Various chassis types: Four wheels and six basic combinations

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If you are familiar with LEGO® cars, especially those built using Technic, you are well aware that the large majority of them share the same chassis configuration, with the front wheels steering, and the drive - if existent - at the rear. This is, of course, no coincidence: this particular configuration is used by many cars in the real world.

However, while it is useful and generally does the job, it is but one of many possible configurations that may be used. Here we will take a look at a few of the most common types. There is no universal recipe for choosing the right one because it usually depends on balancing the pros and cons for a given situation.

So let us begin by dissecting the aforementioned most common front steering, rear drive configuration. It is rather simple and reliable while providing pretty good turning radius and performance, which made it popular on all sorts of vehicles. However, in the LEGO world it has its drawbacks; of the two motors aboard, only one is used for drive, and the other's power is rarely ever employed.

The rear drive and front steering configuration is the most common and can be built very simply and quickly, using just a couple of parts.

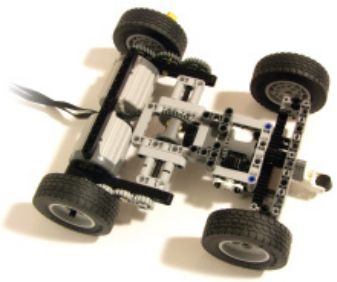
Differental drive, such as this official 8547 robot, allows turning in place, but steers roughly and with lots of skidding.

This is where the differential drive, also known as the tank drive, comes into play. If two motors are used, one connected to the left wheels and the other to the right, all power onboard (i.e. from both motors) is used when the vehicle drives forward or backward. Just like with tanks, this type of chassis steers by letting the motors, and hence left and right wheels, turn at different speeds. An additional advantage this brings is reducing the turning circle down to zero: in fact, if the wheels turn at equal speeds but opposite directions left and right, the vehicle turns in place. These advantages come at the cost, however, of immense skidding and rough steering, whether wheels or tracks are used. The motors have to overcome plenty of friction while turning, to say nothing of the strain exerted on the chassis. Still, for heavy-duty vehicles where mechanical strength is of no concern, it may be very useful.

An interesting alternative is a self-steered chassis with differential drive. If the rear wheels are driven by a separate motor each, it is easy to let the front wheels turn as they like under the steering, if any, exerted by the rear wheels. Two approaches are viable in that case. In the first one, the front wheels may just have lots of caster, i.e. be mounted behind their hub's turning point, similar to e.g. a shopping trolley's wheels that turn readily in whichever direction they are pushed. This is a very simple yet reasonably reliable solution.

A more complex approach uses a mechanism that 'measures' the speed difference between the rear wheels using a differential, and if it is present, mechanically steers the front wheels accordingly, such as the one shown in the photograph on the right. The common advantages of these chassis is again having all power focused on drive and fine handling on smooth surfaces.

However, maneuvering in tight spots or on difficult terrain, as well as turning the front wheels in place, is all the more difficult. Actually, as an extreme example, the front wheels can even be built without any turning ability at all. This straight-wheel differential drive turns even more roughly than its kin, especially on difficult surfaces. It may be said that it is more of a straight-line chassis with the option of correcting the course, than really a chassis with proper steering. But for special types of vehicles, such as high-speed dragsters, that is just what is needed - it uses all the power onboard and is very simple, therefore reliable, strong and light.

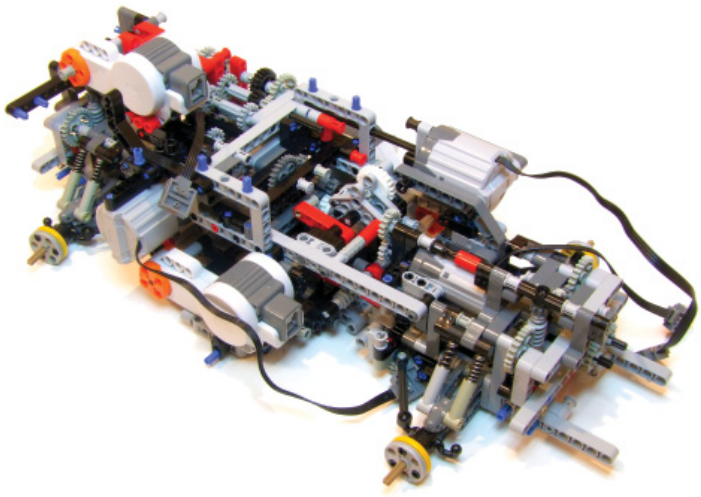


An example of a rear differential drive with self-steering mechanism which turns the front wheels according to the difference in rear wheels' speeds.

Four wheel drive with front wheel steering offers good performance at a cost of slightly complex chassis.

But if using all power onboard or turning in place is not necessary, there are other types of mechanically steered chassis that may be useful. A fine improvement over the standard configuration is upgrading from rear-wheel to all-wheel drive, with front wheel steering. This 4 wheel drive, front wheel steering setup, or 4x4, offers more overall grip and is suitable for offroad vehicles. Still, in that case it is recommended to either omit the differentials, let them be locked when necessary or implement some kind of a limited slip differential, because a full-differential four-wheel drive is notoriously prone to locking on difficult terrain.

An even more advanced version is the 4 wheel drive, 4 wheel steering, or 4x4x4. This retains all the advantages of the 4x4 but allows for even tighter turning and agile handling in any situation. A good example is The LEGO Group's own 9398 Crawler. Its obvious drawback is the complexity, as each wheel needs to turn, drive and is probably suspended as well. Therefore it needs to be properly reinforced, making it large and heavy.



Driving and steering on all four wheels brings top-notch performance, but requires complex mechanics with plenty of reinforcements and testing.

Note that all these criteria apply regardless of whether the chassis drives forward or backward. I.e. rear wheel drive with front wheel steering brings similar pros and cons as the front wheel drive, rear wheel steering. At the speeds of LEGO vehicles, the advantages of rear-wheel acceleration is not that important.

There are, of course, many more chassis configurations, especially if more than four wheels come into the formula. But these are a good starting point because of either their performance or their simplicity. Just keep in mind that it always comes down to the game of balancing: there simply is no chassis, either in LEGO or in the realm of real world vehicles, that can be light, robust, simple, fast, agile on all surfaces and reliable at once.
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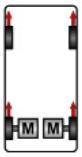
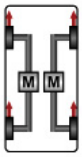
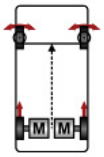
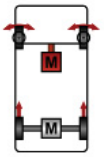
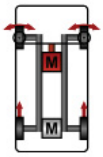
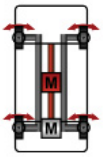
	Differential 2 wheel drive without steering (wheels fixed straight)	Differential 4 wheel drive without steering (wheels fixed straight)	Differential 2 wheel drive with passive or active self-steering	Standard 2 wheel drive and 2 wheel steering	4 wheel drive and 2 wheel steering	4 wheel drive and 4 wheel steering
Configuration						
Description	One wheel on each side of the car is powered by a separately controlled motor. Steering is done by rotating them at different speeds, against the friction done by the remaining two fixed wheels.	Both wheels on each side of the car are powered by a separately controlled motor. Steering is done by rotating them at different speeds. None of them can turn.	One pair of wheels is powered by two separately controlled motors, while the other pair steers according to their motion - passively due to sideways force and caster, or through a mechanism for this purpose.	One pair of wheels (usually rear) provides drive with a motor, typically through a differential, while the other pair steers and is controlled by the other motor. Configuration very common in road cars.	All wheels are driven by a motor, usually each pair having own differential, and the third between the front and rear axles. One pair of wheels (typically front) steers. Common in many off-road cars.	All wheels are driven by a motor, usually each pair having own differential, and the third between the front and rear axles. All the wheels can steer as well.
Pros	• extremely simple to build • very robust • all power onboard focused on providing drive	• very simple to build • all power onboard focused on providing drive • good off-road capability in a straight line • can turn in place	• all power onboard focused on providing drive • good handling and agility on smooth surface • passive version is simple to build	• good handling and manoeuve-ring on all sorts of surfaces • lots of existing reference designs (both within Lego and in general) • relatively simple	• excellent handling, suitable both for performance cars and off-road • even distribution of force ensures excellent grip and response	• best handling on all surfaces and for all applications • even distribution of force ensures excellent grip and response • small turning circle (perfect manoeuvrability in tight spaces)
Cons	• very unreliable and rough steering • huge turning circle • lots of tyre slip	• rather unreliable and rough steering • lots of tyre slip	• difficult to turn wheels while stationary • hard to control on off-road terrain • needs to be finely adjusted	• only one motor provides driving power • possible lock on slippery surfaces if using a standard differential	• only one motor provides driving power • very likely to lock without an LSD on slippery surfaces	• can become quite complex and tends to be fragile • only one motor provides driving power • very likely to lock without an LSD on slippery surfaces