

Functional 4x4 – Building Driven and Steered Axles

TJ Avery, c. 2001 (updated May 2009)

Building a vehicle axle that is driven (powered) and steered has always been a challenge using LEGO elements. Since I was a young teenager, I've built many designs trying to find one that works well.

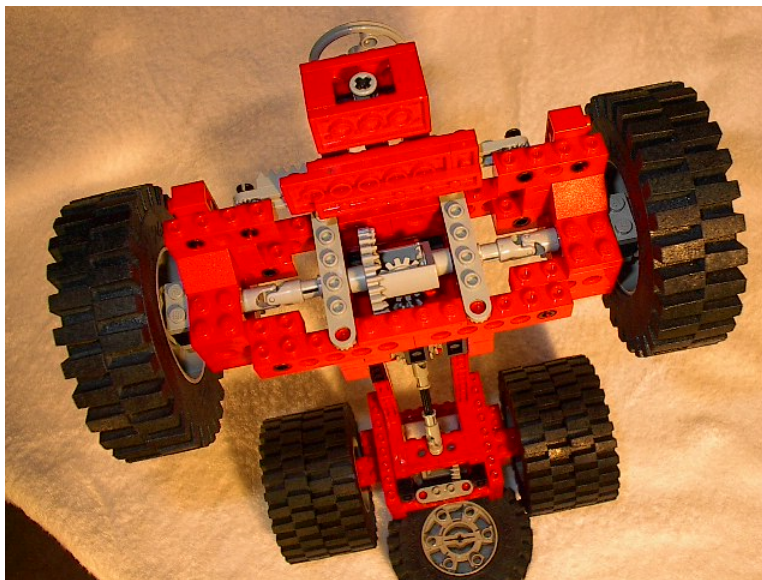
To date, LEGO has produced two Technic designs that have an axle that is both driven and steered (set 8466 4x4 Off Roader and set 8880 super car). These axle designs (although different from each other) can be independently suspended. The designs use specialized, purpose-made steering pieces. They are strong and somewhat effective, although the steering range is very limited for both designs.

This article describes a few of my designs and explains the reasoning of their particular design.

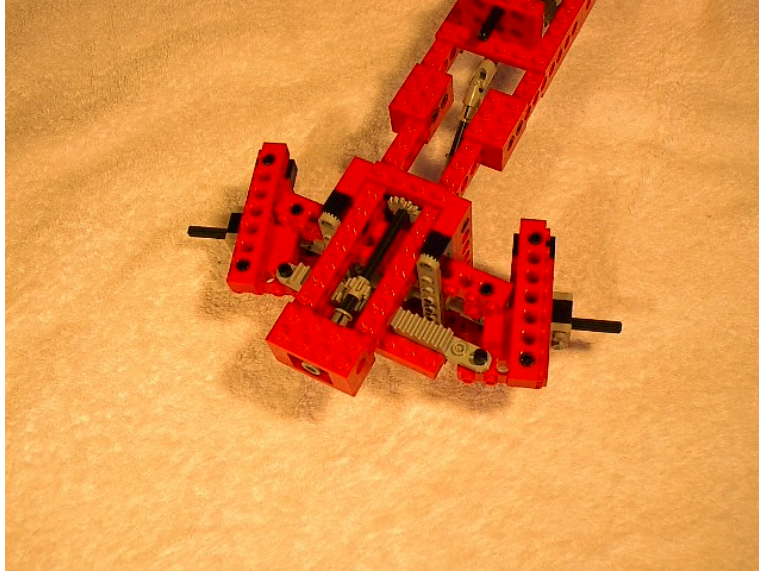
1. Classic Design: Solid Axle, No Suspension

Sometime back in the mid-80's, when I was a young teenager, I had been fooling around with making a driven and steered axle for a long time when I suddenly happened upon an idea. I was looking at the design for the rear axle from LEGO set 8860 (auto chassis), and I rotated it 90 degrees.

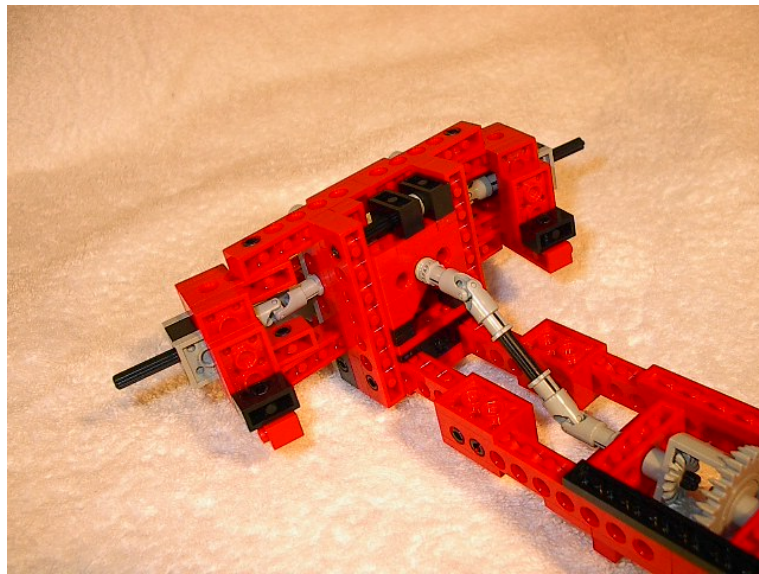
The independent suspension from set 8860 made very nice steering arms when rotated 90 degrees. You can see this in the photo below (if you're familiar with the design of set 8860, then you'll recognize it).



I added some strengthening modifications and also a steering linkage with a rack gear. This solid axle was fixed to a frame (i.e. there was no suspension – the whole thing was solid).

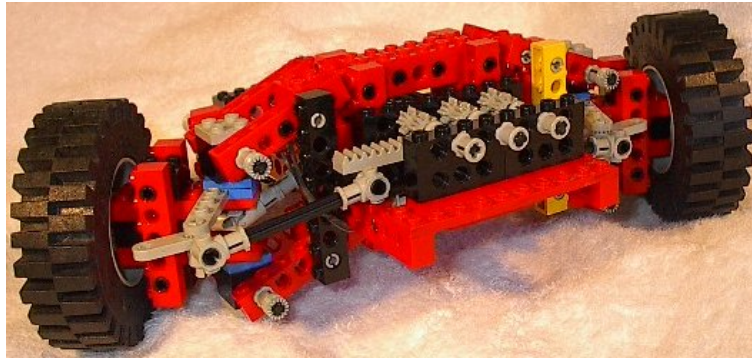


This design is bulky, but it is strong. When built correctly, it is capable of handling a lot of weight.

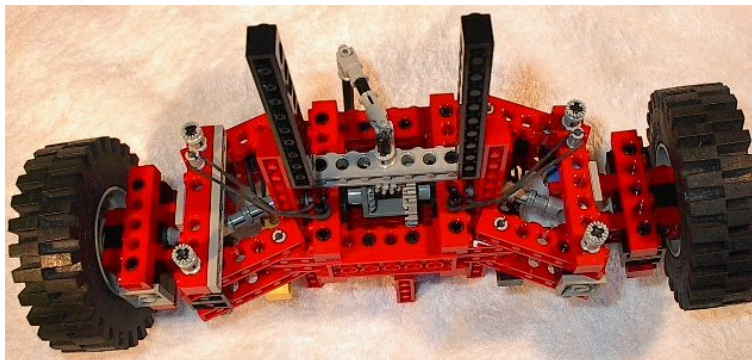


2. Classic Design: Independent Suspension

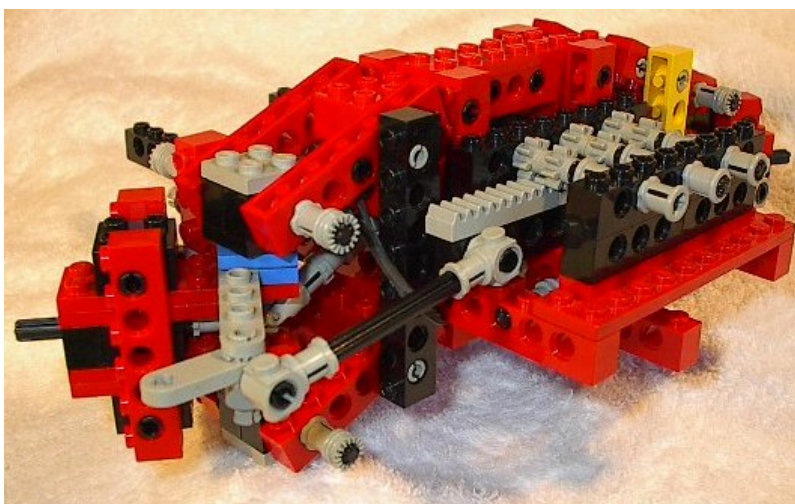
Just for fun, I decided to build a driven and steered axle that had independent suspension that used only parts from the old-school days of the first Technic sets.



This design is a little impractical. The width is too much and it's too low to the ground (well, the wheels just need to be larger in diameter ☺). It also couldn't handle too much weight. The hinged joint (using 2x2 plate turntables) was the weak spot.



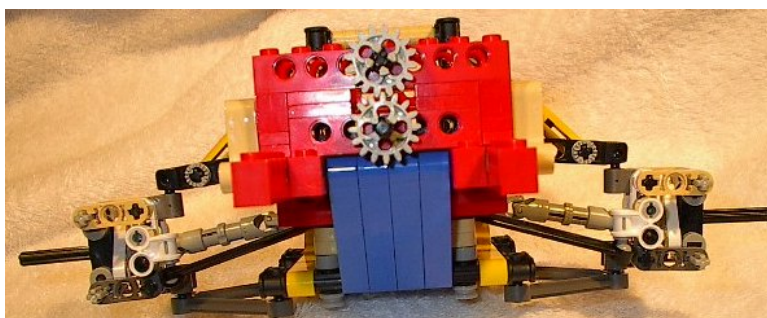
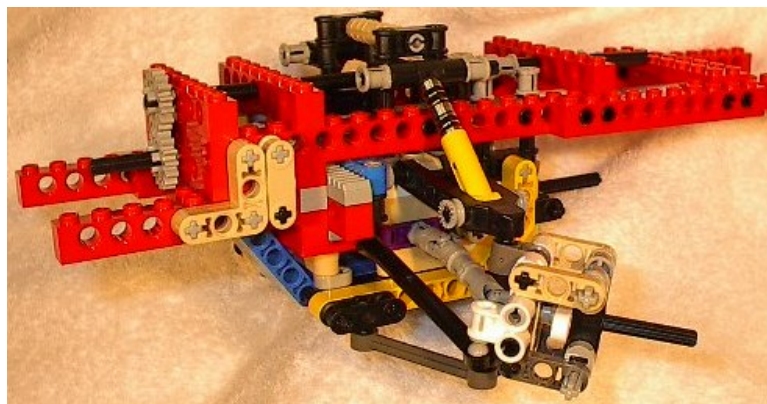
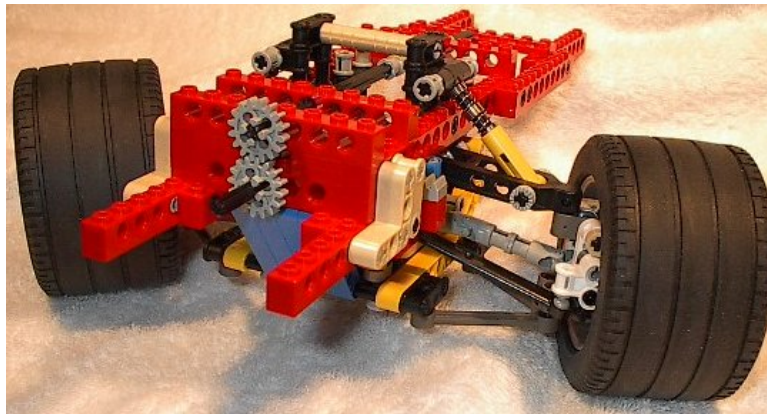
But, it was fun to build and it actually worked!



3. Newer Design: Independent Suspension

In the late 90's (and going into the new century), LEGO started producing many new Technic pieces containing no studs. These liftarms and beams were fantastic pieces that allowed designs not possible before with the standard studded Technic bricks.

I made many attempts to use these pieces to create a driven, steered, and suspended axle. Below is just one example of my efforts. This design worked okay, but wasn't terribly strong.

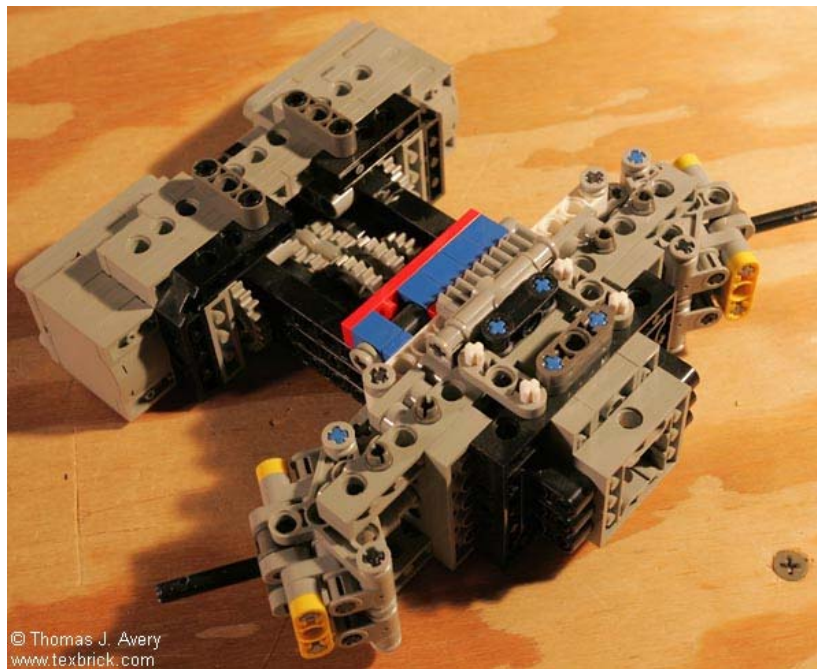


4. Solid, Pendular Axle

This design was used on my 4x4 telescopic boom crane. It's a solid axle that is suited for pendular suspension (the whole thing is solid and rotates about an axis perpendicular to the axis of the wheels).

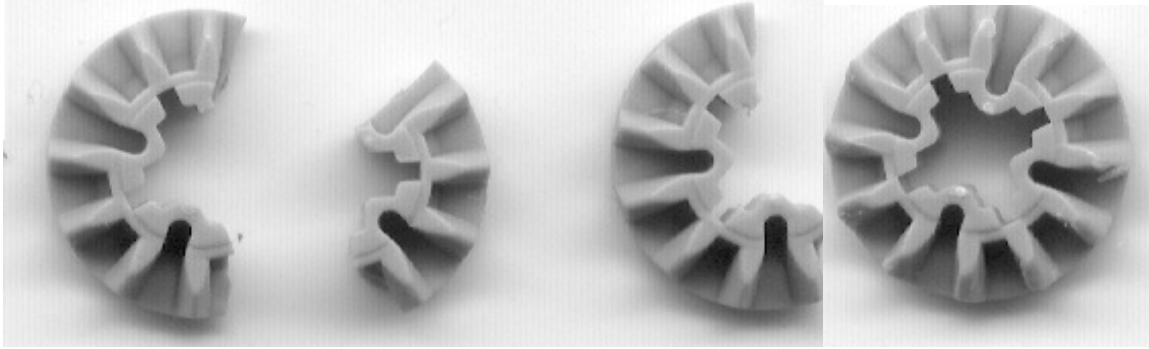
One major problem of all the previous designs is that a set of bevel gears must be used to transmit power from the motors to the differential. Whether a classic-style or modern-style differential is used, you still need to have bevel gears somewhere in the gear train.

This particular design (see photos below) eliminates the need for bevel gears by placing the motors' axis parallel with the wheel axis. This design, however, deviates from a realistic design seen in real vehicles and equipment.

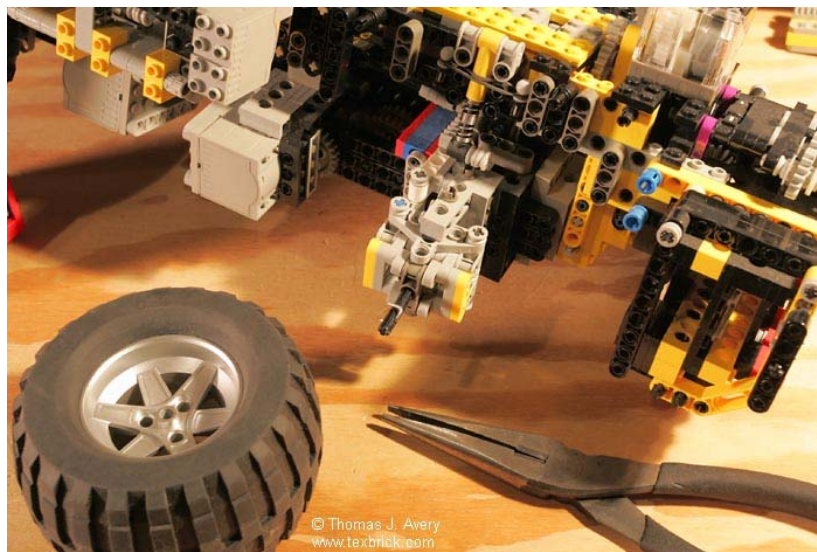


This design marks a change in my philosophy about building driven vehicles. It's always neat and nice to have your motor(s) and gear train set up to mimic real life, but LEGO isn't always well suited to do this AND perform well.

Bevel gears are the Achilles' heal of these "realistic" designs. LEGO bevel gears cannot transmit enough torque to be effective. They will either break (usually the case for the 1/2-stud wide bevel gears) or the teeth will become deformed and "mashed" (usually the case for the 1-stud width bevel gears) resulting in gear slippage.

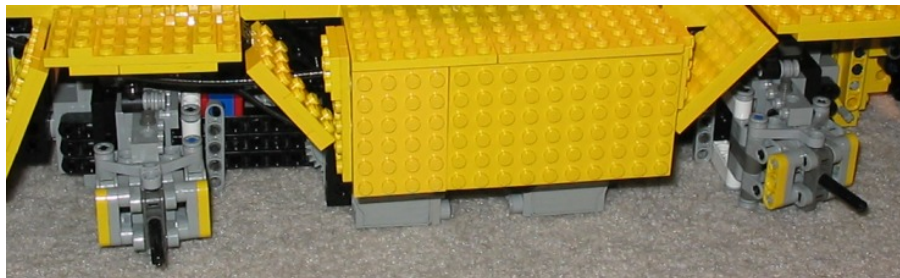


Well, please keep in mind that all this applies to my models, which are typically very large and heavy (so high torque is always required to move them).



Note that I drilled a small hole near the ends of each wheel axle so that a retaining pin could be placed to keep the wheels from sliding off. I also glued the other end of that axle into the U-joint. This is “non-pure”, but I made use of old U-joints that had already broken and split.

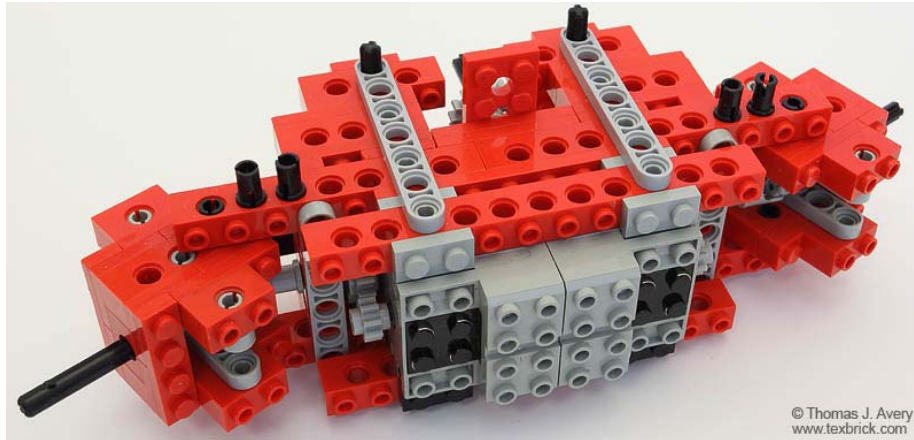
This is necessary when a very heavy load is placed on the axle and wheels – the axle will deflect upwards and the wheel will slowly slide off as the whole model rolls along.



5. Solid Axle, Direct Drive

Continuing my change in design philosophy, I'm now experimenting with moving the motors directly to the axle. This is not realistic (as compared to a typical vehicle in real life), but it has some major advantages:

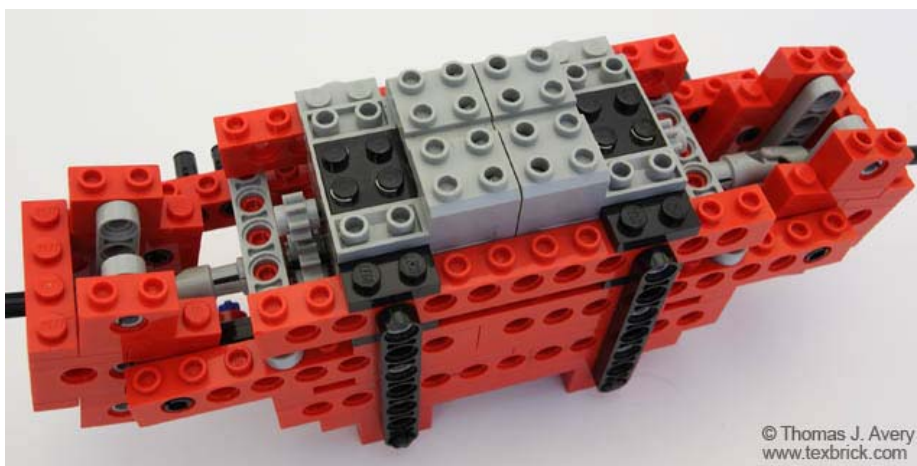
- minimum amount of gears used in the drive train
- no bevel gears needed
- minimum amount of power loss (more efficiency b/c the drive train is small and short)



This may not be realistic, but the end result is that the model will perform well. It will be strong, fast, and you won't have to worry about gears breaking and slipping.

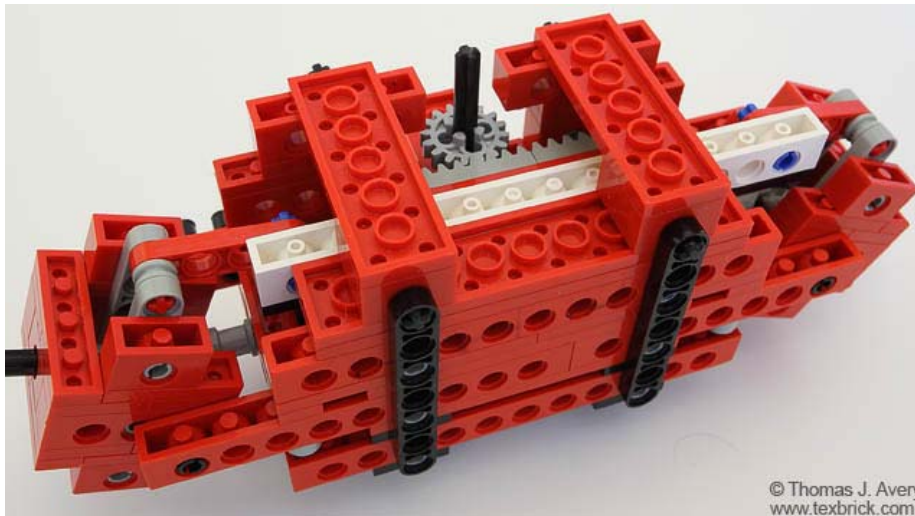
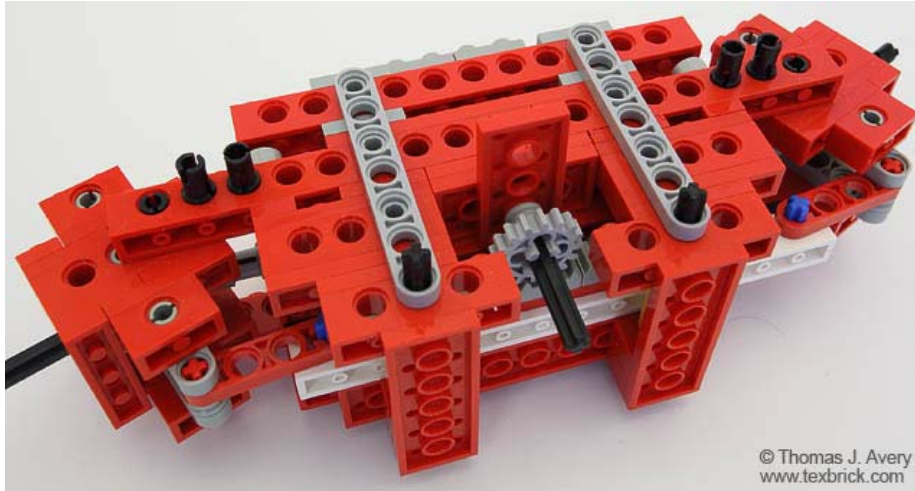
My reasoning is that when you complete the model (like my 4x4 telescopic crane), you really won't see the drive train in action. It will all be covered up. What you WILL notice is the model's performance.

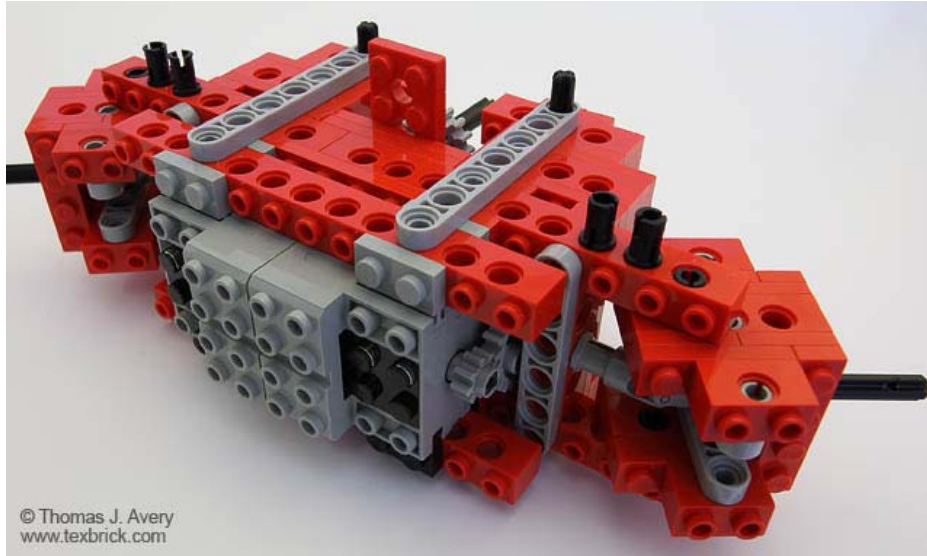
I'd rather have a snappy, well-performing model than one that's sluggish and breaks gears.



Note that this particular design goes way back to the original driven and steered axle I developed over 20 years ago. I've refined it a little bit using liftarms, but the general use of Technic bricks to form the steering arms is the same.

This design has proven itself to be extremely strong and powerful. This might be well suited for use in a large and heavy model.





As always, I do NOT have building instructions for these designs. They are presented here in finished form to show a general concept and to provide inspiration and thought for your own designs. (or maybe you have a suggestion on how to improve them? ☺ email me!)

Happy building!

-TJ Avery