Class “B” Apparatus Driver Course

PHYSICAL FORCES AND EMERGENCY VEHICLE CONTROL

OVERVIEW

- **Physical Influences**
- **Velocity/Forward Momentum/Inertia**
- **Centrifugal Force**

PHYSICAL INFLUENCES

VELOCITY: Forward Motion & Speed

- Acceleration, deceleration, braking

DIRECTIONAL CONTROL: Steering, Maneuvering, “Tracking” Curves In The Road

PHYSICAL INFLUENCES

- Velocity
  - Speed
- Gravity
  - The force that grounds all objects to the earth
- Energy of Motion
  - The energy that any object has

PHYSICAL INFLUENCES

- Friction
  - Occurs when two objects make contact and rub together
- Traction
  - Is the friction of tires on roadway

PHYSICAL INFLUENCES

- Inertia
  - The force that makes a moving vehicle stay in motion in the same direction

WEIGHT TRANSFER - STOPPING

DEFINITION

WEIGHT TRANSFER: Shift of weight as the Emergency Vehicle slows, speeds, maneuvers

- **Emergency Vehicle changes direction; weight shifts to front, back, side, or either corner.**

Class “B” Apparatus Drivers Course

CHANGING VELOCITY

ACCELERATING:

- **Downward force at rear increases**
- **More weight & traction at rear wheels if not spinning**

BRAKING OR DECELERATING:

- **Downward force at front is increased**
- **More weight on front end; improved steering**

CHANGING DIRECTION

- **Curves**
- **Right or left**
- **Centrifugal force and inertia**
- **Higher center of gravity**
- **Emergency Vehicle with “live” loads**

CHANGING DIRECTION

What happens in a high speed sharp right hand turn if brakes are applied suddenly?

- **Weight Transferred To Left Side**
- **Braking Transfers Weight To Front**
- **Left Front Tire Bears Most Weight**
- **Tire Tears Off**
- **Emergency Vehicle Pivots Around It**

SUSPENSION

- **Emergency Vehicle’s suspension tries to balance the forces during directional changes**
- **Smoothes weight transfers**
- **Keeps wheels firmly on pavement**
- **Keeps Emergency Vehicle level**
- **Good Emergency Vehicle Operator’s slow or widen track as vehicle “leans”, and avoid sudden moves**

Brakes

- Brake Fade
  - Is the worst consequence of heated brakes
    - Can make brakes seem to “disappear”
  - Occurs when
    - Heat reaches 700 degrees
    - Heated lining material generates a gas
    - Brake fluid becomes heated
    - Frame transmits heat from the lining to the fluid
    - Discs warp due to heat (extreme cases only)

DRIVING WATER TANKERS

High Center Of Gravity:

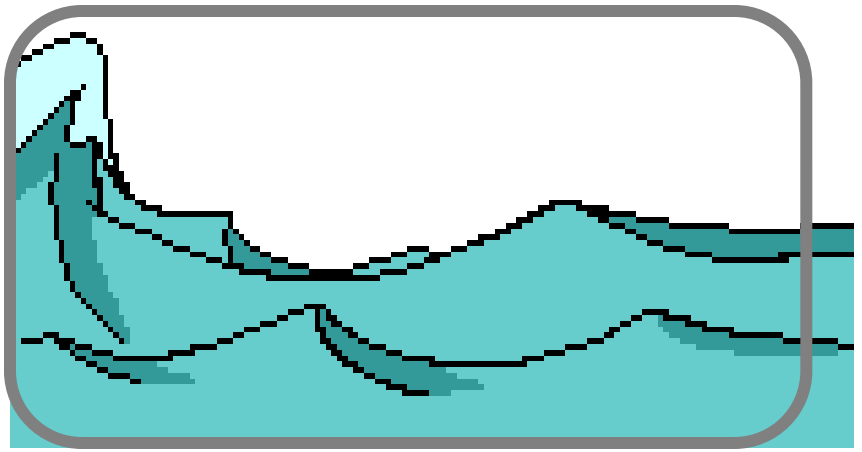
- **Easy to roll over**
- **Can turn over at posted speed limits**
- **On & off ramps should be driven slower**

- **Avoid high speed curves**

DRIVING WATER TANKERS

Danger Of Surge:

- **Liquid movement**
- **Waves**
- **Bulkheads**
- **Watch weight distribution**
- Baffled tanks
- Roll over



Class “B” Apparatus Drivers Course


AT8


E
TEMPLETOWN

PHYSICAL INFLUENCES

- **Vehicle’s Handling Abilities**
- **Proper Driver Attitude**
- **Environmental Factors**
- **Maintenance**

PHYSICAL INFLUENCES

ENVIRONMENTAL FACTORS:

- **Traffic**
- **Weather**
- **Road Conditions**
- **Tire Conditions**
- **Accelerating/ Decelerating**
- **Inappropriate Braking**
- **Abrupt Directional Changes**
- **Curves**

PHYSICAL INFLUENCES

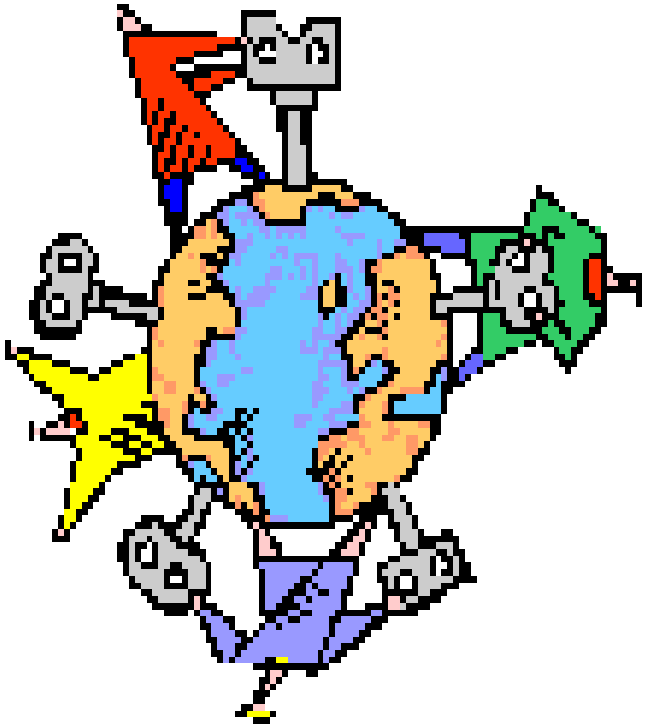
Most important physical forces are:

- **Gravity,**
- **Energy Of Motion (Kinetic Energy),**
- **Traction,**
- **Friction,**
- **Velocity,**
- **Forward Motion,**
- **Inertia, And Centrifugal Force.**

PHYSICAL INFLUENCES

GRAVITY:

- **Acts on Emergency Vehicle when going up/ down hills**
- **Must increase power to overcome this force; may involve gear changes**



PHYSICAL INFLUENCES

- **Center of gravity - point around which objects weight is evenly balanced**
- **Sudden weight transfers**

PHYSICAL INFLUENCES

ENERGY OF MOTION:

- **Energy an object has as it moves**
- **The faster, the more energy**
- **As weight increases so does energy**
- **As energy increases, stopping distance increases**

PHYSICAL INFLUENCES

- **Energy of motion increases as the square of its change in speed**
- **Double the speed, stopping distance increases by 4x**
- **3x the speed, stopping distance is 9x**
- **Reduce speed by 1/2, energy of motion reduced by 1/4**

PHYSICAL INFLUENCES

TRACTION/FRICTION:

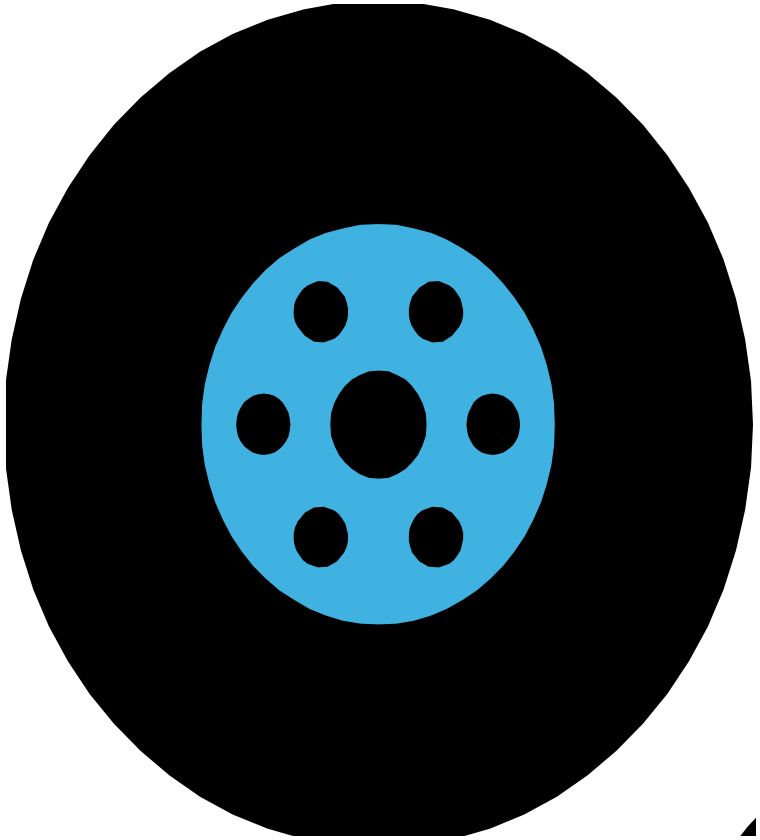
- **Friction between tire and road is traction**
- **Traction allows the vehicle of move and maneuver**
- **Friction is the force of surfaces rubbing together that keeps tires from sliding**

PHYSICAL INFLUENCES

- **Proper tire inflation most critical factor in maintaining traction / friction**
- **Friction is maximum when center of gravity is settled and all wheels are in contact with the road surface**
- **Speeds of 35 - 55 mph enhance good friction**

Wheel = Hub and Tire

40 Square Inches
(Surface Contact Area)
[10% Tire Surface Area]



VELOCITY/FORWARD MOMENTUM and INERTIA

VELOCITY: Speed, Quickness Of Motion

MOMENTUM: Product Of Mass (Weight) X Velocity (Speed)

INERTIA: Force That Allows Objects To Resist Directional Changes

CENTRIFUGAL FORCE

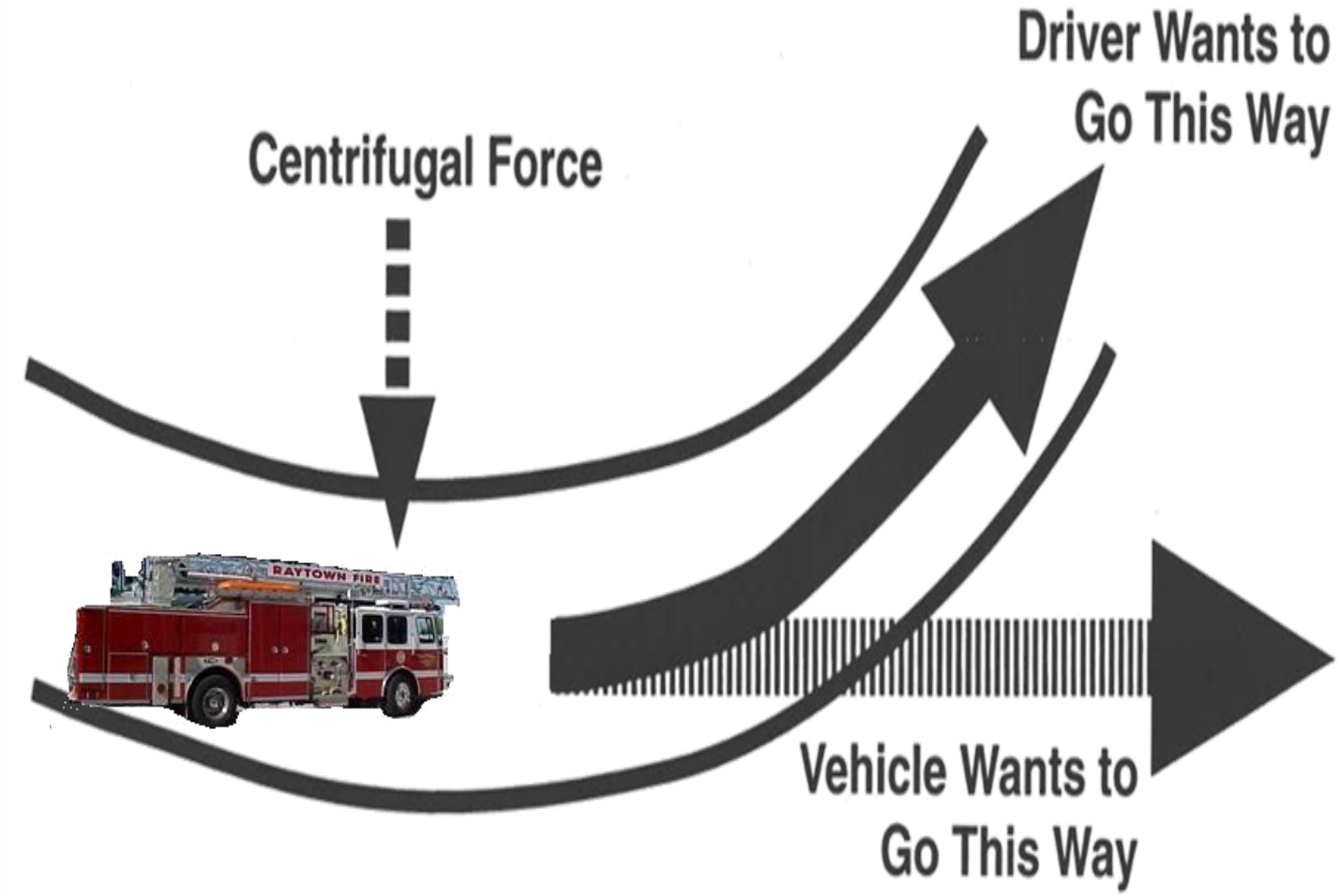
- **Force that pushes an Emergency Vehicle outward in a straight line while rounding a curve**
- **Affected by speed, tire inflation pressure, sharpness of bank of curve, type of road surface, radius of the curve**

CENTRIFUGAL FORCE

- **Acts adversely with velocity, center of gravity, momentum, and inertia to create rollover and uncontrolled skidding**

VIDEO

Effect of Centrifugal Force



Rollover Prevention

Three Key Factors:

- Excessive relative speed causes most rollovers
- Many fatalities can be avoided if occupants wear seatbelts
- Fire and EMS vehicles are involved in rollovers

Rollover Prevention

Components of a Rollover Collision

- **The Driver:**
  - **Training**
  - **Experience**
  - **Physical Condition**
  - **State of Mind**

Rollover Prevention

Components of a Rollover Collision

- **The Vehicle:**
  - **Height, Weight, Width**
  - **Suspension**

Rollover Prevention

Components of a Rollover Collision

- **Common Rollover Circumstances**
  - **Excessive Relative Speed**
  - **Soft Shoulder Drop-off**
  - **Uneven Surface Drop-off and Improper Recovery**

Rollover Prevention

Components of a Rollover Collision

- Physical Dynamics of Vehicle Operations
  - Inertia
  - Momentum
  - Center of Gravity
  - Friction
  - Centrifugal Force

Rollover Prevention

Components of a Rollover Collision

- **Mechanics of Vehicle Operations**
  - **Relative Speed**
  - **Specific Road Conditions**
  - **Effect of Body Roll, Center of Gravity, Tire Sidewall Flexibility**

Rollover Prevention

Components of a Rollover Collision

- **Mechanics of Vehicle Operations**
  - **Effect of Weight Transfer, Understeering, Braking, and Uneven surfaces**
  - **Steering Angle and Tire Friction**
  - **Liquid Slosh Effect**

Rollover Prevention

Road Conditions

- **Conditions That Effect Rollover**
  - **High Center Crown**
  - **Reverse or negative camber**
  - **“S” Curves**
  - **Restrictions of Lane Widths**

Rollover Prevention

Body Roll, Center of Gravity

- **The body of a vehicle pivots around the center of side to side**
- **Keep body roll to a minimum**
- **Radial tires are designed to flex**
- **Consider moving loads**
- **Speed contributes to weight shift and control of vehicle**

Rollover Prevention

Weight Transfer, Understeering, Braking & Uneven Surfaces

- Know how your vehicle handles
- Braking and deceleration of an effect on weight transfer
- Overcompensation & oversteering can cause a vehicle to go out of control

Rollover Prevention

Steering Axle and Tire Friction

- **Six patches of rubber are the only thing holding you on the road**
- **Do not over steer if your vehicle drops off the road surface**

Rollover Prevention

Liquid Slosh Effect

- **Solid loads tend to be more stable**
- **Liquid loads slosh side to side and front to rear**
- **Ideally apparatus should be totally full or totally empty**

Vehicle Rollover

Things To Do:

- ✓**Take you foot off the accelerator and allow the vehicle to slow down gradually**
- ✓**Do not apply full braking**
  - ✓**Soft application of brakes**
  - ✓**Natural deceleration and down shifting**

Vehicle Rollover

Things to Do:

- ✓ **Soft Shoulder**
  - ✓ **Feather the accelerator to maintain control while slowing down**

Vehicle Rollover

Things Not To Do:

- ☒ **Do not attempt to steer back onto the road surface at speed or under acceleration.**
- ☒ **Do not make any sudden or drastic steering movements.**
- ☒ **Do not apply full braking.**
- ☒ **Do not attempt to accelerate over the surface drop off.**

Vehicle Rollover

Off-Shoulder Recovery

- ✓ Reduce speed upon leaving the roadway
- ✓ Stabilize vehicle
- ✓ 9-3 placement on Wheel/Shuffle Steering
- ✓ Control Vehicle, Do not brake
- ✓ Re-enter roadway 1 wheel at a time

Changing Direction

Video

PHYSICAL INFLUENCES

There are many physical forces and laws of nature and physics that act upon the safe passage of an EV.

As the speed, velocity, and directional forces increase, the likelihood of loss of control increase also.

Driving slower, and learning the art of steering rather than braking, greatly affect the controllability of your vehicle


Can this be avoided ?

- VFIS Rollover Video

Review

- **Physical Influences**
- **Velocity/Forward Momentum/Inertia**
- **Centrifugal Force**
- **Show VFIS Rollover Video**