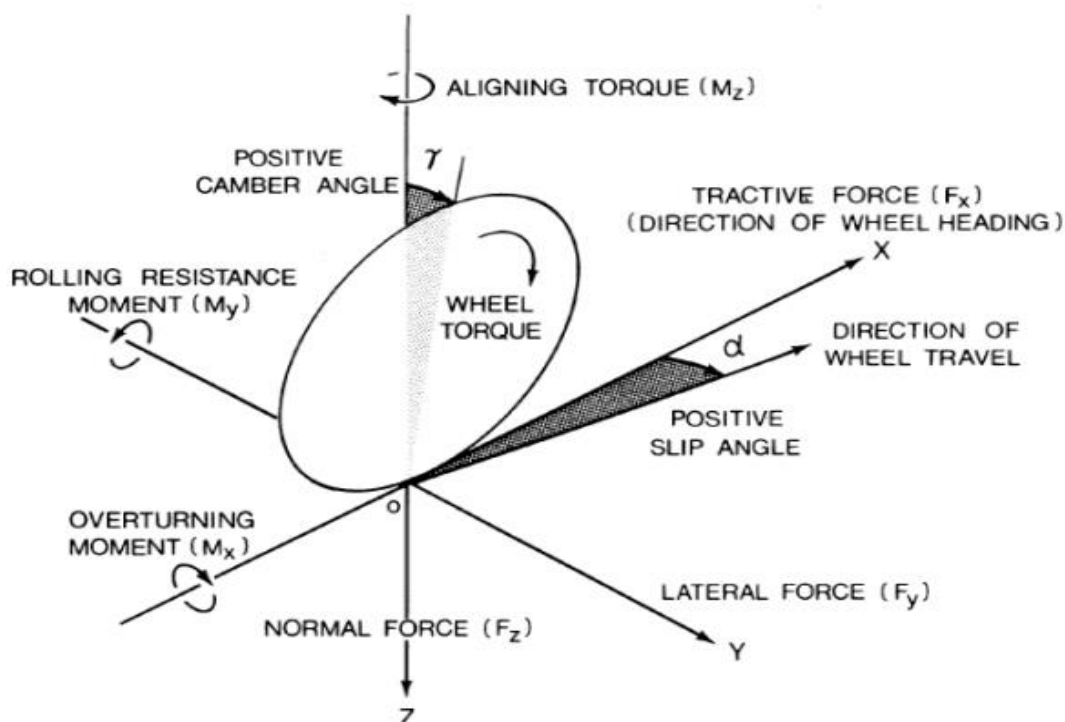




TIRE FORCES AND MOMENTS

- ❖ In any point of contact between the tire and the road surface normal and friction forces are transmitted.
- ❖ According to the tire's profile design the contact patch forms a not necessarily coherent area
- ❖ The effect of the contact forces can be fully described by a resulting force vector applied at a specific point of the contact patch and a torque vector.
- ❖ The vectors are described in a track-fixed reference frame.
- ❖ The z-axis is normal to the track, the x- axis is perpendicular to the z-axis and perpendicular to the wheel rotation axis.
- ❖ Then, the demand for a right-handed reference frame also fixes the y-axis.
- ❖ A non-symmetric distribution of the forces in the contact patch causes torques around the x and y axes.
- ❖ A cambered tire generates a tilting torque T_x .
- ❖ The torque T_y includes the rolling resistance of the tire.
- ❖ In particular, the torque around the z-axis is important in vehicle dynamics.
- ❖ It consists of two parts namely
 - ✓ The rotation of the tire around the z-axis causes the bore torque T_B .
 - ✓ The self-aligning torque T_S takes into account that, in general, the resulting lateral force is not acting in the center of the contact patch





TIRE FORCES

Longitudinal (Driving) Force (F_x):

- ✚ This force acts parallel to the direction of motion of the vehicle.
- ✚ It is responsible for accelerating or decelerating the vehicle.
- ✚ The longitudinal force is generated due to the friction between the tire's tread and the road surface.

Lateral (Cornering) Force (F_y):

- ✚ Lateral force acts perpendicular to the direction of motion and is responsible for the vehicle's ability to turn and corner.
- ✚ It is generated when the tire's tread grips the road surface during a turn.
- ✚ The magnitude of the lateral force depends on the tire's grip, the vehicle's speed, and the angle at which the tire is steered.

Vertical (Load) Force (F_z):

- ✚ The vertical force is the tire's weight or load, which acts vertically downward.
- ✚ It is responsible for supporting the vehicle's weight and providing traction.
- ✚ The vertical force varies depending on the vehicle's weight distribution, load, and road conditions.

TIRE MOMENTS:

Overtuning (M_x):

- ✚ Overtuning moment is a moment around the lateral axis of the tire.
- ✚ It can cause the tire to lean and deform during cornering.
- ✚ The tire's design and construction affect its resistance to overtuning.

Rolling Resistance (M_y):

- ✚ Rolling resistance moment occurs due to the tire's deformation as it rolls over the road surface.
- ✚ It acts about the longitudinal axis of the tire and opposes the vehicle's motion.
- ✚ Reducing rolling resistance is important for improving fuel efficiency.



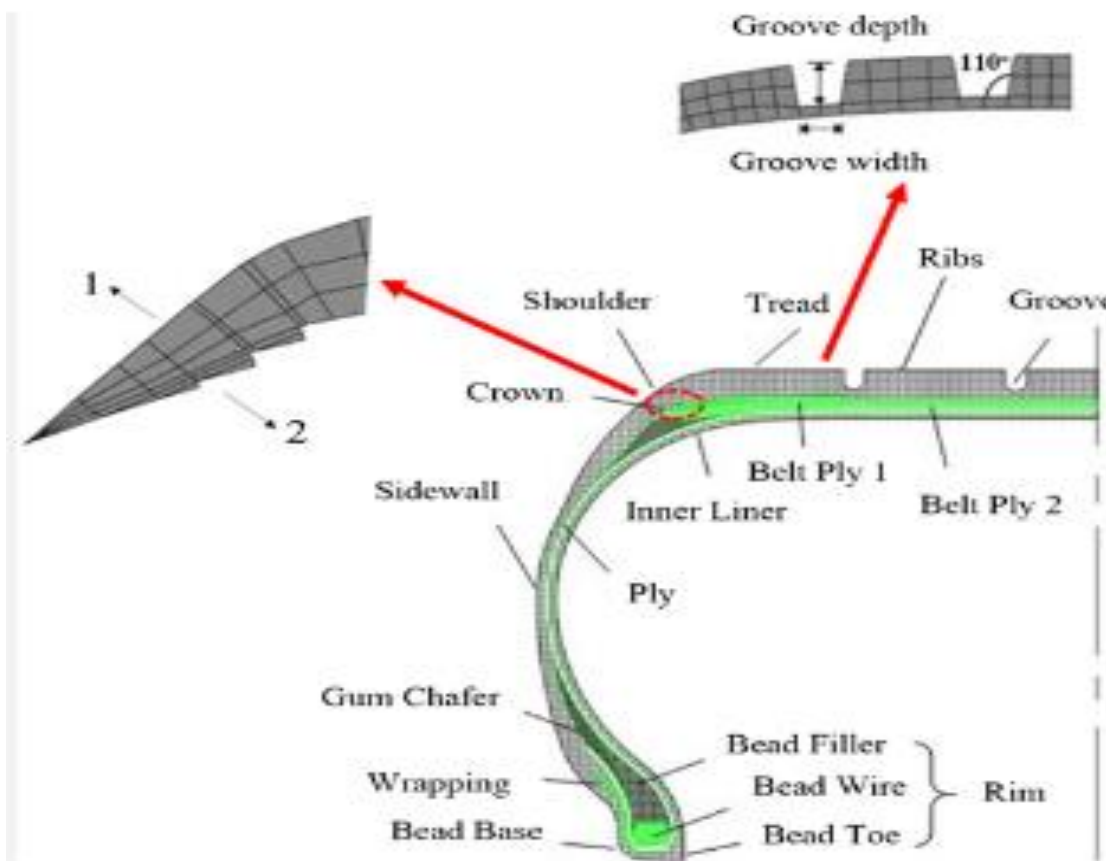
Aligning (Self-Aligning) Torque (M_z):

- Aligning torque is a moment around the vertical axis of the tire.
- It is responsible for aligning the tire with the direction of vehicle motion.
- When you steer the vehicle, aligning torque helps return the tire to its straight-ahead position.

These forces and moments are critical for understanding the behavior of a vehicle's tires and its overall handling characteristics. Engineers and researchers use complex mathematical models and tire testing equipment to measure and analyze these forces and moments under various conditions. The data obtained from these studies help in designing safer, more efficient tires and optimizing vehicle performance.

It's important to note that tire characteristics, such as tread design, tire compound, and tire pressure, greatly influence the generation of these forces and moments. Additionally, vehicle dynamics, including suspension design and alignment, play a significant role in how these forces and moments are transmitted and managed during driving.

TIRE STRUCTURE





TIRES FORCE AND MOMENT, TIRE STRUCTURES



Tread:

- ✚ The outermost layer of the tire is called the tread.
- ✚ It is the part that comes into contact with the road surface.
- ✚ The tread pattern is designed to provide traction, handling, and water dispersion, and it varies depending on the tire's intended use (e.g., summer, winter, all-season, off-road).
- ✚ The tread also includes various grooves and sipes to enhance grip and water evacuation.

Sidewall:

- ✚ The sidewall is the vertical part of the tire that connects the tread to the inner bead.
- ✚ It contains important information about the tire, such as its size, load rating, speed rating, and manufacturing details.
- ✚ Sidewalls are designed to flex, providing cushioning and flexibility for a comfortable ride.

Carcass or Ply:

- ✚ Beneath the tread and sidewall is the tire's carcass, which consists of layers of fabric cords (typically polyester, nylon, or steel) embedded in rubber.
- ✚ The fabric cords provide strength and stability to the tire.
- ✚ The number of layers and the type of cord used can vary depending on the tire's intended use (e.g., passenger, truck, racing).

Beads:

- ✚ The beads are the tire's innermost edges, designed to securely grip the wheel rim.
- ✚ They are typically made of high-strength steel wires coated in brass or other materials to reduce friction and ensure a tight fit on the rim.
- ✚ The beads are responsible for maintaining the tire's shape and preventing it from slipping off the rim during operation.

Inner Liner:

- ✚ The inner liner is a layer of rubber inside the tire that acts as a barrier to maintain air pressure and prevent leaks.
- ✚ It helps keep the tire inflated and provides an airtight seal.

Belts or Steel Belts (in some tires):

- ✚ In certain tire designs, especially in high-performance and all-season tires, steel belts may be added between the carcass and the tread.
- ✚ Steel belts enhance the tire's stability, handling, and durability.

Cushion or Under-Tread (in some tires):



TIRES FORCE AND MOMENT, TIRE STRUCTURES



- Some tires feature an additional layer called the cushion or under-tread between the carcass and the tread.
- This layer can provide extra comfort and insulation against road irregularities.

Tire Compound:

- The tire's compound is the specific rubber formulation used for the tread and sidewalls.
- It affects the tire's grip, wear resistance, and performance characteristics.
- Different types of tires (e.g., summer, winter, all-season) have compounds optimized for their respective conditions.