

TEACHING ADVANCED STUDENTS

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The following was prompted by a BMW instructor forum discussion on what and how to teach advanced students in our driving schools. It was written with some suggestions from Bruce Leggett, an RMC instructor and racer. It is intended to provide instructors with ideas on how to instruct advanced students, very advanced students and even themselves. It deals mainly with driving techniques and exercises. Grip factors, slip angles and track management are discussed. It assumes students are driving production based cars with little or no downforce.

First, some assumptions about 'advanced' students:

They know line theory and know the line on the track they are driving. They are consistent. They have high eyes. They use relatively high levels of braking and cornering. Their overall speed is fairly high. They have good footwork. They have situational awareness. They can feel oversteer and understeer and know how to deal with excesses.

Some things they need to work on:

Higher cornering levels (using slip angles).

Braking efficiency

Maximizing different aspects of the track.

Slip angles

First, I like to remind students of the friction circle (FC) and the fact that tires do their maximum work with some slip. Understeer and oversteer. So the question becomes where do you use understeer and oversteer, and how do you do it?

Oversteer/rotation:

Often, slower corners are enhanced with some amount of trail braking, sometimes with rotation. The concept is to employ the added grip (from braking) on the front tires, along with a lightened rear end, to help cornering. Simple trail braking is the trailing off of the brakes as steering is inputted. It's easy to see on the FC. Rotation is the intentional introduction of slip angles to the rear tires to help the car change direction.

How to rotate? How to teach rotation? The exercise: Find an appropriate slow or medium speed corner and have the student brake a little later and carry the braking a quarter or a third of the way into it for starters. Then the question becomes how/where to release the braking in conjunction with different steering inputs. This is where the explanations can get prolonged with all the variables. Jump off the brakes vs trailing off them; gradual steering input vs quick steering input, and doing one of these combinations earlier or later in the corner. Lots of permutations. They can all be described in class but students really need to experiment on track. They will soon feel how the different combinations work. Again, the first step in teaching rotation is having the student brake

later, carry braking into the corner and experiment with brake release and steering input. The objective is to find good balance.

Oversteer can also be used from mid corner to exit in rear drive cars in some corners. This is power oversteer as opposed to (trail)braking oversteer. The benefit is gaining maximum available grip from the rear tires by 1. having weight transferred to them from acceleration (squat) and then maximizing grip by introducing some slip to them. Power oversteer is lots of fun but easy to overdo. Advanced students should be taught to use it when appropriate but also told when they are exceeding the tires' optimum slip no matter how much fun it is. Be absolutely sure that throttle input is smooth and their eyes are high because a sudden lift from power oversteer, combined with a steering correction can cause the car to spin or go off track to the outside. Also, throttle must be applied at a point late enough that no lift is necessary before the exit.

NOTE ON TRAIL BRAKING

Some hpd schools only teach trail braking (leading to rotation) to advanced students. RMC BMWCCA schools introduce trail braking to new students as soon as they know the line. We want them actively seeking balance at turn in and in the early part of the corner and it requires dealing with 1. the extra grip on the front tires which results from weight transfer from braking. and 2. the tendency of many production cars to understeer under braking which makes a crisp, balanced turn in difficult. In introducing trail braking, smoothness is key i.e. brakes should be smoothly trailed and throttle is smoothly applied after the car has entered the corner. This creates a foundation from which rotation can be introduced when the student is a little more advanced. When a smooth transition from braking to turning is achieved I encourage students to experiment by being less smooth with brake release and steering input. I want them to feel the rear of the car get unsettled, a little loose, which creates some rotation. Have them work at the margins and experiment. It doesn't take good students long to reacquire the smoothness/balance they initially had while also having the car rotate as appropriate. Smooth AND faster. Throughout this exercise it will be necessary to have the student employ higher levels of braking such that the brake release combined with various steering inputs create larger changes in balance. It is difficult to teach trail braking and rotation from light braking levels. Make sure the student is highly aware of where he is braking so that you, the instructor, are confident that asking him to brake a little later and harder won't result in too large a change.

Understeer - when and how?

Understeer allows a driver to get maximum grip from the front tires and is a more stable handling state than oversteer. It is used in faster corners. This is a very good time to introduce the no braking exercise. The exercise: have students drive to a fast corner and reduce speed earlier than normal by lifting or by using very light and smooth braking. Then have the student squeeze on the throttle just before or at turn in and accelerate through the corner. Next time around, do it with a little more speed. Experiment by adding the throttle just before turn in, at turn in and just after turn in. The key here is a

very smooth brake release so the car does not get unsettled. They will enjoy a very stable, slightly understeering platform entering and through fast corners. Eventually they will find the best way to maintain optimum balance and will learn the value of not overbraking.

NOTE:

Employing slip angles at all four contact patches throughout a corner is ideal but it is very difficult to achieve in production cars with no downforce. They often go from understeer to oversteer and sometimes vice versa. As a general rule, to find perfect balance at corner entry it is necessary to put some amount of slip (sometimes indiscernible) in the rear tires in slow and medium speed corners through trail braking, with or without rotation. From mid corner to corner exit a lot depends on the car, tires, setup etc. A BMW sedan with run flat tires will handle quite differently than a Porsche Cayman for instance. In faster corners the situation is much different because the premium is on having the rear tires well planted all the way through the corner. This usually results in some understeer in most cars. .

Other things to teach advanced students:

Camber.

Know exactly where there is positive camber and negative camber. Even very advanced students are surprised how much more grip/speed is available where positive camber exists. The difference between a few degrees of positive vs negative camber is huge. Areas of negative camber should be heartily respected. In positively cambered corners turn in can be done earlier, more gently and at a higher speed. And sometimes it's best to not worry about going all the way to the bottom because your bigger concern is to maintain high speed with a stable handling state. This is a rare case where chasing the last few feet of radius is not beneficial. As an instructor, look for positive camber and push your advanced students a little.

Note

Why does positive camber help so much? There are three reasons. 1. the car compresses against the pavement resulting in extra grip, 2. the car wants to fall 'down' the camber which helps counter centrifugal force, 3. camber increases effective radius, i.e. the steering wheel doesn't have to be turned as much in a banked corner. In theory, if you had a corner with camber (banking) that went all the way to 90 degrees, you wouldn't have to turn the wheel at all.

Uphill/Downhill

Like camber, uphill and downhill portions of the track affect grip. Grip is increased on uphill sections and is diminished on downhill sections. A good example in Colorado is turn 5 at Pueblo where there is an uphill past the apex. This allows the driver to enter the corner earlier, shallower and faster than 'normal' because when the car compresses against the uphill pavement there is added grip which allows more turning ability. At 7 tenths, this means extra steering can be added there. At 9 tenths it means that larger slip

angles can be taken deeper into the corner because at the uphill the tires will gain grip and the slip will be reduced as the car turns. This is for very advanced students only and the way the suspension works (esp. rebound damping) comes into play. For an average A student who is driving Pueblo turn 5 it is appropriate to show him the earlier faster turn in at 7 tenths speed and have them feel how they can add steering when the car compresses. Later it might be appropriate to have them take slip past the apex and into the uphill second half of the corner. It helps to draw the corner and show them on paper the earlier shallower entry and where exactly (past apex) they will get the grip gain.

R Compound Tires and slip angles

Due to the extra grip and different characteristics afforded by R compound tires, instructors need to be careful to whom and how they instruct using slip angles with them on the car. With street radials it's fairly easy to have a student find some slip since it comes on gradually and is easy to feel as well as useable over a fairly wide range. It's more difficult with R compound tires because slip angles requires higher cornering forces and more speed. Also, with R compound tires maximum grip is achieved at fewer degrees of slip than street radials which means the no slip to optimum slip transition happens quickly. Most driving school students will not achieve optimum slip angles with R compound tires. It is important to have students work right at the margin. Have them work the corner backwards ie, find more speed and some slip from mid corner to exit. Then work on mid corner speed and slip, and finally at corner entry. Make small changes and always know if your student is feeling it (good) or making a leap of faith (bad). As an instructor it is somewhat comforting to know that R compound tires do maintain useable amounts of grip at larger slip angles than street radials. It's best not to go there but you can.

R Compound Tires/braking

Keep in mind that we teach in relatively heavy production cars. The extra grip afforded by R tires means more stress on braking and suspension components. The gains are largely in lateral applications but they afford higher straight line inputs as well which will stress braking components. Only with known, proven brake upgrades do you want to use much threshold braking. And even then, since we aren't racing, it's best not to overdo it. As a rule, when an instructor learns that a student is using R compound tires, he should immediately inquire as to braking and suspension upgrades. If the student can't tell you by name what components have been upgraded, assume that you don't have appreciably more than stock to work with and be aware that the extra grip of the tires will stress things.

Brush Braking.

There aren't usually many places on a track where threshold braking is appropriate. The end of straights is most common. However it is very common for advanced students to fall in love with late hard braking and they end up actually overbraking by a few mph and their turn in speed is too low. Discuss with them where brush braking is a better way to go. Often, brush braking is used with medium speed and fast corners. The brakes are applied early and smoothly, and then released early and smoothly to maintain a fairly high speed for turn in without any rotation. Experiment with your advanced student

keeping in mind the need to not over brake. The speed and time you lose by overbraking can never be recovered. Better to enter a corner one or two mph slower with balance than to overbrake by several mph and have an unbalanced car. Also remind the student that the mere act of inputting some steering will slow the car so at the highest possible speed for a corner he may initially feel like he didn't reduce speed enough to make the turn in.

Threshold Braking

Where threshold braking is appropriate the key is having the student use a very specific reference point where threshold braking starts. True threshold braking can only be done in a straight line. Sometimes it is better to compromise the 'ideal' line in order to ensure hard, straight line braking. Don't jump on the brakes; instead, take 3 or 4 tenths of a second for the car to fully transfer weight, allowing max braking force. Using less time will result in not using the available suspension. The front end will not be fully loaded and max braking won't be achieved. Brake release point and technique will depend on what handling state you want when you turn in. But in any event it's important to keep moving the braking point forward a little at a time by using the SAME threshold braking technique. It does little good to know half way through your braking that you braked too early and so you ease up on the braking. You need to maintain max braking and see exactly how much you over borrowed for braking space. Then you can move the braking point a percentage of that amount down track. Always have the student assume some amount of brake fade and never move the braking point all the way to what seems possible by the previous lap over-borrowing. And again, if the student is attempting to learn true threshold braking, you, the instructor must look at the steering wheel. It must be straight ahead. Look!

Driving off line.

This is a very good exercise to test high eyes, awareness etc. It's important to define the 'off' line beforehand e.g., late, wide turn in or pinched exit etc. Merely driving somewhere other than the line is not productive. The student should be able to verbalize exactly where his line differs and what changes are being made, e.g. more speed available here, earlier braking needed here etc. It's amazing how often unknown grip, camber, (speed) will be found with this experiment. This is a difficult exercise to undertake in a large run group. Do it when you and your student have some space on the track.

MSA

Advanced students should always be asking themselves "can I go faster here?" The question really is "if I add any more speed here, can I stay on my line"? If the answer is yes, then there is msa, (more speed available). Very advanced drivers are ALWAYS asking that question, is there msa? If at least some slip angles aren't being employed, the answer is generally yes. The exception is fast corner entries and even then feeling the early onset of some understeer is good. Have your advanced student talk his/her way around the track telling you where there is msa.

Car balance.

It is assumed that an advanced driver knows when the car is balanced. The objective is to use all of the grip available at all four contact patches when possible. Driving exercises

should always be undertaken with full 4 pt contact patch work in mind. It's common for very good, advancing drivers to fall in love with using lots of understeer here and lots of oversteer there. Like type 3 corners, it is sometimes better to compromise. An example is not using much rotation into longer corners. Instead you want to find maximum corner speed asap which is difficult if there is much oversteer early in the corner.

OTHER EXERCISES

In a longer turn, have the student define a target which precedes the track out point, such that when they are in line with it they can start applying throttle and releasing steering input as speed increases. When done right, the steering input will be fully released just at the proper track out point because there is so much speed that any remaining steering input would result in too much slip. This pre exit target is very helpful in long corners.

Find corners where the apex is an arc of some length rather than the more common clipping point. Turn 3 at Pueblo is an example. You want to get to the bottom and hold it there for at least a full second before tracking out. The reason, in this corner, is that the exit is off camber but in other corners at other tracks it is also best to stay on the bottom of a turn for a period of time.

Find a corner where a gear change may not be necessary even though it's common practice. Balance is easier to maintain. Checking exit speed at track out helps.

Find a corner where the downshift involves going down more than 1 gear and have the student make the downshift bypassing the unused gear(s). It requires patience going from say 4th gear to 2nd gear and you'll need a bigger blip. Be sure not to change brake point and level. At Pueblo turn 7 in some cars it's best to go from 4th gear to 2nd gear.

It's not always best to work on speed. Advanced students really need to slow down sometimes to work on smoothness, see the line better, seek perfect balance etc. A good exercise for advanced students is to have them talk while they drive. This will invariably slow them down a little as their concentration limits will be exceeded by talking while driving. In fact, this is a very good exercise we use to see if a driver is driving right at his limit. If he can maintain that pace and consistency while talking we know he has a reserve.

On rainy days, have an advanced student experiment to find a rain line. Talk about it with other drivers. Compare. In the rain, is it better to be in a higher gear to minimize wheel spin on acceleration or in a lower gear to have strong acceleration when grip allows? Talk about it. Make sure the student knows that the number one rule in rain driving is 'drive where the water isn't and the grip is'. Stay away from puddles. Camber factors are critical in the wet.

Discuss with advanced students that due to differences in corner geometry/ camber/grip changes etc every corner has a different rate and method of turn in. This means that one corner may require a turn in where the initial steering input is relatively slow after which

the car takes a set and then to get to the bottom the input needs to be quickened. Other corners are the opposite where you have a quick input followed by a slower one. Some corners require one quick constant motion steering input, some require one longer constant motion steering input. Some corners require one increasing rate steering input, other corners require one decreasing rate steering input. Have your advanced students discuss the differences at different corners.

Learning new tracks: An exercise to use with advanced students, instructor candidates for instance, is to have them pretend they are introducing you to this track for the first time. One procedure is 1. Learn the general shape of the track. 2. Identify high risk areas. These include places where the car could make contact with hard things if it went off track. Also areas where cars will congregate at high speed at corner entries. Also, off camber areas. 3. Identify type 1 corners, those that lead to straights. You must learn to find exit speed from them right away. 4. Identify high speed corners where maintaining speed (not overbraking) is paramount. 5. Identify threshold braking areas and find specific reference points immediately. 6. Identify where grip gains and losses will occur due to camber and elevation changes. These are the basic elements to learn after which specific reference points, rhythm, pace etc. can be learned. When driving a new track for the first time, I prefer to use late apexes for safety and exit speed and gradually work back to the racing line.

Debriefing. The post track session debrief is especially important with advanced students. They have a well established foundation and their own personal history. They are well ingrained to driving the track, 'their way' They need to review what changes they made and what the results were. They can then internalize positive changes and use them in the future. In the absence of this review it is likely they will revert to what they have done before.

FEAR OF TRYING

Some instructors are not comfortable instructing very advanced students. I've heard comments such as "he's faster than I am" and "I don't know what to teach her" My response is twofold. First, remember that even Tiger Woods has a coach who obviously can't play at Tiger's level. Instructing someone who might be 'faster' than you is perfectly appropriate. Second, follow the 'progression'. At RMC BMW CCA we have developed a path along which our driving school students progress. It starts with line knowledge and progresses to consistency, smoothness, balance (including footwork), pace (exit speed, corner speed, entry speed), using slip angles, 360 degree awareness etc. It's not a hard and fast ladder past line knowledge, consistency, smoothness and balance but it can certainly be used as a checklist. An instructor and advanced student should work together as a team to discuss driving techniques, lines, finding grip etc. In fact whenever I instruct an A student, that is my default frame of mind. And almost always we find places where the student could be smoother, better balanced, faster etc. In my opinion we can all benefit from the informed observations and suggestions of an instructor in the car.