The first in a series of articles to assist technicians in the diagnosis and rectification of steering alignment faults. Faulty steering geometry can at best lead to increased tyre wear and at worst dangerous handling. The diagnosis of steering geometry faults is an important skill for any vehicle technician, along with a basic understanding of geometry angles and how to check them. This first article looks at basic geometrical principles.

‘Ackerman’ Steering
When a vehicle travels round a bend, the inside wheel must follow a tighter curve than the outside wheel. To achieve this, the geometry of the steering must be arranged to turn the inside wheel through a larger angle than the outside wheel. The ‘Ackerman’ steering geometry provides a simple solution to this problem. Shown is a representation of true Ackerman.

This geometry results in the inside wheel turning through a smaller radius than the outside wheel. This allows the vehicle to travel around a curve without scrubbing the tyres.

In practice the steering linkage doesn’t need to produce true Ackerman. It is achieved by a combination of the steered angle and the slip angle produced by the cornering force. The slip angle on the outside wheel is greater than that of the inner and this produces varying degrees of dynamic Ackerman effect.

Steering Axis Inclination
The steering axis inclination is the angle formed by a line drawn through the upper and lower swivel joint or steering axis. The inclination of the steering axis is necessary to allow the steering axis line and the contact point of the tyre to intersect close to the road surface.

The advantage of this arrangement is to reduce the offset between the steering axis line and the contact point of the tyre. The size of the offset, also known as the scrub radius, affects the effort required to turn the steering. A larger offset increases the steering effort. Reducing the offset will reduce the loading on the stub axle.

External forces applied to the wheel will attempt to change the direction of the wheel. When the offset is large, the lever ratio is large and the tendency for the wheel direction to change will increase. A reduced offset will limit the effect of bumps, braking forces and acceleration forces on the steering, making it easier for the driver to control the direction of the vehicle. A small toe-in effect under braking can increase stability. This is usually achieved by creating a small negative offset. In general, a front wheel drive vehicle with a positive offset will be set with a small amount of toe-out and rear
wheel drive with a small amount of toe-in. When a negative offset is used then the opposite will apply.

Shown in the diagram bottom left is the effect of the braking forces on different offsets. The green arrow is the driving force, the yellow arrow shows the braking force and the purple arrow will show the resulting effect on the toe angle.

Steering axis inclination also contributes to the directional stability of the vehicle. This effect is because the inclined steering axis causes the body to lift when the steering is turned. The weight acting on the steering axis will always force the wheel to the straight-ahead position to the steering.

**Camber Angle**

The camber angle is the inward or outward lean of the wheel relative to the vertical reference. Originally, the camber angle was used in a similar way to the steering axis inclination. Shown are the three possible options for camber. As you can see the positive camber reduces the offset when combined with the SAI. The downside to positive camber is the tyre thrust generated at the contact with the road. In order for the tyre to sit on the road surface some deformation of the tyre must occur. A reaction thrust is generated by the tyre tending to force the tyre to move outwards. For example, when a vehicle is travelling around a left hand bend the positive camber will tend to force the tyre to the right and reduce the cornering ability of the vehicle. If you also consider that the body roll experienced during cornering will increase the positive camber on the outside wheel this effect is not very desirable. To reduce this effect, high-performance vehicles will use a negative camber arrangement. Again, this will generate a camber thrust but this time in the same direction as the corner. Both negative and positive camber will increase the tyre wear due to the deformation that occurs with this set-up. As a result, most modern vehicles will tend to be set close to zero camber. This reduces wear and rolling resistance generated by the tyre deformation.

**Auto docta**

Q: A 2007 Honda Civic 1.8 has the engine MIL light on. Scanner interrogation of the engine management system reveals that the only DTC is U0103. This DTC comes straight back as soon as we clear it from the system. My information says that this code is referring to an F-CAN malfunction between the engine management ECM and the TCM. Do you have any information I can use that will help me test this circuit?

A: This is most likely to be a communication problem caused by a poor earth. There are several different codes, each of which identifies a different location as the cause of the problem. In this case, DTC U0103 identifies two earth connection points as being the likely problem areas. The first earth connection is on the front edge of the battery carrier and the second is on the door sill behind the front door towards the middle of the rear door or rear panel area as applicable. Remove and inspect the earth bolt - it should have a fluted rather than a normal thread, with no numeric markings on its head. Having confirmed that it’s the correct bolt, ensure that the connection is clean and tight. Clear the DTC and re-check the systems.

Q: The sidelights on a 2004 Renault Clio are not working. The customer reports that the lights stopped working after a long journey with a full load of passengers. Fuses and the lighting switch have been tested and all are OK.

A: The lighting system in this vehicle has a relay that controls the side light operation. It is this relay that you should check. Under the passenger side dash there is a fuse box and attached to the side of this box is a row of relays, one of which affects the side lights. Passengers can easily dislodge relays with their feet – it’s often the cause of light failure with this vehicle.

Q: A 2003 Ford Tourneo Connect 1.8 TDCI is suffering from overheating. As part of the diagnosis, we planned to change the engine coolant thermostat. When the thermostat was removed we noticed that there was an oily residue in the cooling system. Where is contamination coming from and how can we deal with it?

A: This vehicle uses the engine cooling system water to reduce the temperature of the engine oil. The cooling system has an engine oil cooler that is mounted in the cooling system and it’s not uncommon for these coolers to leak either oil into water, water into oil, or possibly both. Change the engine oil cooler and the oil filter housing, remove the coolant thermostat and flush the system thoroughly. It’s also recommended that you change...
Q: A 2001 Citroen C5 1.8 is displaying the MIL lamp and the trouble code P0410 ‘Secondary air injection system - malfunction’. We have checked out the secondary air injection pump system, ensuring that the wiring is good all the way back to the ECM and that the pump is working. The system seems to be operating normally.

A: This trouble code will be generated by a secondary air injection pump problem, so this is where you will find the breakdown. If all the electrical functions of the secondary air injection system are working correctly then you need to look for a mechanical failure.

There have been instances of the filter inside the secondary air injection pump body breaking up. If this occurs, it is possible for the debris to pass through the system and jam the secondary air injection valve. If you find any debris in the system, you will need to replace the secondary air injection pump, clean the hose and check the valve, replacing it if necessary. Check for correct operation and delete the trouble codes.

Q: A 2006 Honda Civic 1.4 has slight clutch slip. The clutch is all right from cold but starts slipping as soon as the vehicle reaches normal operating temperature. We would expect the slip to be pretty much the same right through the engine temperature range.

A: Check the clutch pedal cruise control switch adjustment. Cars without cruise control have a stop bolt that may also have the same effect, if out of adjustment. What happens is that an incorrectly adjusted switch/bolt holds the clutch master cylinder piston away from its stop position. In the stop position, expanding clutch fluid would normally return to the master cylinder reservoir. If the piston is held away from its stop position, as the fluid temperature increases, the expanding fluid cannot escape back to the reservoir. The increasing fluid pressure then partially disengages the clutch causing slip.

To get the correct adjustment of the switch/bolt, loosen the locking nut and turn the switch/bolt anti-clockwise until the end of the thread is level with the pedal bracket. Hold the clutch pedal up and turn the switch/bolt clockwise, until resistance is felt. Release the clutch pedal and turn the switch/bolt clockwise, a further ¾ to 1 turn. Making sure that the switch/bolt does not turn, tighten the lock nut. Check the clutch fluid level after pumping the clutch pedal a few times. Top up as necessary.

**Castor Angle**

The castor angle is the rearward lean of the steering axis relative to the vertical reference. The main purpose of the castor angle is to create a self-centring effect in the steering. Tilting the steering axis in this way means that the driving force acts at the point where the castor angle intersects the road. The resistance between the tyre and the road creates an opposite force that acts along the axis of the tyre. The effect is to generate side force, pushing the tyre back in line with the driving force. The further away from the straight ahead position the greater the side force.

The difference between the vertical reference and the point at which the castor angle intersects the road is called the castor trail. The larger the castor trail the greater the self centring effect. Increasing the castor angle will increase the weight of the steering. Generally, larger castor angles are used on higher performance vehicles to maximize stability at speed. The trade-off for increasing the castor angle is increased steering effort and tyre wear.

**Toe Angle**

The toe describes the angle of each wheel relative to the centre line of the vehicle when viewed from above. The ideal toe angle should ensure that the front and rear wheels are parallel as the vehicle is driving along the road. To achieve this, the static toe angle will have to be set to accommodate the movement in suspension linkages and steering joints. The toe angle can be described as an angle or in terms of the difference measured between the front and the rear of the wheels on an axle. Measuring the toe would appear to be quite simple but if you measure the toe angle it is. However, if the toe valve is specified in mm, the method of measurement must also be specified.

There are three methods used for measuring the toe in mm. If you use a different method of measurement to adjust the toe to that used by the manufacturer then the toe on
the vehicle will be incorrect, leading to increased tyre wear. The three methods shown are European, American and Japanese. You can see from the diagram that the measured toe in mm is very different for each method but the angle is always the same.

Correct toe adjustment is necessary to ensure that the vehicle drives in a straight line. Incorrect toe can lead to pulling problems and increased tyre wear.

**Thrust Angle**

Most vehicles nowadays have independent rear suspension. This allows the manufacturer to arrange the rear wheels with an amount of toe and camber. These angles affect the alignment and handling of the vehicle in the same way as the front wheels. If the rear toe is misaligned, then they will try to steer the vehicle. The relationship between the rear toe and the centre of body is called the thrust axis. Any thrust from the rear is compensated for by the front wheels turning to try to achieve the lowest rolling resistance. The steering wheel will now be out of alignment and the vehicle will crab.

As you can see, there are many variables to consider and, depending on the design of the steering and suspension, varying degrees of compromise have to take place. This is accommodated by the compliance of the flexible bushes used in the steering and suspension mechanism and of course the tyre itself.

Only when the basic principles of steering geometry are understood can a technician undertake diagnosis and rectification. The next article will look at how these angles are measured and adjusted.

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These articles are contributed by ProAuto, an automotive technical training company based in Shrewsbury, Shropshire. The company runs courses from venues nationally, so a course is never too far away. For further details, visit www.proautotraining.com or email info@proautotraining.com or telephone 01743 762050.