Road Science

Cornering Control:

By David L. Hough

Biker Bob just got back into motorcycling, and his new bike seems to have a mind of its own. His new heavyweight machine doesn't respond the same way his 250cc scrambler did 20 years ago. His scrambler would lean just by throwing his weight toward a turn. Today he's on his way home from a ride, approaching the narrow side street where he'll be turning off from the wide boulevard. Bob signals, rolls off the throttle, and leans the bike into a right-angle turn. But the bike doesn't seem to want to turn as tightly as Bob wants it to.

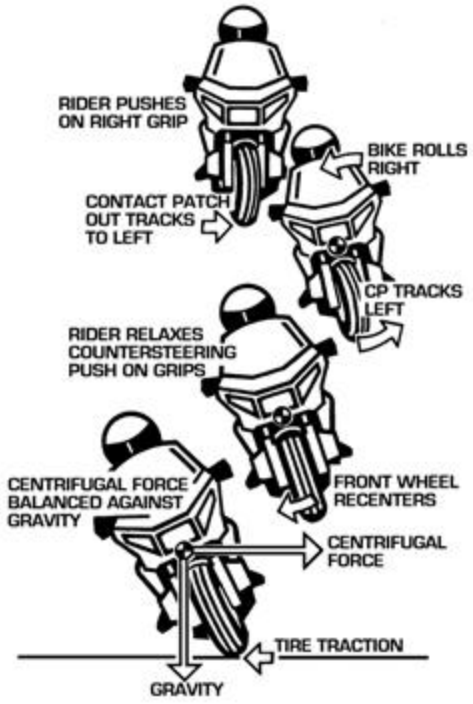
He tries leaning it a little farther by leaning his shoulders toward the right and nudging his left knee against the tank, but the front wheel continues to roll wide, across the centerline. Fortunately, the driver of a car coming up the street sees the bike, and brakes to avoid a collision. It's embarrassing not being able to control the bike as accurately as he'd like. Bob is not alone. Lots of motorcyclists haven't figured out how to steer a bike accurately, especially a big bike at slower speeds.

The action is down at the front tire contact patch

It's very important to understand that accurate two-wheeler steering is a matter of pushing on the handlebar grips, not just leaning weight in the saddle. Obviously, a bike needs to lean toward the curve in order to turn. And you can make it lean just by shifting your weight in the saddle, or nudging the tank with your knees. But the easiest and most accurate way to control lean is by momentarily steering the front wheel opposite the way you want to go. The out-tracking of the front tire forces the bike to lean. To turn left, press on the left grip. To lean and turn right, momentarily press on the right grip. It's called "countersteering".

That momentary push on the grips is just the first part of a process of balancing and steering a motorcycle. That initial input is called "countersteering" because you momentarily steer the front wheel opposite, or "counter" to the direction you want to go. But as the bike leans over to the angle you need to make the corner, you allow the front wheel to recenter, and even steer slightly toward the curve. Leaned over, front tire traction forces the bike to turn. The bike is held at the same lean angle by gravity being balanced against centrifugal force.

Pressing the grips right causes the front wheel to track left, and tire traction forces the motorcycle to lean toward the right.



This process repeats over and over again as a rider makes adjustments to balance and direction. Front end geometry also contributes to balance--the front wheel keeps trying to recenter itself with the bike vertical. But even in a "straight" line, the front wheel weaves slightly from side to side as the bike's geometry and the rider's steering input work together to control balance and direction.

Countersteering is just the first part of the cornering process. As the bike rolls over to the angle of lean you think is about right for the corner, you allow the front wheel to recenter. The front tire pushing the bike toward the turn generates "centrifugal force". The bike is kept from falling over by centrifugal force balanced against gravity.

In a turn, you can control the direction of the bike by small adjustments to steering. To turn a little tighter, push the grips a little more toward the curve. That's what Bob needed to do to avoid crossing the centerline and staying within his lane. Press right to lean right. And what Bob needed to avoid those parked cars on his right is to lean a little more left. Press left to lean left.

It might seem easy enough to countersteer, but sometimes a rider's brain subconsciously confuses the issue, signaling the left and right hands to do different things. It's not uncommon for a rider to be pushing on one grip to lean the bike, and subconsciously resisting that push with the other hand. If it sometimes seems that your bike just doesn't want to lean even when you are pressing hard toward the direction of turn, it's a hint you need to get your hands coordinated.

In simple terms, pressing on the right grip causes the bike to lean (and turn) right.

Lee Parks, author of the book Total Control, suggests steering with one hand. That is, in a right turn, do the countersteering with your right hand. In a left turn, steer with your left hand. What's important is to make a point of relaxing the other arm, to ensure that you aren't subconsciously strong-arming the opposite grip and resisting your "steering" hand. For instance, when turning left, steer with your left hand, and relax your right arm. In a right turn, relax your left arm. If you're having trouble only with left-hand turns, it may be because you're strong-arming the right grip as you manage the throttle. Try flapping your elbow a bit to help relax the "non-steering" arm.

Or, you might try concentrating on moving both grips toward the direction of turn. That is, leaning into a right turn, consciously press both grips toward the right. You might actually be pushing on the right grip and pulling on the left grip, but you can imagine that it's moving the grips toward the curve that pushes the bike over. Press both grips toward the right to lean right. Press both grips left to lean left. It's OK to lean body weight toward the curve while holding onto both grips. Leaning pulls both grips toward the curve, which is actually countersteering, but focusing on leaning can smooth out the steering input.

Or, try moving both grips toward the turn. You might actually be pushing on the right grip and pulling on the left grip, but you can imagine that it's moving the grips toward the curve that pushes the bike over. Its OK to lean your body toward the curve.

It's not just countersteering

While countersteering is the basic technique for accurate steering control, there are some other considerations when cornering, including your cornering line, where you're placing your weight on the bike, and what you're doing with the brakes and throttle.

One of the advantages of a narrow 2-wheeler is that you can follow lines through corners that not only provide better traction, but also decrease the risks of a collision. Yes, you can just follow one of the "car" wheel tracks through a corner, but that doesn't necessarily decrease the risks. Riding a motorcycle, you can use the entire lane, "straightening out" curves. The straighter your line through a corner, the less the demand on tire traction, which helps avoid a slide-out.

The best way to maximize the view is to enter corners from the "outside" of the turn. That is, approaching a right-hander, make your turn-in from a position closer to the centerline.

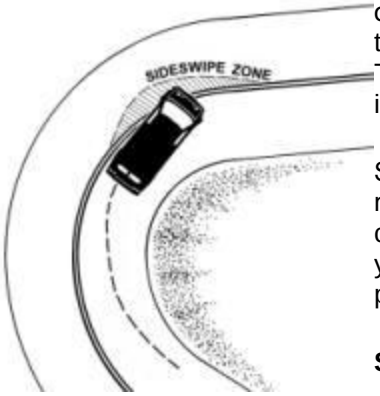
It's also important to improve the view ahead, because what you can see is a big factor in how fast you can corner. To avoid sticking your neck out too far, you always need to be able to bring the bike to a stop within the roadway you can see. You have to assume that there will be hazards in the road halfway around, even if you can't see them yet. And when you're rounding a right-hand corner, your sight distance typically gets shortened by the shape of the landscape.

For a left-hander, make your turn-in closer to the right edge of the pavement.

The best way to maximize the view is to enter corners from the "outside" of the turn. That is, approaching a right-hander, make your turn-in from a position closer to the centerline. For a left-hander, make your turn-in closer to the right edge of the pavement.

Sideswipe Zones

It's also a high priority to avoid getting sideswiped by oncoming vehicles. It might seem prudent to just stay away from the centerline all the time, but that's not necessary. Drivers tend to wander over the line in specific areas, and it's only necessary to avoid those areas. Consider how an oncoming driver sees the road. There is a tendency to enter curves too fast, cut toward the inside too early, then drift wider in the last half of the curve.

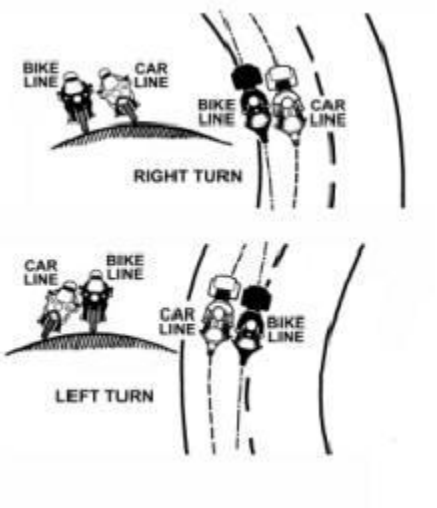


So you don't need to avoid the centerline all the time, you only need to avoid those "sideswipe" areas. As it happens, entering a curve from the outside allows you to cut toward the outside of your lane at the critical zones, increasing your distance from potentially wandering drivers.

Surface Camber

Those twisty secondary roads we enjoy typically have lots of crown in the center, with the pavement on either side slanting off ("cambered") toward the edges of the road. A steep camber in a right-hander works to your advantage, but a steep camber in a left-hander works against you, decreasing traction and eating up leanover clearance.

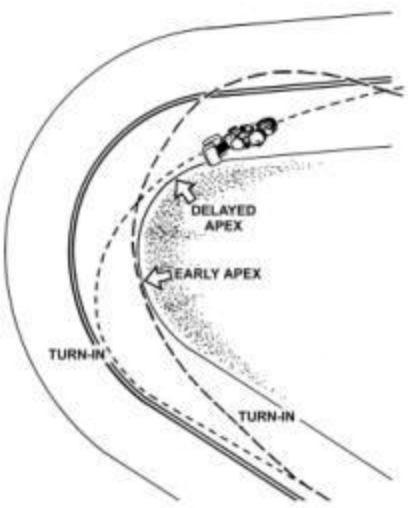
The "bike" line keeps the motorcycle more vertical, especially on crowned roads.



Consider one motorcyclist following the center of the lane (the "car" line) compared to another motorcyclist following a straighter line (the "bike" line) Not only does the bike line keep the motorcycle more vertical, it also places the bike in the lane to take advantage of a crowned road.

Entering a turn from the outside helps make the best of a well-cambered surface. Entering a right-hander, you can carve over toward the right edge of the pavement where the camber is steepest. Entering a left-hander, you can ease over toward the center of the road where it's more level.

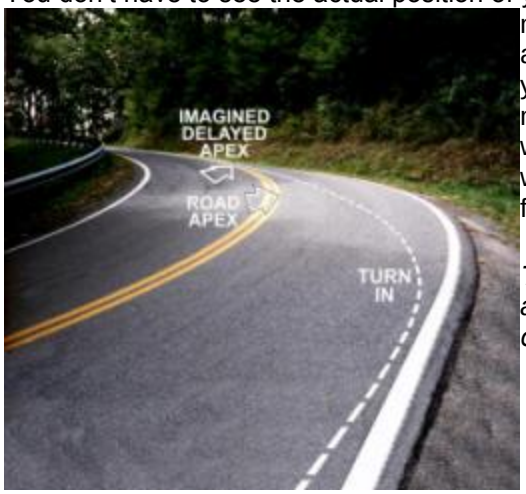
The problem with an early apex is that it points the bike "wide" in the last half of the curve.



We often describe our cornering lines in terms of the "apex"--the imaginary point where the motorcycle passes closest to the inside of the curve. The location of the apex determines the shape of your line. If you turn in early and point the bike toward the inside of the curve too soon, you'll pass by an "early" apex. The problem with an early apex is that you're tempted to carry too much speed into the turn, and then halfway around, realize you're running wide.

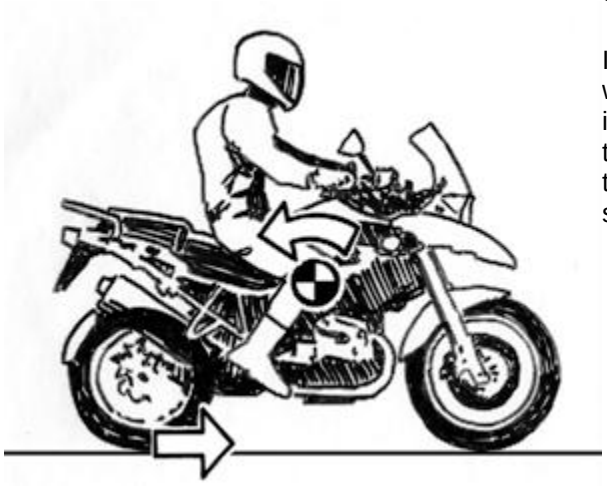
Imagine a "delayed" apex somewhat farther around the turn. In a right-hander you'll need to make your turn-in closer to the centerline, and a bit later. In a left-hander, the turn-in point should be close to the outside edge of the road. The delayed apex (sometimes called a "late" apex) provides a better view ahead, conserves traction during the last half of the turn, keeps you away from those "sideswipe zones," and points the bike more around the curve. A delayed apex line is a good idea for riding public roads where anything can happen.

Let's imagine an ideal "delayed apex" line through a blind right-hand curve. You don't have to see the actual position of your imagined apex, just mentally slide it a little farther around the corner than where you think the actual road apex might be. A delayed apex line works just as well in a left turn, with your imagined apex along the centerline, a little farther around the turn.



To follow a "delayed apex" line, mentally slide the apex a little farther around the corner, even when you can't see the rest of the curve.

When and how you roll on the throttle—or roll off the throttle—has a lot to do with cornering control. For instance, imagine leaning a 100 hp bike into a tight turn, and then suddenly rolling on a big handful of throttle. The rear tire may already be close to the limits of traction, and a sudden increase in power would very likely slide the rear end out. That example makes it obvious that engine thrust can push the bike around.



In a corner, it would be best to maintain the weight distribution on the tires. Even if the bike is in a straight line, rolling on the throttle tends to shift weight onto the rear wheel. Rolling off the throttle shifts weight toward the front. That same front-rear weight shift occurs in a corner.

To maintain traction, it would be best to maintain weight distribution while leaned over.

Rolling on the throttle shifts weight toward the rear, decreasing front tire traction.

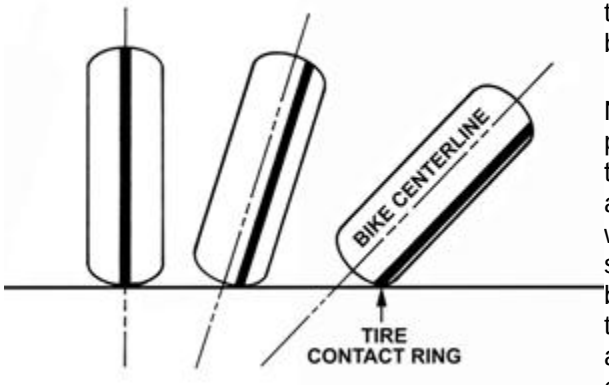
Let's note that even if the tires don't seem to be sliding sideways on the pavement during a curve, they are. In a curve, the flexible tire rubber allows the bike to move in a slightly different direction from where the wheels are pointed. It's called "drift," or more correctly "side slip." Rolling on a bit more throttle tends to increase the slip angle of the rear wheel, pointing the bike more toward the curve.

Rolling off the throttle shifts weight toward the front, decreasing rear wheel traction.

Braking also affects side slip. Imagine jamming on the rear brake while leaned over. It's not difficult to imagine the rear tire sliding out, dropping the bike on its "low" side. Let's note that rolling off the throttle is also rear wheel braking, as engine compression tries to slow the rear wheel.

Tire Contact Rings

As the bike leans over into a curve, the location of the tire contact rings moves off center. That means that engine thrust or braking are off center. So, rolling on or off the throttle while leaned over will push or pull on one side of the rear tire, and that will have an effect on steering the bike.



Not only does a tire's contact ring ("contact patch") move off center as the bike leans over, the ring shrinks in diameter. Even if you're attempting to hold a steady throttle, the bike will decelerate as it leans over onto the smaller-diameter contact rings. To maintain bike speed, you'll need to roll on a bit more throttle as you lean the bike over. One of the advantages of wide, low-profile tires is less change in contact ring diameter, but the tradeoff is the ring moving farther out to the side as the bike leans over.

As the bike leans over toward a curve, the contact ring of the tires is reduced in diameter, and also moves off center.

Put all of this together, and you can see that throttle control affects steering, whether accelerating or decelerating. As it happens, throttle control and cornering lines can work together. If you're following a nice "delayed apex" line, you can ease on the throttle as you turn the bike in, and then gradually roll on more throttle through the rest of the curve. That's much smoother than decelerating toward a mid-curve apex on a trailing throttle, and then getting back on the throttle while leaned over.

The ideal throttle control would be decelerating toward the turn-in point while in a straight line, then easing on the throttle as you lean the bike over. You can continue to ease on more throttle in the last half of the curve, since the bike will be straightening up, and the side loads on the tires will be decreasing.

Throttle-Brake Transitions

With the bike leaned over into a turn, maintaining traction is a top priority. And how you roll on or off the throttle can determine whether you keep the tires hooked up, or they slide out.

Sudden changes in throttle momentarily demand traction. That is, if you were to suddenly roll the throttle open while leaned over, the rear tire would demand more traction as it attempts to accelerate the bike forward. It's very possible to slide the rear tire out from overzealous roll-on.

Easing on the throttle as you lean the bike, and then continuing to ease on more throttle through the curve helps stabilize the bike and avoid mid-turn wobbles.

Sudden braking input also demands traction. If you were to suddenly jam on the rear brake while leaned over into an aggressive curve, you should expect the rear tire to slide out. What may not be obvious is that suddenly snapping the throttle closed has an effect similar to stepping on the rear brake pedal. We must also remember that accelerating or braking both cause weight transfer between the two tires, and that changes the traction available on either tire.

To help maintain traction, both throttle input and braking should be as smooth as possible. When rolling on the throttle, it should be gradual. It's just as important to roll off the throttle smoothly. Likewise, when braking, you should apply the brakes progressively over approximately two seconds. And when releasing the brakes, you should ease them off over two seconds.

You can practice smooth throttle and brake application in a straight line exercise. At a speed of say, 40 mph, ease the throttle closed as you progressively squeeze on the front brake. Don't clutch or shift down. As the bike decelerates to about 20 mph, ease off the brake as you smoothly roll back on the throttle. The goal is to transition from throttle to brakes and back to throttle so smoothly that the bike isn't upset.

Smooth braking helps manage traction, whether straight up or leaned into a corner. Squeeze the lever progressively harder over about two seconds. When releasing the brake, ease it off over two seconds.

Controlling the throttle and brakes simultaneously requires some right hand dexterity. You'll have to find a technique that works for you. Some riders prefer to hold the throttle with thumb and forefinger and brake with the three outer fingers. Others prefer to hold the throttle with thumb and outer two fingers, and brake with the two inner fingers. Which fingers you use for braking may depend upon the force needed at the lever on the bike you're riding.

Two-fingered braking works well for machines with a powerful front brake. The throttle is held between the thumb and outside fingers.

You can expect surface traction to change, even during a corner. A patch of sand or dribble of diesel oil will reduce traction, and you can feel a momentary slip of either or both tires. The typical (and wrong) "survival reaction" when a rider feels a tire slip sideways is to snap the throttle closed, but that can turn a short slide into a major crash. If the tire can regain traction, it will. It's difficult to resist the urge to snap off the throttle, but it's important to hold a steady throttle and steer toward the direction of the skid.

For greater leverage, some riders prefer squeezing the brake lever with the three outside fingers, and holding the throttle with the thumb and index finger.

Uphill, Downhill

While the ideal technique for level turns is to gradually ease on more throttle from turn-in through the exit, uphill and downhill turns require different tactics. When approaching an uphill turn, especially a tight switchback, the front end will be lighter and therefore the front tire will have reduced traction. Rolling on the throttle during a tight uphill turn can cause the front tire to slide out. That's especially likely when carrying a passenger or a heavy load of gear on the back of the bike.

When approaching a tight, uphill turn, maintain a slightly higher speed, to allow inertia ("momentum") to carry the bike up and around. Then smoothly ease on more throttle as you pull the bike upright.

When cornering downhill, you may need to brake to keep speed from increasing. Riding downhill, the front tire will be more heavily loaded, so you can use more front brake in downhill corners. If you're using engine braking to hold speed, remember, engine braking only applies to the rear tire, which already has decreased traction due to the forward weight shift.