# Understanding the Dynamics of Wheel Hoping

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**The Problem:** A kart that is handling poorly can be highly frustrating to a driver. Wheel hopping is particularly challenging problem that can be very frustrating. Not having the kart effectively planted mid and late corner, prevents a driver from accelerating out of the corner and can cause him to lose considerable time on the track.

A racing kart is essentially a three-wheel vehicle. Because karts utilize a fixed axle, they are dependent on a jacking effect that lifts the inside wheel to allow it to turn. The caster and akerman of the frontend steering work together to create a jacking effect. The inside front wheel is lowered and the outside wheel raised when the steering wheel is turned. These forces work with the flex of the chassis to create wheel lift. The lift of the inside rear wheel is a careful balancing act. It needs to lift enough to allow the kart to turn, but not too much to throw off the balance of the kart.


If the kart has too little lift the fixed rear axle will force the kart to drive straight and have a push. Equally too much jack is also not good. **In extreme cases of too much wheel lift, a wheel hop will occur.** In this case the dynamic weight of the kart has transfer too much that it overcomes the grip of the outside rear wheel. This causes it to break traction. This forces the inside wheel to return to the ground. The outside wheel then regains traction and lifts the wheel back up in a hopping fashion. **This problem can often occur in high grip situations and also with tall/heavy drivers that have considerable dynamic weight transfer.** Ultimately, what you are looking for is the minimum unloading of the inside tire as possible that allows the kart to turn. Obtaining the proper unloading of the inside wheel is a balancing act between jacking obtained through steering geometry, chassis flex, and center of gravity.

**Dynamic Weight Transfer:** Dynamic weight is any weight that is not fixed to the kart and moving. On a kart this is essentially the drivers body. When lateral G forces are applied while corner the dynamic weight will be forced to the outside of the kart. This typically creates more grip on the outside wheels.

**Mechanical Weight Transfer:** Mechanical weight transfer is caused by the movement of the frontend steering. Weight is shifted off the inside rear wheel and moved to the outside front tire. The inside front wheel grips the track at initial turn in, once the kart starts turning lateral G forces create additional dynamic weight transfer to the outside front and rear tires.

**Rear / Front Grip Imbalance:** Increased front end grip will increase jacking by making the mechanical weight transfer / jacking of the frontend steering more effective. The rear end grip most be sufficient to accept the dynamic weight transfer caused when the kart is turning. During high grip conditions it is often useful to look to decrease grip to eliminate rolling resistance, but this most be done is such a way that a balance between front and rear grip is maintained.

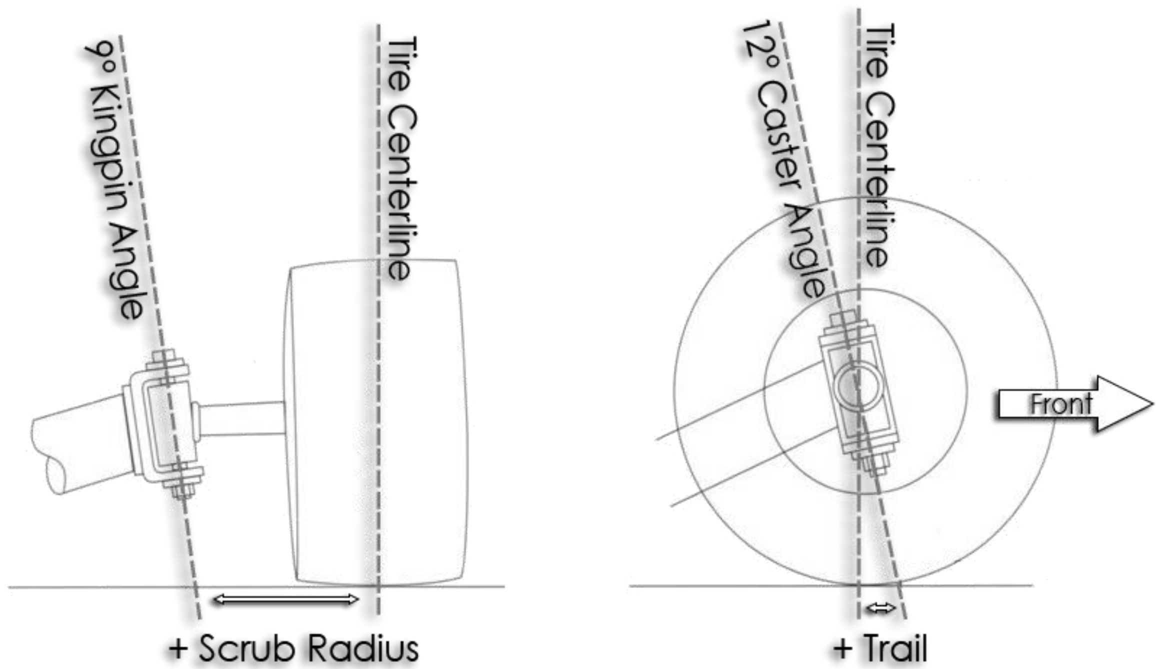
**Scaling:** Kart should be scaled to obtain proper weight balance. 50% left side weight, 42-43% front weight. Cross should be 49.5% If no ballast is available for placement, movement of the seat and placement of the engine should be considered from ways to obtain better weight balance.

**Center of Gravity:** Center of gravity both horizontally (front/back) and vertically (up/down) can affect the handling of the kart. More weight forward allows the kart to turn easier. Typically, you are looking to keep weight as low as possible. The only exception to this is in low grip situations where you are experiencing an oversteer. Seat should be mounted as low as possible until it is just above where it will scrape the ground. Seat can also be leaned backwards to lower the torso of the driver. To reduce hoping, you may want to lower the chassis both front and rear to drop down the center of gravity. The rear axle would be in the top cassette holes and the front with all the spacers underneath to achieve this.

**Caster:** The caster angle of the frontend steering is the largest determinant of the jacking effect. Increasing caster angle will increase jacking and decreasing caster will decrease jacking. **Modifying caster should be the starting point to resolve any excessive jacking and wheel hops. You should be looking to decrease caster as much as possible.** Caster effect slows the kart when driving in a straight line. Caster's main benefit is the create the necessary mechanical weight transfer to lift the inside wheel. You can keep reducing caster until an understeer on initial turn in occurs, at this point more caster is required.

**Akerman:** Akerman effect contributes to jacking effect. Increasing / decreasing Akerman will in turn increase/decrease jacking effect. Decreasing Akerman could help decrease hoping.

**Front Track width:** The frontend track width will affect the jacking effect. The amount of jacking from steering geometry is directly related to the distance between the tire's contact patch and the steering axis as well as the angle the tire rotates about. The distance between these points can be broken down into two elements. Scrub radius and trail. The angle, also called steering axis inclination, can be split into caster and kingpin angle. A wider track will increase jacking. **Narrowing the front end will reduce jacking and is a strategy for reducing wheel hop.** The downside of narrowing the front track, is that it will make the kart harder to turn in on corner entry. Best scenario would be to not have to narrow the front end unless necessary.




**Rear Track Width:** Rear track width will influence rear grip of the kart. Widening the rear track will decrease grip and narrowing will increase grip. A wider track will be more stable and resist jacking. However, in the case of a wheel hop the rear is losing traction and while a slight decrease in jack might occur with a wider track, the lack of rear grip could cause the outside rear to break traction**. Increasing rear track will not be an effective approach to eliminate hoping.** Running max width is probably needed if the kart is running in high grip. However narrowing may actually eliminate hoping by improving outside rear traction.

**Axle:** Axle stiffness will affect the handling of the kart. Axle stiffness works in combination with the flex of the chassis and may work differently depending on chassis stiffness. For most tag karts, increasing axle stiffness will take grip away from the rear end of the kart. A softer axle will add grip to the rear end. It will also affect the stiffness of the kart and cause it to flex less, which will increase jacking. While using a stiffer axle can reduce grip on a high grip track. **However, it is not an effective approach to solving hoping.** A stiffer axle should only be used when the kart is pushing, which is probably a symptom of the kart being stuck to the track and wheel not lifting.

**Front Bar:** The stiffness of the front bar influences front end grip of the kart. Increased front grip increases the jacking effectiveness. **A softer front bar or even removing the front bar can reduce front grip and in turn reduce jacking,** making it an effective solution to resolve hopping. Changing the front bar should be a primary fix if the kart has a front/rear grip imbalance.

**Camber:** Camber changes can affect the front end grip of the kart. Positive camber increases grip and negative camber will decrease grip. **Using more negative camber can be a strategy for reducing wheel hop.**

**Seat:** Seat stiffness will affect the flexibility of the chassis. It acts like a torsion bar between the 4 wheels on the kart. A harder seat will reduce jacking. A softer seat will increase jacking. This is do the influence it has on mechanical weight transfer. However, seat stiffness also impacts dynamic weight transfer. A softer seat will resist dynamic weight transfer and limit jacking effect. The interaction of the seat and chassis is complex and can depend on chassis make/model**. A softer seat can be an good strategy for reducing wheel hop if excessive dynamic weight transfer is contributing to the issue.** This would typically be the case if the driver was tall and larger.

**Seat Struts:** Seat struts add rear end grip. Adding rear grip could help hoping. However, they also stiffen the chassis and acts similarly to a stiff seat. Seat struts will not likely help a hop situation as it is a tradeoff of grip and dynamic/mechanical weight transfer.

**Rear wheel hubs:** Shorter rear wheel hubs reduce grip. Longer rear wheel hubs increase grip. As a wheel hop is caused by breaking traction of the outside wheel, increased grip with longer hubs might help eliminate hop, however, in high grip conditions likely will not help lap times.

**Front Wheel Hubs:** Longer front wheel hubs add front grip. Typically smallest wheel hubs are used standard. Since decreasing front grip is needed to reduce wheel hop, this is not a strategy for reducing wheel hop.

**Tire Pressure:** Tire pressure can be modified to increase/decrease the grip potential of the tires. If the kart is unbalanced in terms of grip front/back, you may want to decrease the air pressure in the front tires and increase in the rear.

**Adjusting for Wheel Hopping:** A driver may feel the kart hop through the middle of the corner, all the way to the exit. This is usually a result of the chassis binding up through the corner. This happens when the chassis does not flex properly through the center of the kart. Hopping is most common under high grip conditions. Basic theory would mandate that if there is more grip on the track, the chassis needs less mechanical grip.

> *NOTE: Before making any changes to correct a hop, ensure that the driver is not trying to use both pedals at the same time, or trail braking, through the corner and is not trying to slide the kart through the corner. Minimal wheel input is key to a balanced handling kart.*

## Fixing the Problem

**To resolve wheel hopping go through the following in order, ideally doing only one at a time.**

1. Lower the seat, vertically, as much as possible
2. Decrease the caster angle (ideally 1-2 degrees at a time)
3. Add a pair of seat struts
4. Widen the rear track width
5. Narrow the front track width
6. Remove the front torsion tube or adjustable bar
7. Lower the rear axle height (raising the rear ride height)
8. Raise the front spindle height (lowering the front ride height)
9. Change to a stiffer rear axle

**Conclusion:** Kart should be first scaled to see if there is an appropriate weight balance left/right, front back, and cross. Seat placement to lower center of gravity and obtain balance is very important. To reduce wheel hop, caster should be first considered, decreasing appropriately. If wheel hop continues, strategies for reducing front end grip should be considered: softening front bar (possibly removing), decreasing scrub radius, and adding negative camber. It is critical to try and reach a front/rear grip balance. Given wheel hoping also accompanies high grip situations, it is probably best to run at max rear width and use a hard axle, even though neither will likely eliminate wheel hop.

**Driving Strategies:** Hoping can be influenced by the driving style of the driver. To reduce wheel hop, the driver should work to later apex corners whenever possible. As jack is increased as the steering wheel is turned more, the driver should look to reduce the amount he is turning. Often when a wheel hops the driver can be forced up out of his seat. Driver can straighten his arms and force himself down in the seat to reduce hoping.