Differential diagram

The type of part-time system typically found on four-wheel-drive pickups and older SUVs works like this: The vehicle is usually rear-wheel drive. The transmission hooks up directly to a transfer case. From there, one driveshaft turns the front axle, and another turns the rear axle. When four-wheel drive is engaged, the transfer case locks the front driveshaft to the rear driveshaft, so each axle receives half of the torque coming from the engine. At the same time, the front hubs lock. The front and rear axles each have an open differential. Although this system provides much better traction than a two-wheel-drive vehicle, it has two main drawbacks. We've already discussed one of them: It cannot be used on-road because of the locked transfer case. The second problem comes from the type of differentials used: An open differential splits the torque evenly between each of the two wheels it is connected to see How Differentials Work for more details. If one of those two wheels comes off the ground, or is on a very slippery surface, the torque applied to that wheel drops to zero. Because the torque is split evenly, this means that the other wheel also receives zero torque. So even if the other wheel has plenty of traction, no torque is transferred to it. The animation below shows how a system like this reacts under various conditions. Animation of a basic system encountering various combinations of terrain. This vehicle gets stuck when two of its wheels are on the ice. Previously, we said that the best four-wheel-drive system will send exactly the right amount of torque to each wheel, the right amount being the maximum torque that won't cause that tire to slip. This system rates fairly poorly by that criterion. It sends to both wheels the amount of torque that won't cause the tire with the least traction to slip. There are some ways to make improvements to a system like this. Replacing the open differential with a limited-slip rear differential is one of the most common ones -- this makes sure that both rear wheels are able to apply some torque no matter what. Another option is a locking differential , which locks the rear wheels together to ensure that each one has access to all of the torque coming into the axle, even if one wheel is off the ground -- this improves performance in off-road conditions. In the next section, we'll take a look at what could be the ultimate four-wheel-drive system: the one on the Hummer. Prev NEXT. Four-wheel Drive Differential. This content is not compatible on this device. We will start with the simplest type of differential, called an open differential. First we'll need to explore some terminology: The image below labels the components of an open differential. When a car is driving straight down the road, both drive wheels are spinning at the same speed. The input pinion is turning the ring gear and cage, and none of the pinions within the cage are rotating -- both side gears are effectively locked to the cage. Note that the input pinion is a smaller gear than the ring gear; this is the last gear reduction in the car. You may have heard terms like rear axle ratio or final drive ratio. These refer to the gear ratio in the differential. If the final drive ratio is 4. See How Gears Work for more information on gear ratios. In the figure above, you can see that the pinions in the cage start to spin as the car begins to turn, allowing the wheels to move at different speeds. The inside wheel spins slower than the cage, while the outside wheel spins faster. Prev NEXT. Open Differentials. This content is not compatible on this device. A differential is a gear train with three shafts that has the property that the rotational speed of one shaft is the average of the speeds of the others, or a fixed multiple of that average. The following description of a differential applies to a traditional rear-wheel-drive car or truck with an open or limited slip differential combined with a reduction gearset using bevel gears these are not strictly necessary â€" see spur-gear differential :. Thus, for example, if the car is making a turn to the right, the main ring gear may make 10 full rotations. During that time, the left wheel will make more rotations because it has farther to travel, and the right wheel will make fewer rotations as it has less distance to travel. The sun gears which drive the axle half-shafts will rotate at different speeds relative to the ring gear one faster, one slower by, say, 2 full turns each 4 full turns relative to each other , resulting in the left wheel making 12 rotations, and the right wheel making 8 rotations. The rotation of the ring gear is always the average of the rotations of the side sun gears. This is why if the driven roadwheels are lifted clear of the ground with the engine off, and the drive shaft is held say, leaving the transmission in gear preventing the ring gear from turning inside the differential , manually rotating one driven roadwheel causes the opposite roadwheel to rotate in the opposite direction by the same amount. When the vehicle is traveling in a straight line there will be no differential movement of the planetary system of gears other than the minute movements necessary to compensate for slight differences in wheel diameter, undulations in the road which make for a longer or shorter wheel path, etc. In automobiles and other wheeled vehicles, the differential allows the outer drive wheel to rotate faster than the inner drive wheel during a turn. This is necessary when the vehicle turns, making the wheel that is traveling around the outside of the turning curve roll farther and faster than the other. The average of the rotational speed of the two driving wheels equals the input rotational speed of the drive shaft. An increase in the speed of one wheel is balanced by a decrease in the speed of the other. When used in this way,

a differential couples the longitudinal input propeller shaft to the pinion , which in turn drives the transverse ring gear of the differential. This also usually works as reduction gearing. On rear wheel drive vehicles the differential may connect to half-shafts inside an axle housing, or drive shafts that connect to the rear driving wheels. Front wheel drive vehicles tend to have the engine crankshaft and the gearbox shafts transverse, and with the pinion on the end of the counter-shaft of the gearbox and the differential enclosed in the same housing as the gearbox. There are individual drive-shafts to each wheel. A differential consists of one input the drive shaft and two outputs, which are connected to the two drive wheels; however the rotations of the drive wheels are coupled to each other by their connection to the roadway. Under normal conditions, with small tyre slip, the ratio of the speeds of the two driving wheels is defined by the ratio of the radii of the paths around which the two wheels are rolling, which in turn is determined by the track-width of the vehicle the distance between the driving wheels and the radius of the turn. Non-automotive uses of differentials include performing analog arithmetic. Two of the differential's three shafts are made to rotate through angles that represent are proportional to two numbers, and the angle of the third shaft's rotation represents the sum or difference of the two input numbers. The earliest known use of a differential gear is in the Antikythera mechanism , circa 80 BCE, which used a differential gear to control a small sphere representing the moon from the difference between the sun and moon position pointers. The ball was painted black and white in hemispheres, and graphically showed the phase of the moon at a particular point in time. In the 20th Century, large assemblies of many differentials were used as analog computers , calculating, for example, the direction in which a gun should be aimed. However, the development of electronic digital computers has made these uses of differentials obsolete. Military uses may still exist, for example, for a hypothetical computer designed to survive an electromagnetic pulse. Practically all the differentials that are now made are used in automobiles and similar vehicles including offroad vehicles such as ATVs. There are many claims to the invention of the differential gear, but it is possible that it was known, at least in some places, in ancient times. Confirmed historical milestones of the differential include: An epicyclic differential can use epicyclic gearing to split and apportion torque asymmetrically between the front and rear axles. An epicyclic differential is at the heart of the Toyota Prius automotive drive train, where it interconnects the engine, motor-generators, and the drive wheels which have a second differential for splitting torque as usual. It has the advantage of being relatively compact along the length of its axis that is, the sun gear shaft. Epicyclic gears are also called planetary gears because the axes of the planet gears revolve around the common axis of the sun and ring gears that they mesh with and roll between. In the image, the yellow shaft carries the sun gear which is almost hidden. The blue gears are called planet gears and the pink gear is the ring gear or annulus. Ring gears are also used in starter motors. A spur-gear differential has two equal-sized spur gears, one for each half-shaft, with a space between them. Instead of the Bevel gear , also known as a miter gear, assembly the "spider" at the centre of the differential, there is a rotating carrier on the same axis as the two shafts. Torque from a prime mover or transmission , such as the drive shaft of a car, rotates this carrier. Mounted in this carrier are one or more pairs of identical pinions, generally longer than their diameters, and typically smaller than the spur gears on the individual half-shafts. Each pinion pair rotates freely on pins supported by the carrier. Furthermore, the pinion pairs are displaced axially, such that they mesh only for the part of their length between the two spur gears, and rotate in opposite directions. The remaining length of a given pinion meshes with the nearer spur gear on its axle. Therefore, each pinion couples that spur gear to the other pinion, and in turn, the other spur gear, so that when the drive shaft rotates the carrier, its relationship to the gears for the individual wheel axles is the same as that in a bevel-gear differential. A spur gear differential is constructed from two identical coaxial epicyclic gear trains assembled with a single carrier such that their planet gears are engaged. Thus, the angular velocity of the carrier of a spur gear differential is the average of the angular velocities of the sun and annular gears. In discussing the spur gear differential, the use of the term annular gear is a convenient way to distinguish the sun gears of the two epicyclic gear trains. The second sun gear serves the same purpose as the annular gear of a simple planetary gear train, but clearly does not have the internal gear mate that is typical of an annular gear. Chinese south-pointing chariots may also have been very early applications of differentials. The chariot had a pointer which constantly pointed to the south, no matter how the chariot turned as it travelled. It could therefore be used as a type of compass. It is widely thought that a differential mechanism responded to any difference between the speeds of rotation of the two wheels of the chariot, and turned the pointer appropriately. However, the mechanism was not precise enough, and, after a few miles of travel, the dial could have very well been pointing in the completely opposite direction. The earliest definitely verified use of a differential was in a clock made by Joseph Williamson in it

employed a differential to add the equation of time to local mean time , as determined by the clock mechanism, to produce solar time , which would have been the same as the reading of a sundial. During the 18th Century, sundials were considered to show the "correct" time, so an ordinary clock would frequently have to be readjusted, even if it worked perfectly, because of seasonal variations in the equation of time. Williamson's and other equation clocks showed sundial time without needing readjustment. Nowadays, we consider clocks to be "correct" and sundials usually incorrect, so many sundials carry instructions about how to use their readings to obtain clock time. In the first half of the twentieth century, mechanical analog computers , called differential analyzers , were constructed that used differential gear trains to perform addition and subtraction. The U. Navy Mk. A differential gear train can be used to allow a difference between two input axles. Mills often used such gears to apply torque in the required axis. Differentials are also used in this way in watchmaking to link two separate regulating systems with the aim of averaging out errors. Greubel Forsey use a differential to link two double tourbillon systems in their Quadruple Differential Tourbillon. A vehicle with two drive wheels has the problem that when it turns a corner the drive wheels must rotate at different speeds to maintain traction. The automotive differential is designed to drive a pair of wheels while allowing them to rotate at different speeds. In vehicles without a differential, such as karts , both driving wheels are forced to rotate at the same speed, usually on a common axle driven by a simple chain-drive mechanism. When cornering, the inner wheel travels a shorter distance than the outer wheel, so without a differential either the inner wheel rotates too quickly or the outer wheel rotates too slowly, which results in difficult and unpredictable handling, damage to tires and roads, and strain on or possible failure of the drivetrain. In rear-wheel drive automobiles the central drive shaft or prop shaft engages the differential through a hypoid gear ring and pinion. The ring gear is mounted on the carrier of the planetary chain that forms the differential. This hypoid gear is a bevel gear that changes the direction of the drive rotation. One undesirable side effect of an open differential is that it can limit traction under less than ideal conditions. The amount of traction required to propel the vehicle at any given moment depends on the load at that instantâ€"how heavy the vehicle is, how much drag and friction there is, the gradient of the road, the vehicle's momentum, and so on. The torque applied to each driving wheel is the result of the engine , transmission and drive axle applying a twisting force against the resistance of the traction at that roadwheel. In lower gears, and thus at lower speeds, and unless the load is exceptionally high, the drivetrain can supply as much torque as necessary, so the limiting factor becomes the traction under each wheel. It is therefore convenient to define traction as the amount of force that can be transmitted between the tire and the road surface before the wheel starts to slip. If the torque applied to one of the drive wheels exceeds the threshold of traction, then that wheel will spin, and thus provide torque only at the other driven wheel equal to the sliding friction at the slipping wheel. The reduced net traction may still be enough to propel the vehicle slowly. An open non-locking or otherwise traction-aided differential always supplies close to equal torque to each side. To illustrate how this can limit torque applied to the driving wheels, imagine a simple rear-wheel drive vehicle, with one rear roadwheel on asphalt with good grip, and the other on a patch of slippery ice. It takes very little torque to spin the side on slippery ice, and because a differential splits torque equally to each side, the torque that is applied to the side that is on asphalt is limited to this amount. Based on the load, gradient, etc. Since an open differential limits total torque applied to both drive wheels to the amount used by the lower traction wheel multiplied by two, when one wheel is on a slippery surface, the total torque applied to the driving wheels may be lower than the minimum torque required for vehicle propulsion. A proposed alternate way to distribute power to the wheels, is to use the concept of a gearless differential , about which a review has been reported by Provatidis, [10] but the various configurations seem to correspond either to the "sliding pins and cams" type, such as the ZF B available on early Volkswagens , or are a variation of the ball differential. Many newer vehicles feature traction control , which partially mitigates the poor traction characteristics of an open differential by using the anti-lock braking system to limit or stop the slippage of the low traction wheel, increasing the torque that can be applied to the opposite wheel. While not as effective as a traction-aided differential, it is better than a simple mechanical open differential with no traction assistance. A relatively new technology is the electronically controlled 'active differential'. An electronic control unit ECU uses inputs from multiple sensors, including yaw rate, steering input angle, and lateral accelerationâ€"and adjusts the distribution of torque to compensate for undesirable handling behaviours such as understeer. This essentially gives each wheel its own differential. This allows Torque vectoring and can send power to any wheel that needs it. Drifting motorsport is a popular motorsport style that has its origins in the mountains of Japan. This style of driving is known for sliding a car through a corner without leaving the road surface. To easily get the car into a slide the

driver can use a Limited-slip differential or a welded differential. A limited slip differential makes the wheels of the vehicle turn at the same speed. Since the inside wheel of the car is going a shorter distance than the outside wheel, this causes slippage. This slippage is what makes it easier to slide the car around a turn. From Wikipedia, the free encyclopedia. This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed. Input torque is applied to the ring gear blue , which turns the entire carrier blue. The carrier is connected to both sun gears red and yellow only through the planet gear green. Torque is transmitted to the sun gears through the planet gear. The planet gear revolves around the axis of the carrier, driving the sun gears. If the resistance at both wheels is equal, the planet gear revolves without spinning about its own axis, and both wheels turn at the same rate. If the left sun gear red encounters resistance, the planet gear green spins as well as revolving, allowing the left sun gear to slow down, with an equal speeding up of the right sun gear yellow. Play media. Interdisciplinary science reviews. Retrieved 20 May General Motors Canada. Retrieved 9 January Theory of Machines and Mechanisms. New York: Oxford University Press. Automotive Computer Controlled Systems. Automotive Science and Mathematics. Retrieved 24 June Automobile Magazine. Retrieved 21 September Spur gear systems Worm drive Rack and pinion Epicyclic planetary gearing Sun and planet gear Harmonic drive Cycloidal drive Non-circular gear. Involute Cycloid. Cogset Derailleur gears Hub gear Shaft-driven bicycle Sprocket. Wheel train. Part of the Automobile series. 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 Transmission control unit Universal joint. Electric motor Hybrid vehicle drivetrain Electric generator Alternator. Portal Category. Categories : Auto parts Automotive transmission technologies Mechanisms engineering Vehicle technology Gears. Hidden categories: Use dmy dates from December Articles needing additional references from July All articles needing additional references Commons category link is on Wikidata Articles containing video clips. 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For instance, you might see for the BOM, but the 60 has been dropped, and one would need to use However, the Dana Aftermarket Media Library can be used to identify all aspects of a particular axle using the Bill Of Materials number. Need help identifying your differential or not sure which replacement or performance parts you need? Ford differential tags are very straightforward, as indicated above. Not sure what the part you need is called? Use our Exploded View Diagrams to identify the part by name. Call our staff of differential experts at Without an ID tag, differentials are identified by the number of cover bolts, the distinctive shape of the cover, the number of ring gear bolts, and ring gear diameter. They can also be identified by whether the center section is an integral or dropout design. Dropout differentials are also referred to as 3rd members or pumpkins. Use the images below to Help Identify Your Differential. AAM 9. AAM AMC Model Chrysler 7 . Chrysler 8 Chrysler 9. Dana 28 IFS Front. Dana 28 Parts Catalog. Dana 28 IRS Rear. Dana Dana 30 Parts Catalog. Dana 35 Parts Catalog. Dana 44 Parts Catalog. D44 HD Aluminum. D44 HD Parts Catalog. Dana 50 Parts Catalog. Dana 50 TTB. Dana 60 Parts Catalog. Dana 70 Parts Catalog. Dana 80 Parts Catalog. Dana S Dana S Parts Catalog. Ford 7. Ford 8. Ford 9. Ford GM 55P Parts Catalog. GM 55T Parts Catalog. Parts Catalog. GM Bolt Parts Catalog. GM Camaro V6 mm. Camaro V6 Parts Catalog. Camaro V8 mm. Camaro V8 Parts Catalog. Camaro ZL1. Camaro ZL1 Parts Catalog. Pontiac G8. Pontiac G8 Parts Catalog. Corvette D36 Parts Catalog. Corvette D44 Parts Catalog. Corvette D44HD Catal

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