



Physics of Driving and Occupant Restraints

Session Goals

1. Understand the natural laws and forces that affect their driving daily.
2. Demonstrate and understanding of how traction, tire pressure, tire tread, and braking may impact a driver's ability to respond to the natural forces and driving conditions encountered.
3. Demonstrate knowledge of why occupant protection is important.
4. Demonstrate knowledge of laws related to occupant restraint.
5. Understand that as the driver, they are responsible for ensuring correct occupant protection use within their vehicle.

Key Vocabulary and Topics

- Gravity
- Center of gravity
- Inertia
- Centrifugal force
- Kinetic energy
- Vehicle suspension balance
- Friction
- Traction
- First collision
- Second collision
- Third collision
- Passive restraint
- Active restraint
- Seatbelt
- Booster seat
- Child car seat / booster seat
- Air bag
- NYS Seatbelt Law

Gravity

You can feel the pull of gravity as you drive up and down hills

- Driving uphill, you will lose speed unless you use extra power
- Driving downhill, you will increase in speed
- Do not ride your brakes downhill, instead use engine compression by shifting into a lower gear BEFORE you go down the hill

Center of Gravity

- The point around which an object's weight is evenly distributed
- A vehicle's stability decreases as its center of gravity rises

Natural Laws - Inertia

What is inertia?

An object in motion stays in motion until acted upon by some outside force.

Can you name some situations where the road or the conditions of the road, will affect speeding up or slowing down of a vehicle?

Kinetic Energy

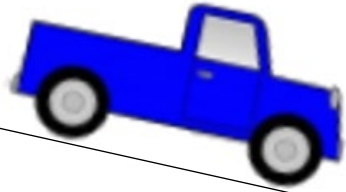
Kinetic energy is the amount of energy an object has because of its motion. If we want to accelerate it, we must apply a force (pushing the gas peddle). Energy then transfers to the vehicle (moving it) to a constant speed. The energy transferred is Kinetic energy.

- What happens when vehicle doubles in speed going from 20 MPH to 40 MPH?

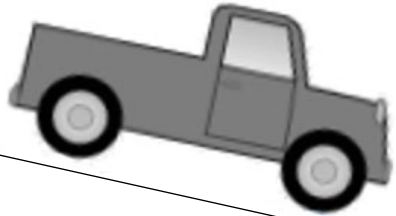
You will need four times the distance to stop the vehicle as the speed increases.

If a vehicle's speed doubles, the forces involved in a collision will be quadrupled.

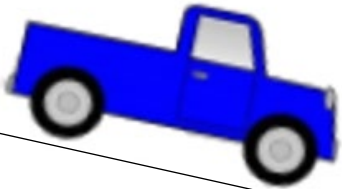
- Knowing this information, helps traffic engineers study traffic patterns and identify where driving errors might occur and determine safe speed limits for these areas.



Empty truck going 25 MPH
will only travel 15 feet



Double truck weight going
25 MPH will travel 30 feet



Empty truck going 50
MPH will travel 60 feet

A vehicles' kinetic energy
increases dramatically with
increases in weight and speed.

Balance

- Balance of the vehicle is so important not only for vehicle control but also for the maintenance of the vehicle
- How can you tell your vehicle is accelerating? You should feel a backward motion as the weight of the vehicle is shifted to the rear.
- How about when your vehicle is decelerating? The weight of the vehicle is shifted forward so you should feel forward motion in your seat.
- What happens if you take turn too fast? The weight of the vehicle shifts in the opposite direction of the turn.

What Factors Contribute to Single-Vehicle Crashes?

- Statistics show that more than 50 percent of occupant fatalities occur as a result of single-vehicle crashes. Why do you think this is?
- Single-vehicle crashes involve too fast for conditions, improper steering or braking or a combination of all three.
- These factors can upset a vehicle's balance and can lead to a loss of traction and loss of control in maintaining the intended path of travel.

Road Surface and Traction

Traction is simply the grip that a tire has to the road

- Without traction, a driver can not control their vehicle (e.g. steering, accelerating, or stopping)

Drivers must learn to recognize conditions that may indicate a change in traction, which in turn will require a change in speed or direction.

What are road conditions that negatively affect a vehicle's traction?

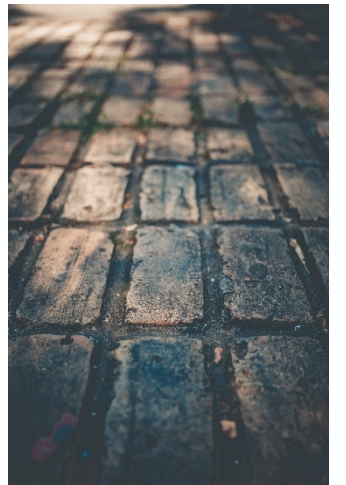
Road Surfaces

What are the different kinds of road surfaces you will encounter when driving?

What are traction concerns for each type of road surface?

What are some road elements that drivers should be cautious of because they may be slippery?

What's the best way to stay in control of the vehicle's traction for each road surface?



Conditions that Affect Traction: Temperature Changes

As the temperature changes on road surfaces, what are some concerns which may arise?

- Warm to Cold?

- Cold to Hot?

What other Road Factors Impact Traction & Control?

- Elevated and shaded areas of a roadway may freeze before other areas.
- Areas where water or wet material has gathered may be slippery.
- Exposure to strong winds when on wet or icy roads may impact control.

Road Design Can Impact Traction

- The surface of the road shoulder may provide less traction & control.
- Roadways that are not flat and straight may impact traction and control. Some examples might include tight curves, pitched or banked roadways, as well as roads which are crowned (higher in the center). ***Have you encountered any of these?***

Tires and Traction

Tread – the grooved surface of a tire that grips the road

When the road is wet, the tread allows water to flow through the grooves and away from the tire, allowing the tire to grip the road.

A worn, bald tire is dangerous!

- Will not grip a wet or icy road
- The tire may puncture causing a blowout

Tire Inflation

- How do you check for proper tread depth?
- How do you know how much air to put in your tire?

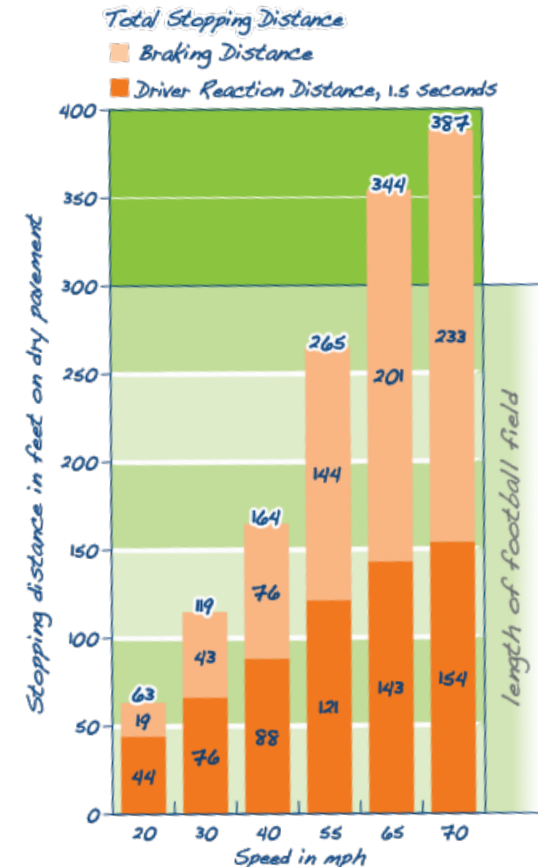


Factors That Affect Braking Distance

- Speed
- Vehicle Condition
- Roadway Surface/Conditions
- Driver Ability
- Hills
- Loads
- Weight of the vehicle
- Tire grip

Note: Braking stops the wheels, not the vehicle

Total stopping distance in feet at various speeds (mph), by the time (distance) it takes the driver to react plus the braking distance. The driver takes the same amount of time to react regardless of speed. As speed doubles, stopping distance quadruples.



Force of Impact

Force of Impact – the force with which a moving object hits another object

Three factors determining how hard something will hit another object:

- Speed
- Weight
- Distance between impact and stopping

Three Collisions When a Crash Occurs

First – the vehicle hits an object

Second – the occupant hits the interior parts of the vehicle, such as the steering wheel or dashboard

Third – the occupants' internal organs slam up against their skeletal structure, resulting in the most injuries in a crash

Three Collisions in a Crash Video

View “Three Stages of a Collision, DDC4 6th Edition – National Safety Council driver course excerpt”

<https://www.youtube.com/watch?v=zSiDRaV7O24>

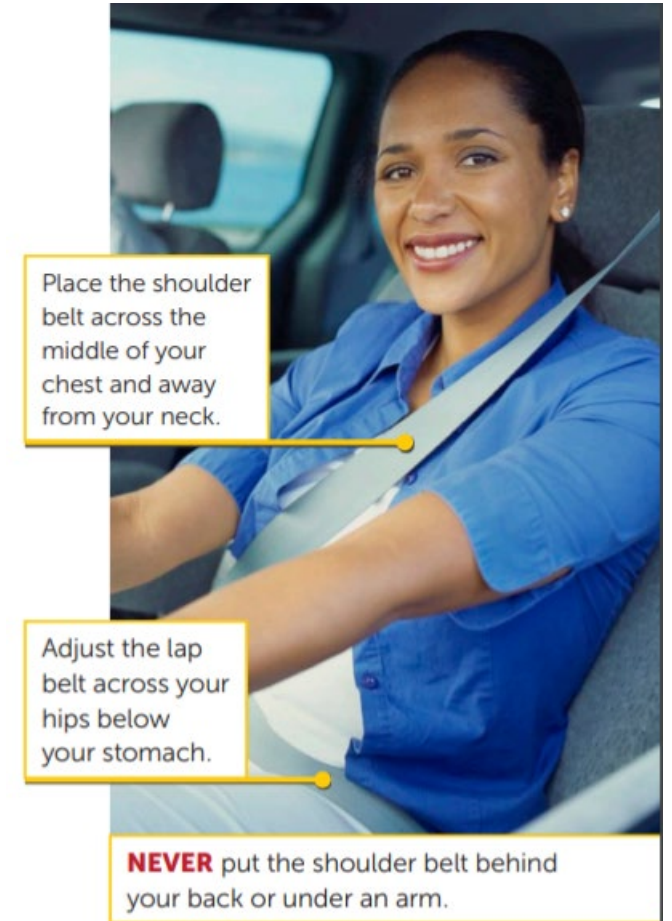
Seat Belt Video

View “Get it Together – Buckle Up” by NYS DMV

<https://www.youtube.com/watch?v=RuZoGfq27Xs&t=19s>

Occupant Protection – Seat Belts

- Wearing your seat belt is the single most effective thing you can do to protect yourself in a crash.
- Air bags are designed to work with seat belts, not replace them.
- Seat belt fit matters – the shoulder belt should lay across the middle of the chest and way from neck; the lap belt should ay across your hips not your stomach
- Everyone in the car should be properly restrained (in a car seat, booster or seat belt, depending on their age and size)



National Highway Traffic Safety Administration. Top 5 Things You should Know About Buckling Up.

Adjusting Your Head Restraints

- The bottom of the head restraint should align with the bottom of your ears.
- Proper adjustment can protect your head and neck in case of a crash.

Don't Forget to Buckle Up in the Back
(NY State law passed in November 2020)

Key Points from NYS Vehicle and Traffic Law

Seat Belt Use for Drivers and Passengers

- All drivers, front seat, and rear passengers must wear seat belts regardless of age (NYS Law passed in November 2020)
- Children under 100 lbs have further requirements

Key Points from NYS Vehicle and Traffic Law

Child Passenger Safety (Car Seats and Booster Seats)

- Children under the age of four must be in a federally approved child restraint system attached to the vehicle by a safety belt or LATCH system.
- A child under age 4 who weighs more than 40 pounds can be restrained in a booster seat with a lap and shoulder belt.

Key Points from NYS Vehicle and Traffic Law

- A child of age 4, 5, 6 or 7 must use a booster seat with lap and shoulder belt or a child safety seat (The child safety restraint system must meet the height and weight recommendations of the restraint manufacturer.)
- A child more than 4 feet 9 inches in height or weighing more than 100 pounds is allowed to use a seat belt that has both a lap belt and a shoulder harness. If the seat belt does not fit correctly, the child must use a booster seat with a lap and shoulder belt.

Can you Name Other Protective Devices in your Car?

- Front and rear crash area zones
- Energy absorbing bumpers
- Side door beams
- Reinforced windshields
- Energy absorbing steering wheel and column
- Padded dash
- Seat belts
- Head restraints

Match These Key Terms

F Gravity

C Center of Gravity

E Inertia

A Traction

B Kinetic Energy

D Vehicle Suspension Balance

- A. The adhesion, friction or grip between the tires and the road surface
- B. The amount of energy needed to propel a vehicle
- C. The point around which an object's weight is evenly distributed
- D. The distribution of the weight of the vehicle on the chassis
- E. An object in motion continues to move straight ahead until acted upon by some outside force
- F. The force that pulls all things to Earth

References

- “Three Stages of a Collision, DDC4 6th Edition – National Safety Council driver course excerpt”
- “Get it Together – Buckle Up” by NYS DMV
- New York State DMV. Chapter 8 Defensive Driving