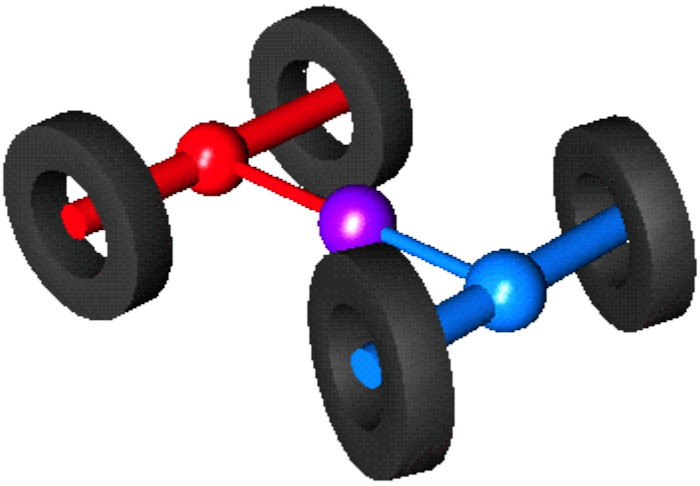
Diffs for Dummies

The subject of diffs, diff locks, traction and spinning wheels pops up often. Many new members are confused with the terminology and sometimes shy about asking what it's all about. "Diffs for Dummies" is an attempt to explain it in simple terms without ever using the words torque, power, torque split, rotational inertia or other such fluff.

Most 80 Series Cruisers are what's known as constant 4WD. That means that all 4 wheels are driven by the engine all the time. Typically in what are known as part time 4WD's, drive goes only to the rear wheels (or on some, front only) until 4WD is engaged when travelling off-highway.

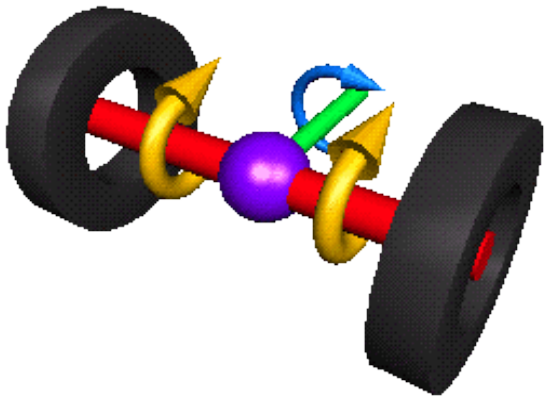


The 80 Series has 3 differentials (they're the 3 spheres shown to the left). One on the front axle (blue), one on the rear axle (red) and one in the transfer case (purple - referred to as the centre differential).

So, what is a differential (diff) and why do we need 3? What's this centre diff lock button do? And what are these front and rear diff locks all about?

Let's see if we can answer some of these questions...

What's a diff?

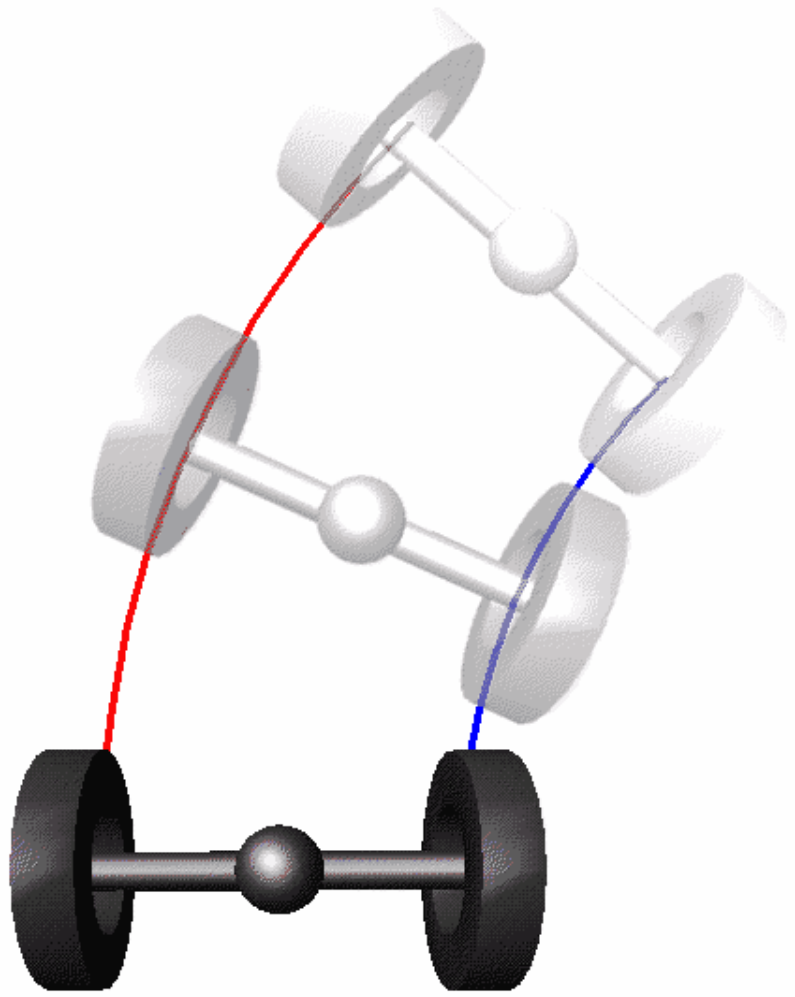


First, the differential. That's the purple sphere in the middle of the long axle housing that the wheels are connected to. If you poke your head under the rear of your 80, you'll see it (of course it's all painted black under there). Under the front of an 80, the diff is off to one side (RHS).

Drive is passed to the diff via the drive shaft (green) rotating. The diff in turn drives the wheels via inside the axle housing.

The special thing a diff does is to allow one wheel to turn at a different rate to the other wheel whilst providing relatively equal drive to both wheels.

So why do we need wheels to turn at different rates?



Let's look at the picture to the left. This is what happens when we turn a corner.

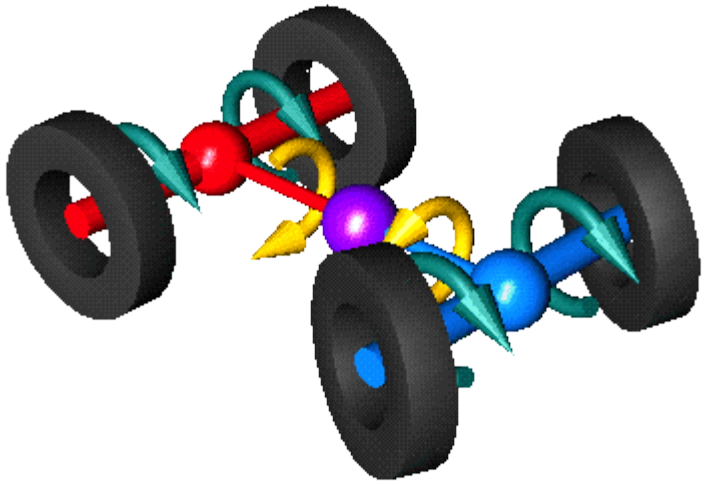
The left wheel in this example travels further than the right wheel. We can see this by the fact that the red curve (left) is longer than the blue (right).

With a differential in there, the two wheels can travel a different distance (or more precisely turn at different rates) whilst still having both being driven by the engine.

Pretty cool huh?

If this were a solid axle without a differential, the inside wheel would have to skid to make the turn. We'll get to this later because there are instances where having the diff mimic a solid axle is a desirable thing.

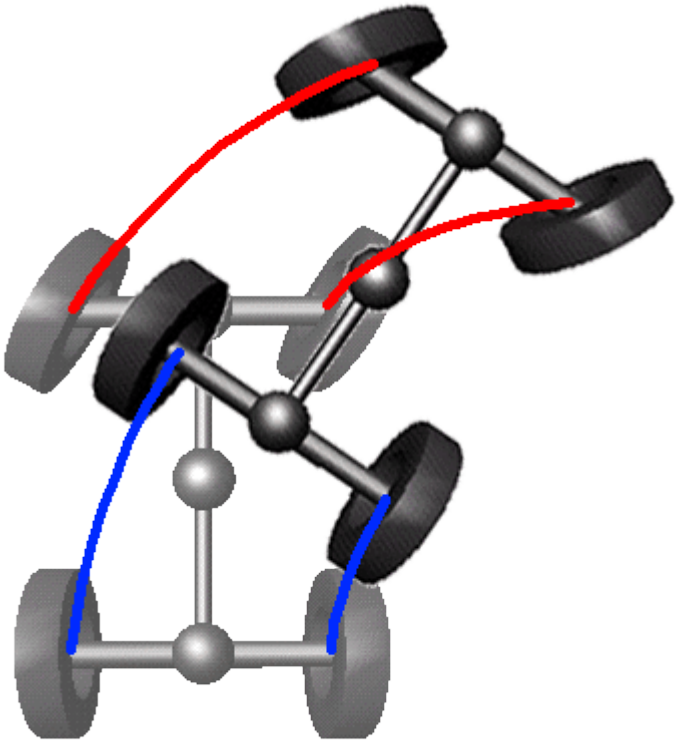
What's a centre diff?



The centre diff (purple sphere) allows the front and rear drive shafts to turn at different rates whilst still driving both drive shafts.

It's enclosed in the transfer case (and looks like a part of the gearbox).

So, why do we need a centre diff?



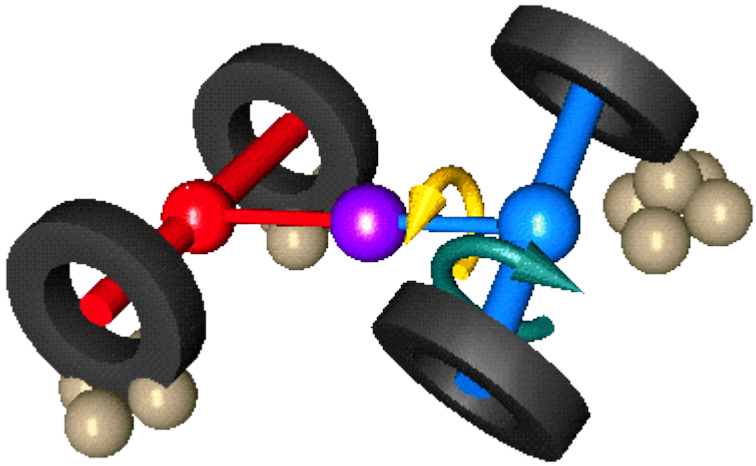
When we study the example on the left, we see that when turning a corner, the front wheels travel a longer distance (red curves) than the do the rears (blue curves).

That means that the front and rear drive shafts rotate at different rates to each other. We need a centre diff between the two drive shafts to accommodate this and to be able to drive both drive shafts at the same time.

If there was no centre diff, it would be impossible for the vehicle to turn a corner without spinning wheels and placing the driveline components under extreme loads.

What happens if a wheel spins?

Drive from the engine is directed through the centre diff (the purple one) and it exerts drive to the front and rear drive shafts. An undesirable phenomenon with diffs is that the **drive exerted on both shafts** is the same amount as that of the **shaft (wheel) with the least traction**.



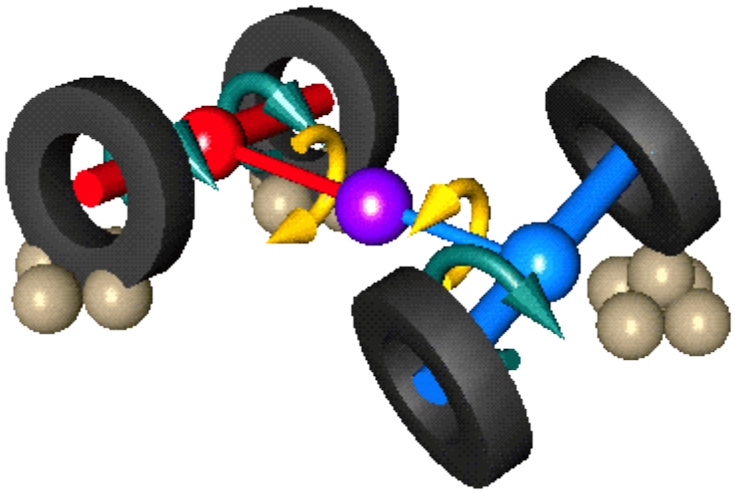
Right here, we're in a situation where we are climbing over uneven terrain and one wheel loses traction (the lower wheel on the blue axle).

It takes very little drive to make that wheel spin and if we follow it back, the drive to both wheels on the blue axle is the same as that on the spinning wheel (i.e. very little).

Uh oh, what can be done?

In an 80 Series, when Low Range is selected or the Centre Diff Lock switch (if fitted) is depressed, an electric signal is sent to the centre diff lock and the centre diff locks.

"Locking" means is that the diff no longer performs the task of allowing the drive shafts to turn at different rates. The front and rear drive shafts are physically locked together. If one is to turn, the other must turn the same amount.



In our situation here, instead of all the drive being lost to the spinning wheel, with the centre diff locked, the rear drive shaft must now turn at the same rate as the front.

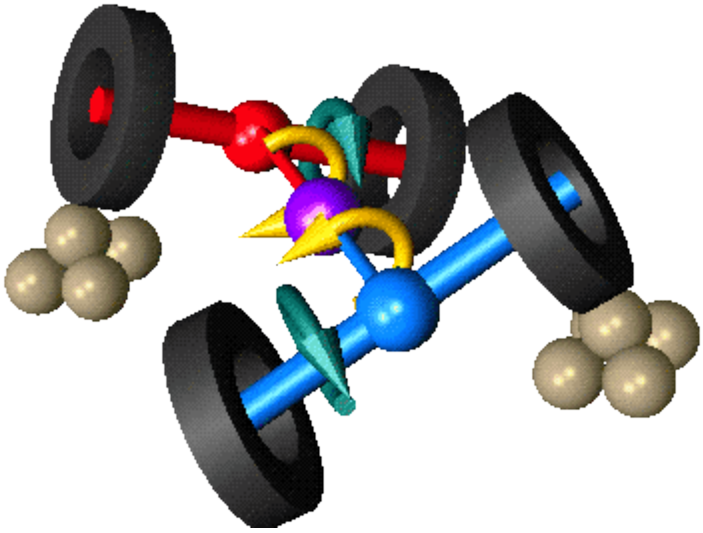
Even though we have no traction at the front, the rear can now drive the vehicle (because the rear has traction at both wheels).

We must be careful when we apply the centre diff lock. If the vehicle is on a surface with good traction (i.e. tarred roads) the wheels would have to spin to turn a corner. It will also place the driveline under extreme load, commonly referred to as "transmission windup".

Going back further still, amount of drive to the front and rear drive shafts (red and blue) from the centre diff is in turn similar to that of the spinning wheel (i.e. very little).

So, the net effect is that there is not enough drive to the wheels with traction, the vehicle stops and all we do is spin that wheel

What if a front and rear wheel loses traction?



Now we're in a situation where a front and rear wheel has lost traction. Drive through the centre diff goes to the front and rear drive shafts and then to the wheels.

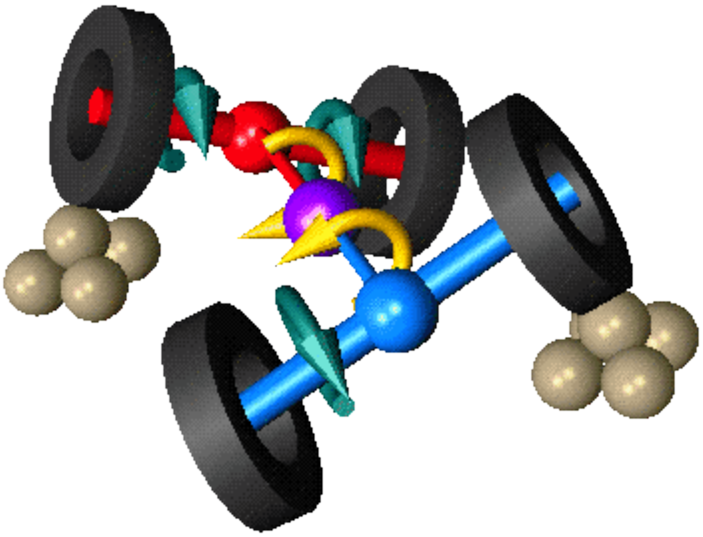
Since a wheel at each end has no traction and since the amount of drive to all wheels is the same as those with no traction, all we achieve in this situation is to spin two wheels.

We get clever and engage the centre diff lock to force the front and rear drive shafts to turn at the same rate. Unfortunately, since a wheel at each axle has no traction, again all we achieve is spinning wheels.

Uh oh, what can we do when front and rear wheels spin?

Enter the optional Front and Rear diff locks available on some 80 Series (there are also a number of excellent aftermarket front and rear diff locks available).

In a similar fashion to the centre diff lock described above, front or rear diff locks ensure that the left and right axle shafts (they're the things the wheels are attached to) at that axle are physically locked together. If one is to turn, the other must turn the same amount.

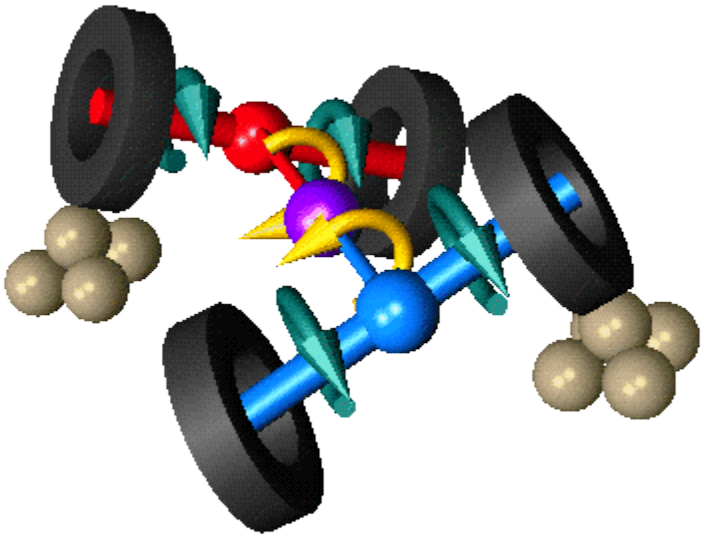


First, let's lock the rear diff lock (and of course, we've already locked the centre diff lock).

Drive through the centre diff (locked) ensures that the front and rear drive shafts turn the same amount.

Drive to the front diff (unlocked) is wasted through the spinning front wheel.

Drive to the rear diff (locked) goes to the rear wheel with traction and to the spinning rear wheel (since the rear diff is locked, the left and right axles must turn at the same rate and we will invariably drive over the obstacle).



Taking this further, when the front diff lock is then locked, the left and right axles at the front are physically locked together and both front wheels must turn at the same rate.

We can now drive not only on the rear wheel with traction, but also the front wheel with traction.

Help! I can't turn!

Care must be taken when engaging centre and particularly rear and front diff locks. If you remember back to the beginning of this article, we rely on diffs to allow the vehicle to turn. As we progressively lock more diffs, it becomes increasingly difficult to turn.

With all three diffs locked, you will notice that the steering becomes very heavy and on any surface other than that with very little traction, it will be almost impossible to make the vehicle turn.