Fundamentals of Automotive Systems
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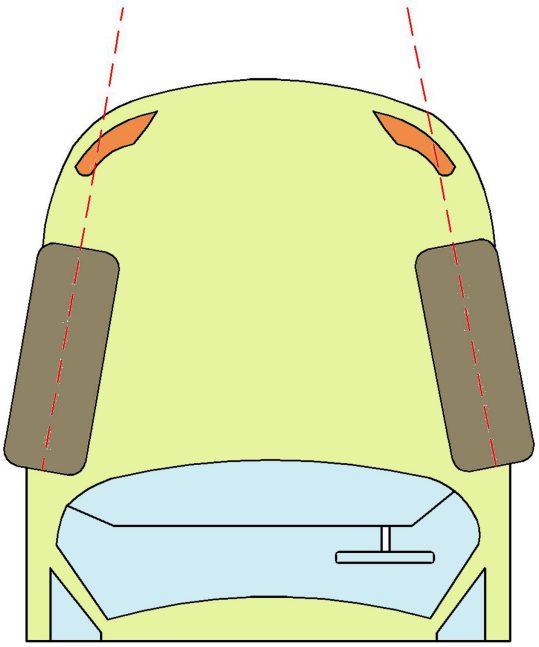
Module No # 11
Lecture No # 64
Wheel Alignment - Part 02

The next parameter that we are going to look at as for as wheel alignment is concerned is what is called as Toe ok. So what is this Toe and what is the impact of Toe? So for that, now what we do is we look at the vehicle from the top, for camber we looked at the vehicle from front, for understanding caster we went to the side. Now to understand toe we looked at it from top. So let us say we look at the steered wheels of a car, right these are the front wheels.



So of course all these figures are exaggerated it just gives us an idea, right. So, if we look at these two front wheels which are steered and we look at it from the top,

we can see that the front ends are pointing in such a way that the front ends are closer to each other than the rear ends, right. So these are the front ends of the two tyres, right and these are the rear end. So, one can observe that the front ends are closer than the rear ends.

So there are different ways in which we can represent this. So toe is indicative of the difference between the leading and trailing edges of the front wheels when viewed from above the car ok. So there is Toe so it can also be expressed as the angle made by the central wheel plane with the longitudinal axis, ok. So suppose if we draw the longitudinal axis, right at the wheel plane. So this is also the toe angle ok.

So, some will represent it by means of this toe angle. So the motivation behind this terminology is that if suppose we stand on our two feet with our toes closer that is what is called toe-in. Right, so this schematic essentially corresponds to a state what is called as toe-in, right. So this schematic essentially corresponds to a state what is called as toe-in. Toe-in is a state where the leading edges of the front wheels are closer to each other than the rear wheels and toe out is the other way around, right.

So as we can readily understand toe out, we can immediately observe that the trailing edges are going to be closer ok. The trailing edges of the front wheels are closer to each other than the front wheels ok. That is in the state of toe-out. So sorry from the no not this is to the leading edges of the front wheels are closer to each other the trailing edges sorry right not the rear wheels that is a mistake. So this is going to be trailing edges are going to be closer to each other than the leading edges right so that is the correct definition of toe-in and toe-out ok.

So what does a toe influence you know like typically what happens is this like toe influences tyre wear and why do we have toe in the first place. You know like toe is the very important setting for straight line performance. Once again you know like we have toe-in to ensure that you know like the straight line performance of the vehicle is good. Because for example let us consider a scenario let us say you know there is a perturbation which essentially tends to turn the vehicle let us say to the left without the loss of generality.

What is going to happen if the vehicles orientation has to change? Please note that the inner wheels have to be rotated by a larger angle than the outer wheel. In a state of toe-in, what has to happen? First this wheel has to be rotated to point straight then it has to be rotated even further. So any perturbation which is not very high is not going to create a significant deviation from the straight line path right with toe-in.

So that is why with toe-in we get better straight line performance but what is the trade off? The steering response is going to be slower because when the driver wants to steer right in the state of toe-in the same what to say the result of toe-in is that to get the required steering angle. We need to rotate by a larger angle right so to achieve the same steering manuever. So it is going to essentially result in slower steering response. Toe-out essentially has the opposite characteristic right.

If we have toe-out we get faster steering response, right, but it is at the expense of straight line stability. That is why if we look out racing cars they have toe out because you want essentially faster steering response. And the race car driver can control the vehicle right but however in passenger cars since stability is important and straight line performance is important, we have slight toe in and but comes at

the expense of slightly slower steering response ok. So that is the impact of toe right.

So toe influences tyre wear right, why tyre wear because too much toe, one side of the tyre is going to scrub, right so that is also not good, right. So toe influences tyre wear it influences straight line behaviour and also cornering characteristics. So these are the facts influences of toe. So excessive toe results in more scrubbing of the tyres, ok, leading to wear, tyre wear leading to higher tyre wear, ok so that is the impact of excessive toe.

Then toe-in results in better straight line stability right as we just discussed and toe- out provides a faster steering response, steering cornering response, ok. So this is the reason why you know like we use toe-in typically in passenger cars and toe-out is used in race cars right ok. So these are some important wheel alignment parameters. There are a few other parameters. So typically this is what to say camber, castor and toe are important what are called primary wheel align parameters by some but there are a few more. Let us quickly look at them right.

So the next parameter which is important what is called as steering axis inclination. So what is steering axis inclination? Okay abbreviated as SAI so steering axis inclination is going to be as the name indicates is the angle made by the steering axis with the vertical. So this is the, we are looking at the vehicle from the front. So we can see that this is the steering axis. So this is the vertical axis at the front, the green dash line.

So the angle made by the steering axis with the vertical direction is what is called as steering axis inclination. So steering axis inclination is the angle made by the

steering axis with the vertical direction when viewed from the front of the vehicle ok.

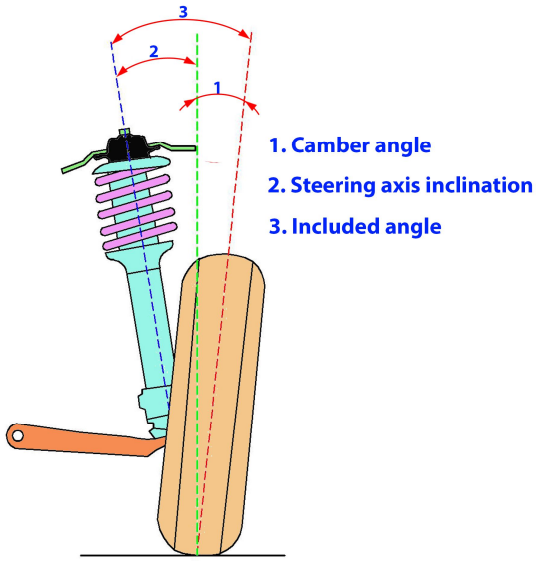
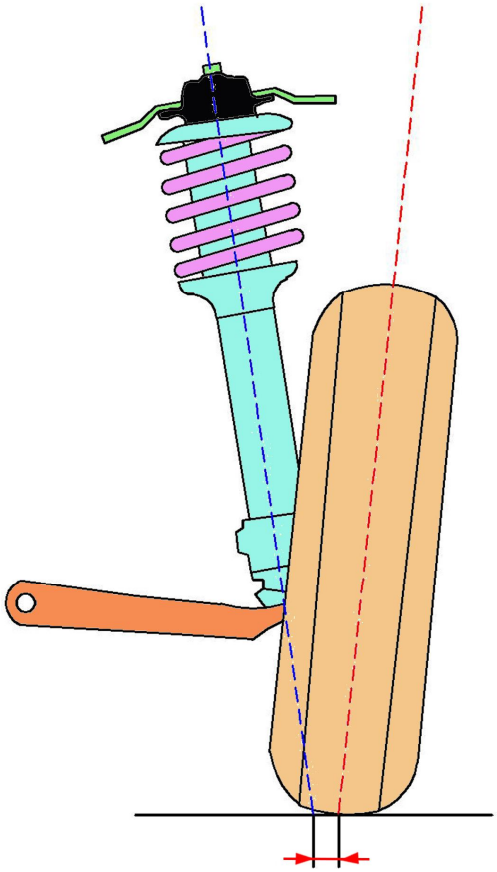


FIGURE FOR SAI & INCLUDED ANGLE

This is also called as king pin inclination okay. So where instead of ball joints we have king pin as we discussed before right. So it is called as king pin sorry king pin inclination, KPI right on vehicles that have kingpins instead of ball joints, right. As we discussed heavily vehicles have king pins in steering system so that is why it is called king pin inclination.

So let us look at few other wheel alignment parameters. The next one is what is called as included angle so what is included angle? Is nothing but so as the name indicates included angle is the angle between the steering axis and the central wheel plane ok. So we can immediately observe that the angle three in this diagram is the included angle right what is angle one? It is the camber and what is angle two? It is steering axis inclination.

So we can immediately observe that included angle is greater than steering axis inclination with the case of positive camber right. Because in this figure what we are I have represented is the case of positive camber. So if you have positive camber inclined angle is greater than steering axis inclination. It is less than steering axis inclination if we have negative camber. So that is the consequence right so that is one more parameter.



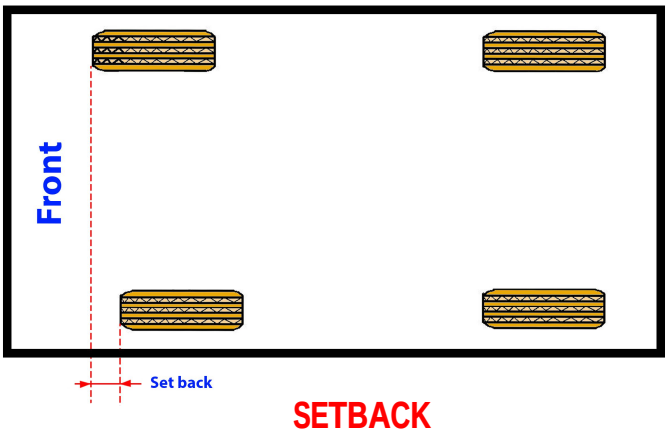
SCRUB RADIUS

Another parameter which becomes the part of this set of wheel alignment parameter is what is called as scrub radius. So what is the scrub radius? So this scrub radius is defined in this way so let us look at this schematic so if we look at this schematic we can immediately observe that this is the steering axis right so if

we project it we see that this steering axis meets the ground closer to the vehicle centre compare to the centre point of the tyre road contact right.

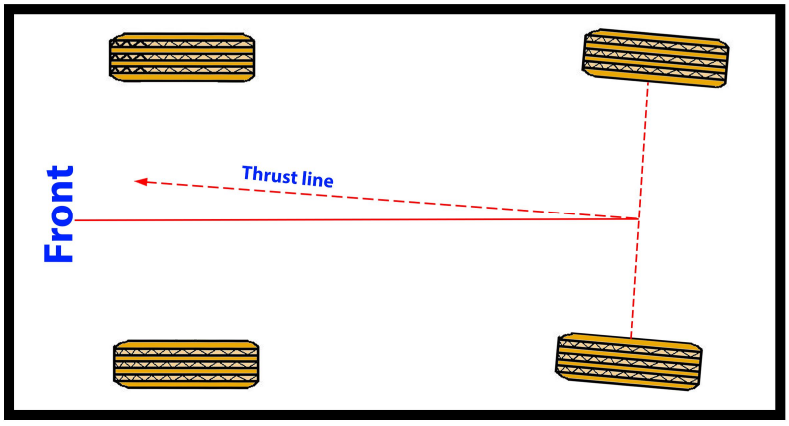
So this case is that is what is called as positive scrub radius. This distance is what is called as scrub radius. It is consider positive if you extend the steering axis and it contacts the ground or the road closer to the vehicle centre than the centre point of the tyre road contact patch. So what is indicated in this diagram is positive scrub radius. So scrub radius is the distance between the points of intersection of the steering axis and the central wheel plane with the ground ok. So it is consider positive when steering axis intersects the ground closer to centre point of tyre road contact patch as shown in this figure.

So what has been illustrated is positive scrub radius ok. So another parameter what is called as setback, ok. So let me quickly define a few more parameters. So these are also important parameters for wheel alignment. So and most of them are self-explanatory and their consequence also is evident right. So of course please note that once again I am reiterating that the most of the schematics, the distances, and the angles are all exaggerated you know just to show the concepts right.



So and by and large wheel alignment you know like poor wheel alignment is also a symptom of some component being bent that is why all these alignments get disturbed, right. So what is set back? So, essentially one front wheel is behind the other right as we can observe okay. So what is the consequence of this? This may lead to uncentered steering wheel or uncentered steering, right. So there is like if you want to go straight we need to give a small steering input or if you keep the steering wheels straight we will be deviating from the intended straight path okay. So that is the impact of setback.

So this is what happens if something some component is bent in the front? Now even if we have let us say what is called as rigid axle in the rear. We are going to look the suspensions shortly. So we can have what is called as thrust angle. So what is this thrust angle? So it is defined in this way. So once again it is exaggerated so we can see that some component is bent, right or deformed, excessively.



THRUST ANGLE

So we can see that if you look at the rear axle's axis you know like if you draw a perpendicular line you know like so called thrust line you know that is not along

the longitudinal axis of the vehicle, right. So this is the longitudinal axis of the vehicle. Now this angle which is made by these two lines is what is called as a thrust angle. So thrust angle is nothing but it is the angle made by the rear wheels with the centre line of the vehicle along the longitudinal direction when viewed from above the vehicle okay. So that is the thrust angle.

Once again a non-zero thrust angle leads to uncentered steering. So we can see that you know like the wheel alignment parameters need to be maintained in proper ranges for tyre wear, straight line performance and cornering characteristics, you know that is the important concept, ok. So I will stop here and then like we would continue in the next class. Thank you.