STEERING GEOMETRY OF TWO WHEELERS

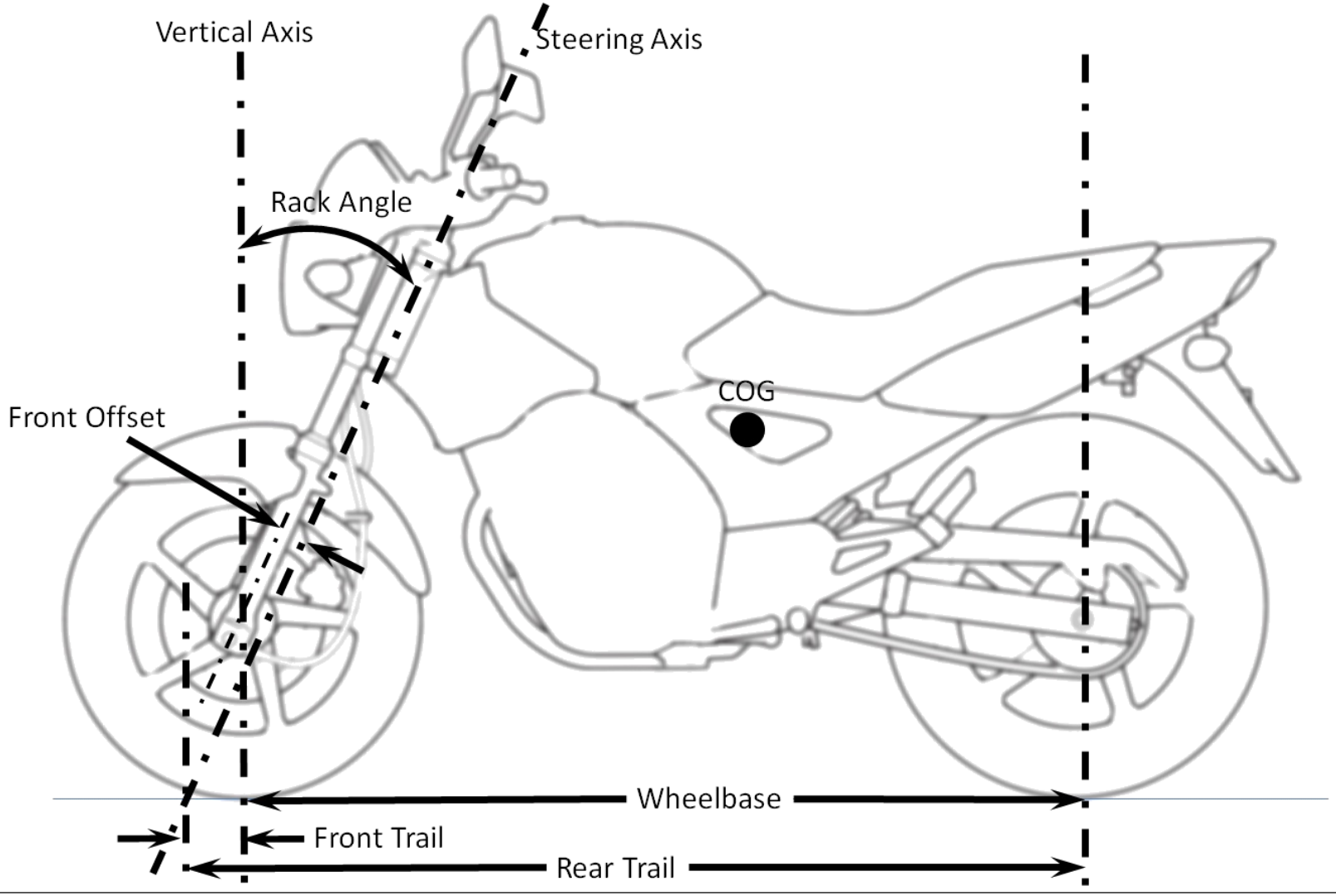
STEERING GEOMETRY

- It is a cluster of geometrical parameters which together, decide characteristics of the vehicle in steady as well as in dynamic condition
- Function of the steering system is
  - To provide a means whereby the driver can drive his vehicle accurately
  - To help rider to draw the vehicle where he wants it to be on the road
  - To provide direction stability for selection of the path

STEERING GEOMETRY

- Two wheelers use combine system incorporating suspensions and steering
- The continuous activation of front suspension system causes constant change in steering geometry
- Mostly, these variations take place within permissible limits but sometimes these variations go beyond controllable limits
- Therefore, the selection of values for the steering geometry is a challenging task

STEERING GEOMETRY



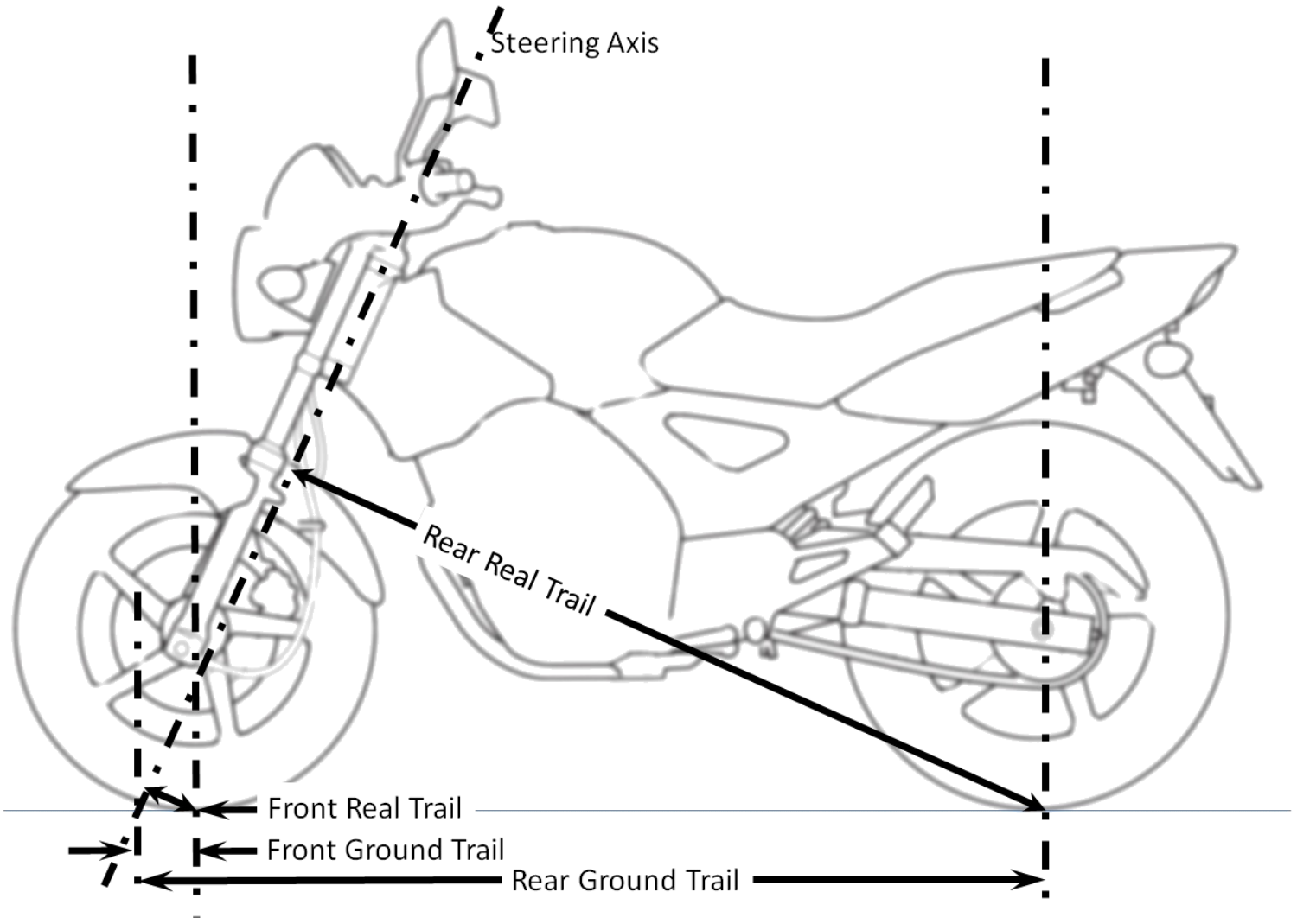
TRAIL

- The trail refers to the distance between the imaginary point where the steering axis intersects the ground and the center of the tire contact patch
- Trail provides steering stability during straight line motion as well as during commuting through corners
- Amount:
  - Front trail – 50 mm to 100 mm
  - Rear trail – 1300 mm to 1500 mm

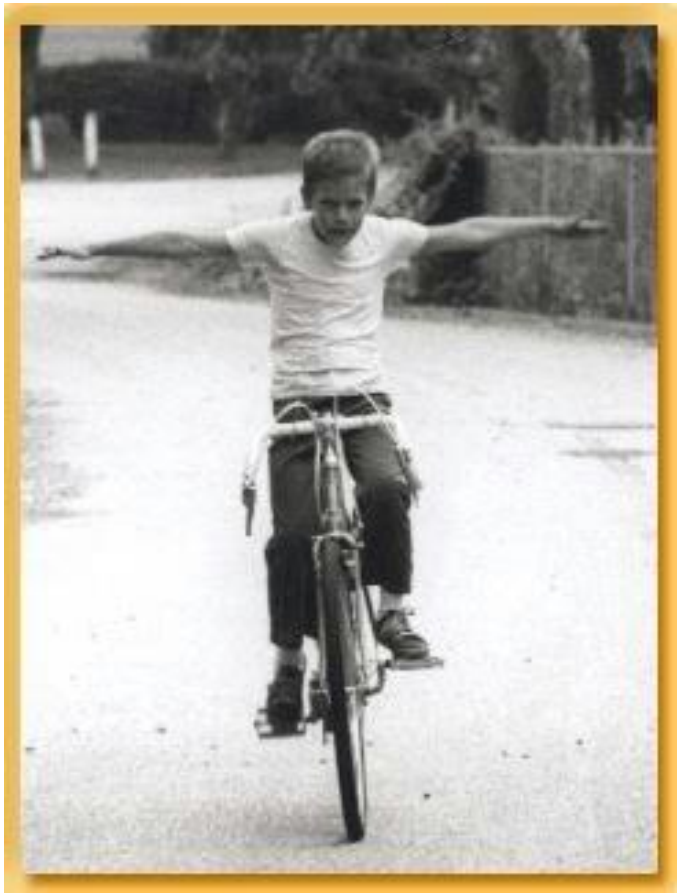
TRAIL

- **TYPES OF TRAIL**
  - Front trail
  - Rear trail
  - Ground trail
  - Real trail, often called Mechanical trail
  - Positive trail and Negative trail

TRAIL

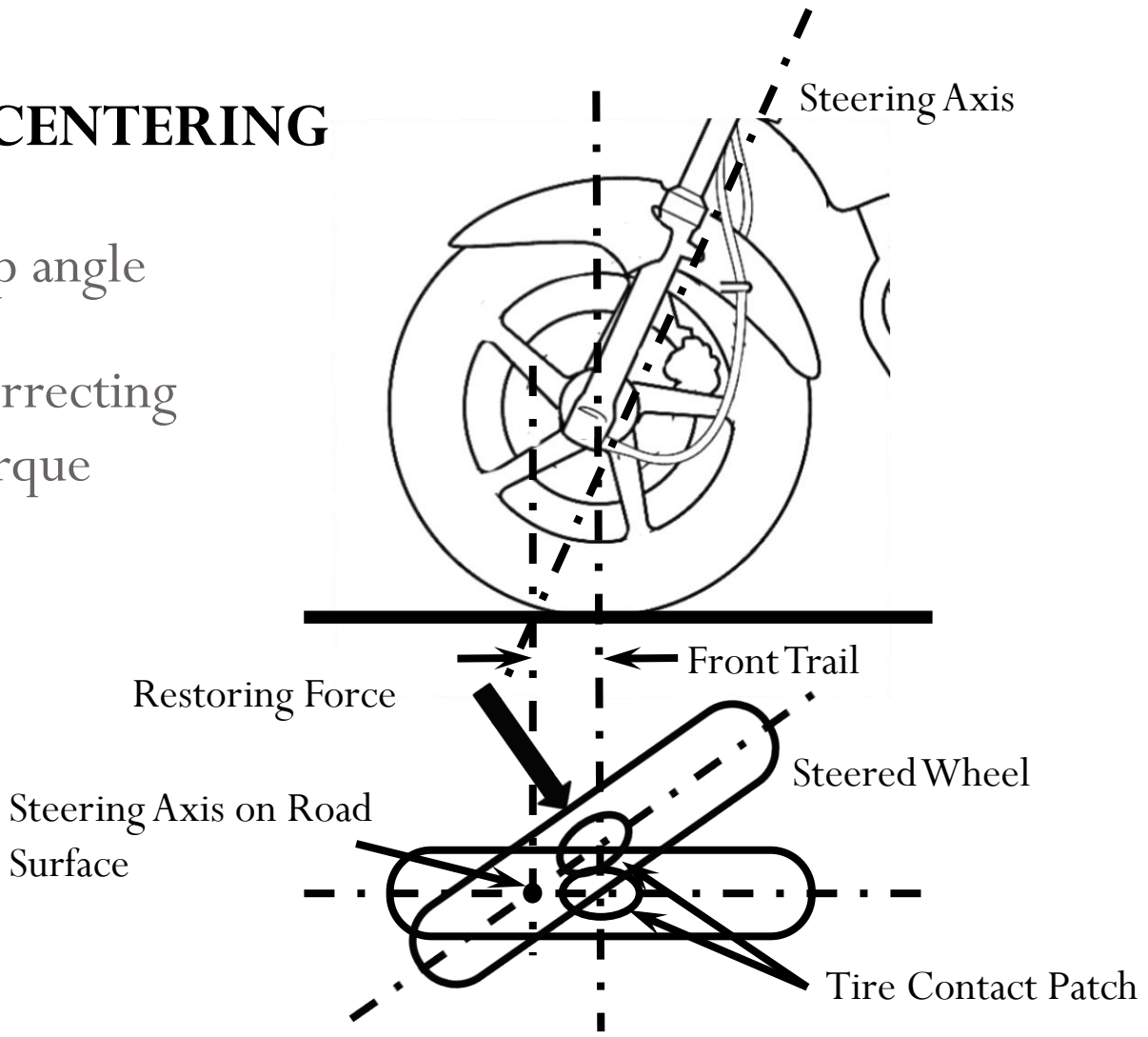

Steering Axis
Rear Real Trail
Front Real Trail
Front Ground Trail
Rear Ground Trail

EFFECTS OF TRAIL



EFFECTS OF TRAIL

- **SELF-CENTERING**
  - Slip angle
  - Correcting Torque



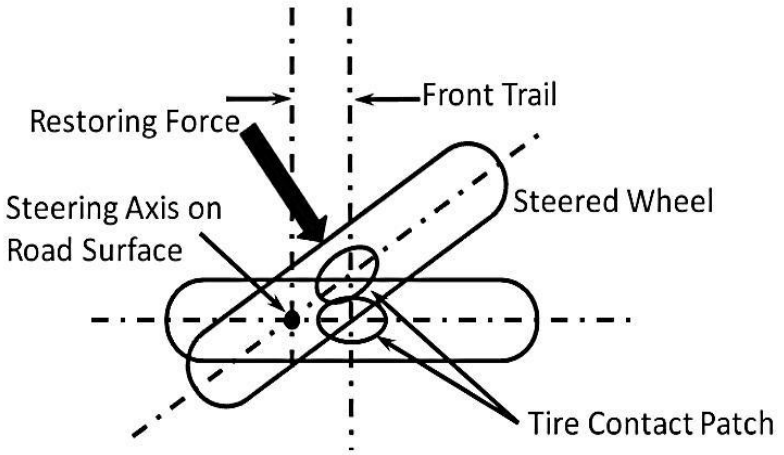
EFFECTS OF TRAIL

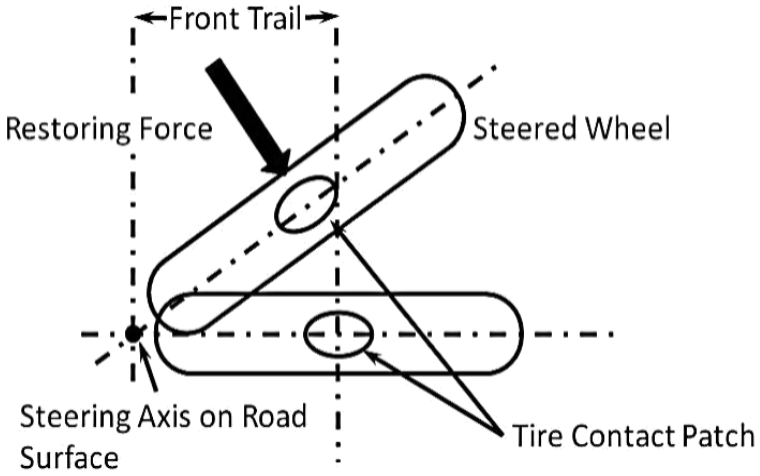
EFFECTS OF TRAIL

- **ROAD RESPONSE**
- The straight line motion of two wheeler is actually a series of correcting torque curves
- A small steering of front wheel generates slip angle, which produces correcting torque to retain the directional stability
- The amount of correcting torque depends on slip angle, tire properties, friction coefficient and trail
- This corrective torque is sensed by the rider through the handlebar

EFFECTS OF TRAIL

- **TURNING ABILITY**



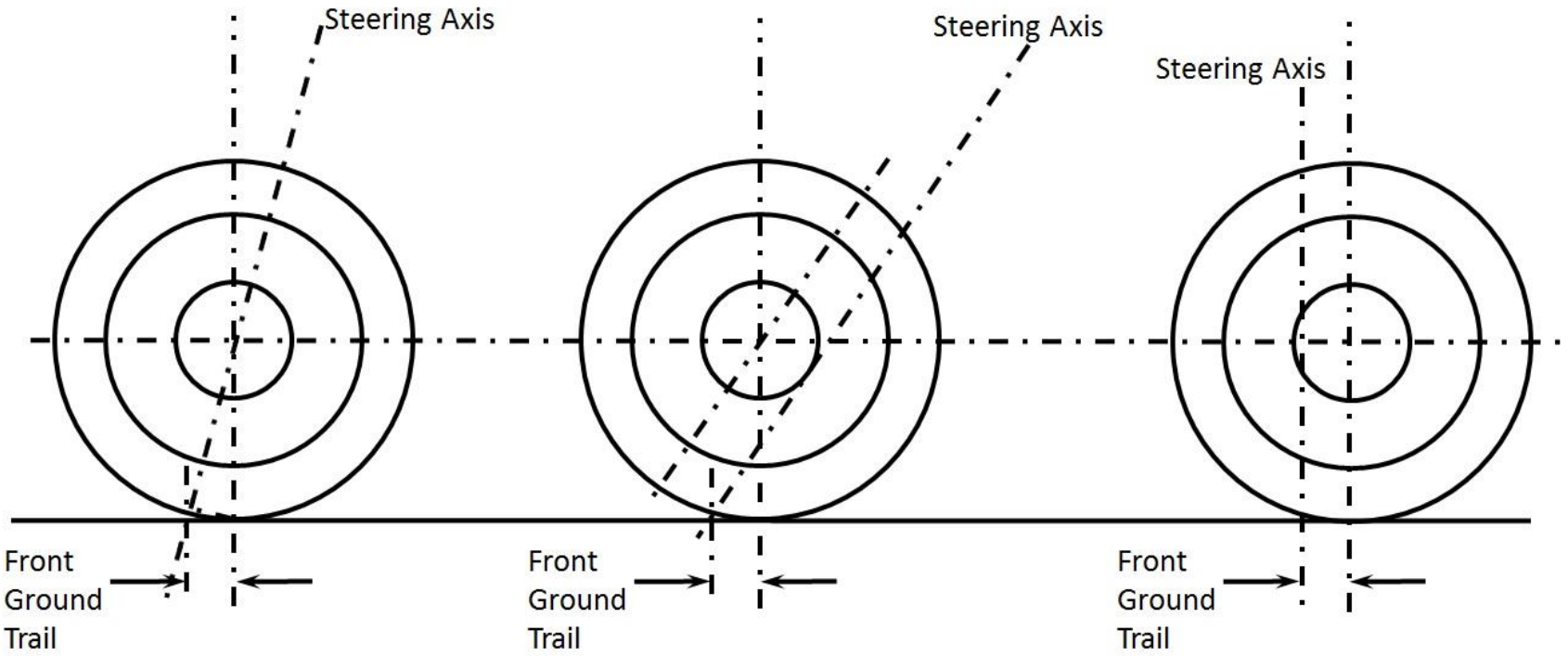


Summary: *Increasing the trail to increase the restoring force and corrective torque on the wheels results as diminished turning ability*

CASTOR

- The Castor or Rack angle is the angle provided between an imaginary center line passing through the steering head and imaginary vertical line passing through the front wheel center
- Basic function is to generate castor effect
- Amount:
  - 15° to 30°. Generally, 27°

CASTOR



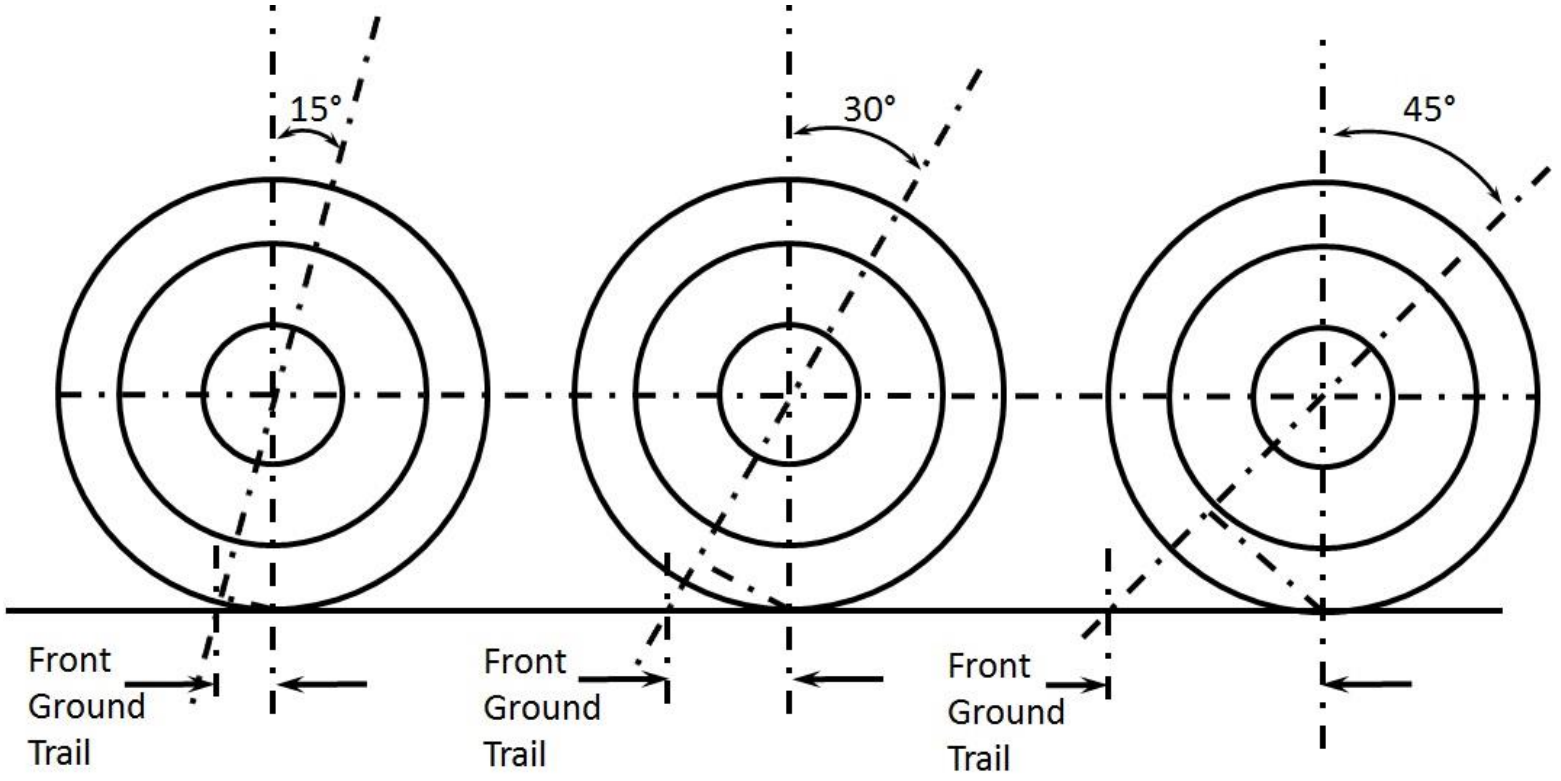
- Hub-Center Steering
- Small Rack Angle
- No Offset

- Offset Fork Steering
- Large Rack Angle
- Positive Offset

- Vertical Steering
- Zero Rack Angle
- Negative Offset

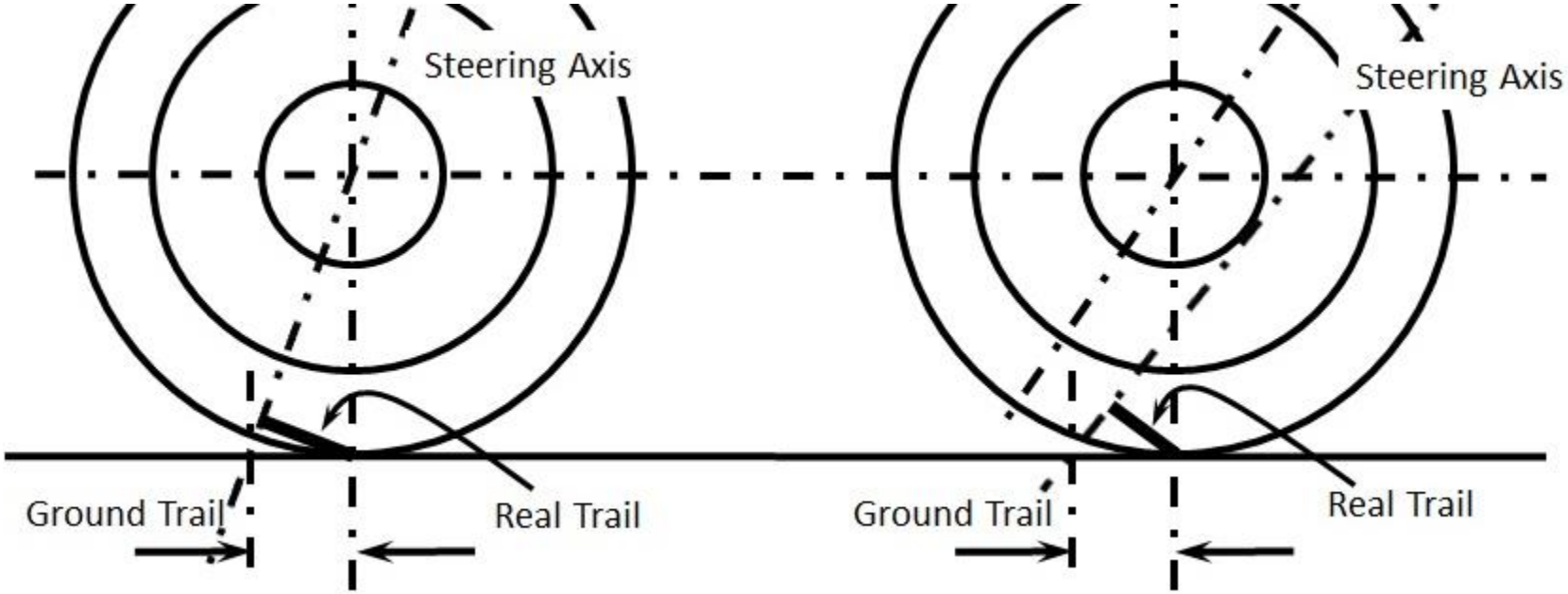
EFFECT OF CASTOR

- Increase in Front Trail for Hub-Center Steering
- Increase straight position



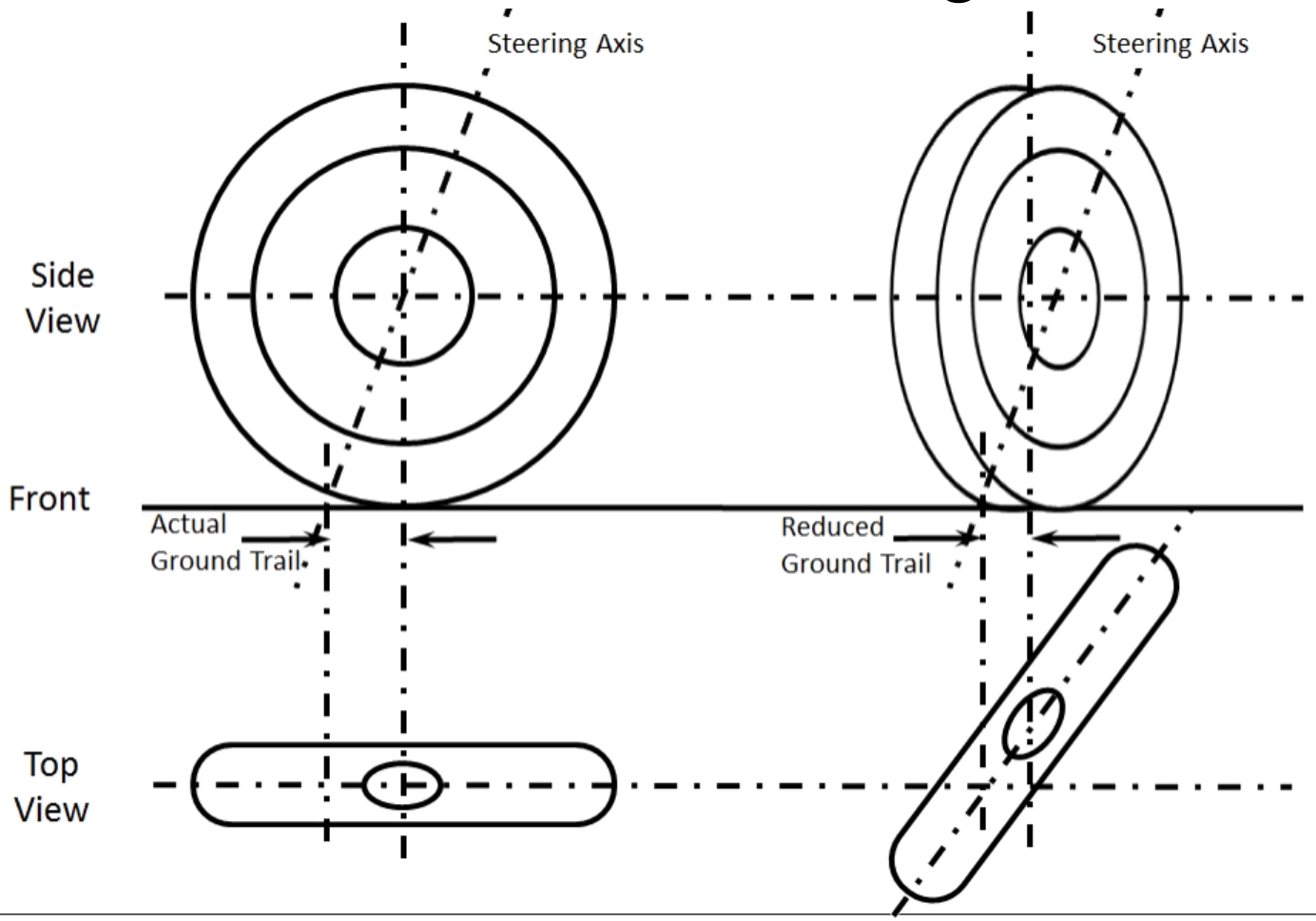
EFFECT OF CASTOR

- Decreased Real Trail due to offset
- Generate quick and easy steering at large rack



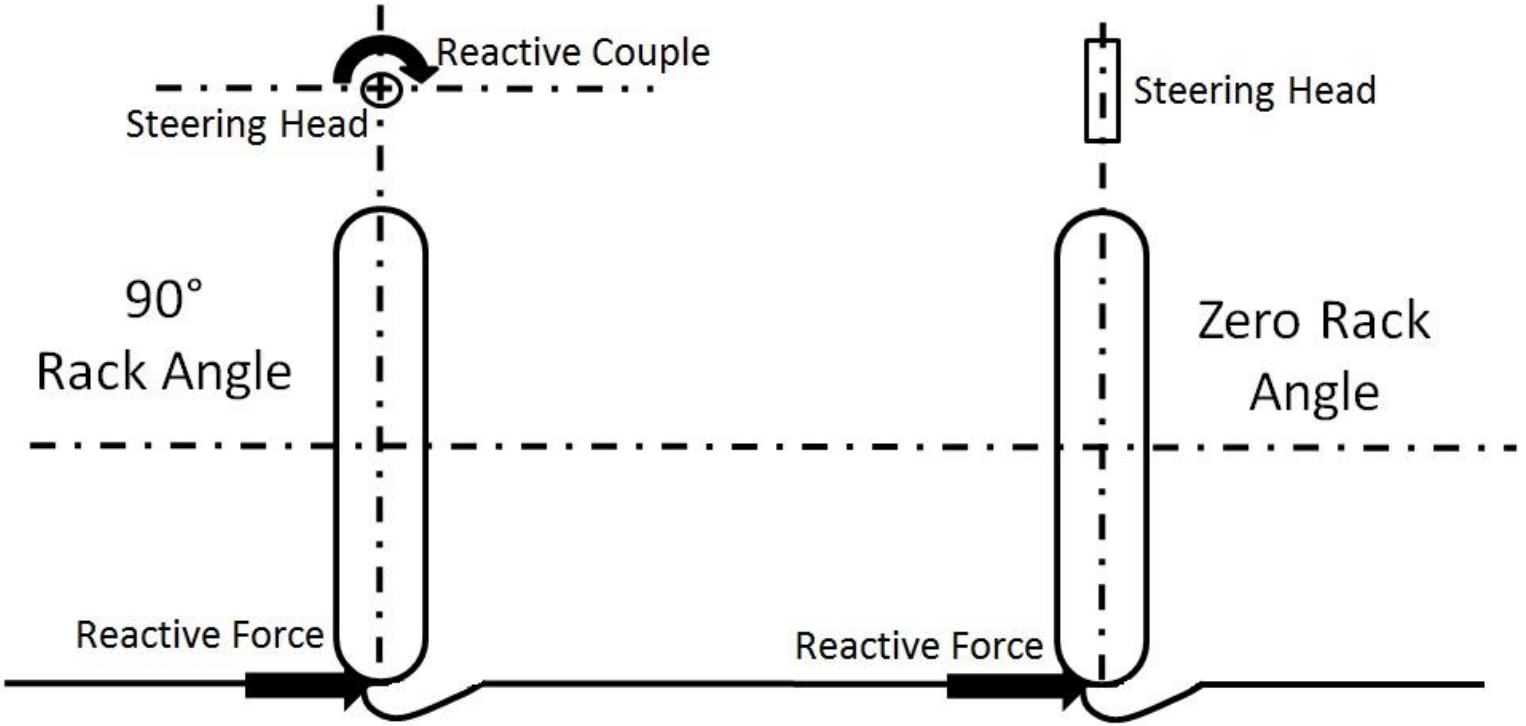
EFFECT OF CASTOR

- **Reduction in Trail due to Steering**



EFFECT OF CASTOR

- **Respond to Reactive Couple**



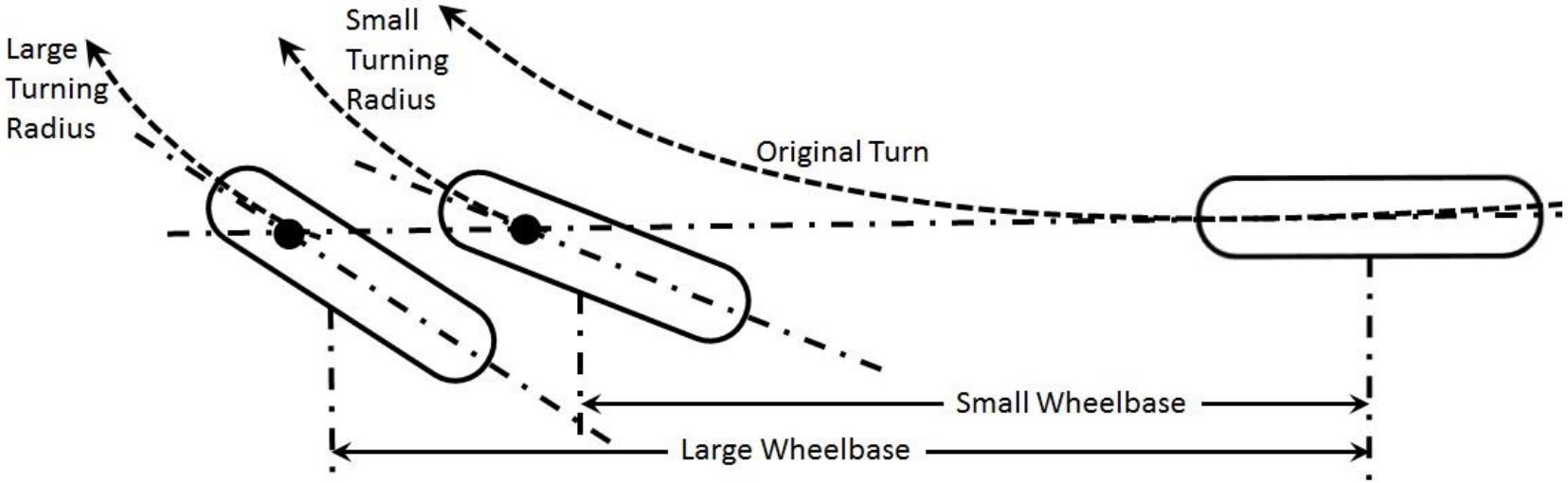
Summary: *Increased rack angle with sufficient amount of trail tends to increase the straight line stability*

WHEELBASE

- The distance between the wheel centers, when measured parallel to ground, is known as wheelbase
- Wheelbase affects handling from the standpoint of turning ability and reaction time
- Amount:
  - 

EFFECT OF WHEELBASE

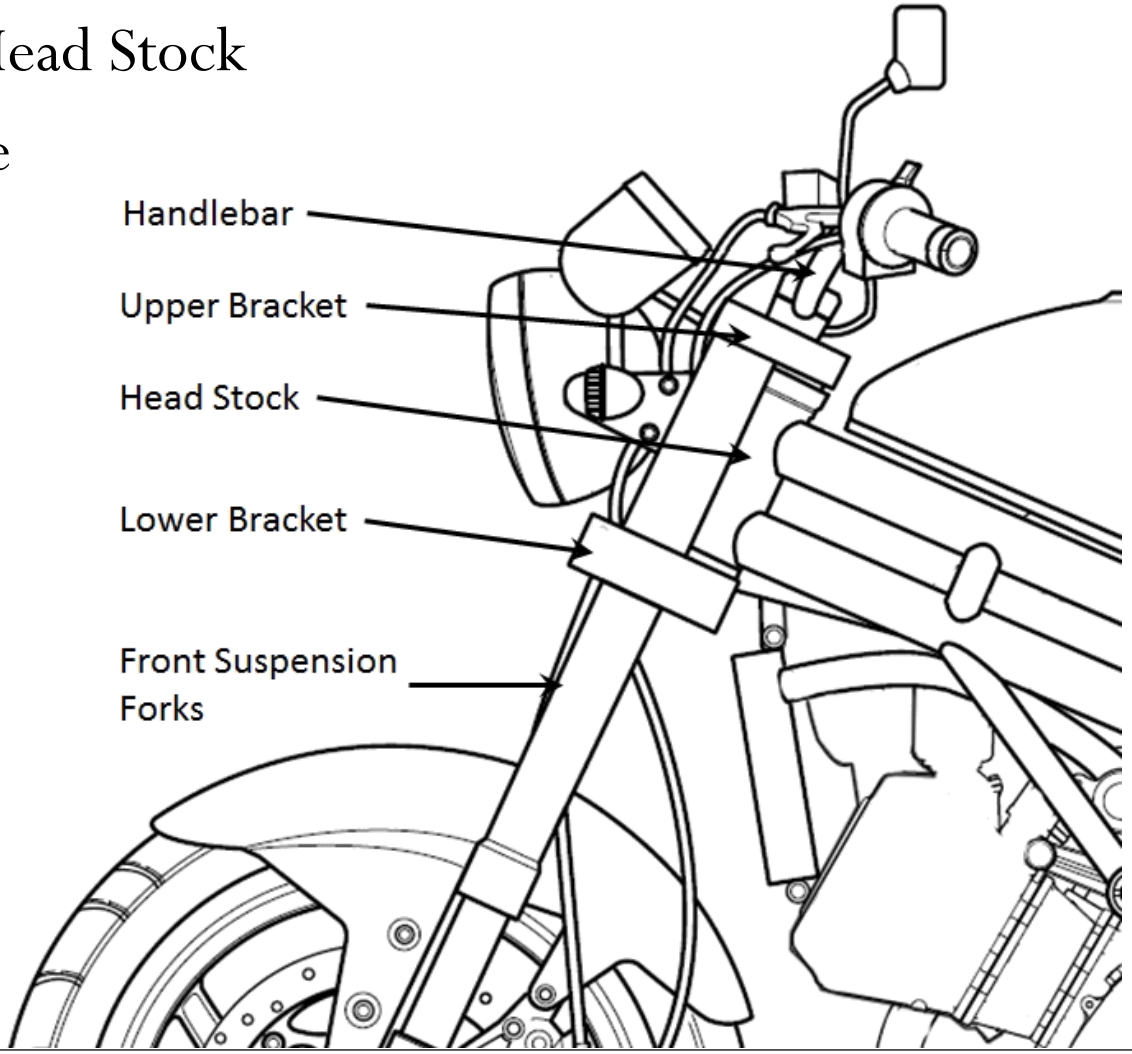
- **Increase in Turning Radius**



Summary: *Large wheelbase gives better directional stability and small load transfer while short wheelbase gives quick handling and maneuverability*

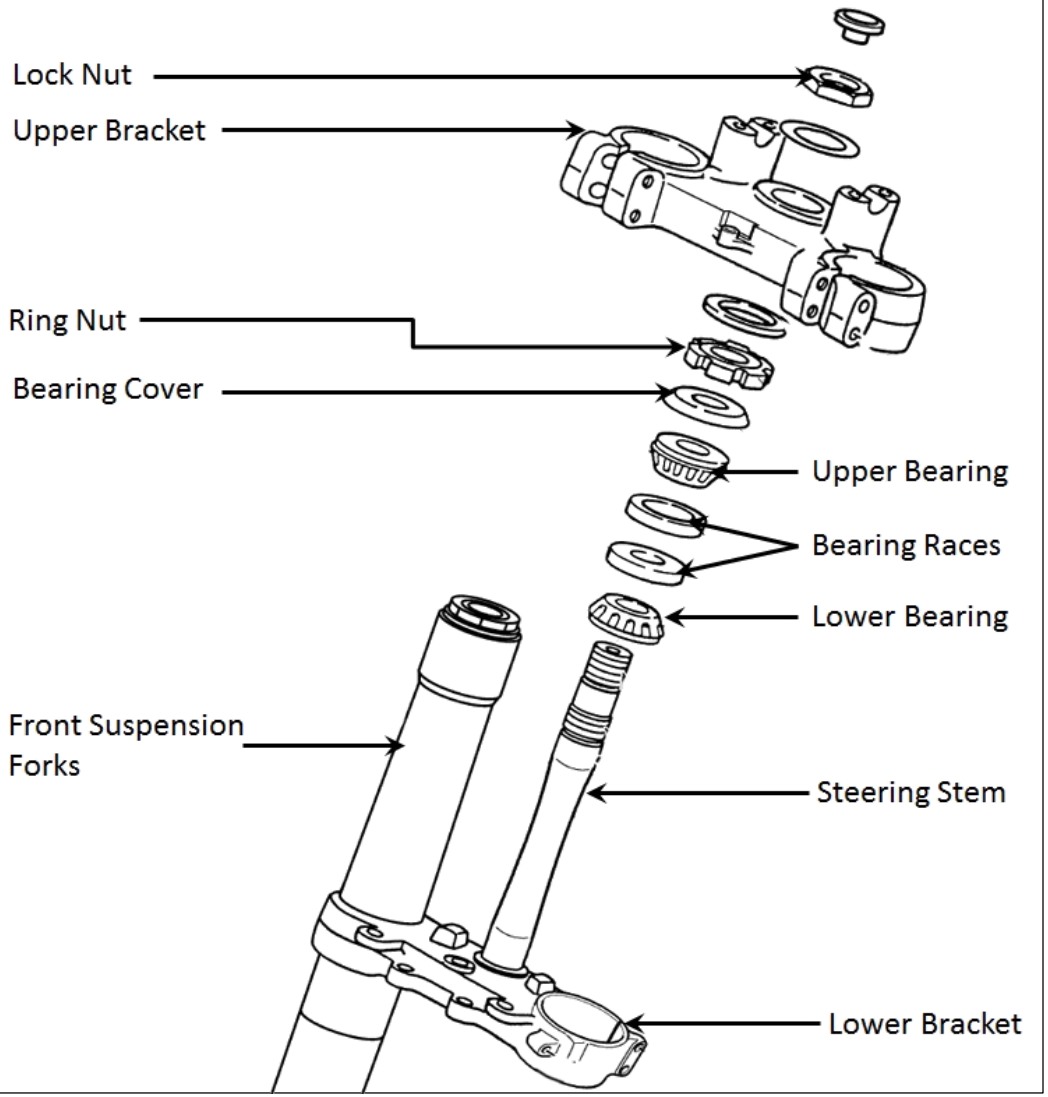
STEERING COLUMN

- Steering Head Stock
- Triple Tree



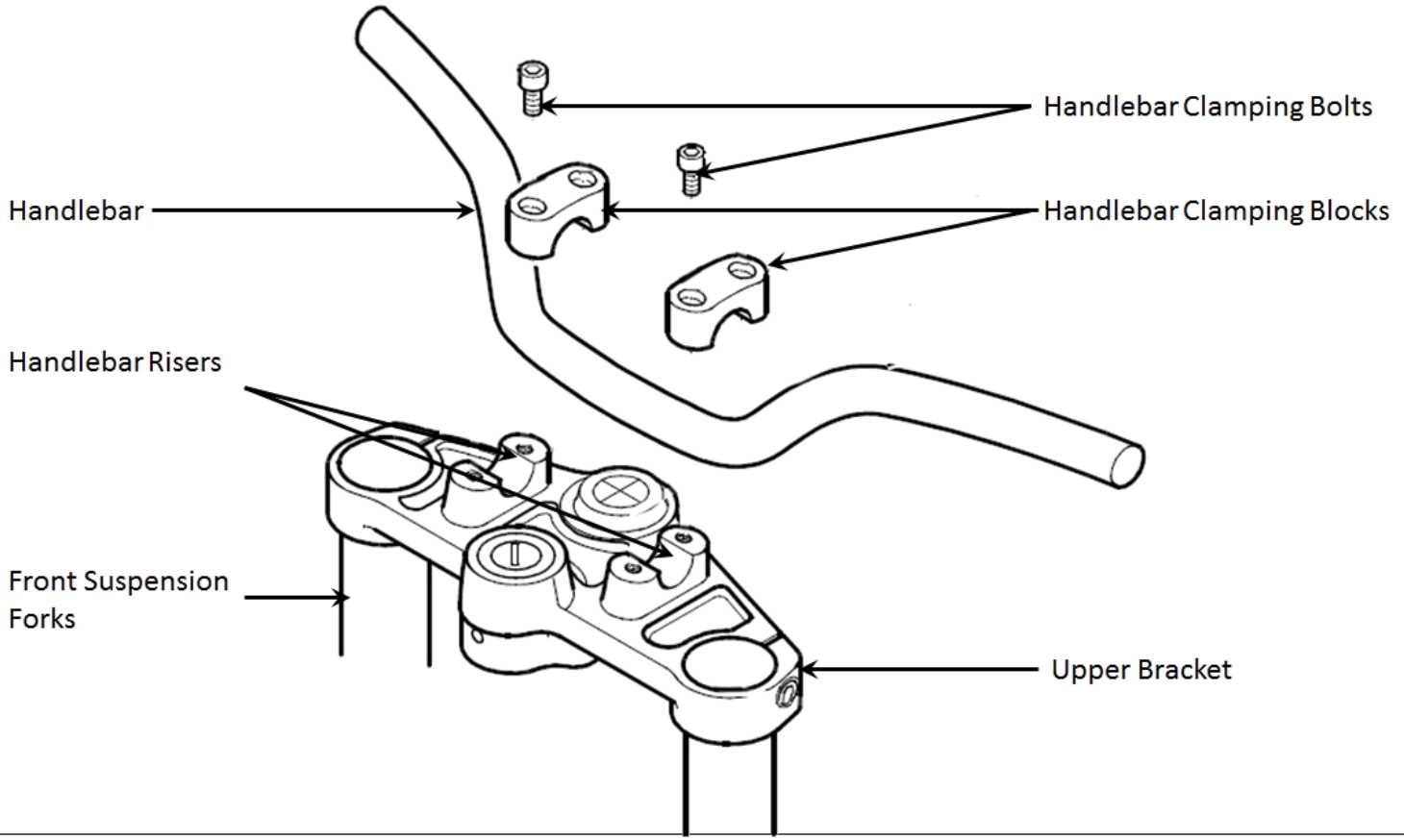
STEERING COLUMN

- Upper Bracket
- Lower Bracket
- Steering Stem
- Fork Offset



HANDLE BAR

- Handlebar communicates the effort of driver to the steering system



HANDLE BAR

- Ape hanger Handlebars

HANDLE BAR

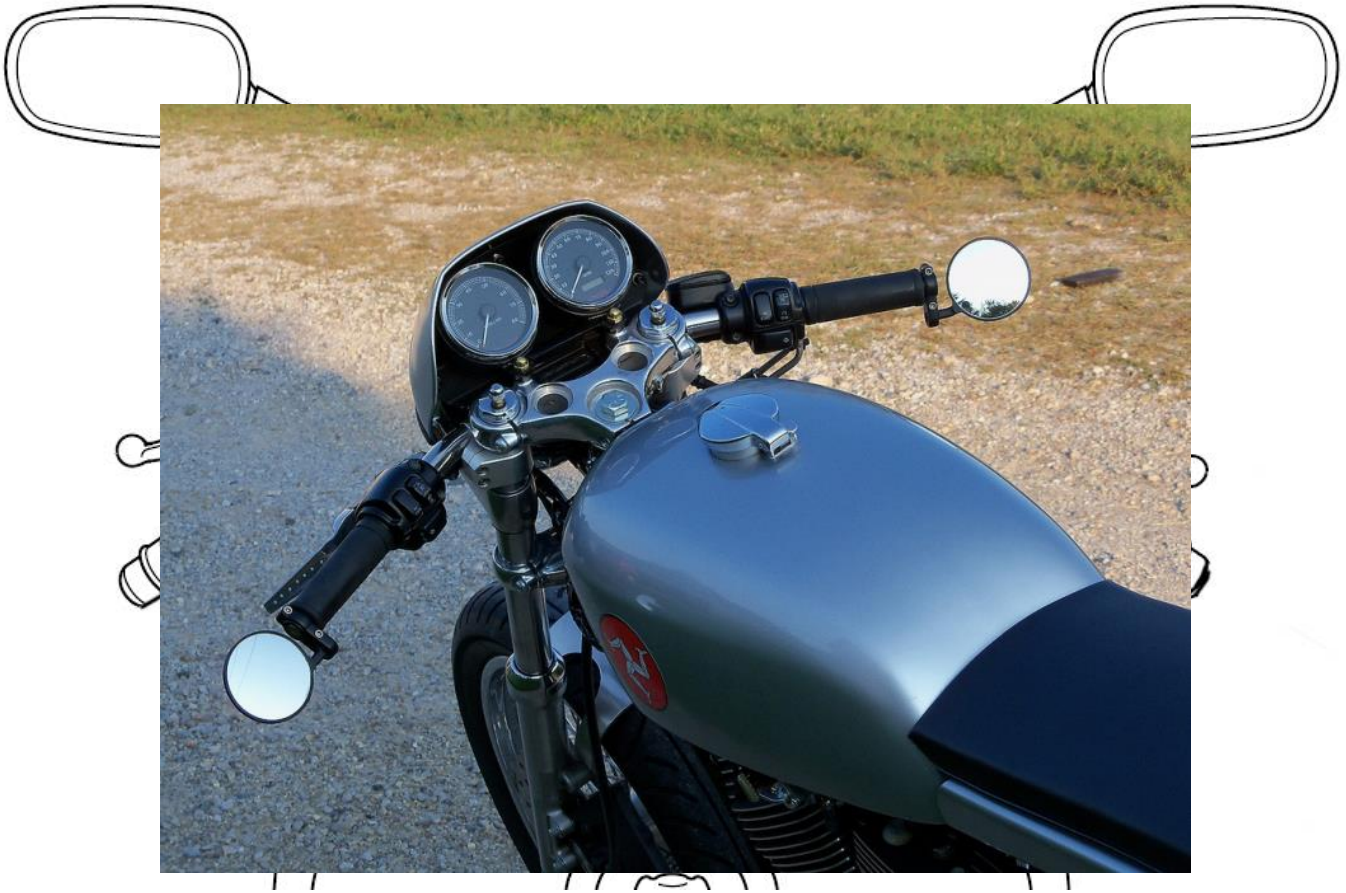
- **Beach Handlebars**

HANDLE BAR

- Drag Handlebars

HANDLE BAR

- **Clip-ons Handlebar**



Brake, Wheel &Tyres

Design consideration of brake

- Laden and unladen vehicle mass
- Static weight distribution
- Wheelbase
- Height of centre of gravity
- Maximum vehicle speed
- Tyre and Rim size
- Vehicle function
- Braking Standards

BRAKES

Brake plays an important role in stopping the vehicle. it is just opposite of clutch.
A brake is applied to rotating axle to stop the vehicle. in a two wheeler you find two types of brakes:

- **Drum Brake &**

- **Disc Brake**

- **Drum Brakes**

Universally drum brakes are widely used in the rear wheel. In India and many emerging nations we find the application of drum brake on both front and rear wheel.

A drum brake uses brake shoes or friction pads to create braking force.

A drum brake assembly contains

- brake shoes or friction pads
- brake pedal or lever
- springs
- brake cable
- brake drum
- brake arm
- brake cam
- Dust seal
- Anchor pin washer
- brake panel.

Brake shoes: The shape of brake shoe is like crescent moon. Brake shoes are made of **two pieces of sheet steel** welded together. The friction material which is called **brake lining** is attached to the lining table either by adhesive bonding or by riveting.

There are holes and slots on this brake shoe for return spring, hold down hardware and self adjusting components.

Each brake assembly has two shoes, a **primary and secondary**. The primary shoe is located towards the front of the vehicle and has the lining positioned differently than secondary shoe. The much needed care to be taken while putting primary and secondary shoe. **The primary shoe comes on left side while secondary shoe comes on right side**.

Break Pedal or lever: It is that component of brake assembly through which input to brake is given.

A front brake is operated through **lever** while rear brake is operated through **pedal**.

Brake Drum: It is made of special type of cast iron. It is positioned very close to the brake shoe without actually touching it, and rotates with the wheel and axle.

When the brake lining touches to the drum it generates friction heat which sometimes goes up to **600F (Fahrenheit)**

Brake drum must be highly heat conductive, sufficiently rigid, lightweight and resistant against wear. Apart from this it must be accurately balanced.

The gap between brake lining and drum inner surfaces is to be maintained accurately all the time.

In some type of brake this is **done automatically** while some brakes **require to be adjusted periodically**.

If the gap is too large it will delay in braking and loose the brake pedal.

If the gap is too small it will increase the wear of brake lining. Sometimes it makes rear wheel to lock up.

Brake Cable: the brake cable is the medium to pass the input given by brake lever or pedal. The rear brake sometime uses shaft system as medium of passing the input.

Springs: The coil type spring used as return spring when the brake is actuated by pressing lever or handle this spring expand and when you release the lever or pedal the springs contract and make the brake shoe to their original position.

Brake cam: Brake cam is work like camshaft.
When the brake lever or pedal is pressed **it will move which will expand the brake shoes**. The one side of brake cam is positioned between front and rear brake shoes gap and other side has teethes which fit on brake arm teethes.

Advantages of Drum brake compare with Disc Brake:

- It is cheaper compare to disk brake
- It is simple to operate compare to disk brake
- It is widely used and sometimes people don't feel comfortable with disc brake.
- It is more effective in rainy condition since the brake shoes are inside the drum.

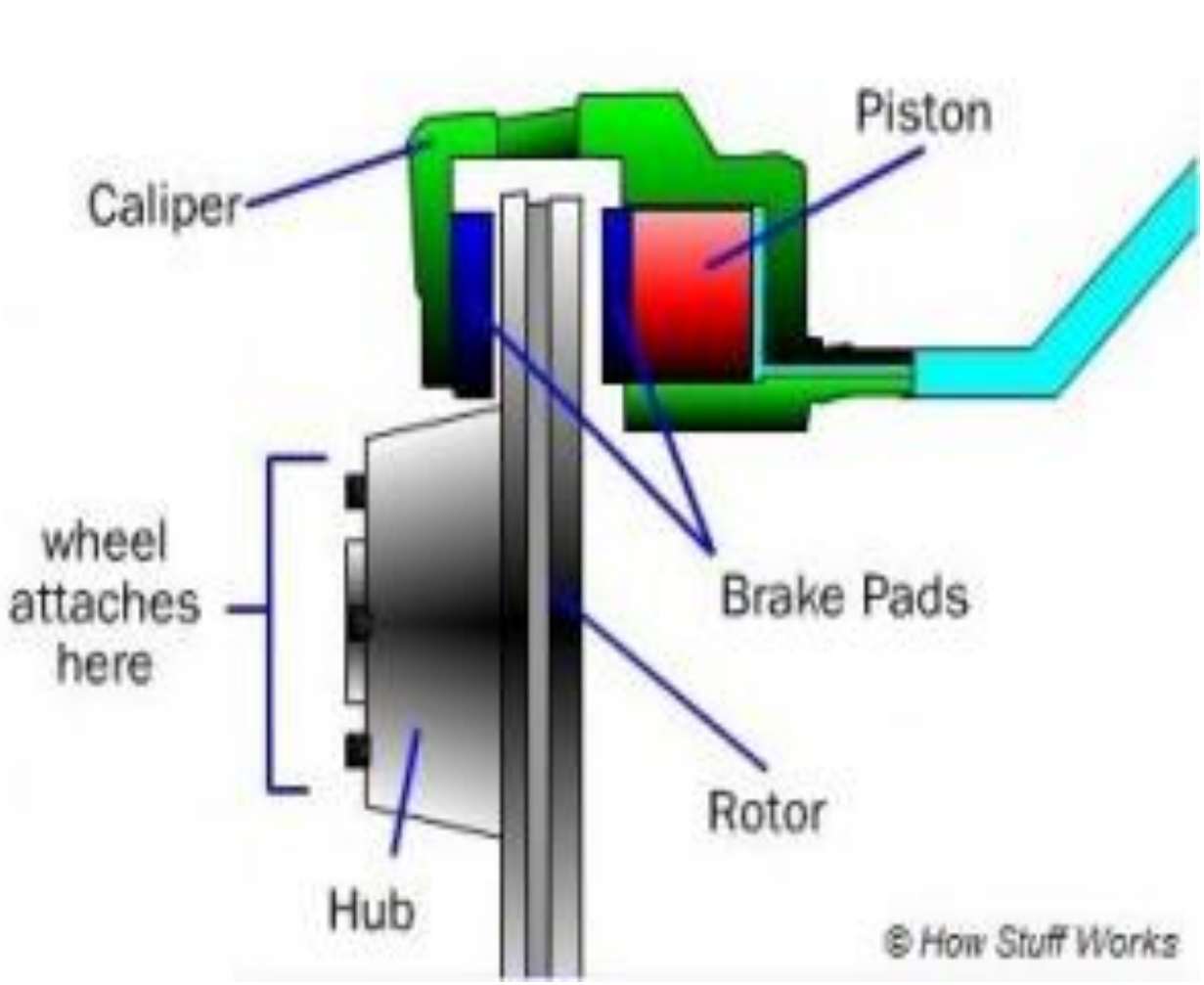
Disadvantages of Drum brake compare with Disc Brake :

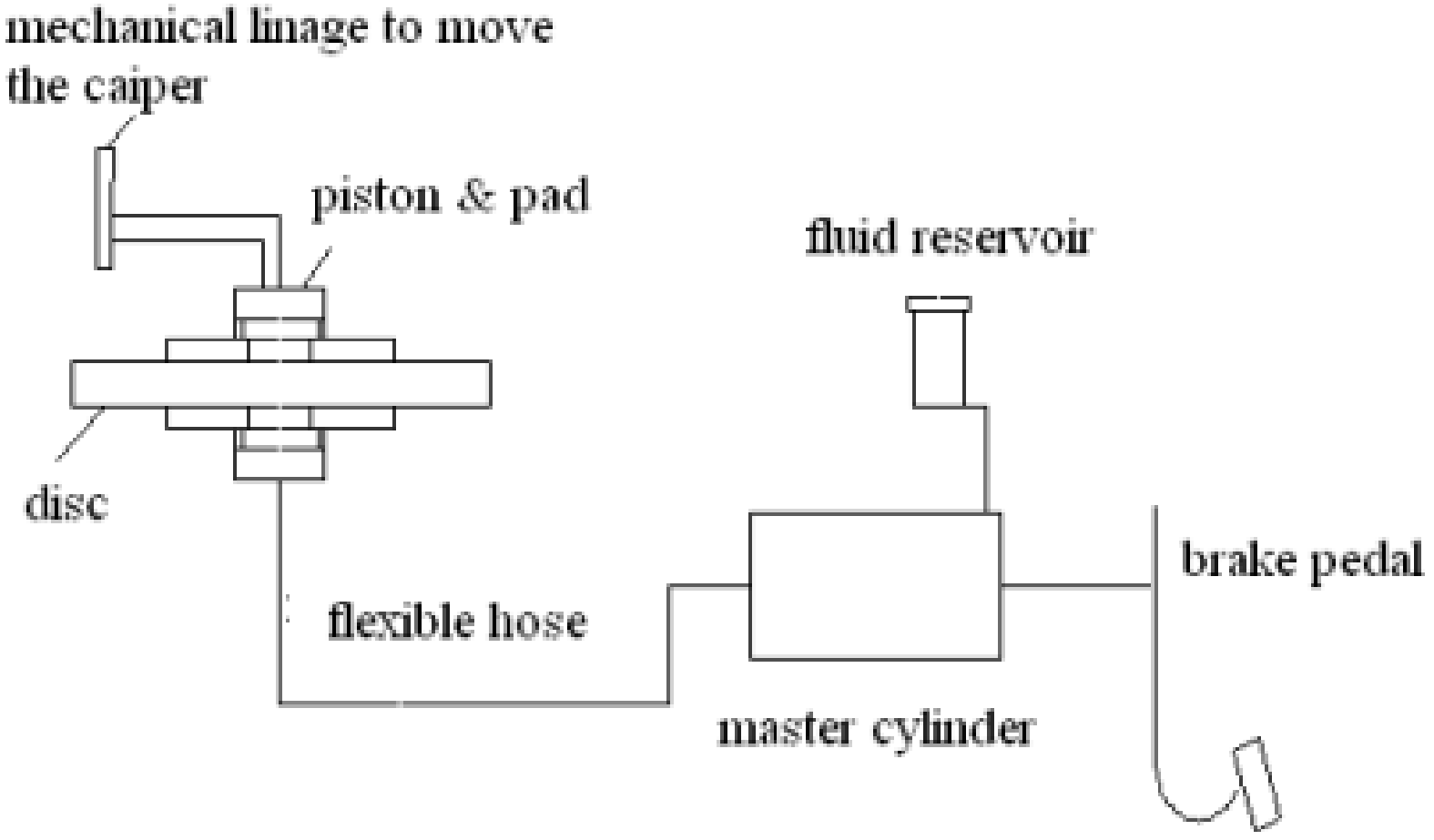
- It is prone to overheating which leads to break fade and wear outs
- It require more manual effort compare to disc brake
- It needs to be adjusted frequently
- They are lesser effective in excessive heat compare to disk brake

drum brake - how it works

https://youtu.be/WXxozXrWmZw

- **Disc Brakes**


Caliper
Piston
wheel attaches here
Brake Pads
Rotor
Hub
© How Stuff Works



Line Diagram of Disc Brake

Components of the Disc Brake Unit

- Brake lever or pedal. (pushes the master cylinder piston)
- Master cylinder. (produces pressure in the brake system)
- Hydraulic lines. (transfer hydraulic pressure from master cylinder to wheel cylinder)
- Disc or rotor
- Caliper unit
- Mechanical linkage (to move the caliper unit in radial direction)

Caliper Unit

The disc brake unit here employs a single piston floating caliper type.

The cylinder is formed as a mono block with the caliper. It has one movable piston, pad, and one stationary pad

Master Cylinder Unit

•The master cylinder is an important unit of the entire disc brake system.

•The typical master cylinder has two main chambers viz. fluid reservoir and pressure chamber.

•The fluid reservoir stores the brake fluid and compensates for any change in fluid volume in the pipe lines.

•A piston operates inside the pressure chamber.

Caliper & master cylinder we get from company is made up of aluminum and we use DOT 3 or 4 fluid for activation and so company recommends that too.

DOT 3 and 4 only grades for hydraulic brakes

DOT 3 or 4 (Glycol Based): Maximum we use these fluids in our motorcycle. Well because we know only about those two grades and we get only these two grades.

DOT 5 (Silicone Based): Yet to come in India. (Not suitable for ABS)

DOT 5.1 (Glycol Based): Either not available in India but this fluid has HIGH BOILING POINT and can mix with DOT3 or 4. So this is the best fluid for our units.

BRAKING MECHANISM

Drum Brake

https://www.youtube.com/watch?v=bnc3VnQ8kUY

Disc Brake

https://www.youtube.com/watch?v=JlRY5u68bs0

Disc Brake

- The master cylinder is an important unit of the entire disc brake system.
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- The fluid reservoir stores the brake fluid and compensates for any change in fluid volume in the pipe lines.
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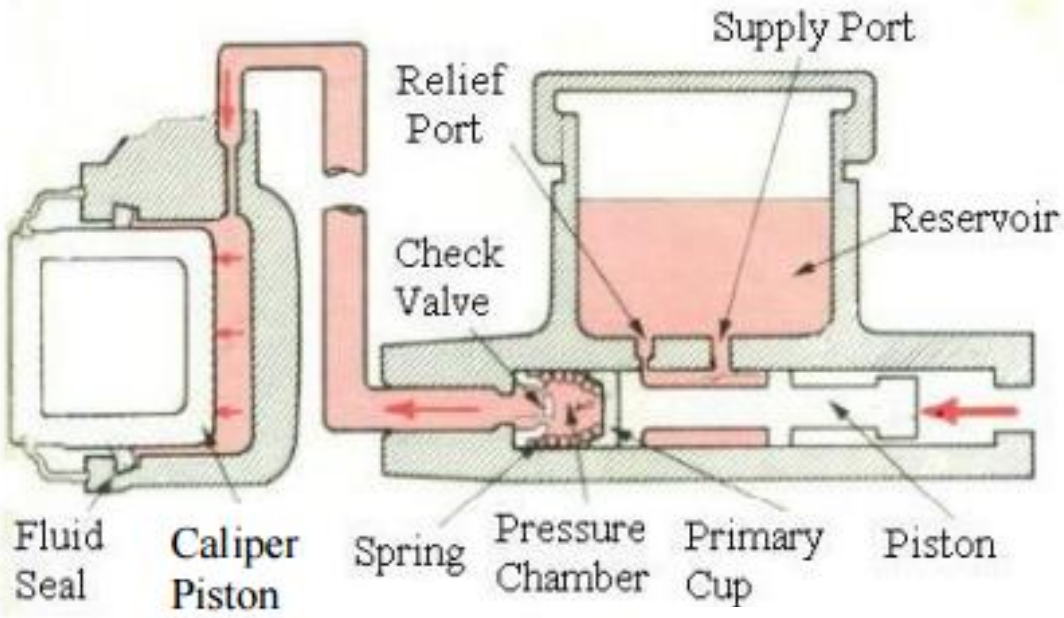
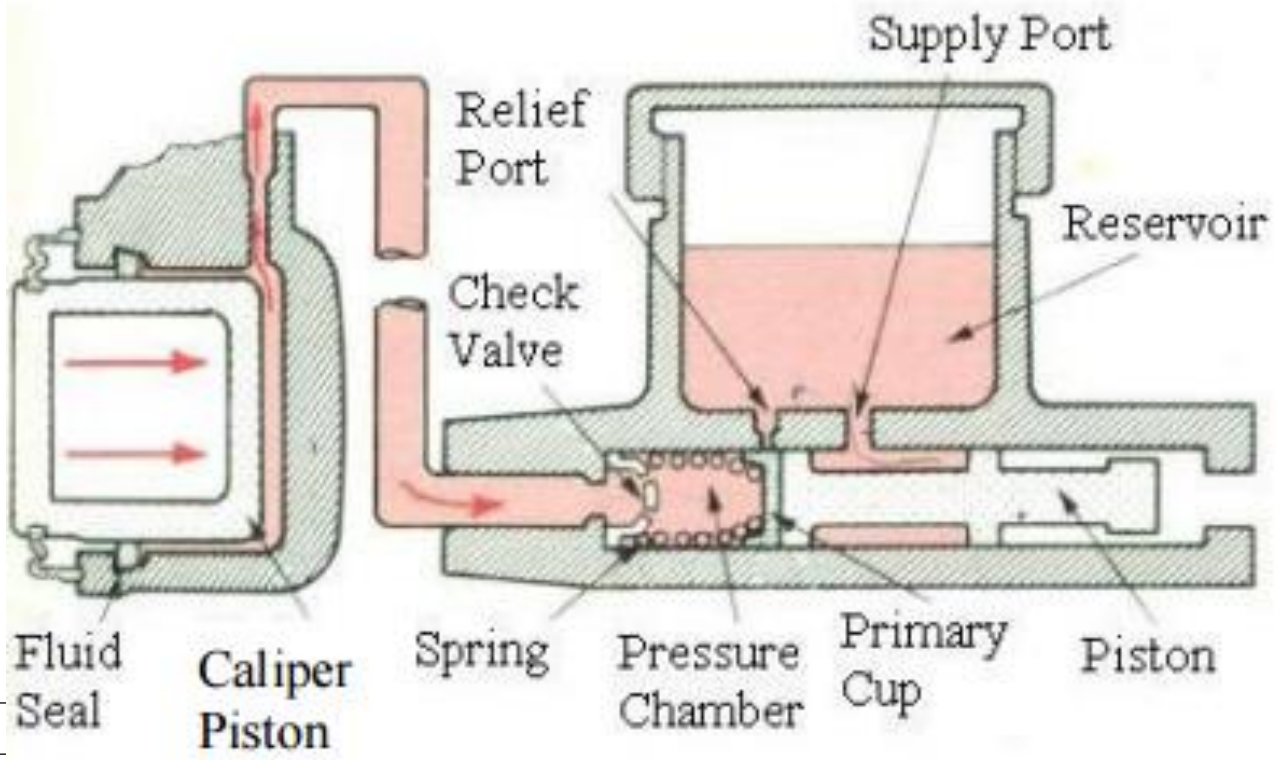
Master Cylinder Unit Working



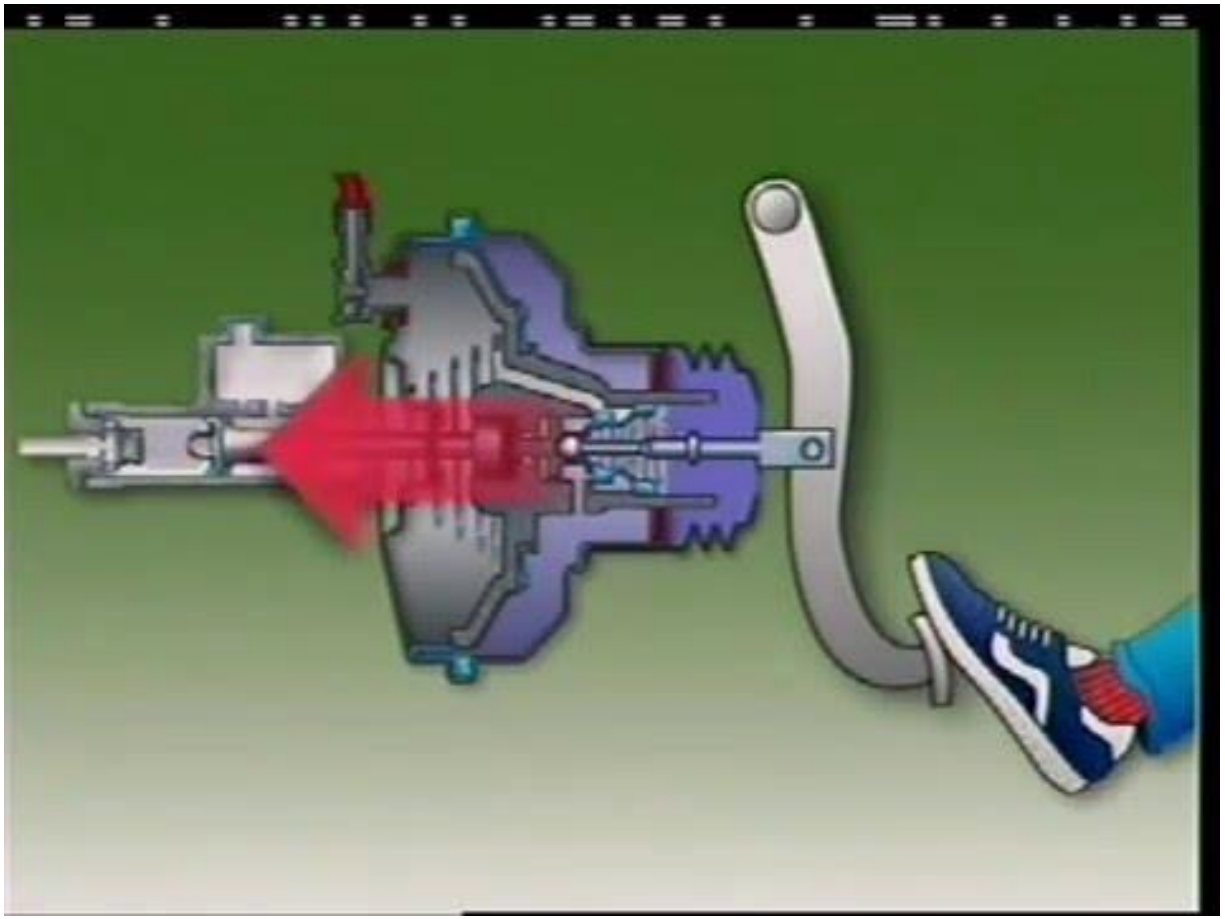
Basic master cylinder when brake is applied

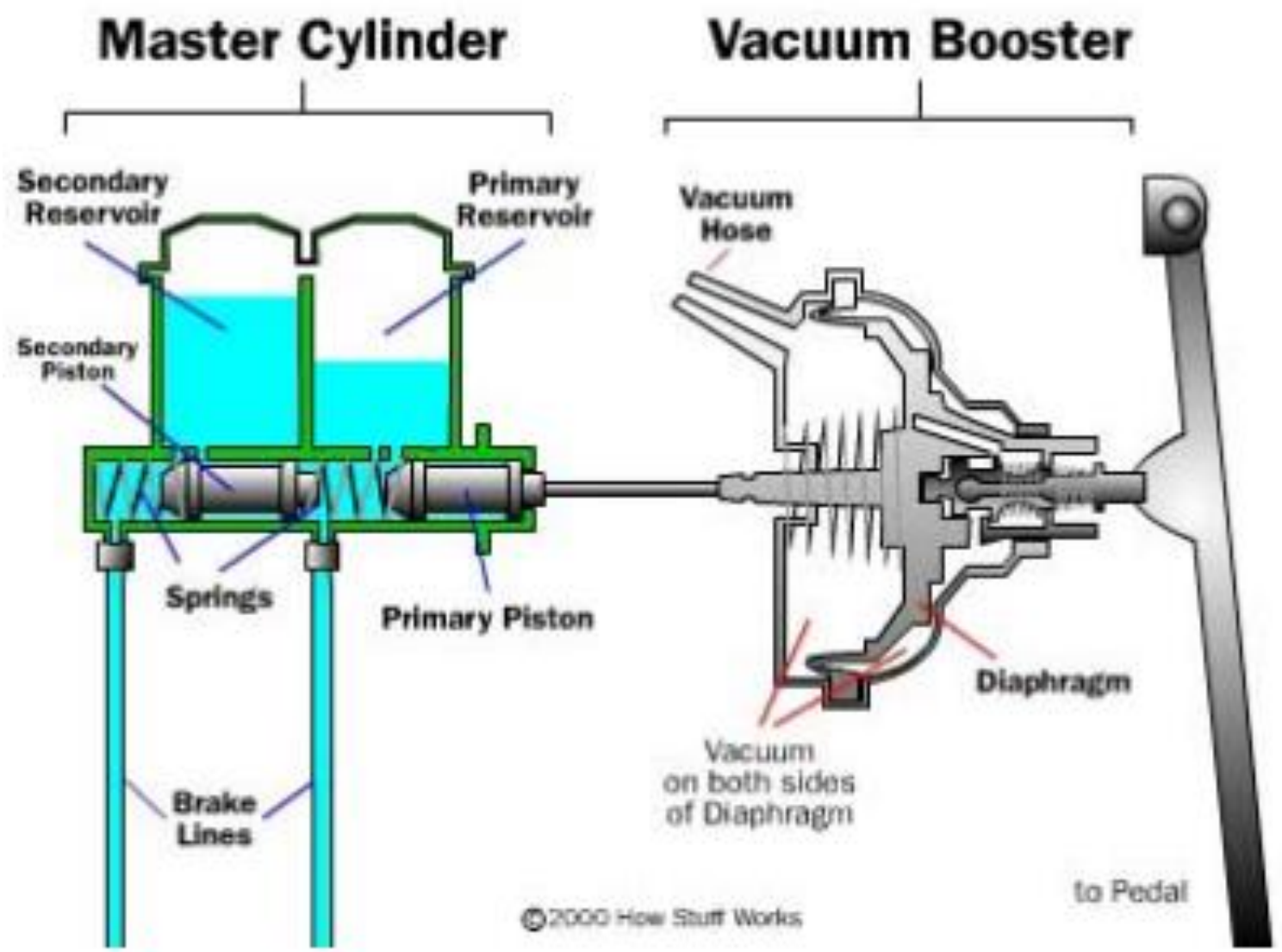
Basic master cylinder when brake is released



Servo Brakes

https://www.youtube.com/watch?v=0sj5d48mcss




Master Cylinder
Vacuum Booster
Secondary Reservoir
Primary Reservoir
Secondary Piston
Springs
Primary Piston
Brake Lines
Vacuum Hose
Diaphragm
Vacuum on both sides of Diaphragm
to Pedal
©2000 How Stuff Works

The vacuum booster is a metal canister that contains a **check valve and a diaphragm**.
A rod going through the center of the canister connects to the master cylinder's piston on one side and to the pedal linkage on the other.

The photo above shows the check valve, which is a **one-way valve** that **only allows air to be sucked out of the vacuum booster**. If the engine is turned off, or if a leak forms in a vacuum hose, the check valve makes sure that air does not enter the vacuum booster. This is important because the vacuum booster has to be able to provide enough boost for a driver to make several stops in the event that the engine stops running

The vacuum booster is a very simple, elegant design. The device needs a vacuum source to operate. In gasoline-powered cars, the engine provides a vacuum suitable for the boosters. In fact, if you hook a hose to a certain part of an engine, you can suck some of the air out of the container, producing a partial vacuum. Because diesel engines don't produce a vacuum, diesel-powered vehicles must use a **separate vacuum pump**.

On cars with a vacuum booster, the brake pedal pushes a rod that passes through the booster into the master cylinder, actuating the master-cylinder piston. The engine creates a **partial vacuum** inside the vacuum booster on both sides of the diaphragm. When you hit the brake pedal, the rod cracks open a valve, allowing air to enter the booster on one side of the diaphragm while sealing off the vacuum. This **increases pressure** on that side of the diaphragm so that it helps to push the rod, which in turn pushes the piston in the master cylinder.

As the brake pedal is released, the valve seals off the **outside air supply while reopening the vacuum valve**. This restores vacuum to both sides of the diaphragm, allowing everything to return to its original position.

Wheel Types

- **SPOKES Wheel**
- **DISC Wheel**
- **SPLIT Wheel**

SPOKES Wheel

The spoke wheels are consisted of a steel rim and spokes that are made up of both steel and other metals.
The spokes are attached to the hub where the brake drum or the disc brake situates,
the other extreme end of the spoke is screwed with nipples on the circular steel rim.
The whole structure makes a sturdy yet flexible wheel base for the rubber tyre.

Cons:
On a motorcycle the tyre is a first contact point with the tarmac, hence if we start sequencing the parts come into play while **absorbing the shocks**, it is the tyres that comes first, whose rubber absorbs the shock first then it is the wheel. And in case of spoke wheels the flexible property of it plays important role in **absorbing shocks next to the rubber of the tyres**. It is then the actual shock absorber takes the charge and effectively absorbs the shocks.

ALLOY WHEELS

The alloy wheels are made up of light weight metal alloys mainly aluminum or magnesium, the process involved in making the alloy wheels is majorly casting, where the extremely hot molten alloy is poured into ready-made cast of the wheel and after cooling down the raw wheel is extracted from the casting mold and then after finishing it is ready for use.

Split rim wheels are different from standard one piece wheels.
Spilt rims are multi-piece wheels, where the tyre is held in place by a locking ring.
Split rims are not normally used on cars or light vehicles.
They are however found on a number of larger vehicle types.
This type of wheel configuration is commonly associated with lorries, tractors, forklifts, and other heavy vehicles used in the construction and mining sectors

Types Of Tyre

Tyres may be classified into two types for two wheelers –

Tubeless And Tube-type Tyres

Tubeless tyres are fitted with alloy wheels
tube-type tyres are usually used on spoked steel rimmed wheels.

There are however, several other classifications depending on tyre
Construction
Radial or Cross ply)

Usage
street, racing slicks, dual sport, offroad knobbies)

The kind of rubber compound
soft, medium, hard, dual compound

TWO WHEELER SUSPENSION SYSTEM

OUTLINE

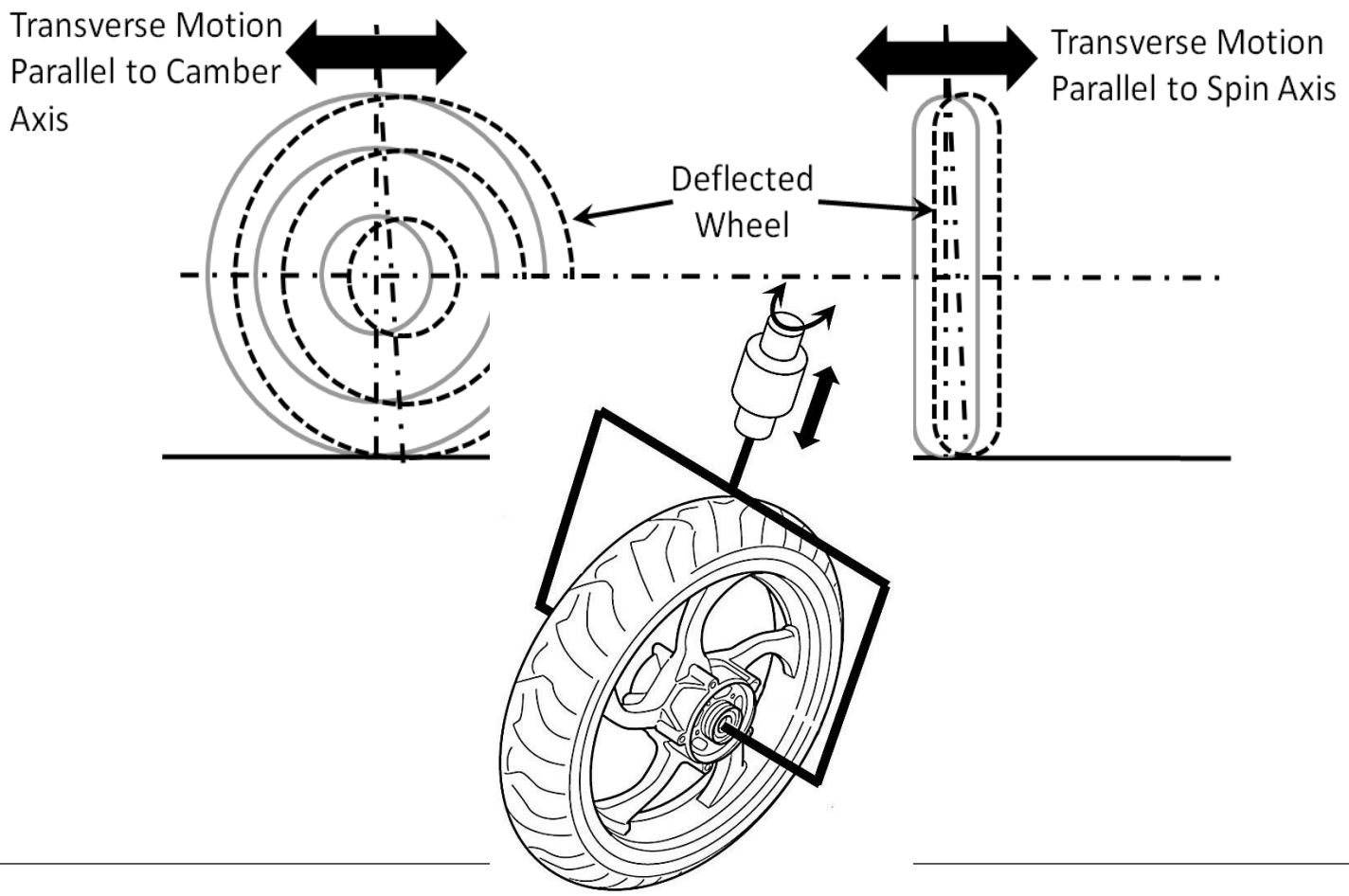
- Need for Suspension System
- Design Considerations for Suspension System
- Spring & Shock Absorber Assembly
- Front Suspension
- Rear Suspension

NEED FOR SUSPENSION SYSTEM

- The suspension mechanism should allow a relative motion between the wheel and the vehicle frame
- All the components which isolate the vehicle frame from the road shocks are communally known as suspensions
- Suspension consists of a spring and a damper
- To perform these function properly, a suspension mechanism should have
  - Kinematic Requirements
  - Dynamics Requirements

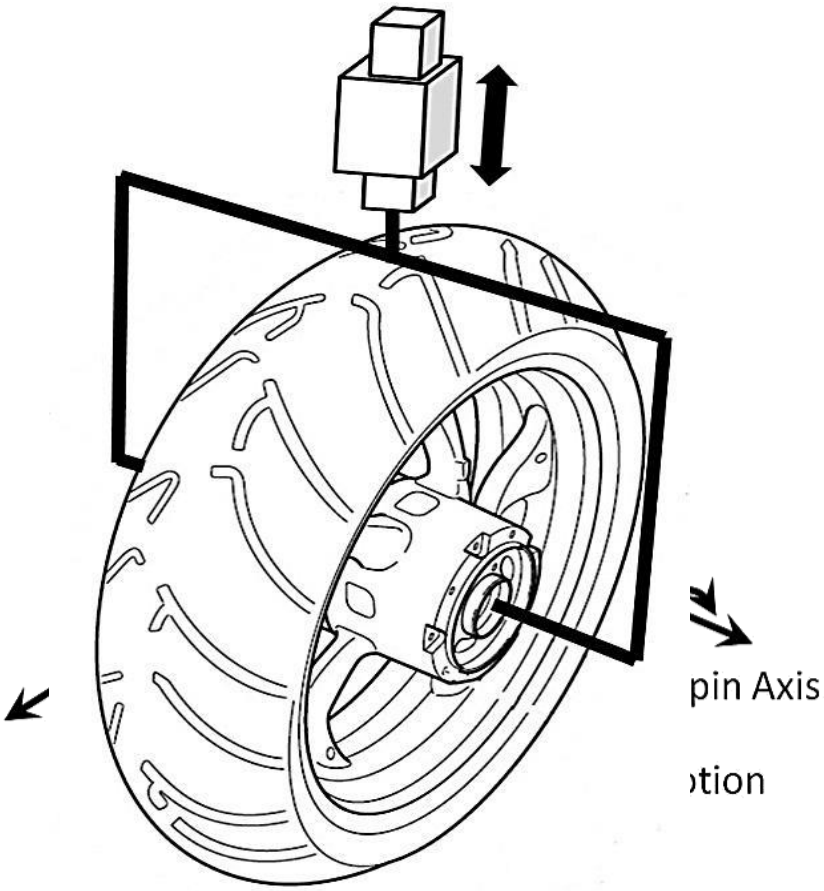
NEED FOR SUSPENSION SYSTEM

- **Kinematic Requirements for Front Wheel**



NEED FOR SUSPENSION SYSTEM

- **Kinematic Requirements for Rear Wheel**



NEED FOR SUSPENSION SYSTEM

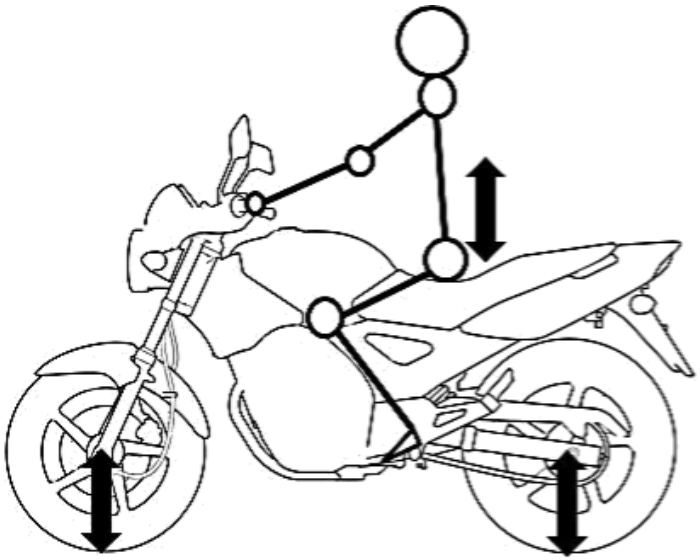
- **Dynamic Requirements for Rear Wheel**
- The front wheel should be able to steer and stop the vehicle while the rear wheel should be able to propel and stop the vehicle
- The suspension members must also resist lateral forces acting on the vehicle
- The suspension system must make the wheel rigid for the taken degrees of freedom
- There must also be some compliance members to limit the untaken degrees of freedom

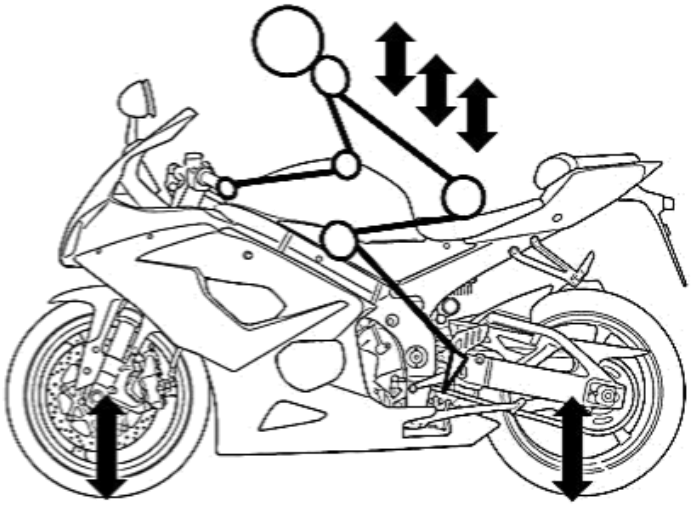
DESIGN CONSIDERATIONS FOR SUSPENSION SYSTEM

- The principal reason for adopting any form of suspension is to achieve highest possible comfort for the
- An efficient system is required that does not convert any of the vertical wheel motion into a movement of the sprung mass.
- Another factor which should be taken into account is the frequency of the disturbances felt by the rider
- Road holding is also greatly affected by suspension characteristics
- Unavoidable compromises should be made depending on the intended use of the vehicle

DESIGN CONSIDERATIONS FOR SUSPENSION SYSTEM

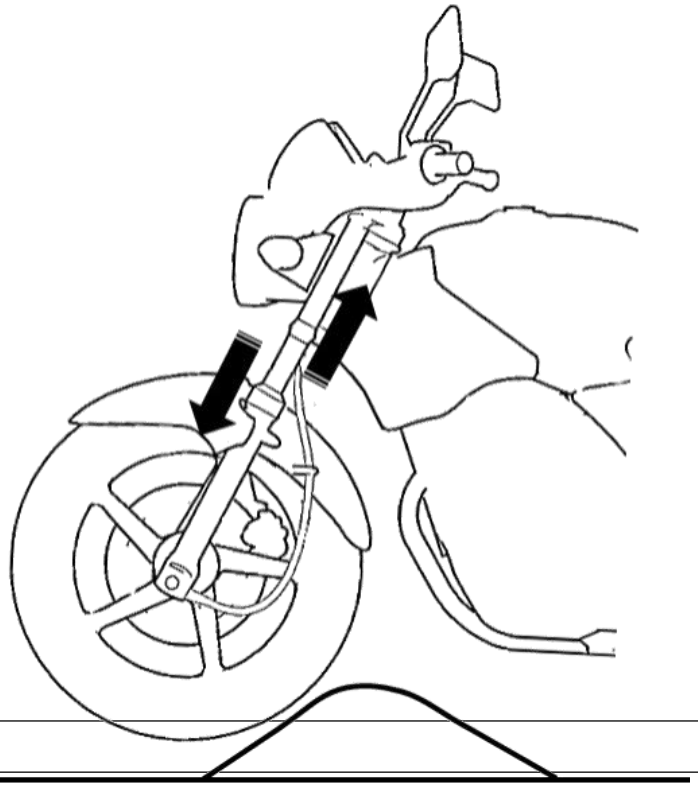
- **Suspension Frequency**
- Most comfortable frequency is between 1 to 1.5 cycles per second (Hz) when applied in the vertical direction with body also stands vertical but this is a most unpleasant frequency when applied with horizontal body





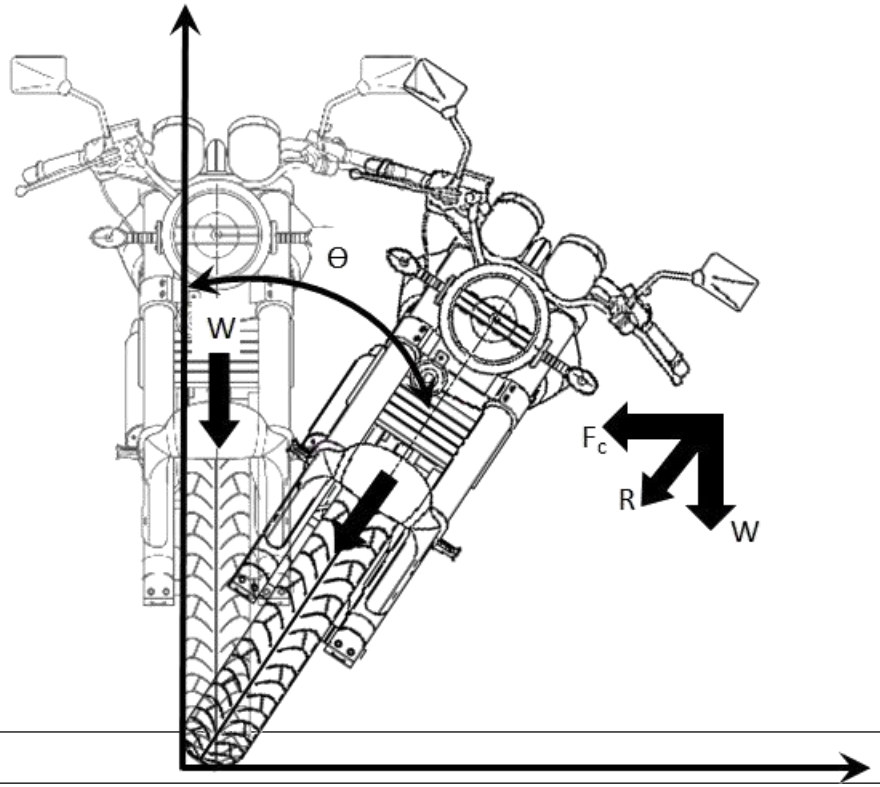
DESIGN CONSIDERATIONS FOR SUSPENSION SYSTEM

- **Sprung And Unsprung Mass Ratio**
- The highest possible ratio of sprung mass to unsprung mass does not beneficial in all cases as the demands of road holding and comfort are often contradictory



DESIGN CONSIDERATIONS FOR SUSPENSION SYSTEM

- **Cornering Requirements**
- The effect of cornering forces, particularly sports vehicles, increase in the static suspension loading where tilting angles exceeds 45 degrees

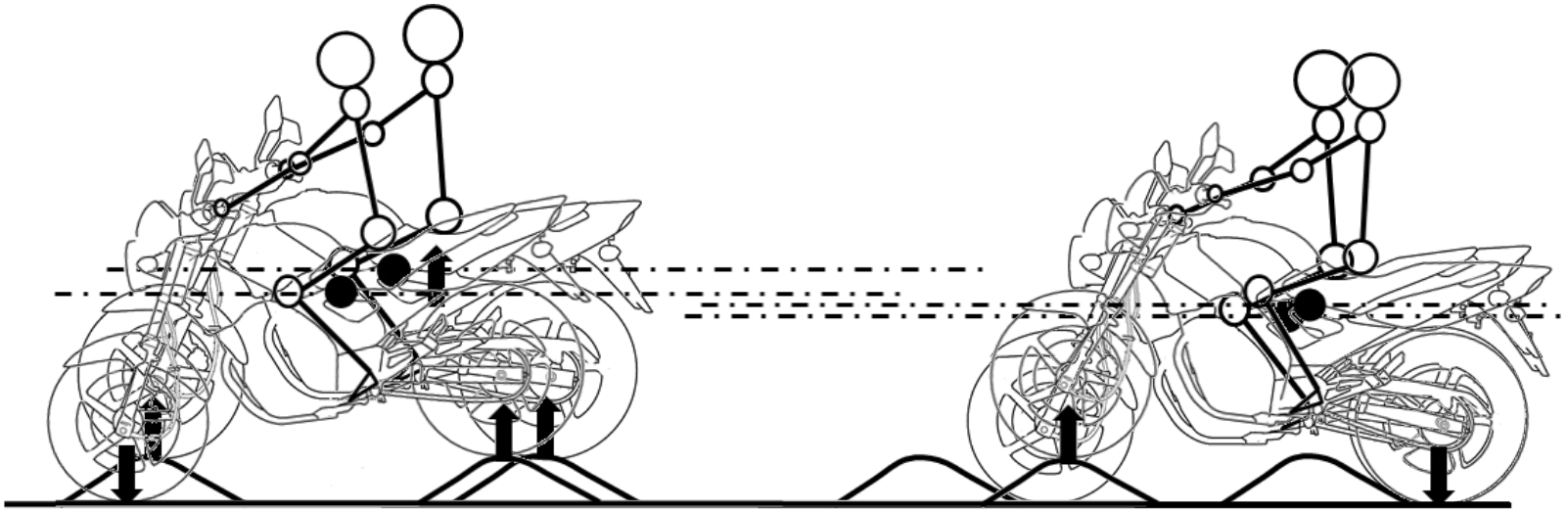


DESIGN CONSIDERATIONS FOR SUSPENSION SYSTEM

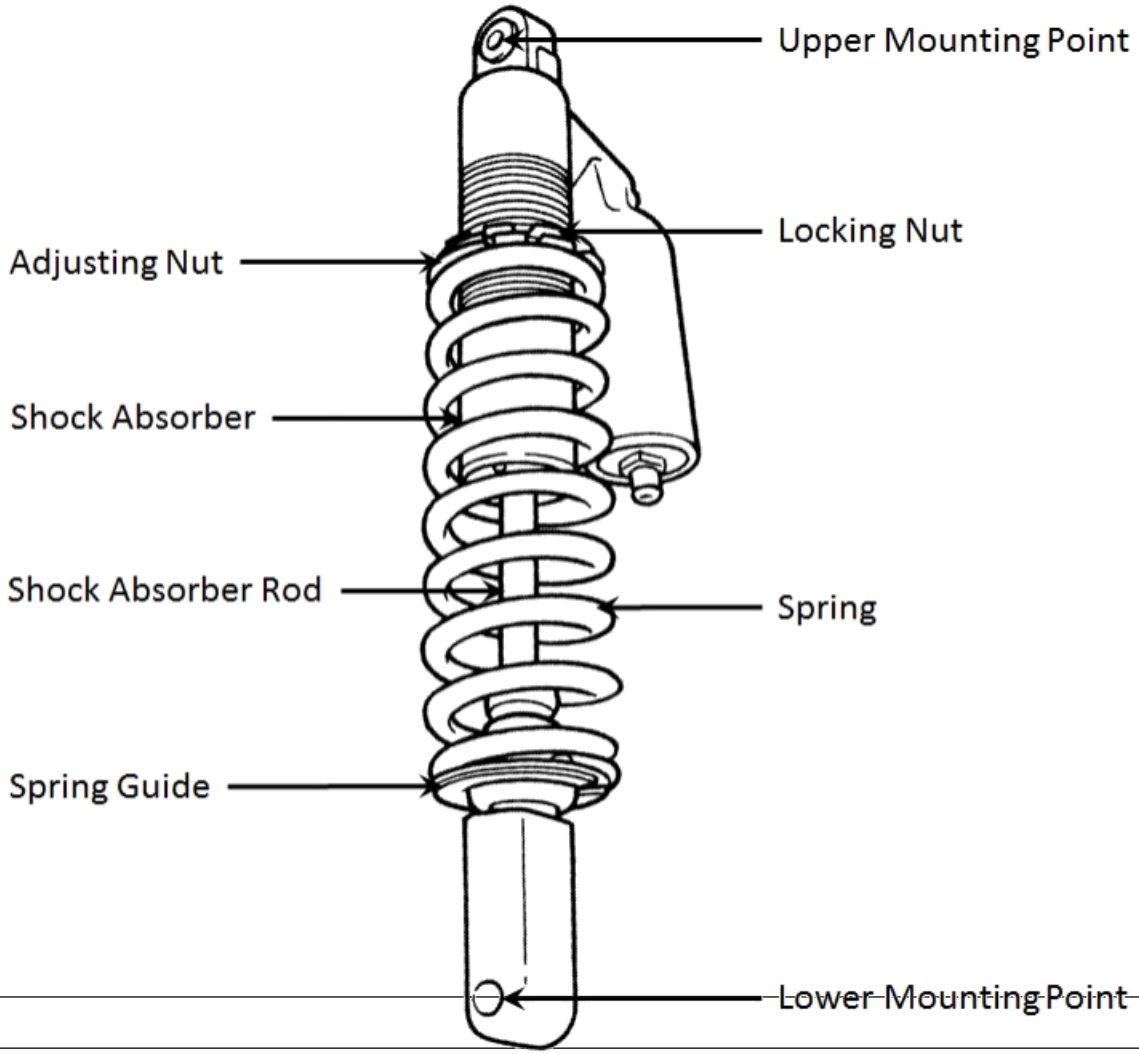
- **Spring Rate and Total Wheel Travel**
- The softer springing can help to achieve more wheel travel. The higher wheel travel is beneficial in following ways:
  - The larger displacement of suspension can absorb larger bumps.
  - The softer spring transmits less movement to the sprung part of the vehicle
  - The wheels are kept in closer contact with the ground, enabling more power to be transmitted at the rear and giving better steering at the front
- However, extreme wheel travel may entail both mechanical and functional problems

DESIGN CONSIDERATIONS FOR SUSPENSION SYSTEM

- **Wheelbase**
- The pitching angle is inversely proportional to the wheelbase i.e. the pitching effect would be half if the wheelbase is doubled



SPRING & SHOCK ABSORBER



SPRING

- The spring is meant to oscillate as soon as the shock hits the vehicle
- This reaction of spring will be decided by its stiffness and spring rate
- The rate is a measurement of the extra force needed to compress the spring by a given small amount

Linear Rate Spring

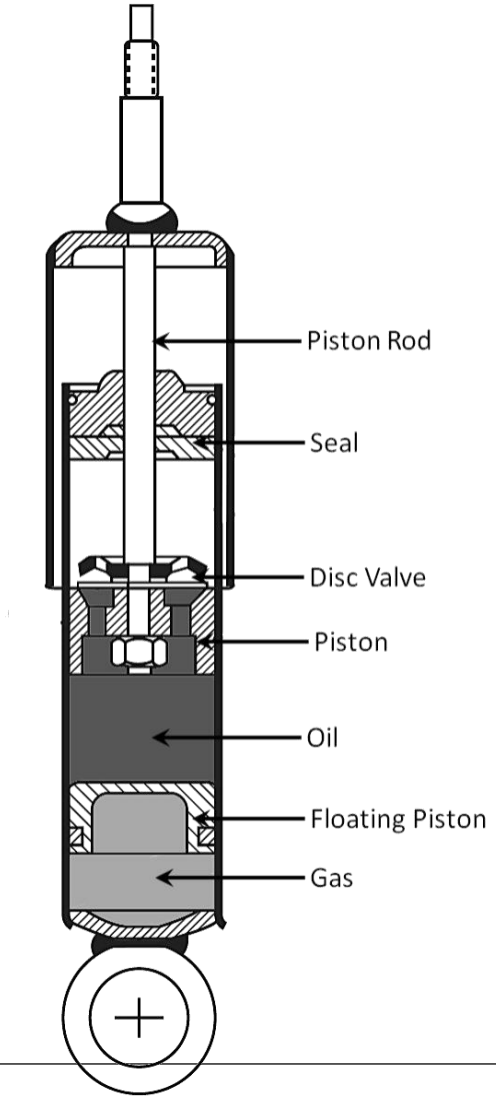
Progressive Rate Spring

Dual Rate Spring

SHOCK ABSORBER

- The main function of any shock or strut is to control ride and handling
- Standard shock absorbers do not support the weight of a vehicle
- The springs support the weight of the vehicle; the shock absorbers control the actions and reactions of the springs
- In absence of shock absorbers, the energy released from the spring would be very quick and uncontrolled
- The shock absorber helps to damp the rapid up-and-down movement of the springs by converting the kinetic energy of movement into heat energy

SHOCK ABSORBER



FRONT SUSPENSION

- Springer Forks Suspension

Springer Forks

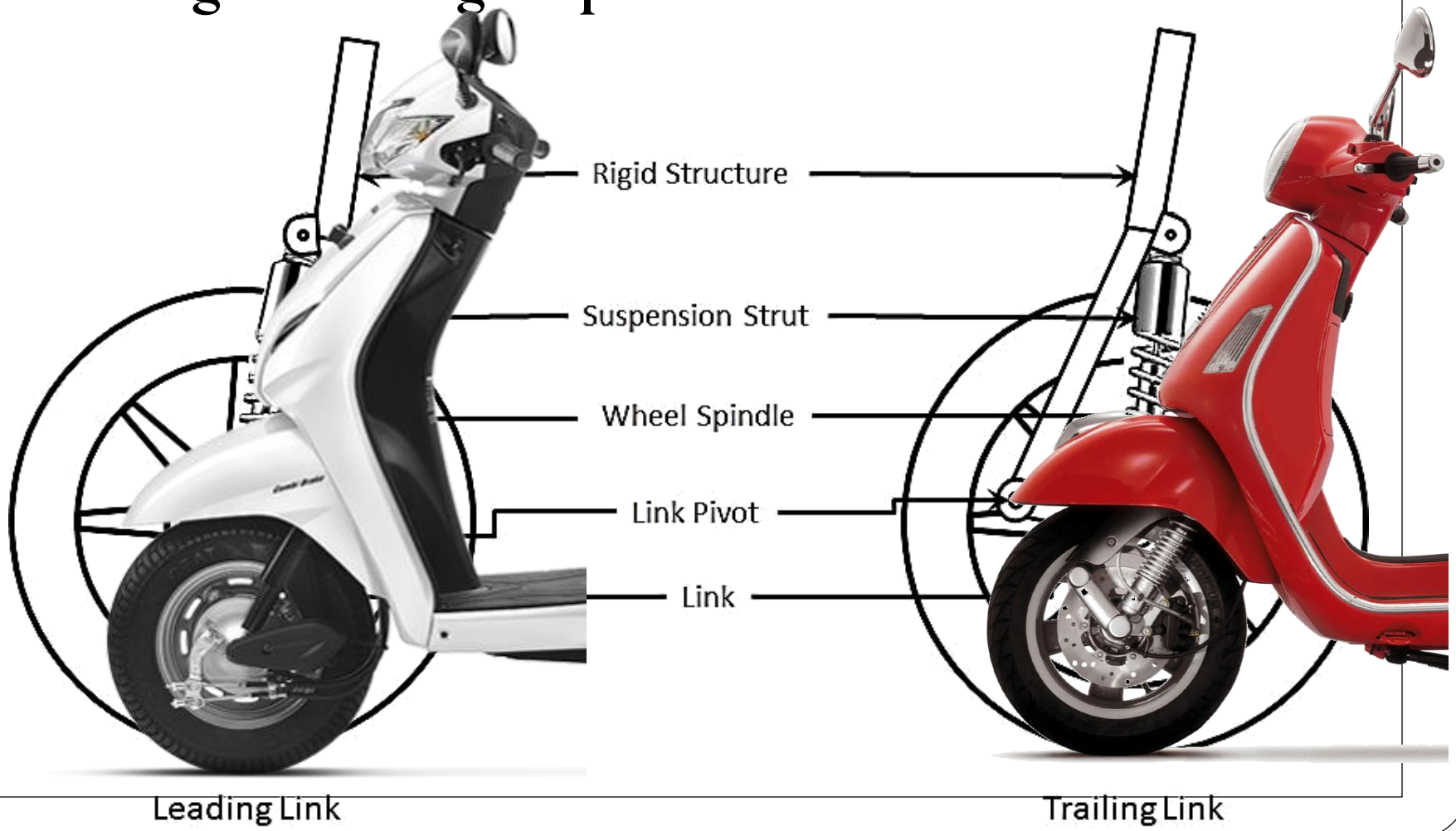
FRONT SUSPENSION

- Girder Forks Suspension

Girder Forks

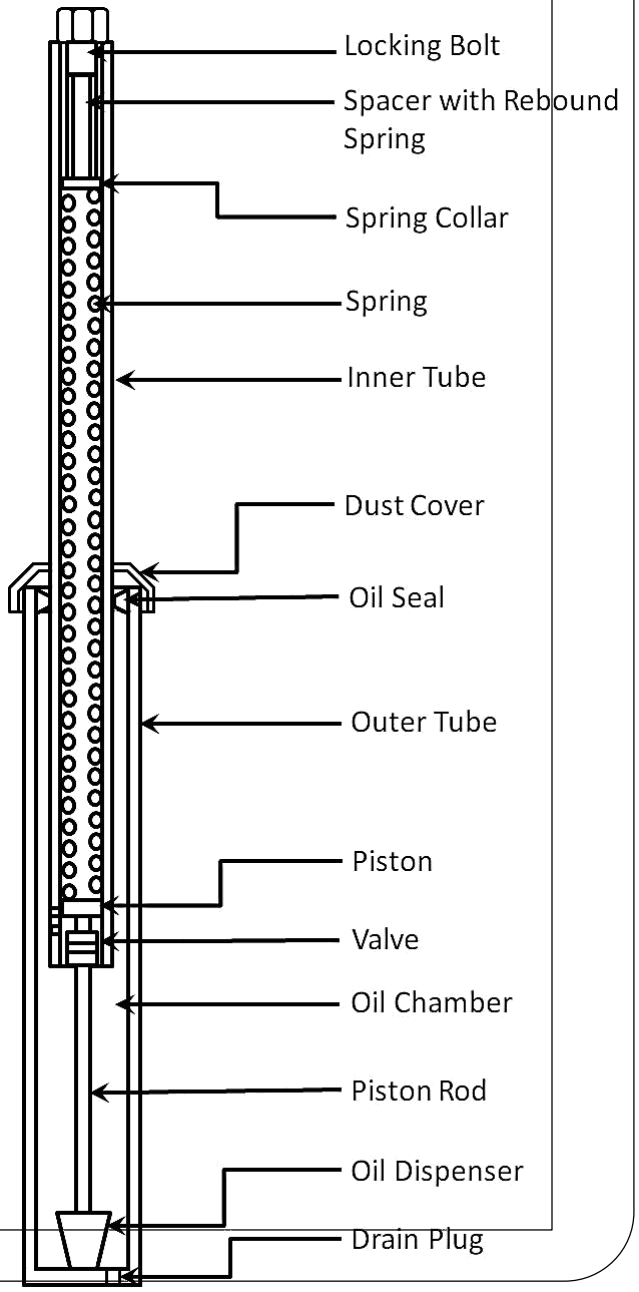
FRONT SUSPENSION

- Trailing & Leading Suspension



FRONT SUSPENSION

- Telescopic Suspension

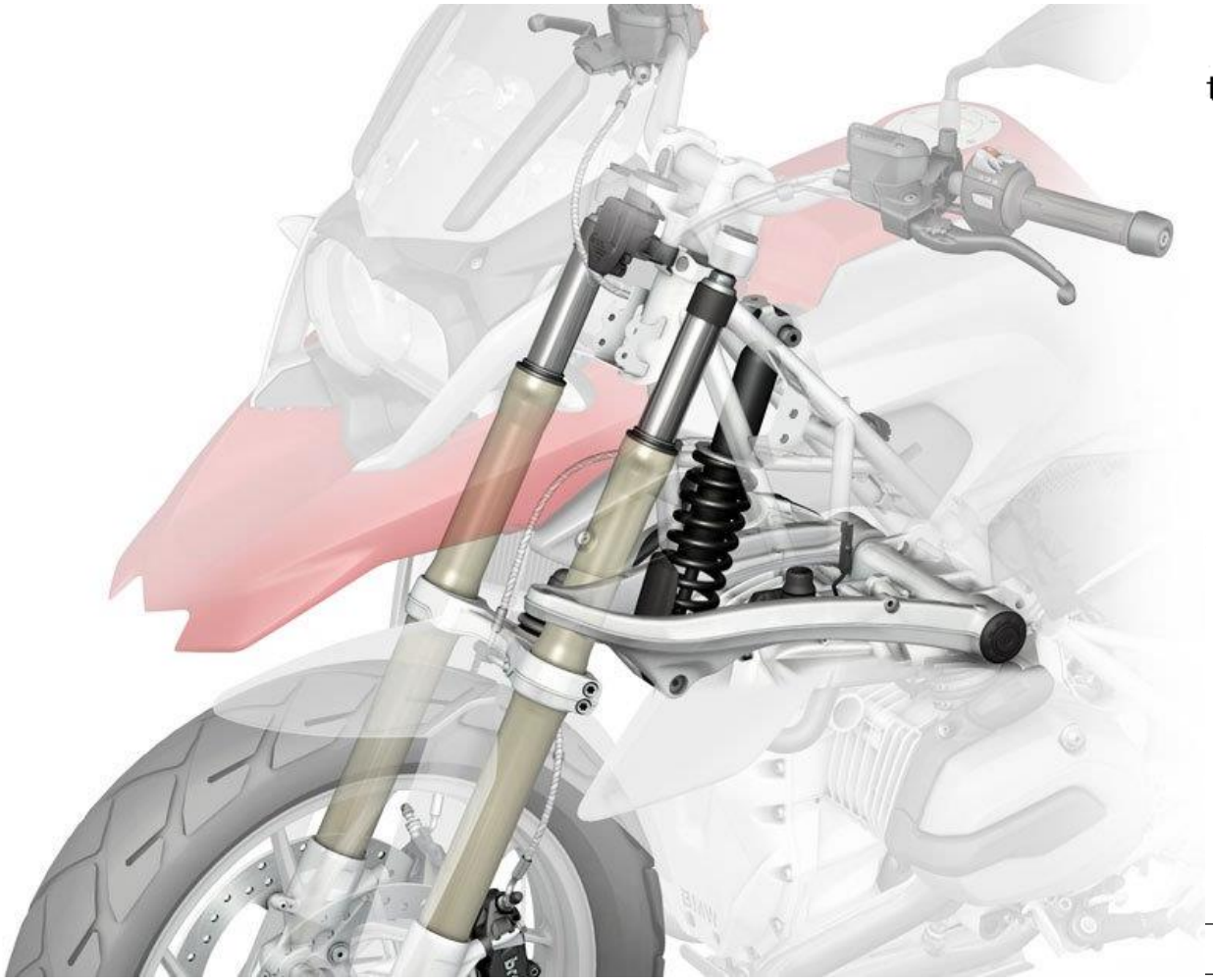


FRONT SUSPENSION

- Inverted Telescopic Suspension

FRONT SUSPENSION

- **Single Link Front Suspension**



FRONT SUSPENSION

- **Single Link Front Suspension**

REAR SUSPENSION

- Hard Tail

REAR SUSPENSION

- **Swing Arm Suspension**

REAR SUSPENSION

- Twin Shock Regular Swing Arm Suspension

REAR SUSPENSION

- **Mono Shock Regular Swing Arm Suspension**

REAR SUSPENSION

- Mono Shock Single Sided Swing Arm Suspension

THANK YOU