 9 radial on the left. Picture also shows a 10-speed cassette

For roadbicycle racing performance there are several factors which are generally considered the most important:



Semi-aerodynamic and aerodynamic wheelsets are now commonplace for road bicycles. Aluminum rims are still the most common, but carbon fiber is also becoming popular. Carbon fiber is also finding use in hub shells to reduce weight; however, because of the hub's proximity to the center of rotation reducing the hub's weight has less inertial effect than reducing the rim's weight.

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Semi-aerodynamic and aerodynamic wheelsets are characterized by greater rimdepth, which is the radial distance between the outermost and the innermost surfaces of the rim; a triangular or pyramidal cross-section; and by fewer numbers of spokes, or no spokes at all—with blades molded of composite material supporting the rim. The spokes are also often flattened in the rotational direction to reduce wind drag. These are called *bladed spokes*. However, semi-aerodynamic and aerodynamic wheelsets tend to be heavier than more traditional spoked wheelsets due to the extra shapings of the rims and spokes. More importantly, the rims must be heavier when there are fewer spokes, as the unsupported span between spokes is greater. A number of wheel manufacturers are now producing wheels with roughly half the spokes of the highest performance traditional wheel from the 1980s, with approximately the same rotational inertia and less total weight. These improvements have been made possible primarily through improved aluminium alloys for the rims.

Most clincher carbon fiber wheelsets, such as those made by Zipp and Mavic, still use aluminum parts at the clinching part of the rim. An increased number of all-carbon rims, such as Campagnolo Hyperon Ultra Clincher, Viva v8 wheels, Bontrager's Carbon Clincher wheels, DT Swiss RRC1250, Corima Winium and Aero (also tubeless, see below) and Lightweight Standard C wheelsets are now available.

Application			
28 x 1¼	700	647mm	Old English and Dutch Bicycles / Old track bicycles

Rolling resistance

There are a number of variables that determine rolling resistance: tire tread, width, diameter, tire construction, tube type (if applicable), and pressure are all important.

Smaller diameter wheels, all else being equal, have higher rolling resistance than larger wheels. "Rolling resistance increases in near proportion as wheel diameter is decreased for a given constant inflation pressure."

Rotating mass

Due to the fact that wheels rotate as well as translate (move in a straight line) when a bicycle moves, more force is required to accelerate a unit of mass on the wheel than on the frame. To accelerate a wheel, total wheel mass matters less than the moment of inertia, which describes the inertial effect of the mass resisting acceleration (inertia) based on its location with respect to the axis of rotation (the center of the wheel hub/axle). In wheel design, reducing the rotational inertia has the benefit of more responsive, faster-accelerating wheels. To accomplish this, wheel designs are employing lighter rim materials, moving the spoke nipples to the hub or using lighter nipples such as aluminum. Note however that rotational inertia is a factor only during acceleration (and deceleration/braking). At constant speed, aerodynamics are a significant factor. For climbing, total mass remains important. See Bicycle performance for more detail.

Dish

The hub flanges of modern tension-spoked bicycle wheels are always spaced wider than where the spokes attach to the rim. When viewed in cross section, the spokes and hub form a triangle, a structure that is stiff both vertically and laterally. In three dimensions, if the spokes were covered, they would form two cones or "dishes". The greater the separation between the hub flanges, the deeper the dishes, and the stiffer and stronger the wheel can be laterally. The more vertical the spokes, the shallower the dish, and the less stiff the wheel will be laterally.

The dishes on each side of a wheel are not always equal. The cogset (freewheel or cassette) of a rear wheel and disc brake rotors, if installed, takes up width on the hub, and so the flanges may not be located symmetrically about the center plane of the hub or the bike. Since the rim must be centered, but the hub flanges are not, there is a difference in dish between the two sides. Such an asymmetrical wheel is called a "dished" wheel.

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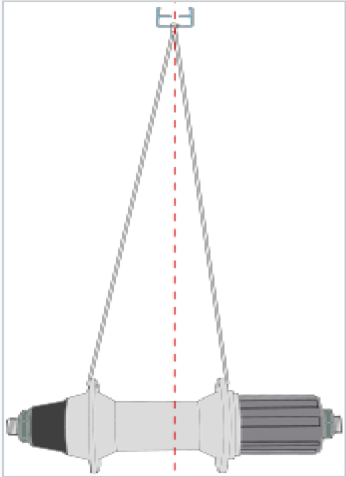

Diagram showing the difference in length and angle of spokes.

The side of the wheel with less dish has slightly shorter but significantly higher-tensioned spokes than the side with more dish. Several different techniques have been tried to minimize this spoke asymmetry. In addition to modified hub geometry, some rims have off-center spoke holes, and the mounting of common J-bend spokes at the hub flange can be altered "inboard" or "outboard".

A truing stand or a dishing gauge, can be used to measure the position of the rim relative to the hub. Thus "dishing" is also used to describe the process of centering the rim on the hub, even in the case of symmetrical wheels.[50]

Stiffness

The stiffness of a bicycle wheel can be measured in three primary directions: radial, lateral, and torsional. The radial stiffness is primarily a measure of how well the wheel absorbs bumps from the surface on which it rolls. Lateral stiffness, especially of the front wheel influences the handling of the bicycle. Torsional, or tangential stiffness is a measure of how well the wheel transmits propulsive and braking forces, if applied at the hub, as in the case of hub or disc brakes.

Several factors affect these stiffnesses to varying degrees. These include wheel radius, rim bending and torsional stiffness, number of spokes, spoke gauge, lacing pattern, hub stiffness, hub flange spacing, hub radius. In general lateral and radial stiffness decreases with the number of spoke crossings and torsional stiffness increases with the number of spoke crossings. One factor that has little influence on these stiffnesses is spoke tension.

Too much spoke tension, however, can lead to catastrophic failure in the form of buckling. The "most significant factor affecting the lateral spoke system stiffness" is the angle between the spokes and the wheel midplane. Thus any change that increases this angle, such as increasing the width of the hub, while keeping all other parameters constant, increases the resistance to buckling.

TECHNICAL ASPECTS:

Bicycle rims and tires came in many different types and sizes before efforts were made to standardize and improve wheel/tire compatibility. The International Organization for Standardization (ISO) and the European Tyre and Rim Technical Organisation (ETRTO) define a modern, unambiguous system of sizing designations and measurement procedures for different types of tires and rims in international standard ISO 5775. For example:

For wired-edge tires the ISO designation lists the width of the inflated tire and the "bead-seat diameter", both in millimeters and separated by a hyphen: 37-622. The bead seat diameter (BSD) is the diameter of the surface of the rim upon which the tire bead sits.

For rims the ISO designation lists the rim's bead seat diameter and the rim's inner width, both in millimeters and separated by a cross, along with a letter code for the rim type (e.g., "C" = Crochet-type): 622x19C

In practice, most tires (and inner tubes) sold today carry, in addition to the modern ISO 5775-1 designation, some historic size markings, for which no officially maintained definition currently exists, but which are still widely used:

an old French tire designation that was based on the approximate outer diameter of the inflated tire in millimeters: 700×35 C.

an old British inch-based designation: 597 mm (26 × 1¼), 590 mm (26 × 1⅜), 630 mm (27 × 1¼), and 635 mm (28 × 1½)

Which designation is most popular varies with region and type of bicycle. For a comprehensive equivalence table between old and new markings, see the ISO

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5775 article, the table in Annex A of the ISO 5772 standard, as well as Tire Sizing by Sheldon Brown.

Most road and racing bicycles today use 622 mm diameter (700C) rims, though 650C rims are popular with smaller riders and triathletes. The 650C size has the ISO diameter size of 571 mm. Size 650B is 584 mm and 650A is 590 mm. 650B is being promoted as a 'best of both worlds' size for mountain biking.[39] Most adult mountain bikes use 26 inch wheels. Smaller youth mountain bikes use 24 inch wheels. The larger 700C (29 inch) wheels have enjoyed some recent popularity among off-road bicycle manufacturers. The formerly popular (27 inch) wheel size is now rare. These rims are slightly larger in diameter than 700C wheels and are non-compatible with bicycle frames and tires designed for the 700C standard.

Children's bicycles are commonly sized primarily based on wheel diameter rather than seat tube length (along the rider's inseam) dimension. Thus, a wide range of small bike wheels are still found, ranging from 239 mm (9.4 in) diameter to 400 mm (16 in).

Smaller wheel sizes are also found on folding bicycles to minimise the folded size. These range from 16-inch diameter (e.g. Brompton) through 20 inches (e.g. Bike Friday) up to even 26 inches.

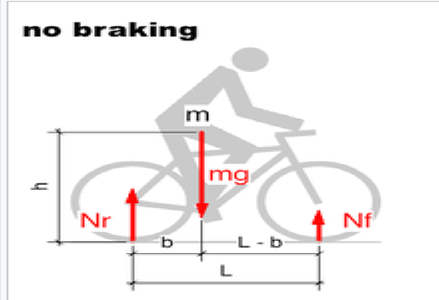
Wheel rims also come in a variety of widths to provide optimum performance for different uses. High performance road racing rims are narrow, 18 mm or so. Wider touring or durable off-road tires require rims of 24 mm wide or more.[40]

26 inch

The common "26-inch" wheel used on mountain bikes and beach cruisers is an American size using a 559 mm rim, traditionally with hooked edges.

Braking according to ground conditions

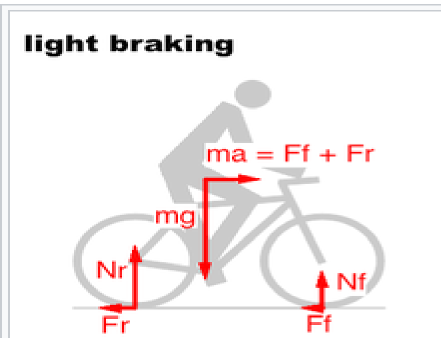
When braking, the rider in motion is seeking to change the speed of the combined mass *m* of rider plus bike. This is a negative acceleration *a* in the line of travel. $F=ma$, the acceleration *a* causes an inertial forward force *F* on mass *m*. The braking *a* is from an initial speed *u* to a final speed *v*, over a length of time *t*. The equation $u - v = at$ implies that the greater the acceleration the shorter the time needed to change speed. The stopping distance *s* is also shortest when acceleration *a* is at the highest possible value compatible with road conditions: the equation $s = ut + 1/2\ at^2$ makes *s* low when *a* is high and *t* is low.



With no braking, on a bicycle *m* is usually approximately over the bottom bracket

How much braking force to apply to each wheel depends both on ground conditions and on the balance of weight on the wheels at each instant in time. The total braking force cannot exceed the gravity force on the rider and bike times the coefficient of friction μ of the tire on the ground. $mg\mu >= Ff + Fr$. A skid occurs if the ratio of either *Ff* over *Nf* or *Fr* over *Nr* is greater than μ, with a rear wheel skid having less of a negative impact on lateral stability.

When braking, the inertial force *ma* in the line of travel, not being co-linear with *f*, tends to rotate *m* about *f*. This tendency to rotate, an overturning moment, is resisted by a moment from *mg*.



In light braking, *Nr* is still significant so *Fr* can contribute towards braking. *Nr* decreases as *ma* increases

Taking moments about the front wheel contact point at an instance in time:

When there is no braking, mass *m* is typically above the bottom bracket, about 2/3 of the way back

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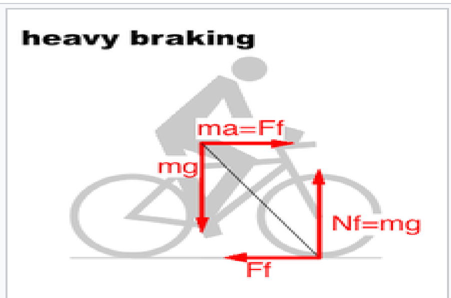
between the front and rear wheels, with *Nr* thus greater than *Nf*.

In constant light braking, whether because an emergency stop is not required or because poor ground conditions prevent heavy braking, much weight still rests on the rear wheel, meaning that *Nr* is still large and *Fr* can contribute towards *a*.

As braking *a* increases, *Nr* and *Fr* decrease because the moment *mah* increases with *a*. At maximum constant *a*, clockwise and anti-clockwise moments are equal, at which point *Nr* = 0. Any greater *Ff* initiates a stoppie.



At maximum braking, *Nr* = 0

At maximum braking, *Nr* = 0

Downhill it is much easier to topple over the front wheel because the incline moves the line of *mg* closer to *f*. To try to reduce this tendency the rider can stand back on the pedals to try to keep *m* as far back as possible.

When braking is increasing the center of mass *m* may move forward relative to the front wheel, as the rider moves forward relative to the bike, and, if the bike has suspension on the front wheel, the front forks compress under load, changing the bike geometry. This all puts extra load on the front wheel.

At the end of a brake maneuver, as the rider comes to a halt, the suspension decompresses and pushes the rider back.

Values for μ vary greatly depending on a number of factors:

The material that the ground or road surface is made of.

Whether the ground is wet or dry.

The smoothness or roughness of the ground.

The firmness or looseness of the ground.

The speed of the vehicle, with friction reducing above 30 mph (50kph).

Whether friction is rolling or sliding, with sliding friction at least 10% below peak rolling friction.

Braking

Most of the braking force of standard upright bikes comes from the front wheel. As the analysis above shows, if the brakes themselves are strong enough, the rear wheel is easy to skid, while the front wheel often can generate enough stopping force to flip the rider and bike over the front wheel. This is called a *stoppie* if the rear wheel is lifted but the bike does not flip, or an *endo* (abbreviated form of *end-over-end*) if the bike flips. On long or low bikes, however, such as cruiser motorcycles[90] and recumbent bicycles, the front tire will skid instead, possibly causing a loss of balance. Assuming no loss of balance, it is possible to calculate optimum braking performance depending on the bike's geometry, the location of center of gravity of bike and rider, and the maximum coefficient of friction.[91]

In the case of a front suspension, especially telescoping fork tubes, the increase in downward force on the front wheel during braking may cause the suspension to compress and the front end to lower. This is known as *brake diving*. A riding technique that takes advantage of how braking increases the downward force on the front wheel is known as *trail braking*.

Braking technique

Expert opinion varies from "use both levers equally at first" to "the fastest that you can stop any bike of normal wheelbase is to apply the front brake so hard that the rear wheel is just about to lift off the ground," depending on road conditions, rider skill level, and desired fraction of maximum possible deceleration.

Front wheel braking

The limiting factors on the maximum deceleration in front wheel braking are:

the maximum, limiting value of static friction between the tire and the ground, often between 0.5 and 0.8 for rubber on dry asphalt,

the kinetic friction between the brake pads and the rim or disk, and

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pitching or looping (of bike and rider) over the front wheel.

For an upright bicycle on dry asphalt with excellent brakes, pitching will probably be the limiting factor. The combined center of mass of a typical upright bicycle and rider will be about 60 cm (24 in) back from the front wheel contact patch and 120 cm (47 in) above, allowing a maximum deceleration of 0.5 *g* (5 m/s^2 or 16 ft/s^2). If the rider modulates the brakes properly, however, pitching can be avoided. If the rider moves his weight back and down, even larger decelerations are possible.

Front brakes on many inexpensive bikes are not strong enough so, on the road, they are the limiting factor. Cheap cantilever brakes, especially with "power modulators", and Raleigh-style side-pull brakes severely restrict the stopping force. In wet conditions they are even less effective. Front wheel slides are more common off-road. Mud, water, and loose stones reduce the friction between the tire and trail, although knobby tires can mitigate this effect by grabbing the surface irregularities. Front wheel slides are also common on corners, whether on road or off. Centripetal acceleration adds to the forces on the tire-ground contact, and when the friction force is exceeded the wheel slides.

Working process:

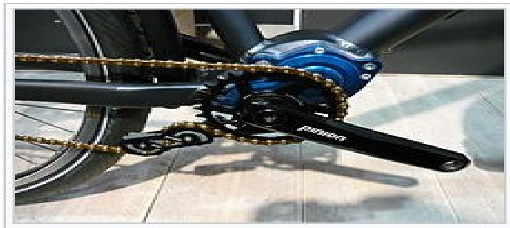
When the Ordinary was first introduced there was no such thing as a chain drive or a rear drive. The only way to power a bicycle was by direct drive- pedalling by crank arms affixed to the front wheel. There were some variations of this including treadle designs and such.

This instructable is intended to help you learn how to rebuild a front wheel hub on any bicycle. Any avid cyclist should know how to rebuild a wheel hub. Rebuilding the hub on your own also saves the time and money that many people spend at bike stores, when they can do the maintenance themselves. Rebuilding a wheel is a very simple procedure, and it can be done with very simple tools. If you can turn a wrench, you can rebuild a bike wheel hub. Plus, it takes no more than 30 minutes.

All modern bicycle wheel hubs are the same. One can use the same tools on a mountain bike wheel hub just as he/she can on a road bike wheel hub. In this demonstration, I will show you how to rebuild the front wheel hub on a road bike. There are many ways to rebuild a wheel hub. I discovered this method on my own, using simple, nonspecialized tools.

Pedaling power is delivered to the rear wheel using the usual right-hand-side crankset/chain/cassette arrangement. On the *non*-drive side of the rear hub, however, is a cog that drives quite a long chain. That chain stretches from the rear hub up to a set of small cogs located near the top of the down tube. A much shorter chain goes from those cogs to yet another cog, mounted on an arm that extends from the head tube. A flexible universal joint connects that cog to another one, that is mounted on an arm that is attached to (and that turns with) the front fork. Finally, a *third* chain extends from the cogs/universal joint down to a drive cog on the front wheel hub.

It's a set-up that's difficult to describe, and that Arte unfortunately hasn't provided any close-ups of, but it's what allows the system to work even when the front wheel is turned to one side.



A bicycle gearbox with chain tensioner

A cyclist's legs produce power optimally within a narrow pedalling speed range. Gearing is optimized to use this narrow range as best as possible. Bicycle drivetrain systems have been developed to convert speed and torque by a variety of methods.

Before the development of chain drive the only way to get a better distance rolled per pedal stroke was having a larger wheel diameter or really circumference. This meant that the fastest cyclists had long legs that could reach the pedals on the largest wheels.

With improvements in chain drives the safety bicycle (double diamond frame) became the norm. The use of a large chain ring on the crank coupled to a small cog at the rear wheel gave more effective ratios of distance/cadence.

Why we are using front wheel:

For several reasons we designed our bikes to be motor-assisted at the front wheel, as opposed to the rear wheel or at the crank. One reason is better weight distribution. With a rear mounted battery (or seat-tube mounted one for that matter), having the motor on the front wheel helps make the bike feel

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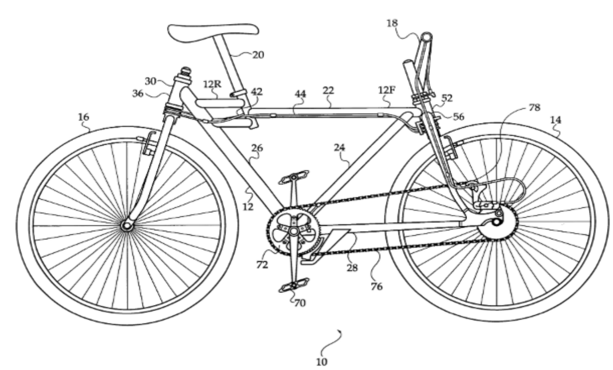
more stable…not only when you are riding it, but also when you are walking it along.

Another benefit is that a front wheel motor allows us to use an internally geared hub in place of a derailleur on the rear wheel. A third reason (and this one is not very commonly known, in fact I have never heard or seen anyone else talk about it) is that it enables much enhanced stability, particularly when negotiating soft or loose ground. On very soft ground the stabilizing effect of small bursts of power from the throttle is quite amazing.

This stability stems from the fact that a motor- driven front wheel always “pulls” in the direction it is pointing, whereas, when driven by force from a rear wheel (as in conventional bike or rear wheel drive electric) “steering” the front wheel to maintain balance can cause it to “plow” sideways instead of rolling in the direction it is pointed. If you have experienced the difference between pushing a heavy wheelbarrow over soft ground vs pulling it, then you have experienced a similar difference (albeit stemming from a slightly different fundamental mechanism).



ADVANTAGES:

Simple is good. This is very low maintenance as it shares the strain on the bike between the front wheel (motor power) and rear wheel (human power and rider weight).

The consequences of climate change and a lack of space in large cities will give rise to a renaissance of cycling. Bicycles need little room to operate; the necessary infrastructure is much cheaper compared to what is required for cars.

Bicycles also satisfy a basic human need for individual mobility. If you commute by car, you have probably noticed that only one person usually occupies a vehicle. Many commuters are already switching to the more economical two-wheeler and the trend is on the up.

I'm wondering if turning a bicycle into a two wheel drive locomotive will offer any mechanical advantage to the system. I just wrote about Tretta AWD bicycles that have the rear wheel connected to the front wheel through an assembly of 3 chain drives.

the weight of the front wheel+power transmission components that would need to be rotated by hand for steering the bicycle would be more, meaning a little more difficult steering).

I think if a mechanical design can reduce the efforts required to drive a bicycle, we'd solve world's energy problems to a great extent.

DIS ADVANTAGES:

Front end of the bicycle becomes heavier, reducing choice of front forks and making it a little harder to lift up a curb.

the chain connecting to the sprocket near the handle-bar, might interfere with the movement of the rider's legs.

since there are three chain drives, the rider's effort might increase, due to the excess moment of inertia.

if the chain is to the right hand side then a tension will be observed while turning to the left, also due to the turning the length of the chain will have to be increased, which in turn will decrease power transmitted.

I own two front drive ebikes and a rear drive. I don't consider any of the three less safe than the others, after maybe 5,000 miles.

You have a lot of pieces to this puzzle. The pedal assist is going to supply power whether you really want it to apply power in certain situations or not. The brakes are going to cut off power and maybe lock the wheel(s). In slides you rarely want to lock the brakes.

The rear wheel is basically locked into the frame. The front wheel is designed to turn, and making the front wheel the power wheel means any turning can be magnified by the motor. In deep gravel, which is great practice, you can see and feel the wheel turning and coming over. You have to fix that. You are either (1) going straight, (2)in a controlled turn, or (3)in a turn where the wheel is going to get very unstable,

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sometimes very fast. You always want to be in number one or number two.

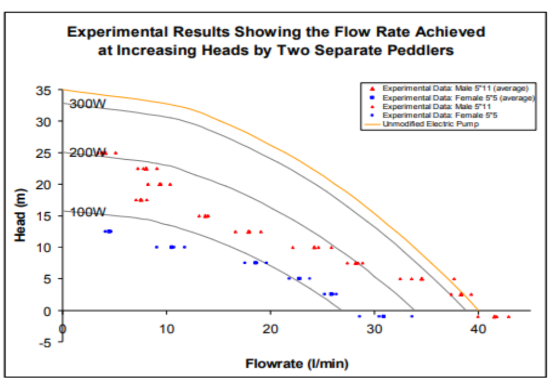
Future scope:

The bicycle has continued to evolve ever since its origins in Karl Drais' workshop. Over the years, the two-wheeled machine has adapted to social preferences and needs. It has gone through many transformations: It has been a flashy new invention with a giant front wheel, a military transporter, an off-road adventurer, an aerodynamic high-speed racer and now, a motorized, multipurpose vehicle that carries people or goods. Charles Darwin would have had fun analyzing the bicycle's various evolutionary phases.

Legend has it that the the bicycle was invented in response to a sociohistorical problem. A volcanic eruption in 1815 in what is present-day Indonesia led to a global climate disaster.

RESULT

shows that the male peddler was able to pump to the maximum testing head (25m) with a flow rate of around 4 l/min. However, the female peddler was less powerful and could only reach 12.5m. At ground level, the male and female peddlers generated flow rates of around 40 and 30 l/min respectively. At a moderate pumping elevation (10m) the peddlers achieved flow rates of around 25 and 10 l/min respectively. The pump affinity laws detailed in Equations 7.1, 7.2 and 7.3 were used to generate the predicted pump performance curves for the pump with 100, 200 and 300W input power.



CONCLUSION

He likened the front wheel of a bicycle to the casters of a shopping cart, which can be rotated to follow the flow of traffic. The point where the front wheel makes contact with the ground on a bicycle may operate as a caster since it is normally 5-10 centimetres behind the steering axis. The path refers to this distance. While a bike with too much trail was too stable to ride, a bike with negative trail was a death trap that would send you flying the instant you let go of the handlebars, Jones found.

He came to the conclusion that the caster effect is what prevents a bicycle from falling over as it begins to tumble. Having a bike's self-stability explained only by the caster trail, Jones believed. It was one of his greatest achievements, according to his book, released 40 years later. A new title for him had been bestowed upon him: "Father of contemporary bicycle philosophy."

With a throttle and pedelec, this is an extremely powerful motor Only a 200-watt device, yet it can reach 35 kilometres per hour on the throttle alone. There's a 1.5-second wait when you start pedalling, but once you get going, it's a lot of fun in the dry.

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