# E230 Aircraft Systems

One Fantastic Landing

6th Presentation

School Of Engineering

# Landing Gear - Purpose

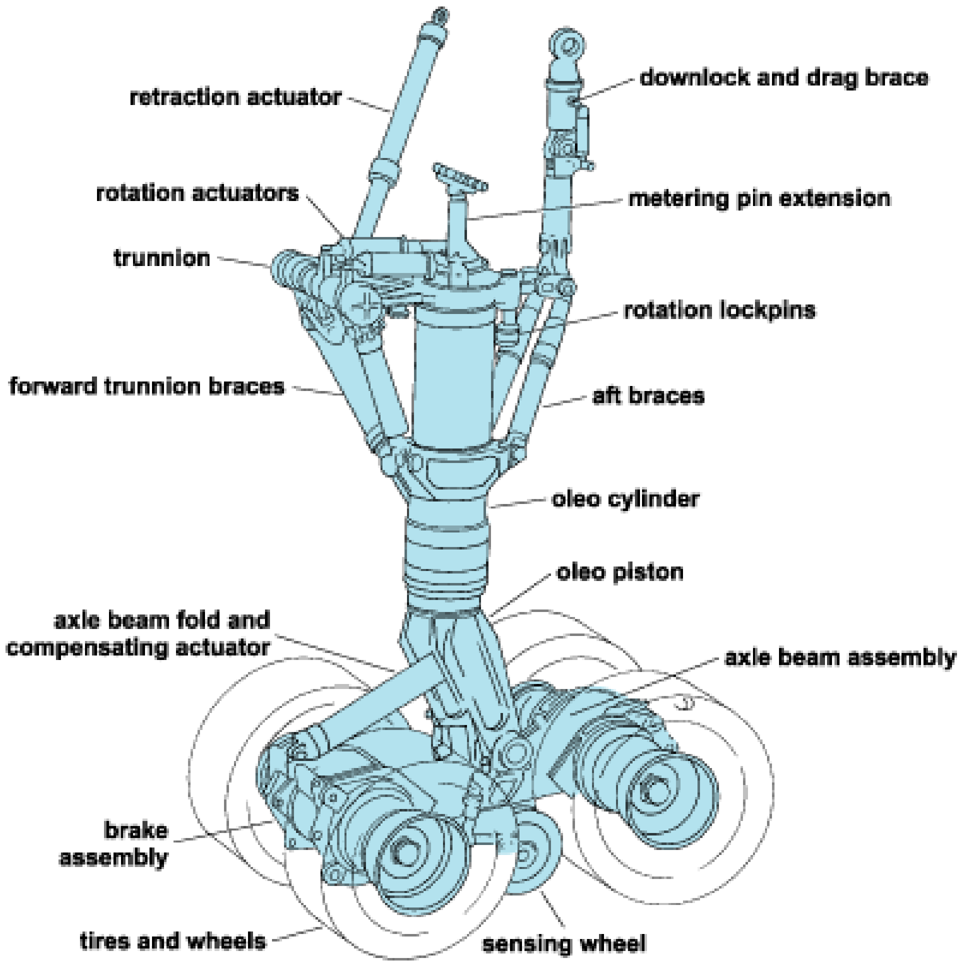
- To provide a support for the plane when at rest on the ground,
- To provide a stable chassis for taxiing, braking or rolling during take-off and landing
- To provide a shock absorbing system during landing.

**Antonov 225 Main Landing Gears**

http://www.youtube.com/watch?v=x9HHfnNr1cg

# Landing Gear Systems

- Strut
- Shock Absorber
- Extension / Retraction Mechanism
- Brakes
- Wheel
- Tires



# Landing Gear Configurations

**Tail-wheel (or Tail-dragger Gear** ) versus **Tricycle (or Nosewheel Gear** )

| Advantage | Disadvantage |
|---|---|
| Simplistic in design | Poor handling characteristics |
| Shorten the runaway distance for take-off or landing | Higher chance of a "ground loop" as CG behind main wheel axis |
| Operate the aircraft over rough field operation or terrain | Poor pilot visibility during taxiing and it is more difficult to land |
| Large clearance between the propeller tips and the ground for propeller-driven planes. | Difficult to load or unload heavy cargos and for passengers due to the steep slope of the cabin floor |

| Advantage | Disadvantage |
|---|---|
| Better visibility over the nose, thus easier to taxi and steer. | Greater weight and drag incurred by adding the large nose wheel strut |
| Parallel thrust of the engine to the direction of travel, hence allowing faster acceleration during take-off. | Usually require complex retraction mechanisms to reduce drag. Add weight to aircraft. |
| More stable during take-off, landing and taxiing as CG in front of main wheel axis. Reduce "ground loop" effect. | Need to perform weight and balance calculation periodically to ensure weight distribution for braking effectiveness |


# Design Objectives

The landing of an airplane often involves stresses in excess of what may be considered normal; therefore, the landing gear must be constructed and maintained in a manner that provides strength and reliability needed to meet all landing conditions.

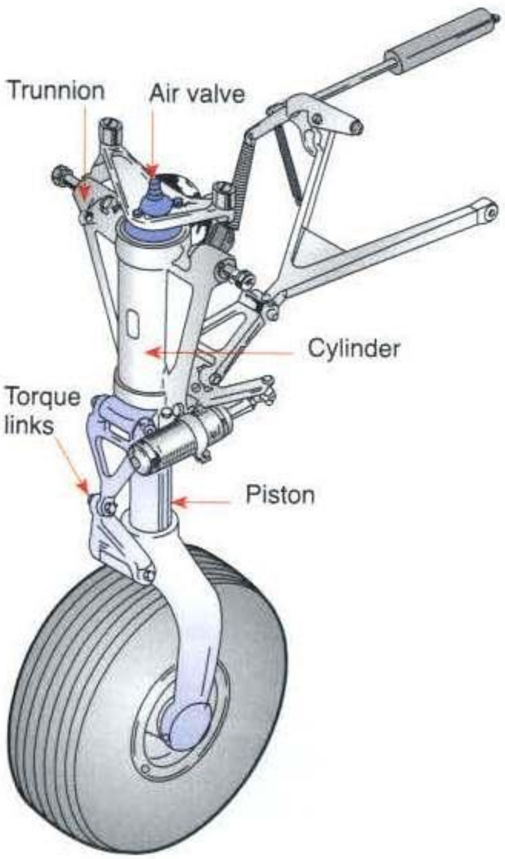

A hard landing occurs when the vehicle impacts the ground with a greater vertical speed and force than in a normal landing. The average vertical speed in a landing is around 400 ft per minute. A reading higher than this, is considered 'hard'.

# Design Considerations

- Each landing gear designs or configurations has its own advantages and disadvantages. Selecting the best arrangement for a given aircraft depends on the environment and purpose the plane is designed for.

- In spite of all these design considerations and variations, designers will always try to select the simplest, lightest, and least expensive solution possible to fulfil the objectives while maintaining safety.

# Classification of Landing Gears




*Nose landing gear assembly*

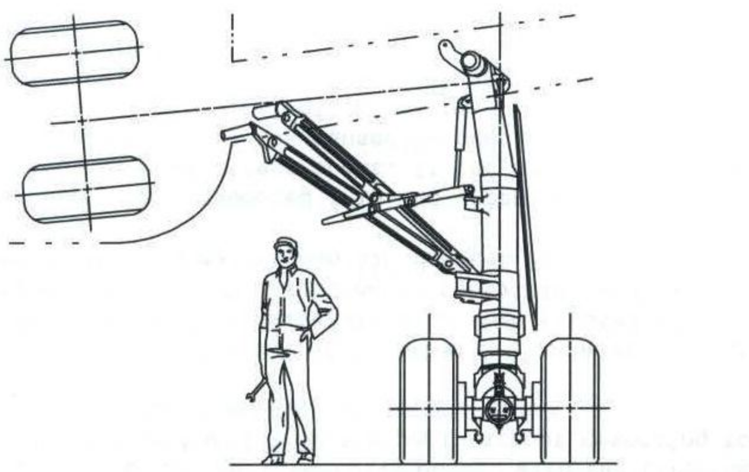
1. **Non-Absorbing Landing Gear and Fixed Gear**
   - Includes rigid landing gear, shock-cord landing gear, spring landing gear
   - Rigid: helicopters, sailplanes.
   - Usually non-retractable, Light weight, less complex
2. **Shock-Absorbing Landing Gear**
   - Dissipates landing energies by forcing fluid through

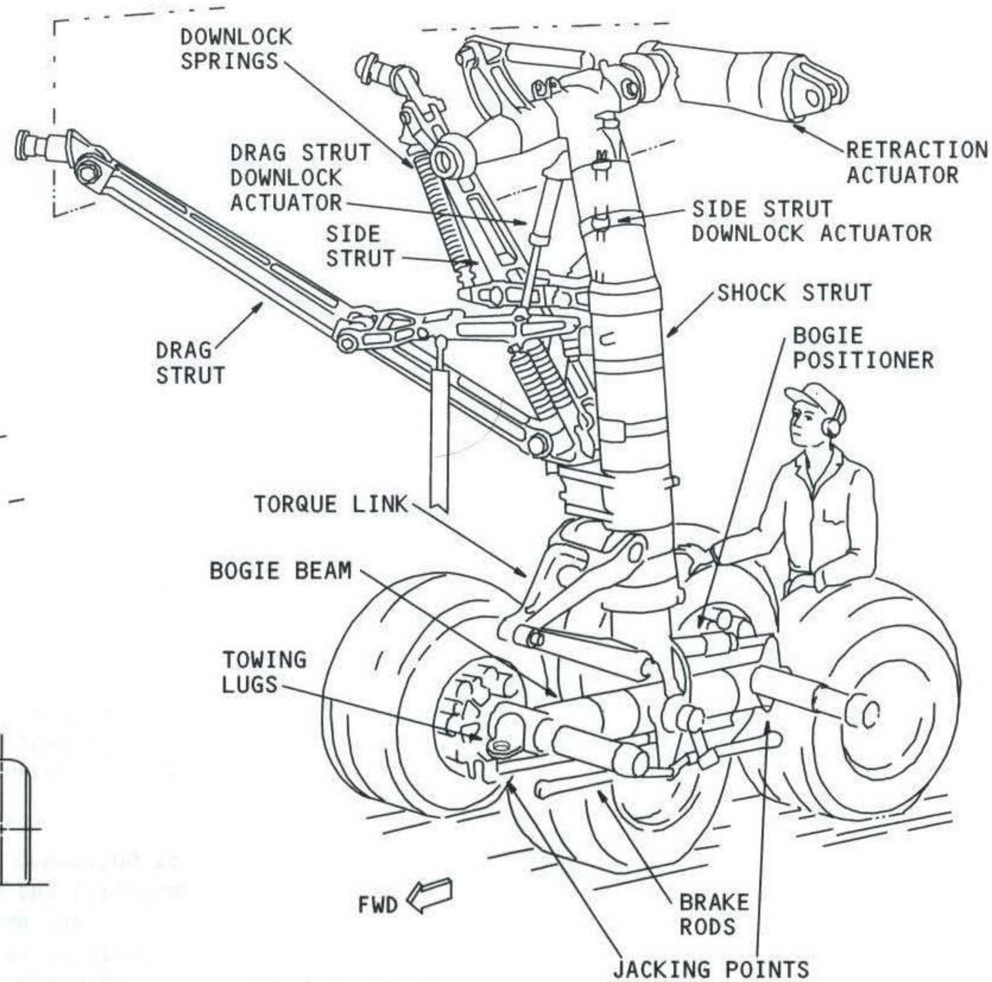
     a restriction
   - Air-Oil Oleo most common nowadays.
   - Usually retractable by hydraulic, electric or

     mechanical to eliminate drag during flight

# Main Landing Gear Components

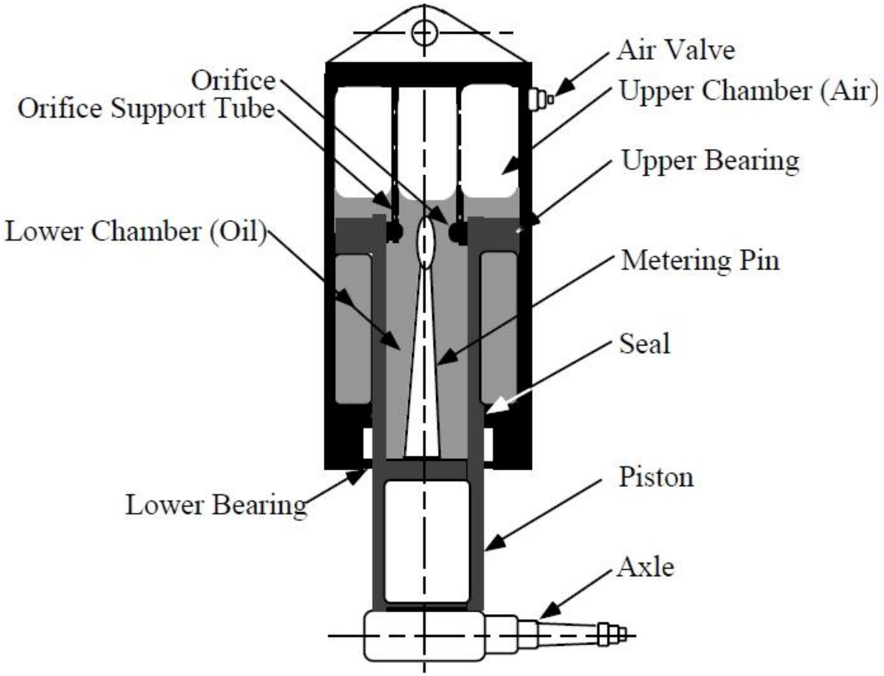
The main landing gear is designed to support and to stabilize the assembly itself. The terms used for the landing gears may vary according to manufacturers.





# Shock Absorption System

The main role of the shock absorber is to zero the vertical component of the airplane velocity during landing, with no rebound and limited load transfer to the vehicle structure (and occupants). Its secondary requirement is to allow a comfortable taxiing (cushioned by air inside the strut).

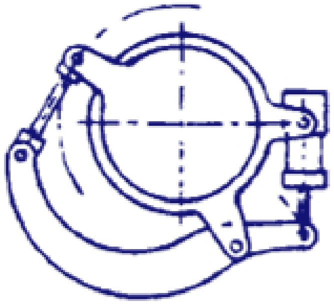



A typical pneumatic or hydraulic shock strut (metering pin-type) uses compressed air or nitrogen combined with hydraulic fluid to absorb and dissipate shock, and it is often referred to as the “air-oil” type strut.

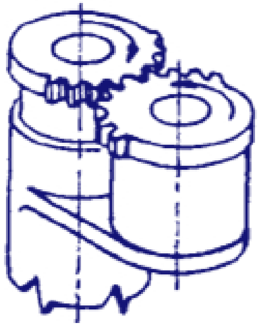
# Nose Landing Gear Steering Systems

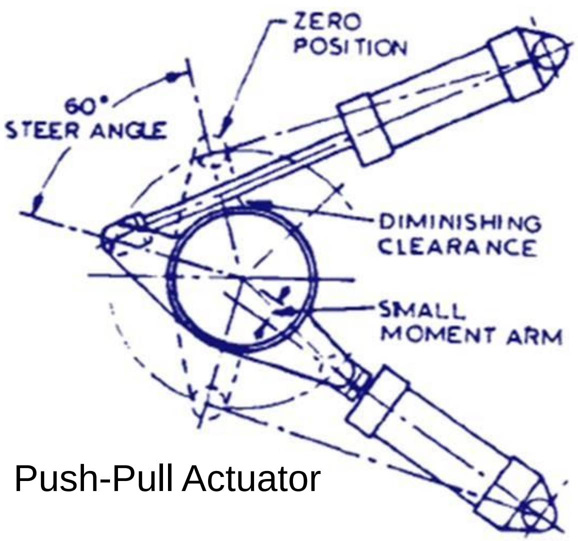
- For light aircraft, steering by rudder (yaw effect) or by differential braking that involves applying the brakes to the left or right wheels as required to turn the aircraft.
- For large transport aircraft, steering achieved using hydraulically assisted systems as followed -

Multiplying Linkage

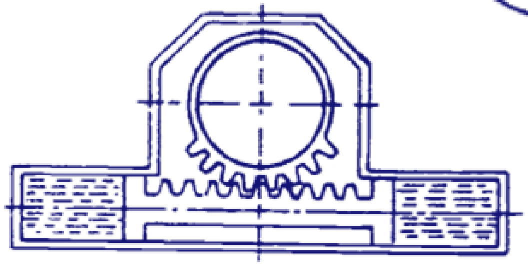


Rotary Actuator



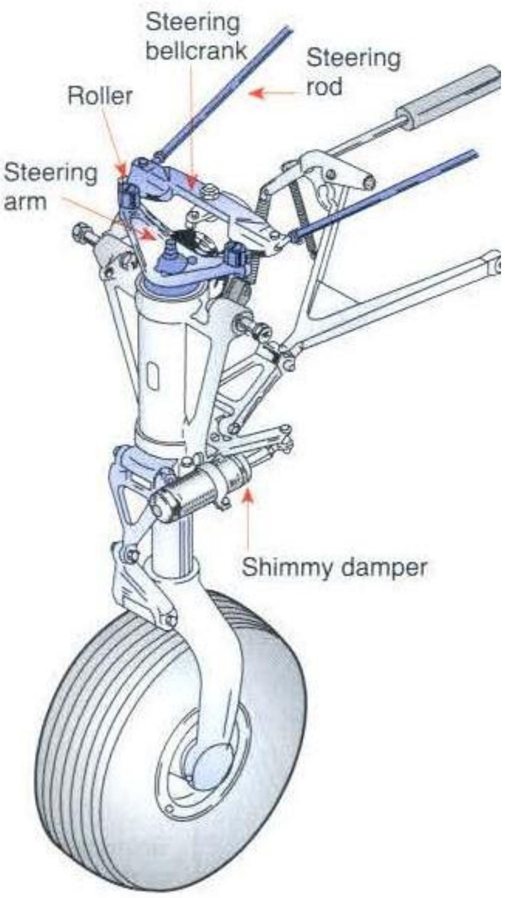



Push-Pull Actuator



Rack and Pinion

# Nose Landing Gear Features



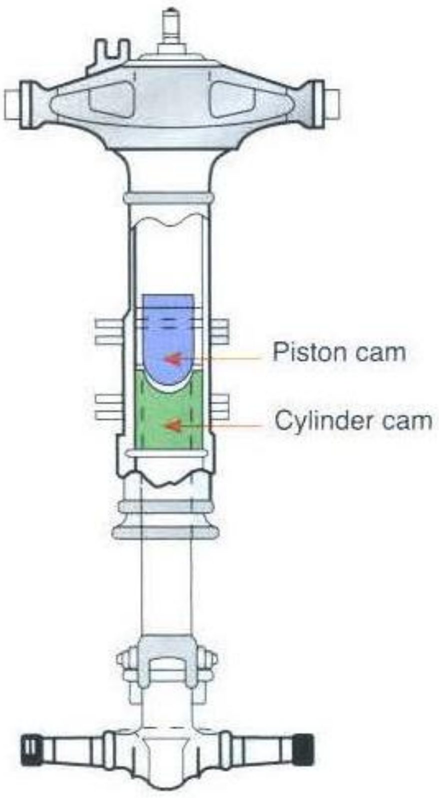

*Nose wheel steering for a retractable landing gear*

## Shimmy Damper

Wheel is said to shimmy when it oscillates about its caster axis. A shimmy damper is a hydraulic snubbing unit that reduces the tendency of the nose wheel to oscillate from side to side.

## Centering Cam

A centering cam or a centering spring may be used to ensure that the gear is centered prior to retraction. This is facilitate disconnection of various elements involved




*Nose wheel centering cam*

# Retraction and Extension Systems

A retractable landing gear is installed whenever a drag improvement is worthy. Landing gear extension is a primary operation and always its actuation has high redundancy. There are different solutions and various systems for the mechanism to obtain suitable landing gear movement. These include

- Mechanical and/or Electrical Systems
  - ✓ Crank mechanism or uses a lever pulled by the pilot
  - ✓ Use a mechanical latch system to lock wheels “up”
  - ✓ Uses a central electric motor and push-pull rods to open/close doors and position the gear.
  - ✓ Uses micro-switches to detect when gear position.
  - ✓ For light aircraft only

# Retraction and Extension Systems

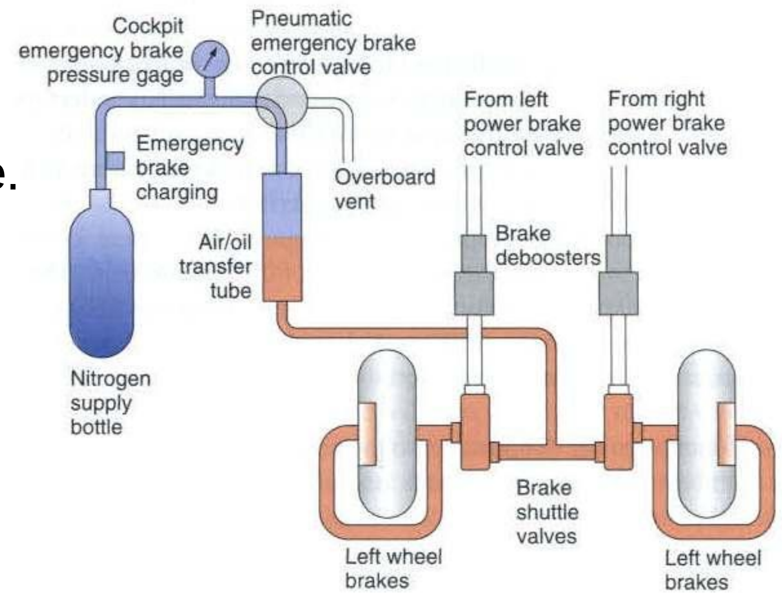
- Hydraulic Systems
  - ✓ Used where landing gear is considered too large or economically not viable by other methods
  - ✓ Hydraulic power generated by engine-driven pumps, electric pumps.
  - ✓ For emergency operation, hand or wind-driven pumps
  - ✓ Most common system of retraction for larger aircraft types.

Testing for the Boeing 787 Dreamliner. Gear swing tests replicate the extension and retraction of the landing gear, as they would function on a regular flight. Successfully swinging the landing gear into a stowed position and back down into a landing position verifies the installation and functionality are working as expected

# Emergency Extension Systems

There are four possible methods of dropping or extending gear when hydraulic power is lost:

- Using air bottle to "blows" the gear down. Substituting air pressure for hydraulic pressure.
- Operation of a hand crank or ratchet extends the gear.
- Separate and backup hydraulic system (may be hand pump)
- Mechanical system which releases Up-locks, thus allowing gear free-fall into the down-and-lock position. Mechanism should be designed in such a way that gravity and aerodynamic drag favours extension with no power from the hydraulic system.




*Emergency brake system for a large jet transport airplane*

# Position Indications and Warnings

It is imperative that the flight crew has a absolute indication of the gear position and status. The following features or mechanism will help determine that -

- **Squat Switches** are switches operated by the extension and compression of the landing gear struts. When the gear struts is compressed, the switches are "open" and an electrically operated lock prevents the raising of the gear, and vice versus.

- **Aural Warning Horns and Indicator Lights** When the gear is in retracted position and the aircraft is at landing speed, the aural warning and indication lights will warn the pilot that the gear is not in the "Down" position (GPWS related).


http://www.meriweather.com/320/fd-320.html

# Wheels & Brakes

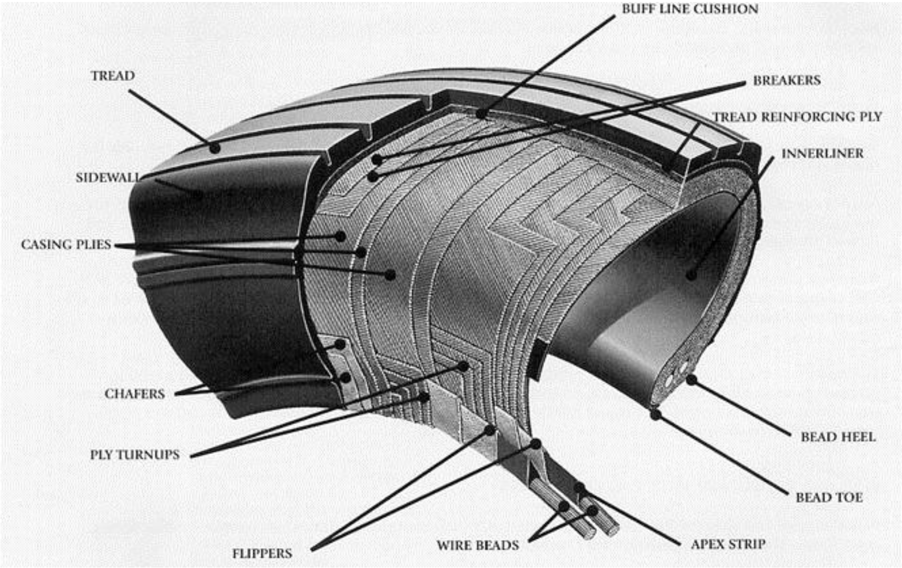
The tires and wheels of an aircraft are subjected to severe stresses during landing and in taxiing over round ground. The failure of a tire or wheel can lead to extremely serious accident.

For that, it is vital that tires and wheels inspected and monitored for its condition for all environments under which the aircraft may operate.

# Tires (Tyres)

Tires are the aircraft-to-ground interface and subjected to braking and steering forces. They also contribute in a minor extent to shock absorption. Tires for aircraft must endure higher loads and higher speeds than automobiles and trucks; the safety issue is much higher as well.

Practically all modern aircraft tires are tubeless. The external layer in contact with the ground is the treaded, and made from rubber (similar to automotive tire, but much thicker).



# Causes of Tire Failures

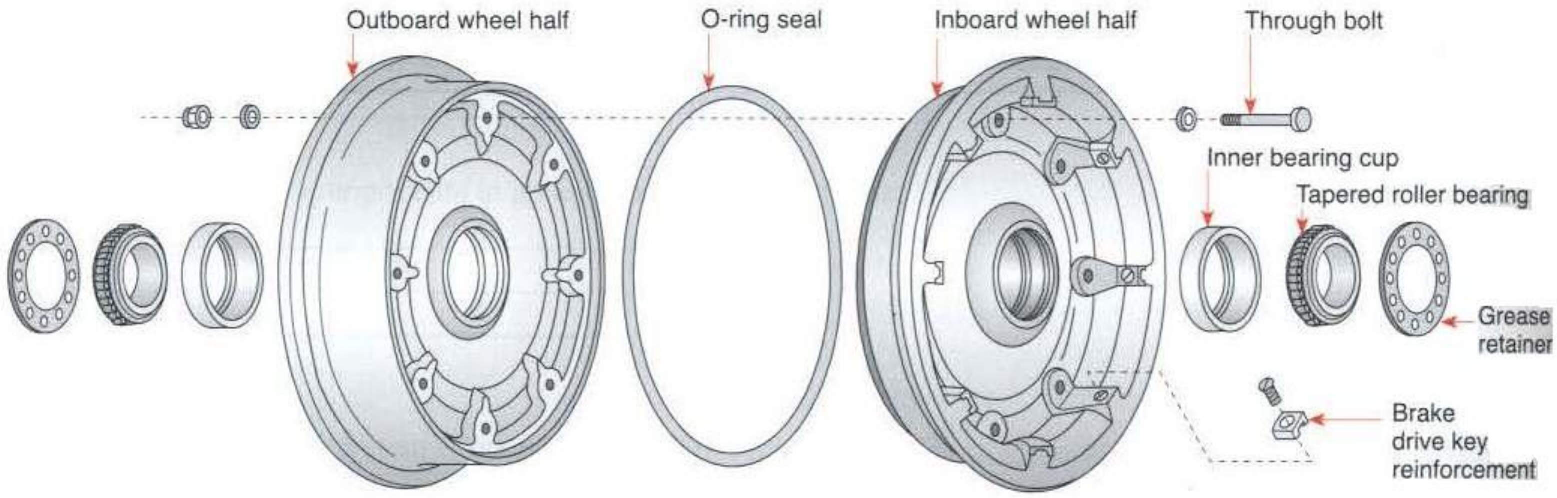
Tire bursting incidents occur regularly from time to time. New and differing tire technologies lead to different bursting behaviours.

Typically, the common causes for tire failures:

- ✓ Foreign Object Damage (FOD).
- ✓ Inadequate Tire Pressure.
- ✓ Rejected Take-off
- ✓ Overweight landing
- ✓ High taxi speed combined with heavy gross weight and a long taxi distance
- ✓ Sidewall overheating.
- ✓ Prolonged brake application

# Wheels

Aircraft tires are too stiff to be stretch over wheel rims. Damage will occur to the bead of the tire**.** As such, split rims (forged half-wheels) are used. They are made of light alloy and are attached together with bolts made of high-tensile steel bolts and nuts with an O-ring seal installed between the two half-wheels.




*Exploded view of a typical two-piece wheel for a light aircraft*

# Wheels Fusible Plugs

High performance aircraft have one or more fusible plugs in the inbound wheel half. These plugs have a hole drilled through their center filled with a low melting point alloy.

In the event of an aborted take-off or other emergency braking, so much heat is produced in the brakes that the air in the tires tries to expand, resulting in a pressure rise so high the wheel could explode. To prevent this, the center of the fusible plugs melts and deflates the tires in a few seconds when the wheel reaches a dangerous temperature.

# Brakes

Most airplanes are equipped with disc brakes, with a functioning principle similar to that of the automotive systems, but based on different sizing principles.

The various brake designs to reflect the variety of braking capabilities required for different-sized aircraft. Light aircraft can rely on a single disc brake or simple shoe brake because the landing speed is slow and the aircraft is light in weight.

Large transport aircraft land at high speeds and weight several hundred tons. Such aircraft require very powerful multi-surfaced brakes in order for the brakes to be effective at slowing down the aircraft.

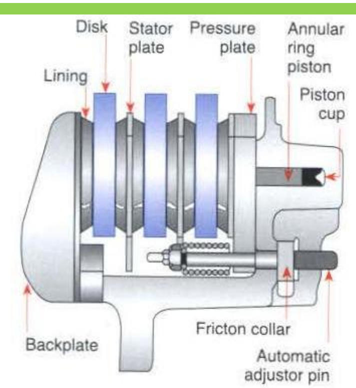
MD-11 Brake cut-out half-side

# Types of Brakes

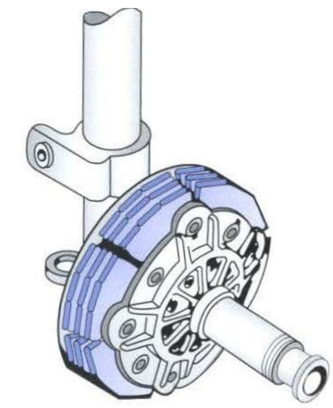
Two basic types of brakes are in use, energizing (E) and non-energizing (NE). Energizing brakes use the friction developed between rotation and stationary parts to produce a wedging action. Non-energizing brakes does not use this wedging action.

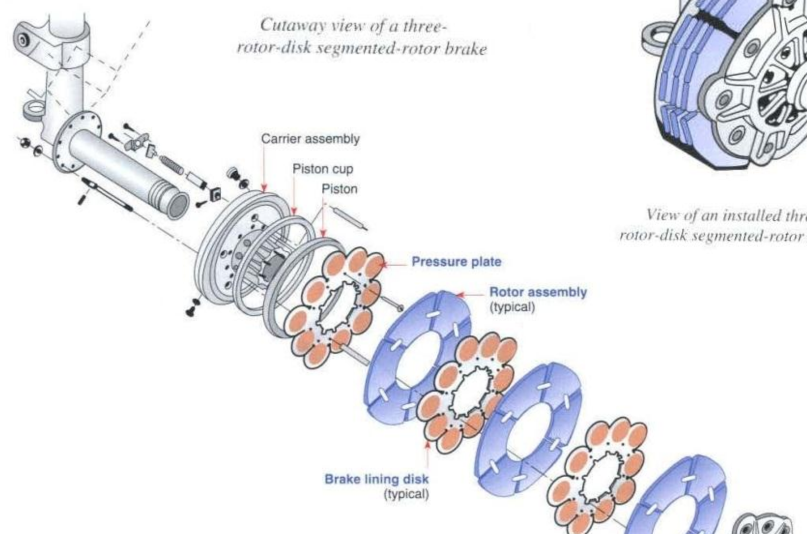
Some of the various brake designs are as follow:

- Drum-type servo brakes (E)
- Expander tube brakes (NE)
- Single-disk brakes (NE)
- Multiple-disk brakes (NE)
- Segmented rotor disk brakes (NE)



*Cutaway view of a three-rotor-disk segmented-rotor brake*


*View of an installed three-rotor-disk segmented-rotor brake*



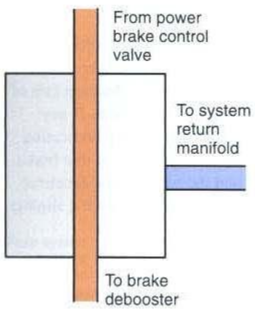
*Exploded view of a three-rotor-disk segmented-rotor brake*

# Anti-Skid System

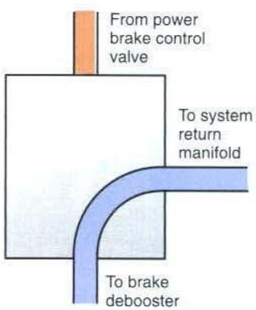
Aircraft are usually equipped with anti-skid systems to prevent of aircraft control on the ground by skidding of the wheels. Several reasons apply why anti-skid systems are in use on many modern aircraft:

- Prevents wheel lockup
- Prevents skidding
- Reduce possibility of hydroplaning
- Reduce excessive heat build up

A good anti-skid system will have two main features: Wheel sensors that can detect a change in the rate of deceleration and a valve system that can rapidly released and apply, which will prevent a skid

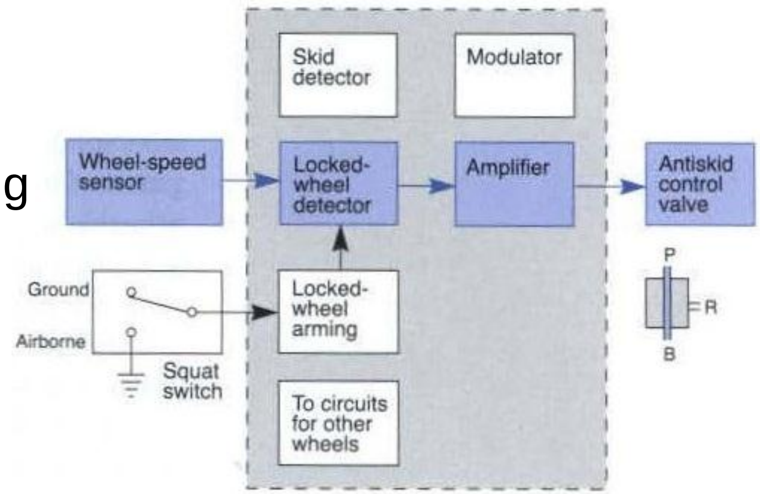



For normal operation, the valve serves only as passage between brake control valve and debooster.




When wheel-speed sensor determines a skid is imminent, it directs antiskid control valve to shut off flow to debooster and vent debooster to system return manifold.

*Antiskid control valve*




Antiskid control box

*Antiskid control box with the airplane on the ground. The wheels have built up a speed of 20 mph or more and the antiskid valve is open, allowing full pressure to be applied to the brakes.*

# Learning Objectives

- Understand the functions and design considerations of a landing gears system.
- Identify the various landing gear configurations
- Understand features of a Nose Landing Gears.
- Identify and understand the various functions and features of other peripherals components of a landing gear major components (i.e. tire, wheels, brakes)