Cornering Supplement #6

Low- and High-Speed Turning

15

You Put Your Right Knee In

We have already pointed out that shifting your weight is not a very effective way to initiate a lean for turning and balance. Keeping your knees against the tank and leaning with the motorcycle in turns prevents the center of gravity from shifting and generally gives you better control and stability.

There are some cornering situations, however, where shifting your weight off-center can be used to your advantage. We will be covering some of these special riding techniques and how they apply to low-speed tight turns, turns at highway speeds, and decreasing-radius turns.

Slow, Tight Turns

Tight turns are intimidating to some riders because they require relatively large lean angles at low speeds. Leaning out or counterbalancing can make tight turns easier and more controllable. To fully understand what "leaning out" does, let's first consider why large lean angles are necessary to make tight turns.

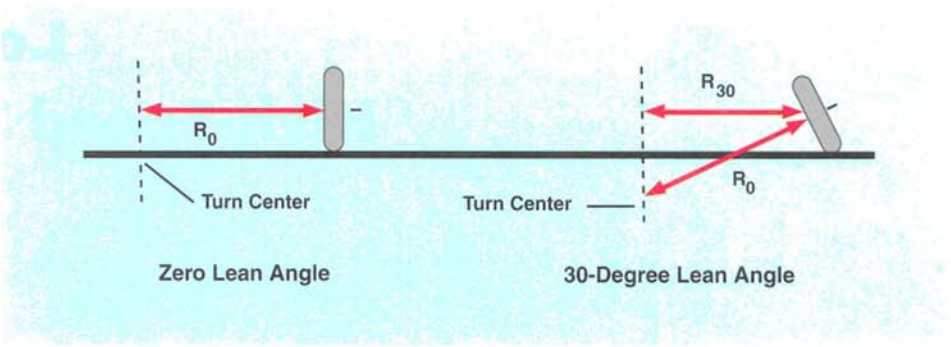
If you were to stand next to your motorcycle, turn the handlebars full-lock to the left, and walk it without leaning, your motorcycle would follow a circle that is entirely a function of the steering angle. To ride through a turn using this same technique, you would have to go slowly and lean your body inward, keeping the centrifugal force low. It should be possible to make a circle of about the same size as when you walked the motorcycle depending on your skill and the steering angle you can manage. Once that point is reached, the only way to decrease the turn radius further is to lean the motorcycle.

To illustrate why leaning the motorcycle causes the turn to tighten, take a look at Diagram 15-1. On the left, you see a view of a motorcycle rear tire. The front tire is not shown to keep the diagram simple. Imagine that the motorcycle is being turned sharply to the left with a nearly zero lean angle and the steering is at or near the stop, just like our previous "walking experiment." The center of the curve and the turn radius (R_0) are shown.

On the right is a similar view with a lean angle of about 30 degrees. Imagine the steering angle is still at or near the stop. The distance to the "center" of the curve is the same, but the center is now well below the surface. Neglecting wheelbase effects, you can pretend that the motorcycle is now riding around the base of an upside-down cone. The **effective** turn radius (R_{30}) is measured from the point on the surface that is directly above the center of the turn. Looking at Diagram 15-1, we see that R_{30} is significantly shorter than R_0, which means that the turning radius when leaning at a 30-degree angle is tighter. As the lean angle increases, the "cone" gets sharper, and the effective turn radius gets smaller.

Remember what happens to the relationship between weight and centrifugal force in a steady turn? To maintain balance, these two opposing forces must offset each other. With large lean angles, the weight has a greater lever arm and cen-

Diagram 15-1: The effect of lean on turn radius



trifugal force has a smaller lever arm. This means that more centrifugal force is necessary to balance if lean angle were to increase.

Some of the required centrifugal force results from the tighter turn, but this may not be enough to balance the increased effect of the weight. If you could steer more into the turn and make it even tighter, that could produce the centrifugal force necessary for balance. If you are unable to steer more in a very tight turn, you must increase speed to maintain balance. In other words, you have to add power to turn tighter. As strange as this might seem, it is required to maintain your balance in this situation.

Perhaps you have had the experience of using a small amount of power to recover balance in a low-speed, tight turn instead of touching your foot to the ground. This works well because it takes only a small increase in speed to produce useful change in centrifugal force. You should use the throttle smoothly and gently since it is easy to get too much centrifugal force if the engine's throttle response is rapid. Using a higher gear, slipping the clutch, or using some rear-brake pressure to limit your power to the rear wheel can result in smoother overall control.

There are limits to how far you can lean the motorcycle and how much speed you can use to maintain balance. Your lean angle is limited by the ground clearance. The effect of centrifugal force (or speed) is limited by the amount of traction available and your ability to control acceleration precisely at low speed. In a low-speed, tight turn, the front tire is tracking a much wider arc than the rear. This means that the front is going faster and will likely run out of traction first if too much speed is used.

Leaning Out

Once you are at the maximum steering angle and your speed is near the limits of traction, it would seem that you couldn't tighten up a turn any further. Leaning farther would require more speed to balance the weight, unless there was some way to lean the motorcycle farther *without* leaning any more weight. This would require a weight shift in the opposite direction of the lean. One way to accomplish this is by rider counterbalancing, or "leaning out."

Reducing your turning radius by increasing lean angle is a simple matter of geometry. The turn radius is dependent mainly on the steering angle and the amount of lean of the motorcycle's wheels. On the other hand, the balance condition is determined by the relation between weight and centrifugal force acting through the center of gravity of the rider-motorcycle combination. We can call the "lean" of the center of gravity the "effective" lean angle. If we can move the overall center of gravity away from the center of the motorcycle, we can affect balance (and speed) without changing the turn radius. This also means that you can balance at a greater motorcycle lean angle as long as you don't increase the effective lean angle any more.

Two views of a motorcyclist leaning out to tighten up a turn.

The motorcycle lean angle and the effective lean angle are the same when you lean with the motorcycle. "Leaning out" shifts your weight (and therefore the composite center of gravity) slightly to the outside. This makes the effective lean angle less than the motorcycle lean angle as shown in Diagram 15-2. ***ML*** stands for motorcycle lean, which is measured from vertical to the motorcycle centerline, and ***EL*** stands for effective lean, which is measured from vertical to the line through the composite center of gravity.

With a smaller effective lean angle, the need for centrifugal force to maintain balance is reduced. This means that the large lean angle necessary for a small turn radius can be maintained at a lower speed than if you were to lean with the motorcycle. Your maximum lean angle is still limited by any parts that might drag. Leaning out permits cornering at a slightly lower speed in situations where traction might be lower than normal. Lower speeds also allow you to maintain a greater traction reserve. The actual amount of lean will "feel" like it is less because you are more vertical than the motorcycle.

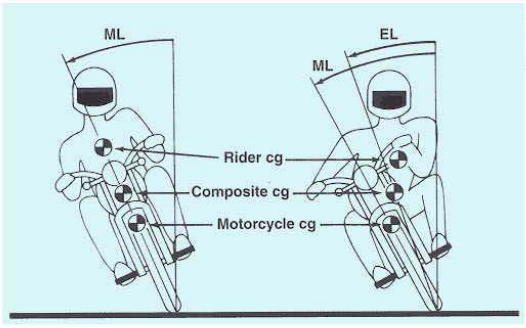
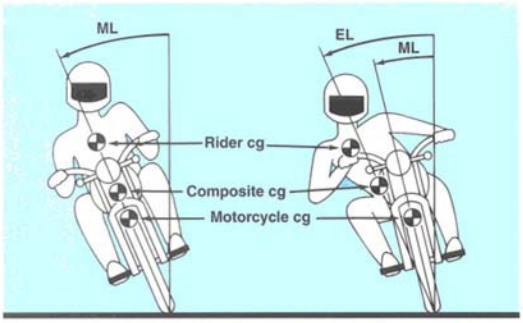


Diagram 15-2: The effect of leaning out

The effectiveness of "leaning out" depends on how much you can shift the composite cg. A heavy rider on a light machine can produce a relatively large cg shift, while a light rider on a heavy machine may not be able to shift the composite cg very much at all. Other factors being equal, this means that on any given machine, heavier riders have the potential to turn more tightly at slower speeds than lighter riders. With the proper technique, every rider can benefit

Diagram 15-3: The effect of leaning in



from knowing how to counterbalance in slow, tight turns.

Highway-Speed Turns

Balance is not a problem when turning at highway speeds. Plenty of centrifugal force is available for balance at high speed. The greater force requires more traction, and we have already covered traction management in previous chapters. Another concern is having enough ground clearance for the lean angles required. Centrifugal force can compress the suspension and reduce ground clearance at highway speeds. What can you do if you have to tighten your turn radius when there isn't enough ground clearance to lean more?

The simplest answer is to gradually reduce speed. Rolling off the throttle or braking abruptly may result in the stability and control problems that we discussed in the last chapter. It may also aggravate your ground-clearance problems if the suspension compresses even further. If you need to tighten your turning radius quickly when you are already leaned well over and your ground clearance is limited, deceleration is not a very attractive option. Fortunately, you have another choice, *if* you have managed your traction effectively and have enough reserve.

When we discussed slow, tight turns, we showed that turn radius is determined mainly by your lean and steering angles. You normally increase your steady-turn steering angle indirectly by countersteering. The motorcycle leans more (or less) and the front-end geometry helps do the rest. Effective steering angle increases *as a result* of greater lean to "track" the reduced turn radius.

If the lean angle cannot be increased any more, the problem becomes how to increase the steering angle and reduce the radius. We would then have to prevent the resulting centrifugal force from decreasing the lean angle and increasing the turn radius. "Leaning in" is a technique that can help in this situation.

Leaning In

We already saw how, in tight turns, you can shift the composite cg away from the centerline of the motorcycle by shifting weight to the outside. This produces an effective lean angle that is less than the motorcycle's lean angle and reduces the demand for centrifugal force. If you run out of ground clearance while you still have adequate traction in higher-speed turns, the challenge becomes how to counteract *more* centrifugal force. If you can't slow down, your effective lean angle must be *greater* than the motorcycle's lean angle.

You can accomplish this by "leaning in," or concentrating more weight on the inside of the turn as shown in Diagram 15-3. Again, ***ML*** stands for motorcycle lean angle, which is measured from vertical to the centerline of the machine. ***EL*** stands for effective lean angle, which is measured from vertical to the line through the composite cg.

Leaning in can help if you unintentionally enter a turn too fast. If you enter a turn slightly overspeed and you have sufficient traction reserve, you might choose to keep the throttle on to maintain ground clearance and suspension stability; then press to lean more and shift your weight to the inside. The actual technique may be as simple as hanging out a knee on the inside of a turn, or you might shift your weight on the seat.

If you are riding much too fast, one technique is to countersteer to straighten the bike and brake

hard in a straight line to reduce your speed, then quickly countersteer to re-enter a tighter radius at a lower speed. These methods are not recommended for routine riding. They simply give you an option if you have misjudged the appropriate entry speed for a turn. Your technique has to be precise to successfully execute this maneuver. It is especially important to look far through the curve to maintain visual directional control.

You may have seen racers hanging out a knee at the track. They use this effect to push the limits of traction and ride faster through turns. On the street, you have to maintain a reserve to deal with less predictable conditions, as we have already discussed. When you use the technique of "hanging off" to decrease the radius of a turn, you must remember that more traction is needed. Leaning in doesn't create additional traction, it simply permits you to use more of the available reserve.

As with "leaning out," the effectiveness of "leaning in" depends on the weight of the rider relative to that of the machine. Heavier riders can produce more of an overall weight shift than lighter riders, but any rider using this technique can produce more ground clearance when cornering at highway speeds.

Summary

Counterbalancing (or "leaning out") can be useful when making tight turns at low speeds, when steering angle can't be increased, or when speed must be kept low because traction is marginal. "Leaning in" permits sharper turns at any given speed when ground clearance limits motorcycle lean angle. It is useful in highway-speed turns and in decreasing-radius turns as long as there is sufficient traction.

Neither technique has any direct effect on the amount of traction available because they don't change the tire loading or the coefficient of friction. There is no magic that will allow you to corner faster than traction will allow. These leaning techniques are valuable to help deal with the limits of steering angle or ground clearance, and for the rider's comfort.

Self-Test for Chapter 15: Low- And High-Speed Turning

Choose the best answer to each question.

1. How can you make tight turns easier and more controllable?
   a. Slip the clutch.
   b. Tap the brakes.
   c. Lean out or counterbalance.
   d. Put your foot out and use it as a pivot point.
2. Which of the following will tighten your turn radius if you can't lean more?
   a. Gradually reduce speed.
   b. Gradually increase speed.
   c. Brake hard.
   d. It's not possible.
3. When should you "lean in" while cornering?
   a. For all high-speed turns.
   b. While accelerating at the exit.
   c. For slow, tight turns.
   d. When you enter a turn slightly overspeed.
4. "Hanging off," the technique road racers use to decrease the radius of a curve, creates more traction. True or false?

(Answers appear on page 176.)