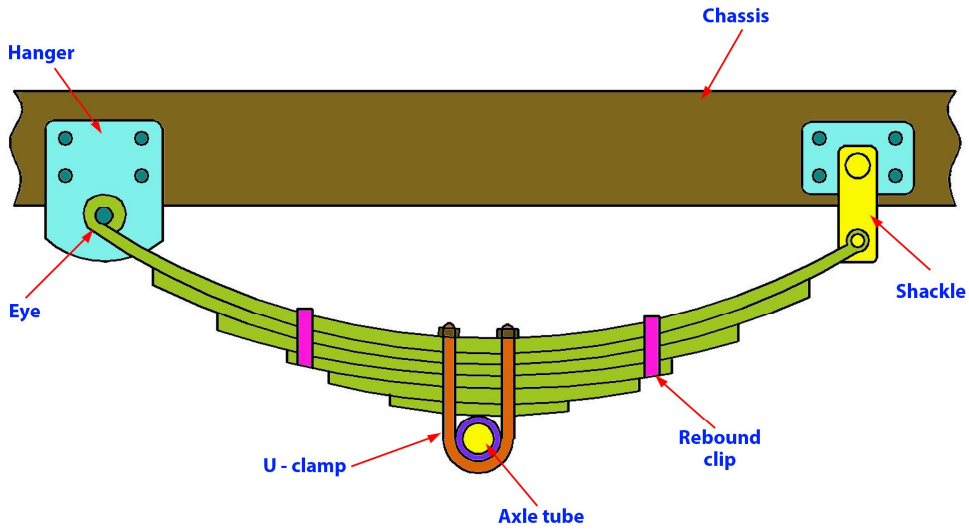
Fundamentals of Automotive Systems
Prof. C.S. Shankar Ram
Department of Engineering Design
Indian Institute of Technology - Madras

Module No # 11
Lecture No # 66
Introduction to Suspension System – Part 02

So if we look at a broad level what are the components of a suspension system that are used to achieve these functions. So the first set components are springs okay springs are nothing but energy absorbing elements right so we get a disturbance or excitation from the road that energy is absorbed by the spring right and then we have dampers or shock absorbers which essentially ensure that these vibrations are dampen down alright.

So that is an important requirement so springs provide compliance right dampers shock absorber provide energy dissipation. So there are energy dissipating elements okay then there are various suspension links okay and also other components to provide support to the suspension okay we will look at these components as we go along. So broadly you know like these are the 3 classes of the suspension components. So first let us look at springs okay which are energy absorbing elements so let us look at different categories of suspension springs okay.

So the first type of suspensions spring that we are going to consider are what are called a leaf springs so what are these leaf springs okay? So leaf springs are very popular you know like they have been around for quite a long time so what does the leaf spring do right so let us look at this leaf spring.



LEAF SPRING

So this is a simple schematic of a leaf spring so what happens in a leaf springs is that there are these metallic leafs you know like which one could observe here right one could essentially held together by these clips they are bolted to this axle and held together by a clamp right and at the two ends of this leaf springs you know like they are fixed to the vehicle body or vehicle frame.

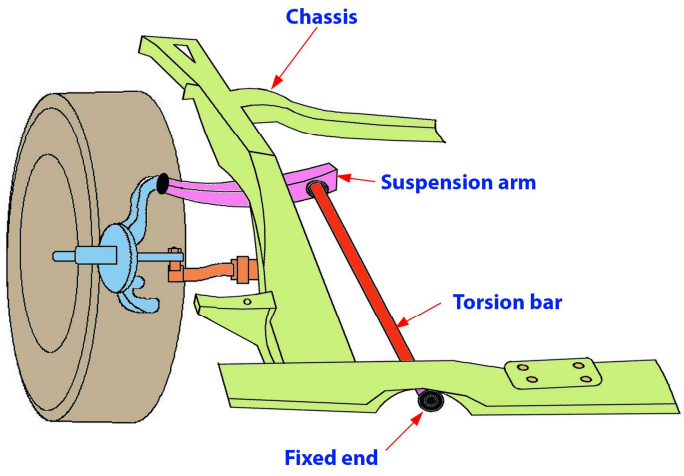
So the leaf of the individual leafs of the leaf springs are curve so when they are subjected to load they are going to deform and that is going to result in a springing action right so it is very simple in construction right. And very effective too you know so if we look at leaf spring so these were one of the earliest types of springs that were used in road vehicle and still being used right so it is constituted of course I should say here we are looking at the first category alright which is a leaf spring right.

The leaf spring is constituted of leaves okay that are fastened through a central bolt and they are also held together by clips which we can observe here alright. So we can observe that there are clips which are holding the leaves together. Now we can

see that these clamps attach the leaf spring to the axle when we come to rigid axle suspension with the leaves springs we will see more details on how they are attached you know to the axle you know.

And as the wheel assembly moves up and down because the wheels are fixed to the axle right as the wheel are displaced what is going to happen is that the wheels are these are leaves of the leaf spring are going to deform and absorb the energy you know like it is coming in due to the what to say these vibrations okay.

So the main advantages of these leaf spring are that they are simple in design you know they we can have multiple leaves to make it is stiffer okay and you know pretty easy to operate and what to say install and maintain in a vehicle right but there are some limitations, limitations are that they are heavy they can weaken with time and due to the mass you know they are susceptible to sag okay so the effectiveness of the leaf spring goes down with time okay that is an limitation of leaf springs okay. So this one common type of springs which are which have been around for a long time and still quite popular right.



TORSION BAR

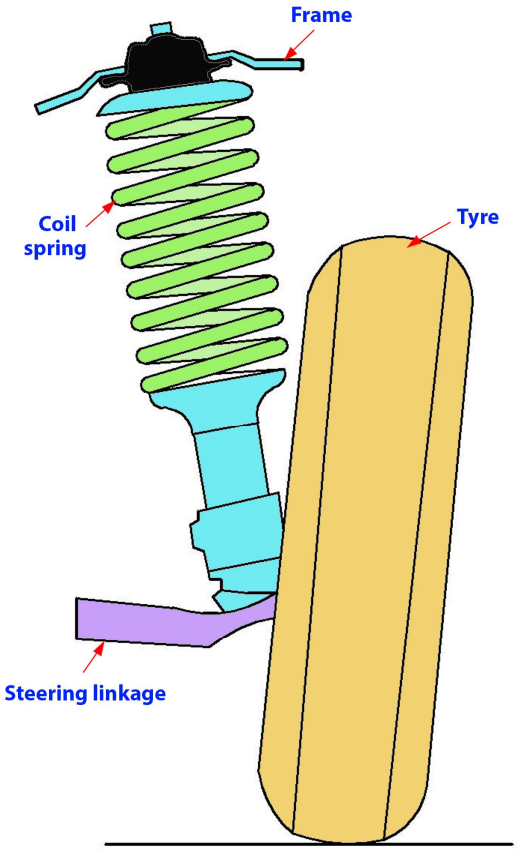
So the second type of energy absorbing element is what is called as a torsion bar what is that torsion bar okay? So a torsion bar as the name indicates essentially is a structure you know like which will ensure that energy stored in it when it is twisted. So let us look at what happens in a torsion okay. So this schematic provides a simple representation of a torsion bar what happens is it this is the torsion bar as we can observe.

So, one end of the torsion bar is connected to the suspension arm so as the wheel travels up and down the suspension arm is going to act like a lever right. So because this is going to travel up and down so what will happen the other end of this torsion bar is fixed to the vehicle frame so this motion is going to twist the torsion bar. And the torsion bar has a torsional stiffness right through which it stores the energy coming in due to the vibrations okay so that is the simple realization of a torsion bar okay.

So a torsion bar essentially consist of a steel rod that is attached to the vehicle body at one end the other end of the torsion bar is attached to a suspension component okay typically something like what is called as a control arm okay and that acts as a lever right. So as the wheel travels up and down and undergoes a vertical motion the vertical motion is going to be converted to a twist of the torsion bar right.

So the vertical motion of the wheel assembly results in a twist of the torsion bar which essentially results in storing the energy right. So that is and some torsional stiffness is provided to the suspension system right. So the main advantage of this is that durable and takes very little space right particularly in terms of volume and also along the width of the vehicle body right so that is a big advantage but one limitation is that the effective spring rate or the effective spring constant or the stiffness or let me call it as stiffness okay is difficult to adjust okay.

Suppose we want a certain stiffness level you know it can be done but it is challenging okay there are better solutions to do that.



COIL SPRING

So but this is certainly air option right so moving on the most common spring that is used today you know like in road vehicles is the coil springs so what is this coil springs? So let us look at coil springs next. So a coil spring is nothing but a metal rod that is or bar which is essentially wound up in a coil right so that is essentially a coil spring right so as we can see a coil spring is nothing but a steel rod or bar that is wrapped into a coil okay so that is a coil spring right as we can observe here it is a most common type of spring and that we have always be exposed to right.

So the main advantage is that they are compact right and they are pretty what to say we can essentially get the desired spring rate or the stiffness right by designing the coil spring carefully okay. So that is an important advantage but then please note that the coil spring is going to provide support only along its axis. So it is very compact and consequently used where space requirement is a constraint or space availability is a constraint.

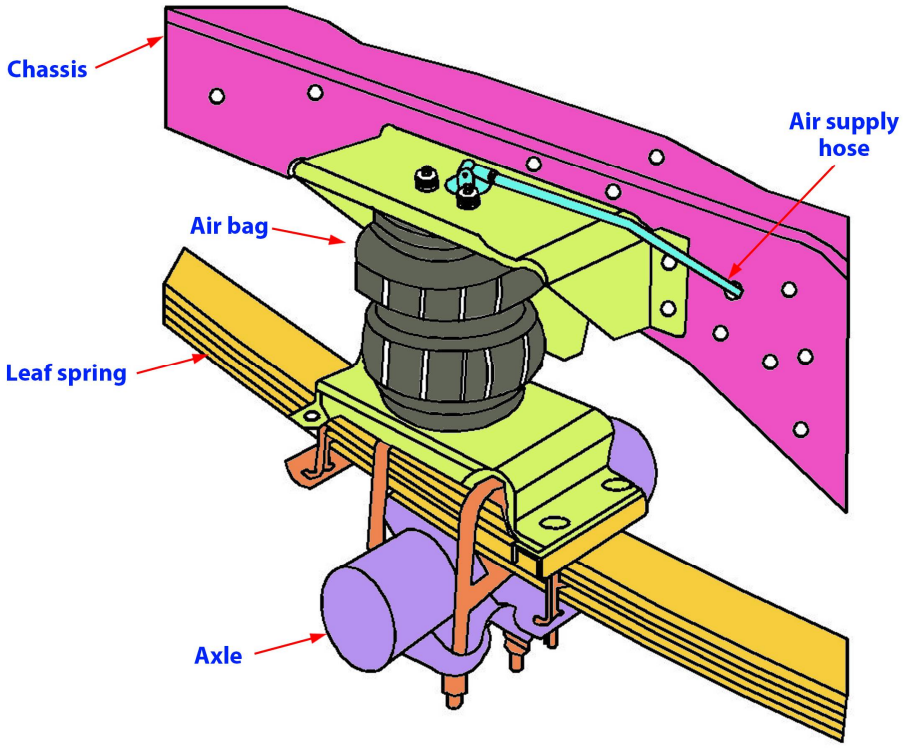
However the coil spring will provide support to the suspension and to the vehicle body only along its axis. Consequently they require additional suspension elements okay which we will encounter as we go along right. So additional elements to provide support to the suspension along the lateral, and longitudinal directions. See at a very broad level one can think of a suspension as something you know like which connects the wheel assembly the axle to the vehicle body.

So that is a connection right so when we are connecting it you know like it should provide some support some compliance along all the axes not only the vertical but also longitudinal and lateral axis right and try to serve multiple purposes it should dampen out the vibration level along the vertical axis to result in good ride comfort but also at the same time it should try to minimize motions along the other axis like pitch role and so on right.

So there are multiple requirements so we have other elements to take care of these requirements along with a coil spring okay the way it is realized okay along the lateral and longitudinal directions okay so coil springs are quite popular right.

So now today if we look at heavy trucks and buses alright so the most common energy absorbing element which is used what is called as an air spring or a

pneumatic spring okay. So such suspensions are commonly called as air suspensions so what is this air suspensions okay.



PNUEMATIC SPRING – AIR SUSPENSION

So an air suspension essentially uses the compressibility of air right so makes use of the fact that air is a compressible fluid and uses that fact to observe the energy right when the when we have vibrations right in the wheel assembly and the vehicle body.

So what happens is that like we have what is called as an air bag or a bellow you know like which is filled with compressed air and that is placed between one can see that the axle and the chassis or the vehicle frame right. So as the axle vibrates you know like due to the vibration on wheels this air compressed air in the bellow

takes up the vibrations alright absorbs the vibrations because of the it is of the compressible nature of the fluid which is working fluid which is air okay.

So currently used very commonly found in trucks and buses they use the compressibility of air to absorb vibrations. So typically what we have is that like we have an, the entire system right consist of a compressor of course we need air supply we need a storage reservoir. But now we can understand why it is popular in trucks and buses because as we have already discussed in a truck and a bus already we have a storage of or availability of compressed air why?

Because we have an air brake system so this makes an natural fit their right so we already have a source of compressed air so we need these we need control valves right control system and rubber cylinder or bellow or what is called as this air bag okay so here in this schematic okay. So that is what and this, such a system also is amenable to real time control so which has led to what is called as an electronically controlled air suspension okay. So today there are vehicles with this so called ECAS systems okay Electronically Controlled Air Suspension.

So what happens in this electronically controlled air suspensions the air pressure is modulated to regulate the deflection the suspension deflection right and the suspension performance okay.

So for example some common you know like uses of this system is to provide what is called as the self-leveling action. So what is self-leveling suppose you know like we are the truck or bus is travelling on uneven roads and there are changes in the loads as we discussed from fully laden to fully unladen. But we want a constant ground clearance or a what is called as a ride height okay this air suspension can adjust the suspension deflection to maintain a constant ride height okay.

So that action is what is called a self-leveling okay self-leveling essentially implies that a constant an almost constant ride height or ground clearance of the vehicle above the road is maintained okay even which changes in load okay so that is an important function another function is that it can help in lowering the vehicle body particularly when we are doing high speed driving.

See for example we are high speed buses right so if the roads are pretty good you know we are going on nice highways at nice roads at high speed so this air suspension can also be used to reduce the body height why because as we know when we corner there is going to be significant role and reducing the height lowers the CG location also that will result in better role stability right. We can also have rising of the vehicle body particularly when we go on off- road operation let us say we have mining trucks and so on right where the road itself is going to be very uneven.

So want to we are anyway going to go slow and there is anyway going to be significant role right so then what happens is that like we do want to increase the ground clearance a little bit. So that like we have space between the uneven road and the components of the vehicle right so one could also have this rising functionality using in off -road conditions okay. So that is a broad discussion of air suspension so these are some common springs or energy storage elements that are used. So we would continue in the next class and look at shock absorbers and other components of suspension okay thank you.