Heavy Equipment Technician

Frames & Suspension Fundamentals

Suspension, Wheels and Systems

First Period

Module 190102a
Objectives:

1. State the functions of a vehicle frame.

2. Identify types, designs and components of frames commonly used in truck and trailer applications.

3. State the functions of a vehicle suspension system.

4. Explain the operating principles of common suspension systems.
Objective One

State the functions of a vehicle frame.
A platform for all attaching parts such as engine, transmission and suspension components.
Frame Functions:

Support the Load.
Handle Shock Loads.
Handle Torsional Loads.

Acceleration, deceleration and suspension are Load Forces acting on the frame when operated on rough or uneven roads surfaces.
Frame Functions:

Maximum Bending Moment:

The point at which the maximum bending force is concentrated on a given area of the frame, depending on design and load distribution.
Ladder frame is the **most common** frame in use.
Objective Two

Identify types, designs and components of frames commonly used in truck and trailer applications.
Frame Design:

- Upper Slider Frame
- Slider Pin Release Lever
- Lower Slider Frame
- Slider Lock Pins
- Trailer Body

Slider Frame

Common on van trailers, but not for very heavy loads.

Allows wheels and suspension to be moved forward or backward in relation to the trailer body.

Load weight can be varied between the tractor and trailer.
Frame Construction

Common Frame Rail Configurations:

Channel

Box

I - Beam

Channel rail being the most common.
Frame Construction

Frame Rail Terminology:

- Upper Flange
- Web
- Channel Frame Rail
- Lower Flange
Frame Design: Ladder Frame

Two Frame Rails Run Parallel to One Another for the Entire Length of the Vehicle.

- Rear Crossmember Channel Type
- Channel Crossmember
- Frame Rails
- Alligator Type Crossmember
- Overslung Crossmember
- Front Crossmember Plate Type
- Gussets

The rails are held together by crossmembers that are bolted, riveted or welded to frame rails.
Frame Design: Ladder Frame

Alligator type of crossmember provides greater rigidity than single channel unit...

Crossmembers provide **strength**, **rigidity** and **flexibility** in order to **absorb torque**
Gussets are triangular pieces of steel plate that are bolted or welded to the crossmember and web of the frame rail, to prevent frame weaving.
Frame Strength

Frame Strength Depends On:

Type of Material..

Size and Shape of the Frame Rails..

Frame Materials:

Steel (Most Common, can be Heat Treated)

Aluminum Alloy
Frame Materials

Yield Strength

Refers to the maximum amount of stress that a material can withstand without being permanently deformed.

Measures in kPa or psi.

Higher the yield strength, the stronger the material.
# Frame Materials

<table>
<thead>
<tr>
<th>Frame Material</th>
<th>Yield strength kPa</th>
<th>Yield strength psi</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mild steel</td>
<td>248,000</td>
<td>36,000</td>
</tr>
<tr>
<td>High strength, low alloy steel (HSLA steel)</td>
<td>345,000</td>
<td>50,000</td>
</tr>
<tr>
<td>Aluminum-manganese-silicon alloy..</td>
<td>255,000</td>
<td>37,000</td>
</tr>
<tr>
<td>Copper-aluminum alloy</td>
<td>414,000</td>
<td>60,000</td>
</tr>
</tbody>
</table>

Heavy duty truck tractor and trailer frames are usually made from heat treated alloy steel with a yield rating of **748,000 kPa (110,000 psi)**.
Frame Size and Shape:

Section Modulus:

- Width of Flange.
- Depth of Web.
- Material Thickness.

Size and shape of the section modulus has a direct effect on strength:
Frame Size and Shape

- Rail Flange
- Frame Reinforcement
- Inner Frame Reinforcement
- Inner Frame Reinforcement
- Web

Reinforcement increases the Frames Section Modulus:
Resisting Bending Moment (RBM)

Is a term that is used to express Overall Frame Strength.

Directly proportional to the yield strength of the material and the section modulus.
Suspension System Functions

Secures axle to the frame while maintaining drive train alignment and reducing tire wear.

Supports the weight of the vehicle and its cargo and maintain lateral stability during operation.

Cushions shock loads created by tires striking irregularities in the road surface.

Allow the axle to move up and down relative to the vehicle frame, so the tires follow the contours of the road surfaces.
Objective Three

State the functions of a vehicle suspension system.
Secure Axles To The Frame

The suspension system securely connects the axle to the frame, and rubber bushings may be used to reduce noise and vibration.
Suspension must hold the axles in alignment with the frame to get proper handling of the vehicle, to prevent dog tracking and reduce tire wear.

Secure Axles To The Frame

Wheels Must Be Parallel to the Frame Rails.

Suspension must hold the axles in alignment with the frame to get proper handling of the vehicle, to prevent dog tracking and reduce tire wear.
Support Vehicle Weight and Maintain Stability

Suspension must support:

- Weight of the cargo.
- Weight of the vehicle above the suspension system.
Support Vehicle Weight and Maintain Stability

Sprung Weight

Components supported by the suspension system. (frame, engine, transmission, cab, etc)
Support Vehicle Weight and Maintain Stability

Unsprung Weight

Components not supported by the suspension system. (tires, axles, wheels, etc)
Support Vehicle Weight and Maintain Stability

Suspension must maintain vehicle lateral stability:

Centrifugal force and gravity are additional forces that act upon a vehicle that is in motion.

The stiffer the suspension, the better the vehicle’s side to side, or lateral stability.
Cushion Shock Loads

Energy Absorbing Devices:

- Rubber Cushion
- Leaf Spring
- Air Spring

Absorb shock loads that are created when the tires strike irregularities in the road.
Maintain Contact between the Tire and the Road Surface

Maintaining contact between the tire and the road surface ensures:

- Traction
- Smooth Acceleration
- Quicker Stopping
- Proper Handling

[Diagram showing frame rail, leaf spring, and stopped position]
Maintain Contact between the Tire and the Road Surface

When contacting a bump, the spring absorbs the energy (jounce) and then releases it (rebound), while maintaining good tire to road contact.
Suspension Limiting Components

Axle Stops:

Axle Stops: Limits vertical travel of the axle housing.
Objective Four

Explain the operating principles of common suspension systems.
Suspension Limiting Components

Torque Rods:
Transfers axle torque to the frame and stabilizes axle housing against operational forces.

Longitudinal Torque Rod connects axle housing to frame crossmember.

Transverse Torque Rod connects axle housing to frame rail and provides axial stability.
Rubber Bushings

Equalizer beams have rubber bushings that have sufficient elasticity to allow up to 7.62 (3”) of lateral movement to allow a loaded vehicle to negotiate a turn.
Shock Absorbers

Basic Shock Absorber:
Is used to control (dampen) spring oscillation. *(bouncing)*

Uses hydraulic fluid flow through valves and orifices to control piston movement.
Shock Absorbers

Improves tire to road contact.

Spring oscillation if not controlled, will result in wheel hop, tire cupping and make a vehicle difficult to control.

Two types of shock absorbers:

- **Single Acting**: Controls only spring jounce.
- **Double Acting**: Controls jounce and rebound.
Shock Absorbers

- Piston Valve
- Base Assembly
- Check Valve

Shock Absorber in Jounce Condition
Shock Absorbers

Orifices

Piston Valve

Base Assembly

Check Valve

Shock Absorber in Rebound Condition
Suspension Operating Principles

Four Types of Suspensions:

1. Solid Mount Suspension.
2. Leaf Spring Suspension
3. Rubber Cushion Suspension.
4. Air Spring Suspension.
Solid Mount Suspension System

Best suited for vehicles with:

- High Center of Gravity..
- Operate off Road or Rugged Terrain..
- Require Long Suspension Travel
Solid Mount Suspension System

Advantages

Very rugged, low maintenance, excellent lateral stability.

Disadvantages

Poor energy absorbing capacity, and a rough ride.
Solid Mount Suspension System

Oscillation of the equalizer beam, allows axles to follow rough road irregularities, while maintaining good tire to road surface contact.

Equalizing beam is sometimes referred to as a walking beam.
Solid Mount Suspension System

Equalizer Beam Reduces Shock Loads

The action of the equalizer beam reduces the effect of shock loads by 50%..
Solid Mount Suspension System

Pivot point is centered between axle housings.

Frame only moves $\frac{1}{2}$ the distance of the axle:
Leaf Spring Suspension

Semi-elliptical, Multi Leaf Spring:

Most common and most versatile, and may be made from heat treated steel, carbon fibre or reinforced fibreglass.
Leaf Spring Suspension

Semi-elliptical, Multi Leaf Spring:

Spring Rate – load required to deflect the spring a certain distance. (1”)

Load Range – maximum load carrying capacity.
Leaf Spring Suspension

Spring rate (**deflection**) is reduced and load ranged is increased when:

- Number of spring leaves, leaf thickness or leaf width is increased.

Two types of leaf Springs:

1. Constant Rate.

2. Progressive Rate.
Leaf Spring Suspensions

Constant Rate Springs Assemblies:

300 kg Load
Spring deflects 3 cm

600 kg Load
Spring deflects 6 cm

Have a constant rate of deflection under load.
Double the load, double the deflection.
Leaf Spring Suspension

Progressive Leaf Spring Assemblies:

Have a variable spring rate, and provides a good ride when unit is empty, and also a good load range.
Leaf Spring Suspension

Progressive Leaf Spring Assemblies:

The more load that is placed on the spring, the shorter the effective length becomes. (The stronger the spring becomes)
Leaf Spring Suspension

Auxiliary Springs:

- Auxiliary Spring Brackets
- Front Bracket
- Auxiliary Spring Assembly
- Rear Bracket
- Main Spring Assembly
- Auxiliary Spring Assembly

Auxiliary spring is mounted on top of the main spring.

Also called an overload spring.
Leaf Spring Suspension

Auxiliary Springs:

Are used to increase load capacity without affecting ride quality.

Supports the load only when loaded to the point where the ends of the auxiliary spring, contacts the auxiliary spring brackets.
Applications of Leaf Spring Suspensions

Steering Axle Suspension

Often use an insulating lining between the leaf spring leaves to reduce friction, fretting and corrosion.

Rear spring shackle connected to frame accommodates changes in length as the suspension jounces and rebounds.
1. Axle
2. Dowel
3. Caster Adjustment Shim
4. Spacer
5. Shock Absorber Lower Mounting Bracket
6. Spring Assembly
7. Spring Pin & Rubber Bushing Assembly
8. Forward Spring Bracket
9. U-bolt
10. Axle Pad
11. Spring Centre Bolt & Nut
12. Shock Absorber Bushing
13. Shock Absorber
14. Spring Shackle
15. Shackle Bracket
16. Shock Absorber Upper Mount
17. Frame Rail
Steering Axle Suspension

Leaf Spring Suspension with Rubber Insulators

Spring is allowed to slide between the rubber insulators to provide a Progressive Spring Rate
Steering Axle Suspension

Leaf springs are prone to oscillation.

Shock absorbers provide:

Resistance to spring oscillation, which gives a firm, stable ride.

Slower transfer of weight from one axle to another, during acceleration and braking.

Reduced wear on suspension, steering components and tires.
Drive Axle Suspension

Single Drive Axle Suspension:

Wear shoes cast into the brackets allow the spring to float for spring length change, and provide variable spring rate.
Drive Axle Suspension

Single Drive Axle Suspension:

Torque rods are adjustable and used to position and align the axle, as well as transfer torque from the axle to the frame. They stabilize the spring against torque, created when braking and acceleration.
Tandem Drive Axle Suspension

Two types:

1. Standard Leaf Spring Suspension

2. Leaf Spring Suspension With Equalizer Bars
Standard Leaf Spring Suspension

Forward Spring Bracket
Forward Torque Arm
Spring Seat
Rear Torque Arm
U-bolt Retainer

Equalizer Bracket
Equalizer
U-bolt
U-bolt Pad
Spring Liner
Rear Spring Bracket
Leaf Spring Assembly

Mostly used on trailers. (Four Spring Dayton-reyco)
Standard Leaf Spring Suspension

Equalizer pivots in the Equalizer Bracket.

The stops built into the Equalizer Bracket limit the equalizer travel.

Pivoting action of the equalizer allows axles to oscillate, providing good tire-to-road contact and improved ride characteristics.
Hendrickson Suspension - Most common, similar to solid mount but has better ride.
Rubber Cushion Type Suspension

Frame Hangers

Vertical Drive Pin

End Bushing

Torque Rods

Vertical Drive Bushing

Transverse Rod

Equalizer Beam

Centre Bushing

Saddle Assembly

Rubber Load Cushions

Also called rubber block.
Rubber Cushion Type Suspension:

Very common, uses rubber blocks in place of leaf spring..

Inexpensive, durable and good load carrying capacity..

Very poor ride characteristics.
Rubber Cushion Type Suspension:

A. No Load

B. Full Load

Uses vertical drive pins to maintain alignment..
Rubber Cushion Type Suspension:

Vertical drive pin allows saddle to move up and down, but resists front to rear and side to side movement, maintaining alignment of saddle with the frame rails.
Rubber Cushion Type Suspension:

Load Cushion

Vertical Drive Pin

Vertical Drive Bushing

Vertical Drive Bushing Cap

Frame Hanger

Saddle

Washer

Bumper

Stop Nut

Rebound **Stop Nut** restrict upward movement of Vertical Drive Pin when rebound conditions exists, and when subjected to high centre of gravity or offset loads.
Air Spring Suspension

Does not give the lateral stability of other types of suspensions.

Not used for high center of gravity loads or off road.
Air Spring Suspension

Uses compressed air in rubber bags to absorb shock loads..

Has a superior ride..
Reduces driver fatigue..
Reduces damage to vehicle and cargo..

Provide constant frame height regardless of load..
Less change in driveline angle.
Air Spring Suspension

**Air System Components of a Typical Air Spring Suspension System**

- **Air Supply**
- **Air Reservoir**
- **Two-way Control Valve**
- **Pressure Protection Valve**
- **Control Pressure**
- **Ride Height Control Valve**
- **Dump Valves**
- **To additional air springs**

Air Spring Suspension Diagram
Air Springs are made of plies of natural rubber and reinforced cords.
Pressure Protection Valve:

Ensure that a minimum safe air pressure is maintained in the air reservoir for air brake operation, if a large leak were to occur in the suspension system.
Ride Height Control Valve

Controls the amount of air flow to and from the air bag, to maintain a constant distance between the axle and the frame.

It is automatic and also adjustable.

Has three positions:

1. **Supply** - supply air to the air bag.
2. **Closed** - to trap air in the air bag.
3. **Exhaust** - remove air from the air bags.
Ride Height Control Valve

Incorporates a delay:

A small amount of clearance is built into the valve to act as a delay.

Prevents actuation of the valve by abrupt movements of the axle, such as speed bumps and pot holes.
Ride Height Control Valve

1. Ride Control Valve.
2. Control Shaft.
3. Overtravel Lever
4. Linkage Rod.
5. L-rod

Overtravel Lever (3) is in the Closed Position.
Ride Height Control Valve

Jounce Position:
Overtravel lever rotates control shaft clockwise, which opens the inlet valve, allowing air to flow to air spring.
Ride Height Control Valve

Overtravel lever rotates control shaft counterclockwise, which opens internal exhaust valve, allowing air flow out to atmosphere.

Rebound Position:

Overtravel lever rotates control shaft counterclockwise, which opens internal exhaust valve, allowing air flow out to atmosphere.
Two-way Control and Dump Valves:

Two-way Control Valve

Air Supply

Pressure Protection Valve

Air Reservoir

Ride Height Control Valve

Control Pressure

Dump Valves

To additional air springs

Two-way Control Valve is a two position air control valve, and is mounted in the cab.
Two Way Control and Dump Valves:

Two-way Control Valve

Air Supply

Air Reservoir

Pressure Protection Valve

Ride Height Control Valve

Two Way Control and Dump Valves:

Control Pressure

Dump Valves

To additional air springs

Two-way Control Valve controls **Dump Valves** to exhaust air from air springs, to lower suspension.
Two Way Control and Dump Valves:

Can adjust manually for sudden load changes, as in loading or dumping a load.

When the operator moves the control valve into its normal position, the suspension is raised and ride height control valve operates as usual.
Cab Air Suspension:

A. Supply from Air Reservoir.
1. Frame Rail.
2. Shock Absorber.
3. Air Spring
4. Vertical Linkage Rod.
5. Mounting Bracket.
6. Lateral Control Rod.
7. Cab Underbody.
8. Outboard Control Rod Bracket.
10. Level Valve.
11. Horizontal Control Lever.

Air Spring will give a smoother ride while maintaining cab level with the frame.
Two shock absorbers are used to dampen the up and down motion of the rear of the cab.
The End