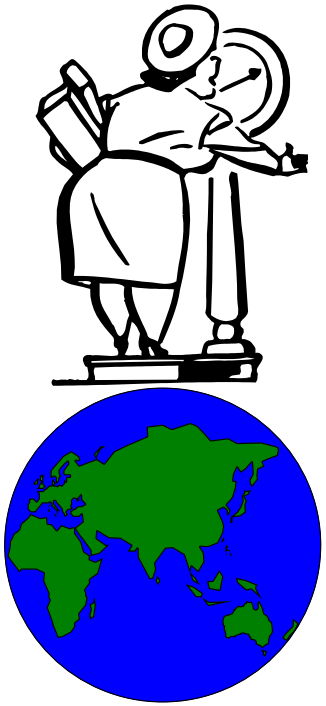
Natural Laws Affecting Vehicle Control

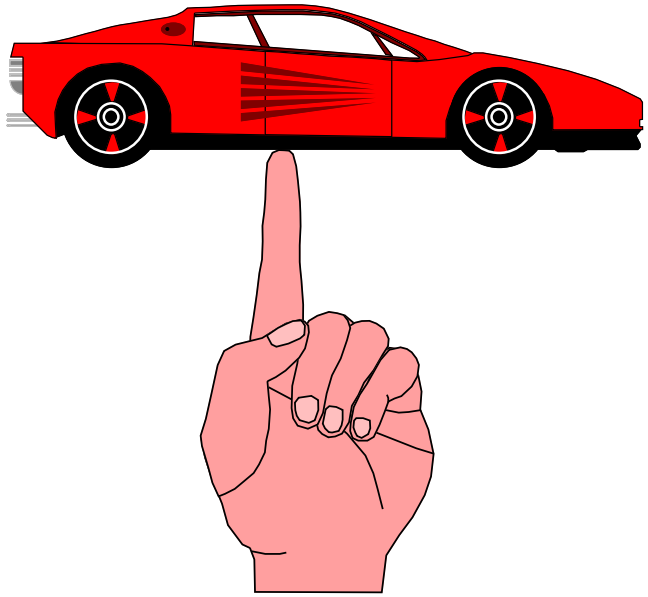
GRAVITY

The natural force that pulls all things to earth

Throw a ball into the air and it_____



Gravity gives objects their _____



The center of gravity is where a body's mass is _____

ENERGY OF MOTION

The white truck and the dump truck are going the same speed

Which vehicle has more energy of motion?

Why?

EFFECT OF SPEED AND WEIGHT

Look in your manual on page 2-3 to understand stopping distances at different speeds.

Takes THREE times the distance to stop

Takes SIX times the distance to stop

EFFECT OF SPEED AND WEIGHT

To stop a vehicle going 60 mph would generate approximately enough heat to boil one-half gallon of water!

INERTIA – what is it?

Inertia wants to keep these parked cars at rest

Inertia also wants to keep these moving cars moving

INERTIA

When driving through this curve, inertia creates the sensation that you are being pulled to the outside of the curve. Why?

Because you are traveling in a straight line, and inertia wants to keep you going in a straight line. SLOW DOWN FOR CURVES!!

MOMENTUM

- **Momentum is inertia in motion**
- **Momentum is the product of speed and weight**

A truck filled with potatoes traveling at 20mph has more momentum than a 3,000 lb car traveling at the same speed

As momentum increases so does the potential for lots of damage in a collision

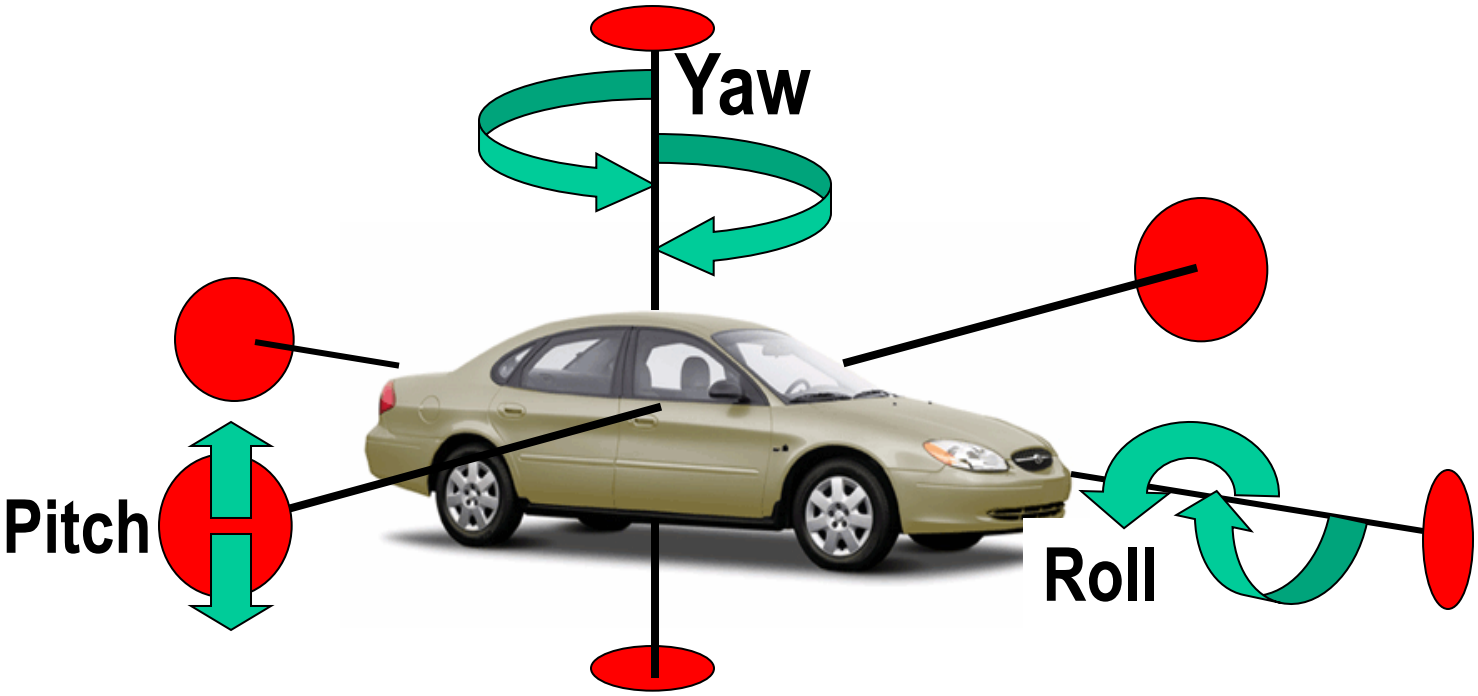
MOMENTUM

A 150 lb passenger traveling in a vehicle going 30 mph will have momentum

No matter how strong that passenger may be, he/she will not be strong enough to stop the body's momentum if the vehicle comes to an abrupt stop during a crash

Photos courtesy of AAA Foundation

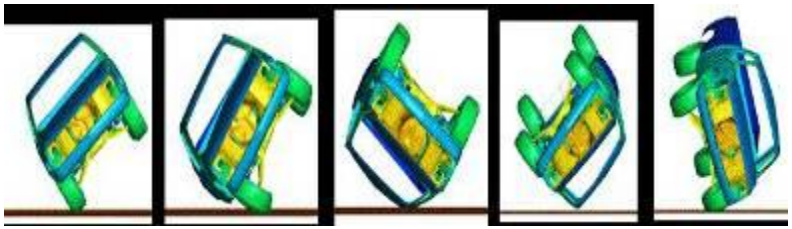
PITCH, ROLL, YAW



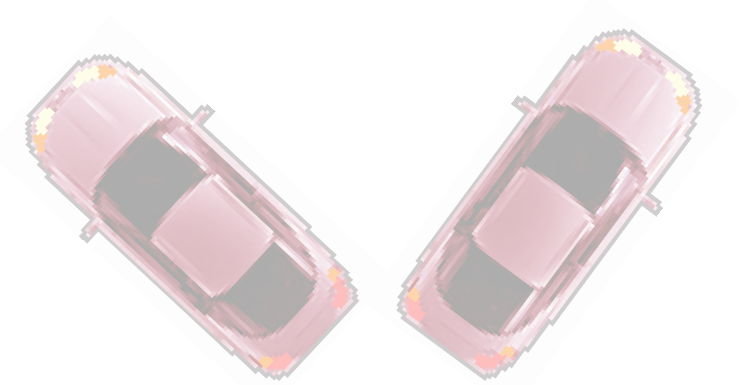
PITCH, ROLL, YAW

Pitch

Roll



Yaw



FORCES OF IMPACT

When two objects collide, three factors determine how much force there will be on impact

1. Speed

2. Weight

3. Duration

FORCES OF IMPACT

3. Duration

When a collision stops a vehicle in a very short time the impact will be greater than if it took a longer time to stop

FRICTION

Friction is the force when two surfaces move against each other and one surface resists the other

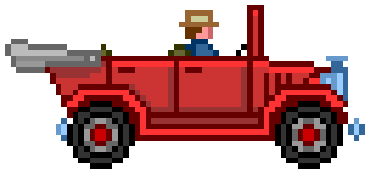
The amount of friction between the surfaces depends on:

- **What the surface is made of**
- **What is on the surface**
- **How rough or smooth it is**
- **How much force is pushing the two surfaces together**

FRICTION: 4 Types

1. **Static: The holding force between two surfaces**

2. **Sliding: Friction that slows down a sliding object**



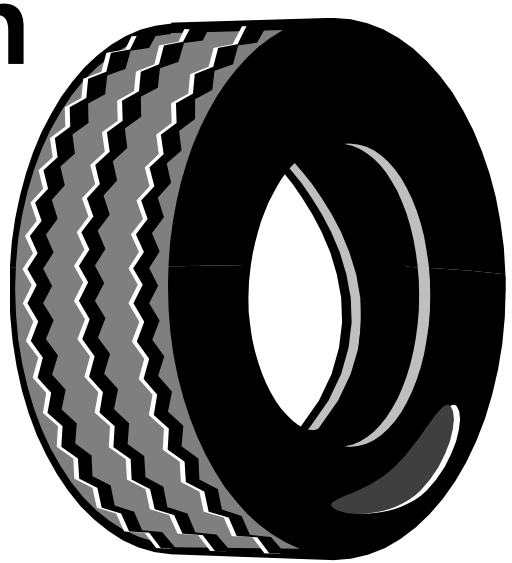
3. **Rolling: Friction between the ground and tire/wheel**

4. **Internal: Friction that occurs from resistance to motion within elastic objects**

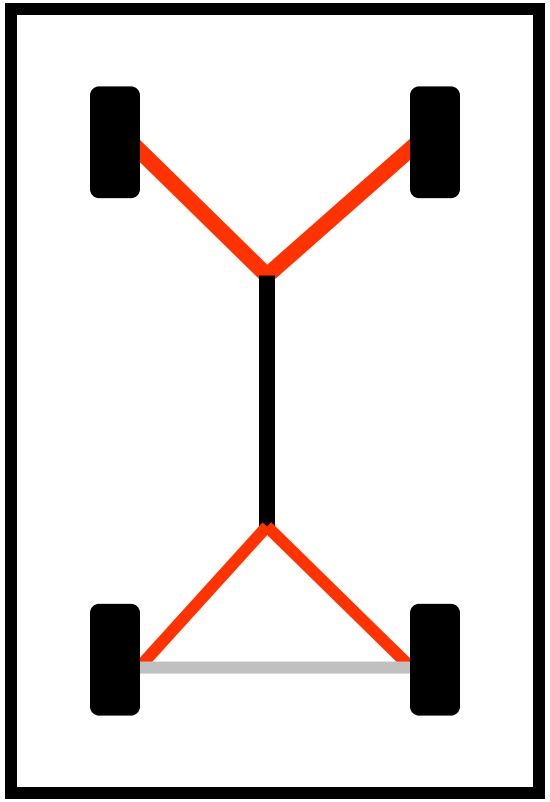
FRICTION

Traction is used to accelerate, brake and turn

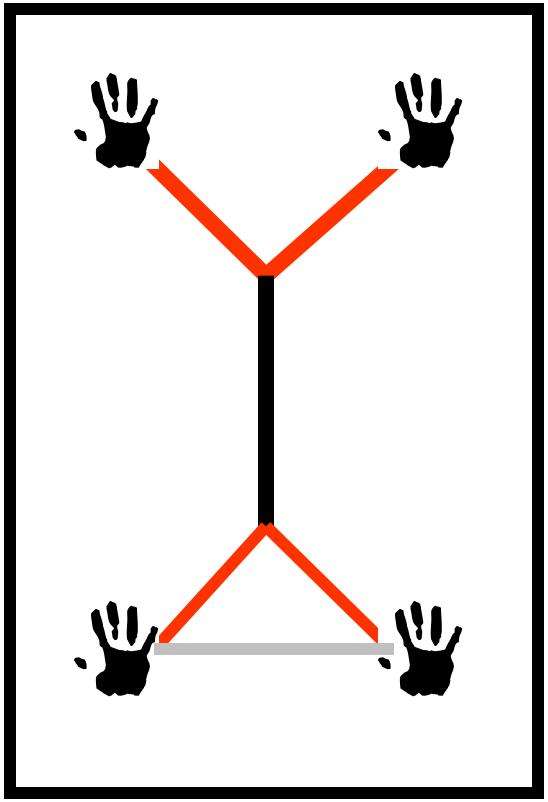
Tires rolling over a surface usually generate friction, which in turn creates traction



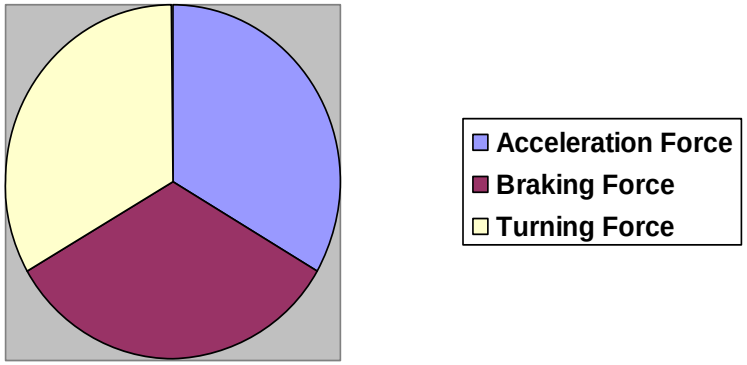
TIRES AND TRACTION



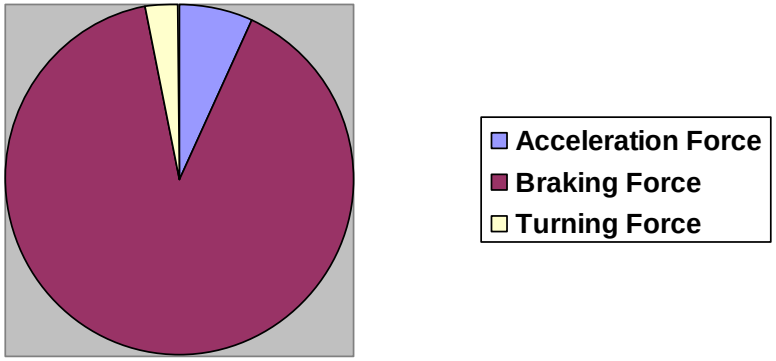
The size of a tire's "footprint" contact on the surface is about the size of a small hand



Consumers of Traction

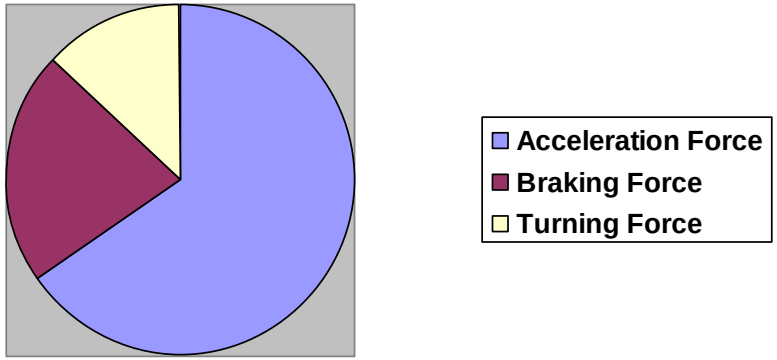


1. The 3 Traction Forces if they were evenly distributed



2. Hard Emergency Braking in a Curve
   - Braking consumes 90% Traction Force
   - Turning Force needs at least 60% more Traction. What could happen?

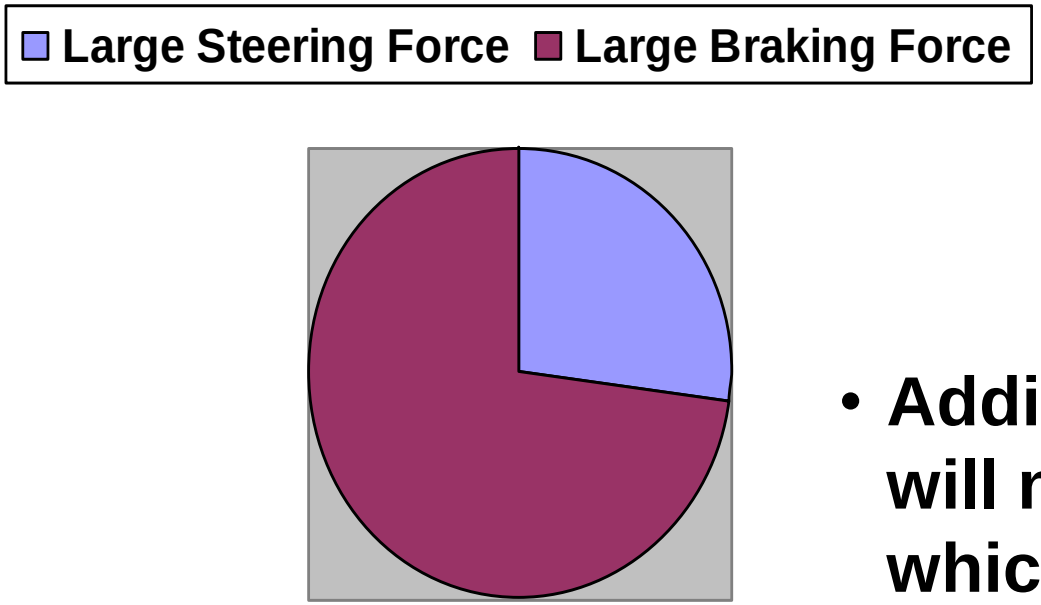
3. Acceleration through a curve, DEER IN ROAD!!
   - Acceleration consumes 75% Traction Force
   - 40% more Braking Force and 35% more Turning Force is needed
   - What could happen?



Pie charts are not exact

Traction Pies

Large Steering and Braking Forces Exceed Traction Limits



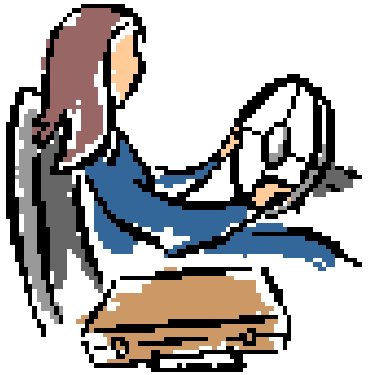
Pie charts are not exact

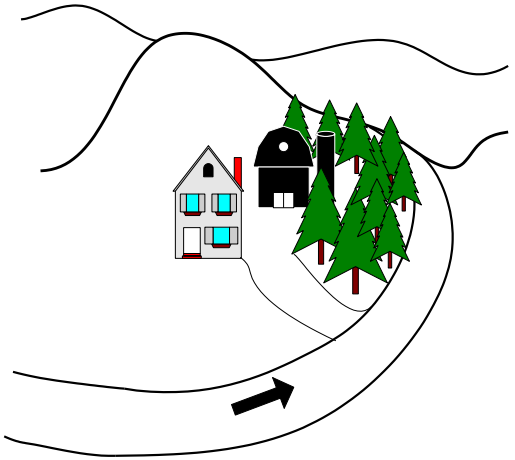
In a hard braking situation, most of the traction is needed for braking

- **Adding hard steering will need more Traction which is not available**
- **The result will be loss of Traction and loss of control**

EFFECT OF FORCE IN A CURVE

- **Inertia must be overcome for the car to turn, aka you need to slow down.**
- **When traveling in a straight line, inertia wants to keep the car going in a straight line**
- **Turning the steering wheel into the curve creates friction between the tires and the road surface allowing the vehicle to follow the curve**





FORCE EFFECT ON OCCUPANTS

- **As the car enters a turn, inertia wants to keep the vehicle and occupants going straight**

The seat position and seat belt hold passengers in place through the curve

FORCE EFFECT ON BRAKING DISTANCE

What could happen to braking distance if:

- **The driver's condition isn't ideal?**
- **The vehicle's condition isn't ideal?**
- **The road conditions are not ideal?**

Photos courtesy of AAA Foundation

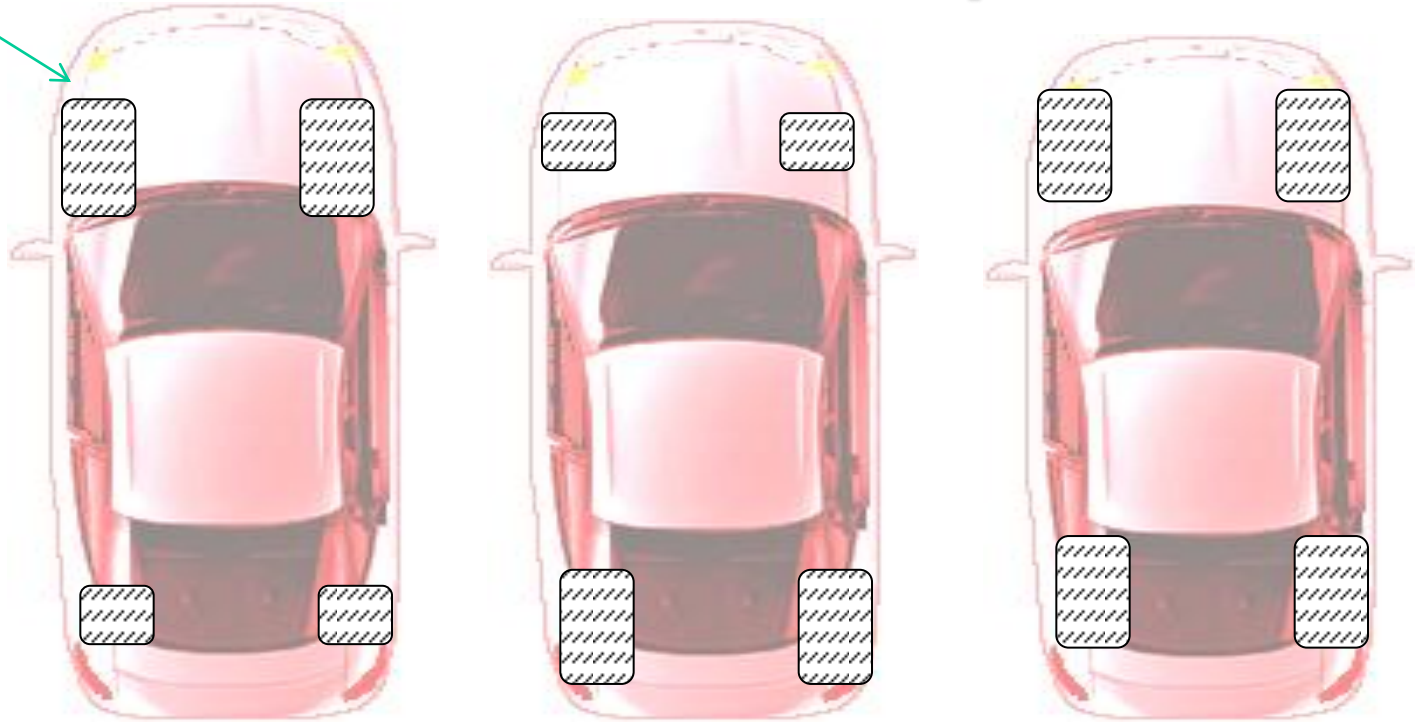
MAINTAINING VEHICLE BALANCE

- **The design balance for a vehicle is only reached when the vehicle is not moving, or is moving in a straight line at a constant speed**
- **As soon as the vehicle accelerates, brakes, or turns, the vehicle balance is changed**
- **As soon as motion occurs, weight transfer on the tires changes the size of the tire patches**

CHANGES TO A VEHICLE'S FOOTPRINT

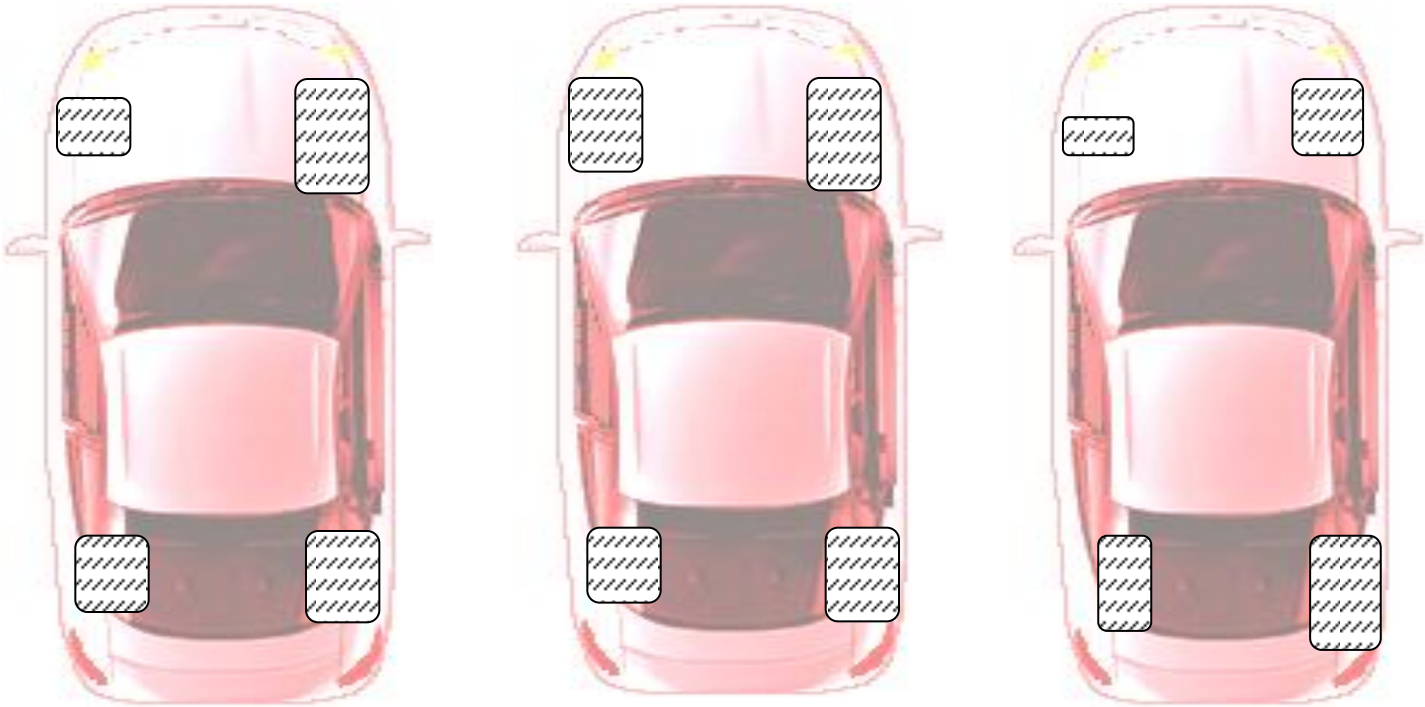
Describe the driving maneuvers that create these footprints

Stopping because weight is being transferred to front tires.



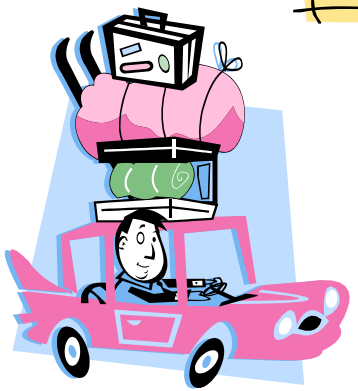
CHANGES TO A VEHICLE'S FOOTPRINT

Describe the driving maneuvers that create these tire footprints



MAXIMUM VEHICLE LOAD

Load capacity includes the combined weight of people, fluids and cargo that the vehicle is designed to safely handle



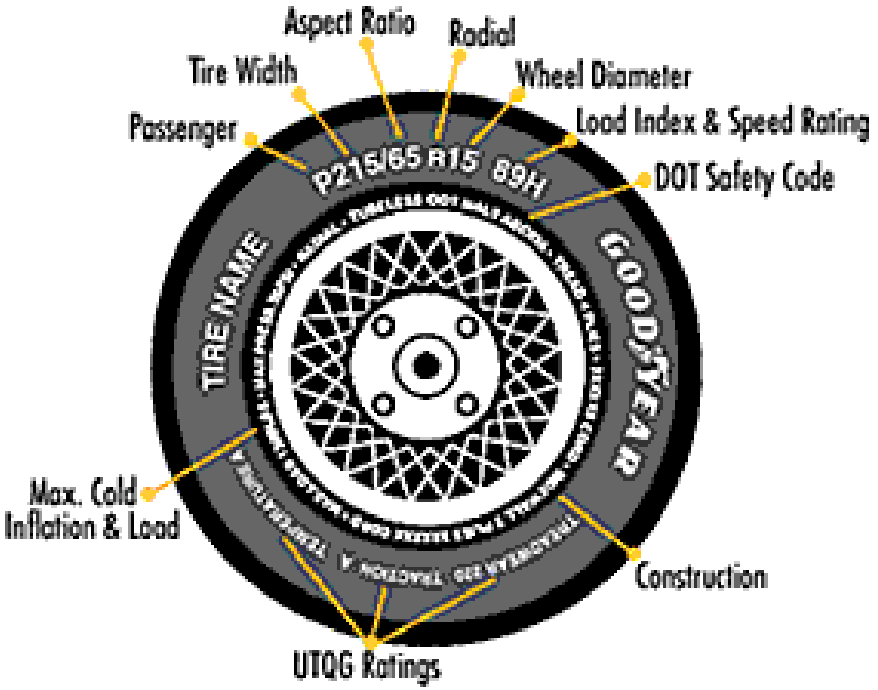
THE ULTIMATE VEHICLE OVER LOAD

- Operating a vehicle above the Gross Vehicle Weight Rating (GVWR) is a potential safety hazard

Frame, suspension, brakes and tires are not designed for weights above the rating the manufacturer has set

MAXIMUM TIRE LOAD

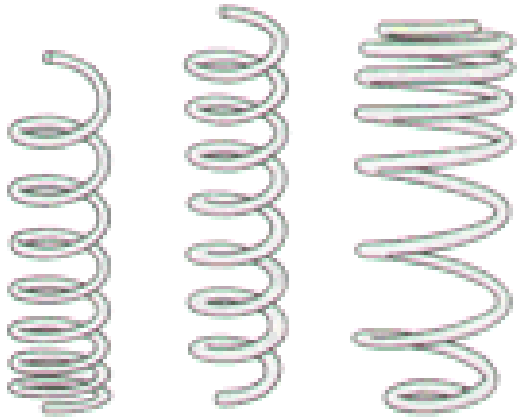
All tires have the maximum load limit stamped on the tire along with other safety information



Graphic courtesy of Goodyear Tires

VEHICLE SUSPENSION SYSTEM

- Helps to smooth out weight transfer
- Helps keep all four wheels firmly on the ground
- Helps keep the vehicle flat and level



LOAD EFFECT ON BALANCE

What could occur if the driver of this vehicle made a quick steering maneuver?

Photo courtesy of AAA Foundation

SEATING FOR BALANCE AND CONTROL

- Knees
- Legs
- Feet
- Back and Shoulders
- Arms
- Hands

Photo courtesy of AAA Foundation

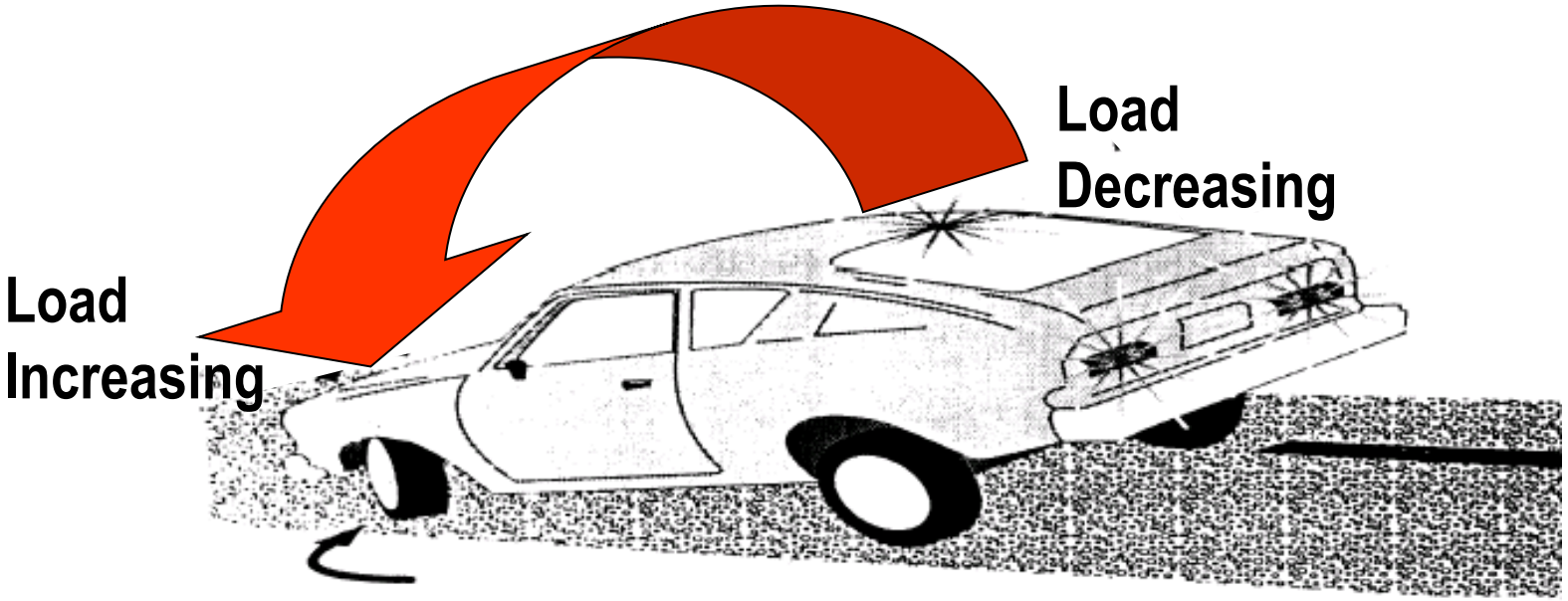
STEERING FOR BALANCE AND CONTROL

- Sit at a safe distance from the wheel
- Use a balanced hand position
- As speed increases, steering need is reduced for turns and other maneuvers

Photo courtesy of ADTSEA

EFFECT OF HARD BRAKING

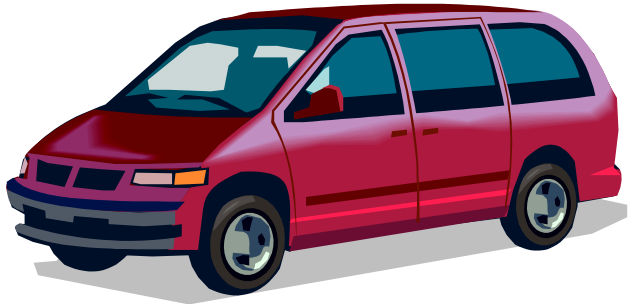
Applying hard braking causes weight to shift sharply to the front tires. If the weight shift exceeds available traction, the tires will skid and steering control is lost



BALANCE AND CONTROL WITH ACCELERATION

- Releasing Brake
- Covering Accelerator
- Light Accelerator Pressure
- Progressive Accelerator Pressure
- Thrust Accelerator Pressure

Drivers have choices about the type of acceleration needed to keep the vehicle in balance and under control



BALANCE AND CONTROL WITH BRAKING

How do each of these affect balance and control?

- Heel
- Ball of Foot
- Amount of Pressure on Pedal

CONDITIONS CAUSING TRACTION LOSS

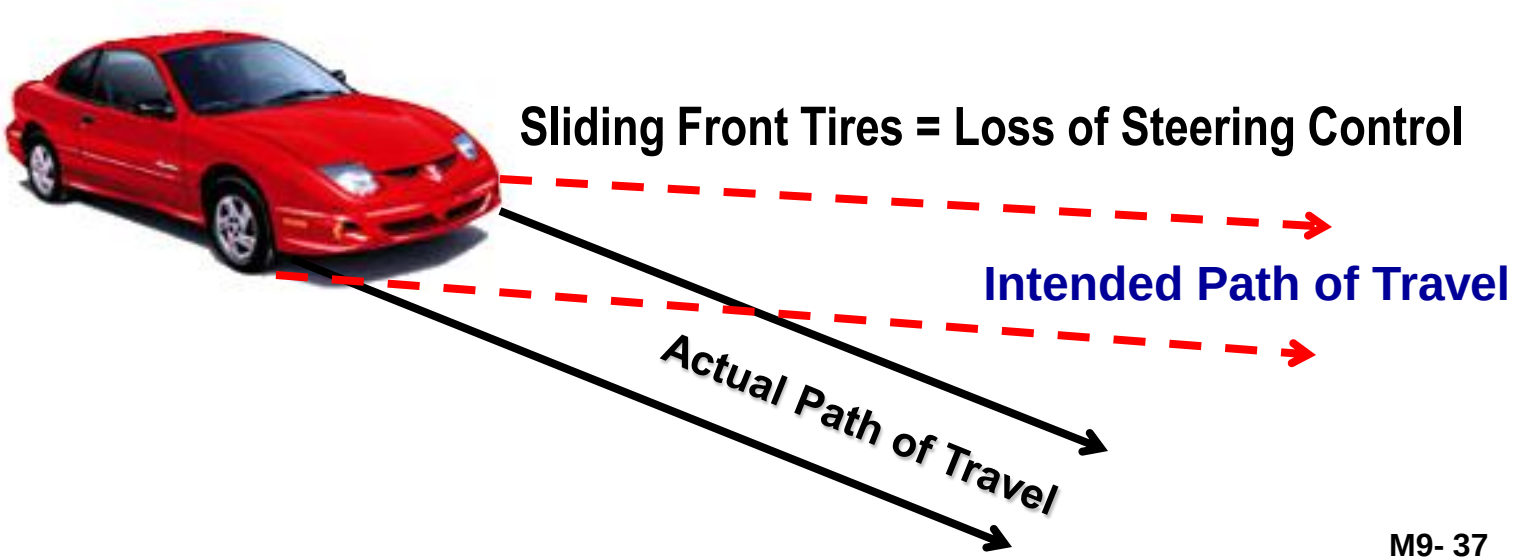
- By the driver
- By the vehicle

- By the surface of the road

Photos courtesy of AAA Foundation

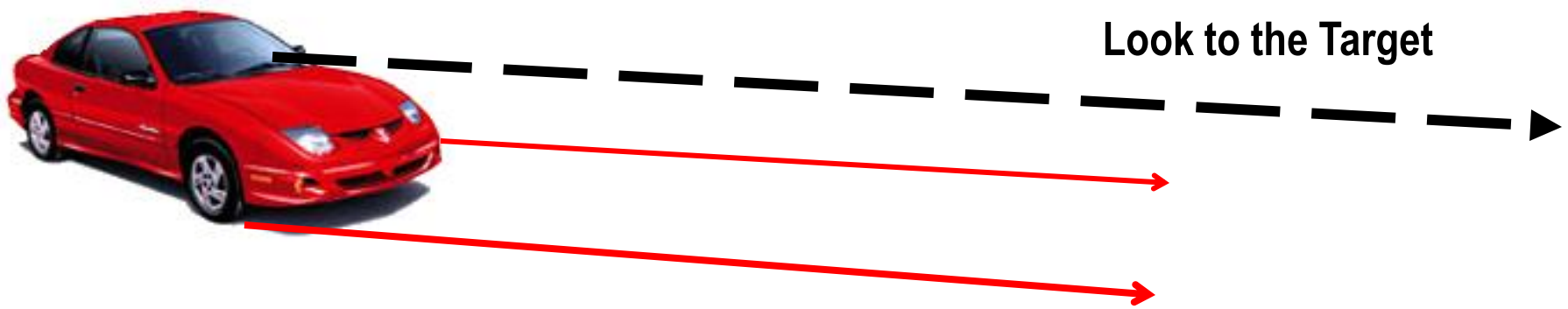
TRACTION LOSS TO THE FRONT

- The front tires go from rolling to sliding resulting in loss of all steering control



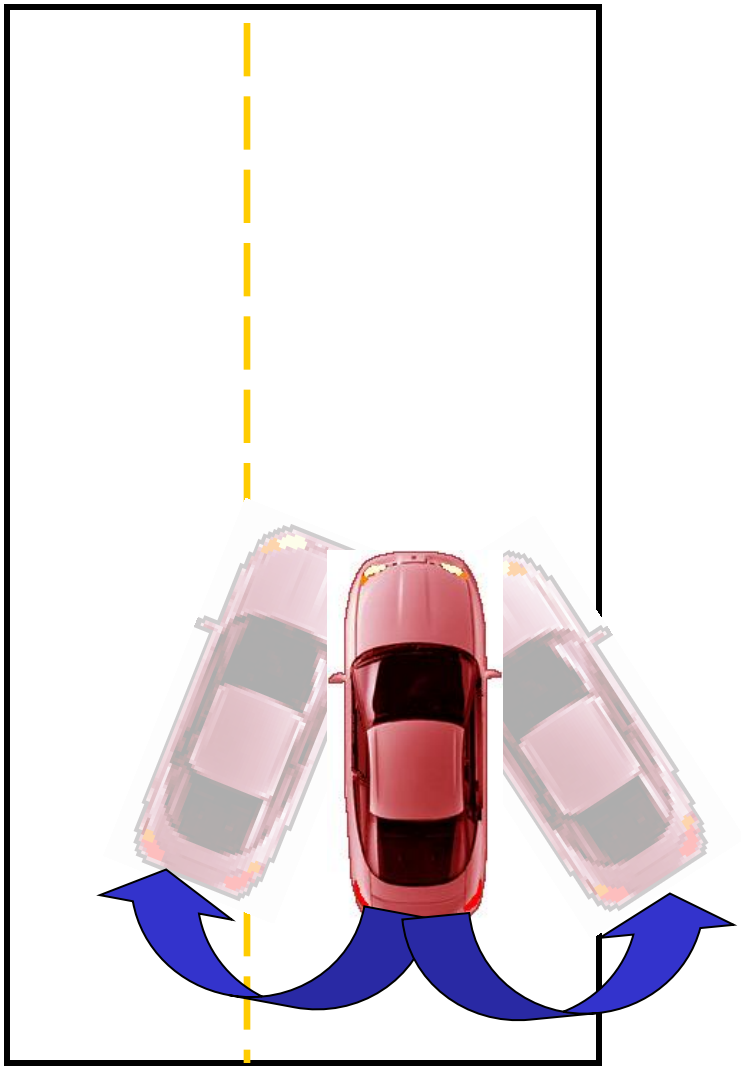
RESPONDING TO FRONT WHEEL TRACTION LOSS

- Look to the target
- If braking, ease off the brake pedal
- Reduce steering input



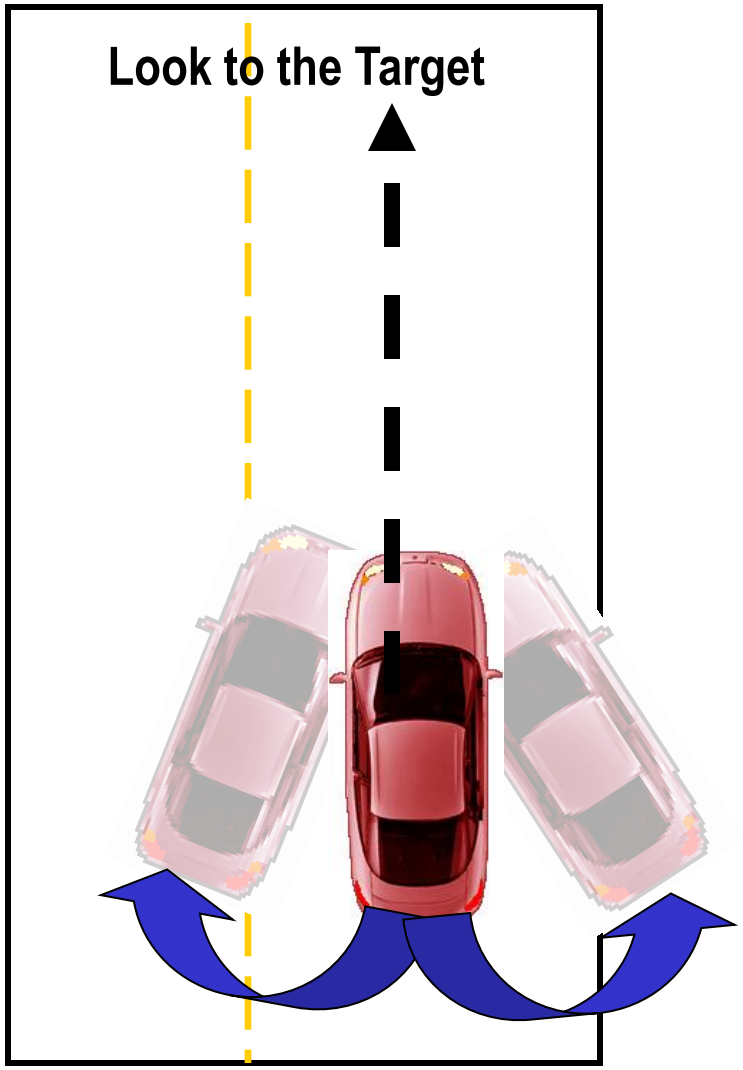
TRACTION LOSS TO THE REAR

- The rear tires lose traction and the rear of the vehicle moves left or right as it tries to overtake the front of the vehicle



RESPONDING TO TRACTION LOSS TO THE REAR

- Look to the target
- Release the accelerator or brake to gain rolling traction
- Steer no more than necessary
- Maintain constant attention to steering until the vehicle is back under control



FRONT WHEEL DRIVE TRACTION LOSS

- Front wheel drive vehicles have more weight over the drive wheels giving the tires more traction
- Actions when traction loss occurs:
  - Going downhill, shift to a lower gear
  - Avoid over-acceleration on slippery surfaces
  - Reduce speed
  - Reduce steering input

REAR WHEEL DRIVE TRACTION LOSS

- Rear wheel drive vehicles have less weight over the drive wheels than front wheel drive vehicles
- Avoid traction loss by:
  - Controlling acceleration
  - Reducing speed

ALL WHEEL DRIVE TRACTION LOSS

- All wheel drive vehicles use power on all the wheels
- If a driver over-accelerates, loss of traction to all four wheels can occur
- Avoid traction loss by:
  - Controlling acceleration
  - Reducing speed
  - Reducing engine power