



Title:	Learning to race 4.0 Racing lines, corners, cornering – How to go around the track, crashing.
Objectives:	<p>Instruct student in the ‘lines’ that racers take and what different lines exist. Finding the fastest way around the racetrack. Understanding corners and cornering.</p> <p>What to do in a crash.</p>
Goals:	<p>At the end of this period of instruction the student will understand what racing lines are, what different types of racing line exist and how to decide on what lines to use and the different types of corner that will exist on racetracks and the concept of corner apex, counter-steering and cornering. The rider will understand that the two goals of racing are to find the fastest laptime and to beat the racetrack better than all the other riders.</p> <p>Riders will learn what they should do should they crash.</p>
Subject:	<ol style="list-style-type: none"> 1. Racing lines – How to go around the racetrack 2. Racing line 3. Optimal/qualifying line 4. Overtaking/defensive line 5. Different types of corners 6. Corner apex 7. Corner entry 8. Mid-corner 9. Corner exit 10. Counter-steering 11. What to do in a crash situation
Procedures	Classroom instruction, one-on-one discussion, group discussion, on-track instruction, video demonstration
Technique	<p>Using pictures, track diagrams, white board instruction, track walking and on-track instruction, develop riders understanding of racing lines and different corner types.</p> <p>Physical demonstrations about crash and post-crash behaviour. Physical practice of actions.</p>
Most Common Mistakes	Not understanding the racing line concept, always apexing too early, not understanding the different types of racing line.



	Not understanding the issues with crash behaviours.
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Summary	<p>This section is the first that really introduces actual racing concepts to the rider.</p> <p>The reason for racing is to beat other riders and to win races. It is NOT to turn up and do an expensive trackday that happens to have a mass start. The rider must first decide if they are there to go racing. Once decided, they can then work on racing skills.</p> <p>In order to proceed around the racetrack and win those races, the rider must decide on and take a 'line' from one point on the track to another. This line is called the racing line and determining the best racing line for each rider around each racetrack is the first step to success. If the wrong line is chosen and taken, the laptime will not be optimal and the race outcome will be less than optimal. Finding and choosing the best racing lines is a skill every rider needs to develop in conjunction with using their other riding and racing skills.</p> <p>One of the main objectives of searching for and finding the best racing lines is to make the corners as short as possible in order to make the straights as long as possible. This is because it is on the straights where racers go fastest, and hence make the fastest lap time.</p> <p>It must also be understood from the beginning, that there is no single best racing line for motorcycle racing at any racetrack. Different bikes and different riders with different characteristics and skills will be able to utilise different lines around each corner. However, it is also true that there are generally better and worse ways to traverse any given corner, so optimal lines that are similar do exist.</p> <p>There are only three types of racing line on a race track. These lines will be different for different riders, but there are only three types. Not only three lines, but three types of line.</p> <p>1) The Optimal/Qualifying Line The theoretical best line around the circuit for potentially the fastest lap time. Used when you are on your own trying to make up time or when qualifying and are in the clear. However, using this line while racing leaves opportunities for competitors who are close enough to "take the line" and upset your own line. The Qualifying Line tends to start very wide out on corner entry, allowing high mid-corner speed and fast corner exit.</p> <p>2) The Racing Line The line that is taken to go around another rider, either outside or inside. It is generally slower than the Qualifying Line as it is a compromise and therefore there may be a number of these lines that can be taken around any given corner, for any given bike/rider combination.</p>
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3) The Overtaking or Defensive Line

A line that allows the overtaking rider to keep his bike upright for longer and use the brakes more effectively. This line often causes the rider being overtaken to have to deliberately slow down or be unable to turn onto their preferred line (the blocking maneuver) and therefore have to wait before turning, hence making them slower into and then out of the corner. The Overtaking Line tends to be very fast into the corner, but sacrifices optimal speed mid-corner and on corner exit.

To take advantage of each of the three fundamental racing lines you need to know from where each of them starts, where each will take you on the track and where it will take you in the corner. This means that your **reference points** will be slightly different for each line.

This means that you must practice each type of line before you need it. You need to know what you are looking at as you approach the corner, otherwise you will only be guessing where you are, and the result that you achieve will be luck of the draw. Not knowing where you want to be for each corner leaves you open to riding on instinct. Turning in too early, braking too early, not knowing the corner exit, being too early or too late on the throttle are some of those instinctive actions. The more experimentation you do with racing lines the more knowledge of the track you will have and the more options you will develop. This is one of the reasons why we practice. We don't practice to just ride around the track the same way lap after lap wearing out bikes and tyres. Practicing different lines is vital if you are to find the fastest ones.

You must make a definite decision when to turn the bike into the corner (turn-in point) and therefore make the rest of the corner easier to get right.

Look where you WANT to go, not where you ARE going. If you look where you ARE going you will tighten up your frame of reference and this will cause you to slow down because you will perceive everything as happening too fast. If you lift your eye line to look where you WANT to go, you will open up your frame of reference and things will then be perceived as happening much more slowly and you will have time to work out what is happening. Don't look down at the kerb or at the mark in the asphalt in the turn!

Breaking open the space you have to work with is one of the keys to going faster. Moving your vision away from the corner apex to the corner exit and then to the 'Vanishing point' (as the vanishing point always moves away from you) allows you to move ever more quickly to that next point and hence to go faster around the track. This is the Joining the dots method, where you aim to build a line of as many dots as possible. Logical thinkers can develop this method for themselves.

Another method of setting your corner line is to use the Big-Picture-Method. In this method you build up a picture of the whole corner in your mind and picture yourself

in it as you do it. Using this method provides opportunity to derive your racing lines before you even go to the track. Watching videos of other riders can help to build this bigger picture. For people who are more kinesthetic in their learning and behaviour this method work seems to work well.

Corner types

There are only three different types of corner, but also three different types of camber. Adding them all together and combining one type after another with straights long and short and many different combinations can be imagined and built to create the many different racing circuits we have. Add into that mix the possibility to use natural ups and downs of different terrains and we can see that race circuits can be either quite simple, or very complex, quite slow and technical or very fast and flowing.

The different types of corners are:

- 1) Constant radius, where the radius of the corner does not change;
- 2) Increasing radius, where the corner opens out to larger radius from the entry to the exit;
- 3) Decreasing radius, where the corner radius deduces from entry to exit and the corner tightens up.

The different types of camber are:

- 1) No camber, where the circuit is flat;
- 2) Positive camber, where the circuit slopes inwards towards the inside edge of the corner. Positive camber corners can be small or larger camber;
- 3) Negative or off-camber, where the circuit slopes outwards towards the outside edge of the corner. Negative camber corners are always small amounts of camber as too much is too dangerous and not useful.

Each different type of corner requires a different riding method to navigate them as fast as possible, and they often also require different set-up of the motorcycle to go as fast as possible around them. This demonstrates how, if one circuit contains many different types of corner, setting up the motorcycle (eg gearing, suspension, geometry) is always a game of compromise and that it will almost never be perfect for all corners on a given racetrack. The rider must then negotiate each corner the best that they can by manipulating body position, braking, gearing and throttle.

However, the rider is able to modify how they ride the motorcycle and how they choose to go around any given corner. So, this is the art of choosing the racing line and how that racing line is ridden.

This subject is complex and takes a lot of time and practice to understand and find the solutions. At a very basic level the following approaches can get a rider started on that journey. The following is only the beginning of that journey:

Flat corners: Require lower rate suspension springs with more initial pre-load as lean angles are higher and suspension needs to be compliant;

Positive and negative camber corners: Require higher rate suspension springs with less initial pre-load as lean angles for positive camber corners are lower so more weight is on the springs but for negative camber corners need more rapid movement of the wheels towards the track surface.

Constant radius corners: Require steady corner entry, steady throttle control and low front brake input, but might require some rear brake to hold the line or bring the bike back into line, mid-corner. Suspension should be compliant;

Increasing radius corners: Require wide corner entry possibly with trail-braking to bring bike into the late apex, followed by strongly increasing throttle on exit allowing the bike to drift as far to the outside of the circuit as possible to build as much speed as possible. Suspension should control rearwards pitching of the motorbike;

Decreasing radius corners: Require heavy braking entry and often more than one apex, or no particular apex but rather following the corner around potentially under heavy trail-braking in order to get the motorcycle to flow into the smaller radius part of the corner. At the final apex the front brake can be released and the rear brake applied in order to get the bike to turn more sharply. Judicious application of throttle on corner exit is needed due to higher lean angles that tend to be necessary to navigate decreasing radius corners. Suspension needs to offer strong hold-up in the front end as heavy braking is used in entry and mid-corner.

Managing corners

The following are some very initial guides to corners and cornering:

Counter steering:

'Counter steering' and 'Counter-leaning' are the two techniques that make the motorcycle initiate a turn. To initiate a turn toward a given direction, the rider momentarily steers 'counter' to the desired direction (ie "steer left to turn right"). To negotiate a turn successfully, the combined center of mass of the rider and the bike must be leaned in the direction of the turn. Steering briefly in the opposite direction causes that lean. Turning the handlebars one way makes the motorcycle effectively 'fall' to the opposite side. The bike then starts to turn the way it has fallen, then the rider turns the bars that way and the bike follows that curve. The physics of this are to do with angular momentum, centre of gravity and balance in a process called PRECESSION.

Another way to cause the bike and rider to lean is by applying appropriate torques between the bike and rider, or **Counter-leaning**. In a manner that is similar to the way a gymnast swings up from hanging straight down on uneven parallel bars or a child can start swinging on a swing from rest by pumping their legs, on a sufficiently

light bike, a rider can initiate a lean and turn by shifting their body weight. On heavy bikes, shifting body weight is less effective at initiating leans. This technique works by employing the natural tendency of most bikes to steer towards the direction they are leaned.

Therefore, to initiate the turn, the initial steer torque and steer angle are both opposite to the desired turn direction. But, the sustained steer angle is generally in the same direction as the turn. The sustained steer torque required to maintain that steer angle is usually opposite the turn direction (ie the rider will need to maintain pressure on the bars opposite to the corner direction). The actual magnitude and orientation of both the sustained steer angle and sustained steer torque of a particular bike in a particular turn depend on the bikes forward speed, the bikes geometry, tyre properties, and the combined bike and rider mass distribution.

Corner entry: Before entering a corner, the rider must know what type of corner it is, which will determine the solution the rider will apply to making their way around the corner as fast as possible. At the corner entry, the rider must find the best point to start the corner, brake the correct amount to set their entry speed, select the correct gear and decide what line they will need to apply for their current situation (racing, overtaking, qualifying). In most cases the racing line will be selected prior to the corner, but in some cases, when other riders are present, the racing line might be selected closer to corner entry.

Mid corner: At mid corner, the rider is navigating the corner at the fastest possible speed for the corner (which will be fast or slow depending on the corner) and is turning the bike ready to seek the corner exit. For constant radius corners, mid corner might require the rider to bring the bike back onto the line, for increasing radius corners the rider will be seeking to increase speed for the exit, while for decreasing radius corners the rider will be seeking at mid corner to brake further and turn tighter in order to accommodate the smaller corner radius. Remembering also, that as the motorcycle turns in the corner, leaned over, that this action itself reduces the speed of the motorcycle. So, not all the slowing down needs to be done using the brakes. Trail-braking is an advanced technique that needs experience and skill development.

Corner apex: This is the point in the corner where your speed is the lowest it will be for the corner, where your lean angle is generally highest and is the point where you change from corner entry/mid-corner, to corner exit. Corners require either early or late apex meaning the corner apex is either early in the corner close to the entry, or it is further around the corner, nearer to the exit point.

Corner exit: The rider must seek to exit the corner with maximum possible speed in order to reach the next corner as fast as possible and in the right position to enter the next corner or straight on the correct line. Riders typically try to open the throttle as much as possible on corner exit, especially when that exit leads to a straight. Riders should, with eyes up and looking along the track, seek the points

that are disappearing, Vanishing points, to aim for along the track, that will pull them along the track at the fastest possible speed.

What to do if you crash

Crashing: If the rider themselves is that rider that crashes or falls down, there are certain things they must be taught to do:

- 1) Stop sliding or tumbling – do not try to get to feet before they have stopped moving,
- 2) Determine if they are injured or not – do a quick mental/physical check about what is hurting,
- 3) Determine where they are – have a look around to see where they are and what is happening around them,
- 4) Move rapidly to safety – this is dependent upon the path being clear and the rider being sufficiently healthy to be able to move. If the rider is in the middle of the track and other riders are still approaching, they **MUST** stay where they are. It is easier for on-coming riders to avoid a stationary object than to avoid one that tries to get out of the way, so the approaching rider has no idea which way they are going to go. If the fallen rider stays put, they stand a much better chance of being avoided. When the way is clear, the rider must move away from the crash site to the nearest safe point at a marshal point, wall or similar space,
- 5) Leave their bike where it is, until directed to do otherwise by race officials,
- 6) If or when directed by race officials, the rider may help retrieve their bike from the crash site,
- 7) Do **NOT** sit or stand with the bike on the side of the track trying to repair it or figure out what is wrong. Get out of the way of the track.
- 8) If the motorcycle experiences a technical problem, get off the track smoothly and safely to the nearest safe point (run off road, marshalling point, track exit). Do **NOT** dart across the track in an unsafe manner.



Assessment Sheet
Learning to race 4.0
Racing lines, corners, cornering - How to go around the track

Item	Pass/Fail	Comment
Understanding the three types of racing line		
Practicing different lines on the track during practice		
Understand the main different types of corners		
Competence at riding around different types of corner		
Improving lap times due to improving racing lines		
Demonstrating an overall understanding of racing lines and their effects on lap times and racing.		
Demonstrating an understanding and competence of counter-steering		



Overall Comments:

A large, empty rectangular box with a black border, intended for writing overall comments.

Guardian/Student Signature:

Trainer Signature:

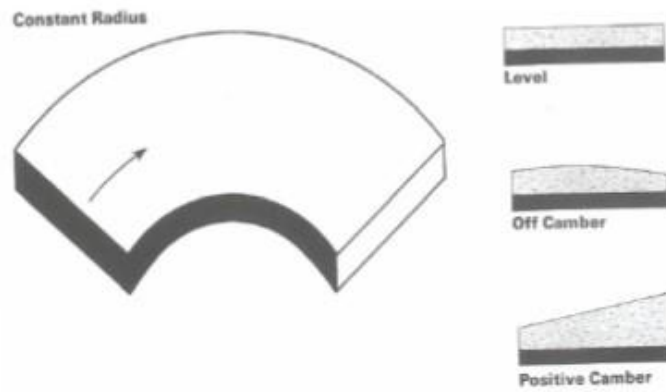
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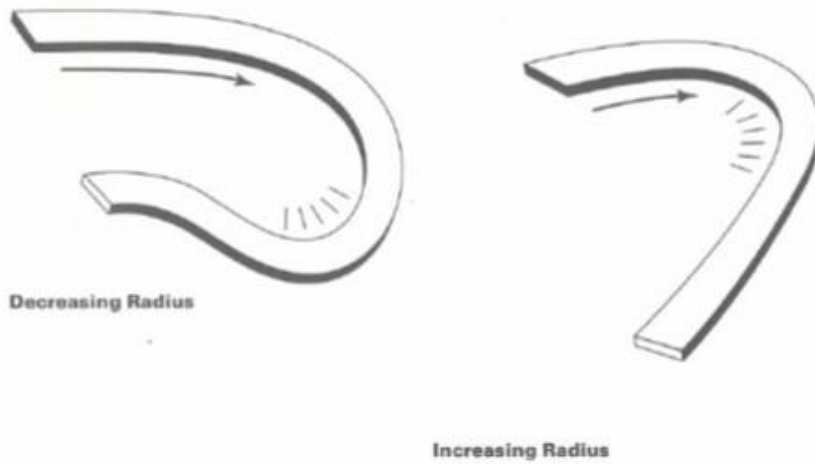
Examples of the: 1) Qualifying line, 2) Racing line, 3) Overtaking/defensive line



How those lines look from a wider perspective.



Changes in Radius



The three different types of corner and the three different types of camber.

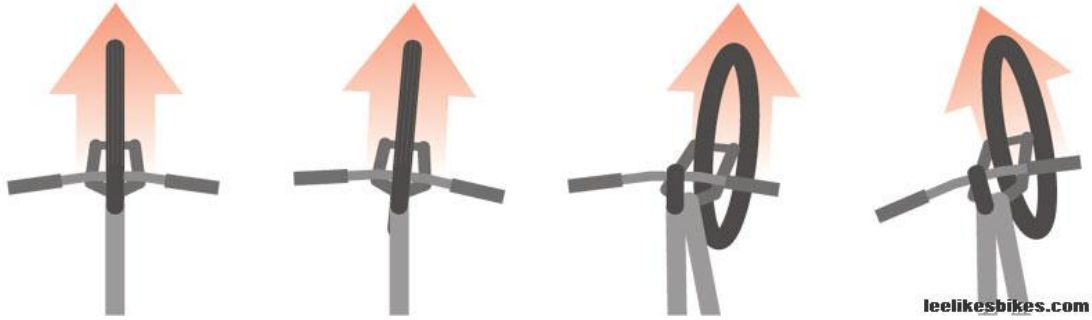
Countersteering into a left turn

You need speed.

1. Turn bars slightly to the right.

2. Bike will lean to the left.

3. Relax. The bars will turn to the left. You're carving!



The basics of counter-steering. Practice on your bicycle in the backyard.



Notice how bike #2 is counter-steering to get the bike to turn to the right. Even though the front wheel is in the air, turning the handlebars to the left has caused the bike to lean to the right. Notice that the movement is subtle, but the effect is large.