Transportation Engineering- II
Lecture 5

Elements of Design Safe Stopping Distance

- **Important Driver Characteristics**
- **Two most important driver characteristics**
  - Visual and Hearing Perceptions
  - Perception-Reaction Process

Perception-Reaction Process

- Perception
- Identification

- Emotion
- Reaction (volition)

PIEV or PRT

Used for Signal Design and Braking Distance (Horizontal Curve)

Perception-Reaction Process

- **Perception**
  - Sees or hears situation (sees deer)
- **Identification**
  - Identify situation (realizes deer is in road)
- **Emotion**
  - Decides on course of action (stop, change lanes, etc)
- **Reaction (volition)**
  - Acts (time to start events in motion but not actually do action)

Perception-Reaction Process

- Typical Perception-Reaction time range - **0.5 to 7 seconds**
- American Association of State Highway and Transportation Officials (AASHTO) recommends **2.5 sec** PRT for stopping sight distance

$$\mathbf{d_r = 1.47(v)(t)}$$

where:

d_r = Distance traveled during PIEV process (feet)

v = velocity (mph)

t = perception-reaction time = usually 2.5s

Perception-Reaction Distance Example

- **Is this frog in crisis?**

65 mph

PRT = 2.5 sec

190 ft away

Distance traveled during PIEV = 1.47*65*2.5 = 238.9 ft> 190 ft

Perception-Reaction Distance Example

A driver with a perception-reaction time of 2.5 sec is driving at 65 mi/h when she observes that an accident has blocked the road ahead. Determine the distance the vehicle would move before the driver could activate the brakes. The vehicle will continue to move at 65 mi/h during the perception-reaction time of 2.5 sec.

Sight Distance

- **Sight Distance:** *Sight distance is the length of the roadway a driver can see ahead at any particular time.*

1. Stopping Sight Distance (SSD)
2. Passing Sight Distance (PSD)
3. Decision Sight Distance (DSD)

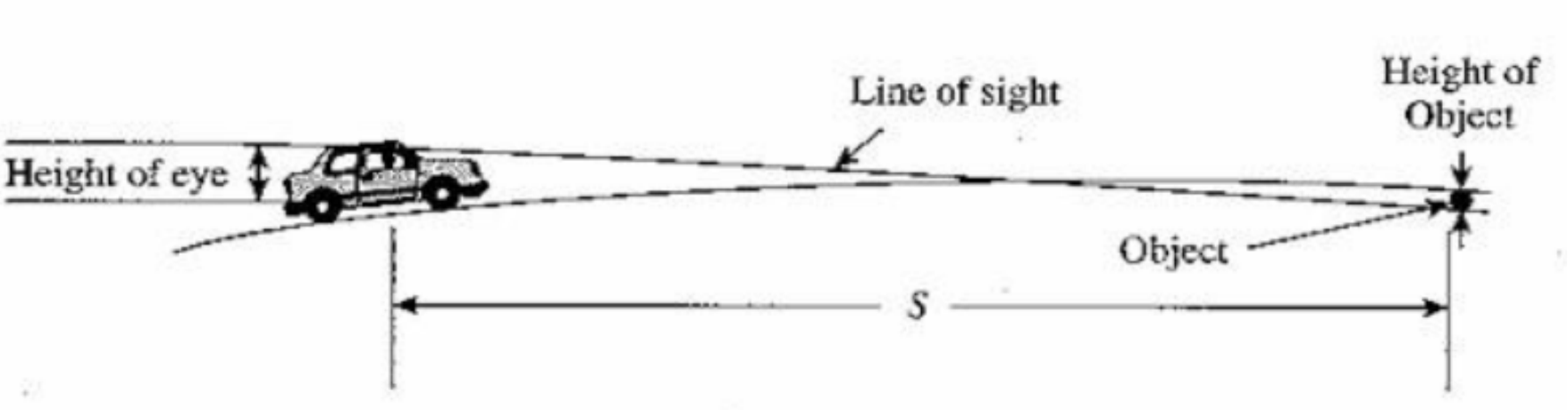
Why Sight Distance is Needed

- A driver's ability to see ahead is needed for **safe and efficient operation of a vehicle** on a highway
- The designer should provide sight distance of sufficient length that drivers can control the operation of their vehicles to **avoid striking an unexpected object in the traveled way**
- **Two-lane highways** should also have sufficient sight distance to enable drivers to use the **opposing traffic lane for passing** other vehicles without interfering with oncoming vehicles

Stopping Sight Distance (SSD)

- **Stopping Sight Distance (SSD)**
- Length of the roadway ahead that is visible to the driver or the distance along a roadway throughout which an object of specified height is continuously visible to the driver.
- The available sight distance on a roadway should be sufficiently long to enable a vehicle traveling at or near the design speed to stop before reaching a stationary object in its path

Stopping Sight Distance (SSD)



Height of Driver's Eye = 3.5 ft or 1.08 meters (Research findings)

Height of Object

SSD & DSD = 2 ft

Smaller objects seldom involved in crashes

Representative of the height of automobile headlights and taillights

PSD = 3.5 ft or 1.08 meters

Stopping Sight Distance (SSD)

- **Composed of Two Parts**

- Distance traveled during perception/reaction time
- Distance required to physically brake vehicle

$$SSD = PRD + BD$$

- PRD = dr = 1.47(Vi)(t)
- dr = Distance traveled during PRT(feet)
- Vi = velocity (mph),
- t = PRT= 2.5s (generally)

Stopping Sight Distance (SSD)

- **Braking distance on a level roadway is calculated as:**

$$d_b = 1.075\frac{V^2}{a}$$

- **Effect of Grade**

$$d_b = \frac{Vi^2 - Vf^2}{30(F \pm 0.01G)}$$

d_b = Braking distance, ft

V_i = initial speed, mph

V_f = final speed, mph

G = grade, %

F = Coefficient of friction = a/g

a = deceleration, ft/sec^2

g = acceleration due to gravity = 32.2 ft/sec^2

Approximately 90% drivers decelerate at rates greater than 11.2 ft/S^2

Stopping Sight Distance (SSD)

- **Stopping Sight Distance – Level Terrain**

$$SSD = 1.47 * V * t + 1.075 \frac{V^2}{a}$$

- **Stopping Sight Distance – On Grades**

$$SSD = 1.47 * Vi * t + \frac{Vi^2 - Vf^2}{30(F \pm 0.01G)}$$

SSD – Variation for Trucks

- **The recommended stopping sight distances are based on passenger car operation and do not explicitly consider design for truck operation**
- Trucks need longer stopping distances for a given speed than passenger vehicles
- One factor that tends to balance the additional braking lengths for trucks with those for passenger cars - **truck driver's ability to see substantially farther beyond vertical sight obstructions because of the higher position of the seat in the vehicle**
- **Separate stopping sight distances for trucks and passenger cars, therefore, are not generally used in highway design**

SSD Example-1

- A motorist traveling at 65 mi/h on an expressway intends to leave the expressway using an exit ramp with a maximum speed of 35 mi/h. At what point on the expressway should the motorist step on her brakes in order to reduce her speed to the maximum allowable on the ramp just before entering the ramp, if this section of the expressway has a downgrade of 3%?

SSD Example-2

- Use basic assumptions to determine SSD at 60 mph on

a) 0% grade, b) 3% grade

Passing Sight Distance – Two-lane Highways

Passing Sight Distance (PSD)

The passing sight distance is the minimum sight distance required on a two-lane, two way highway that will permit a driver to complete a passing maneuver without colliding with an opposing vehicle and without cutting off the passed vehicle

Passing Sight Distance – Two-lane Highways

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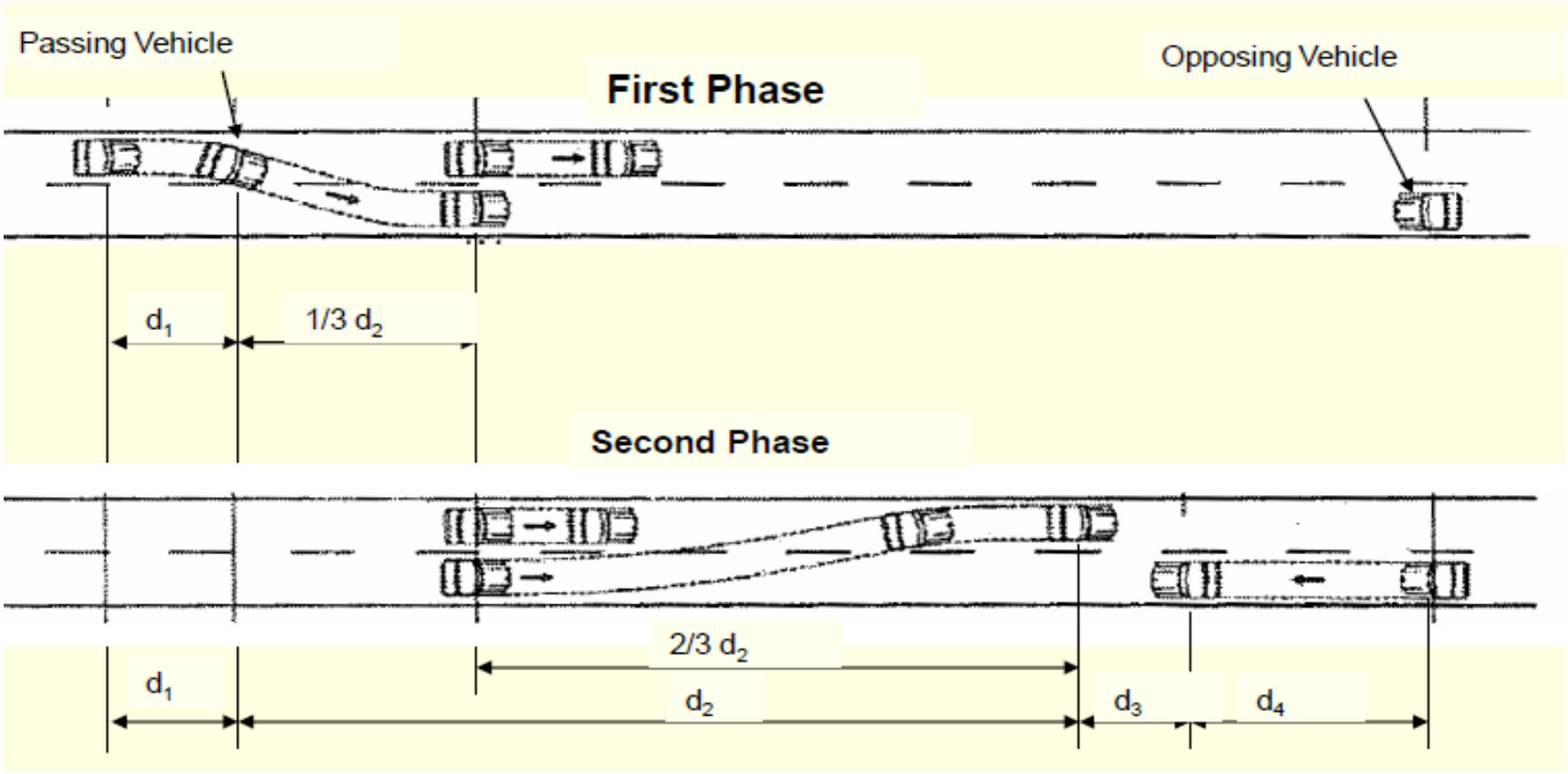
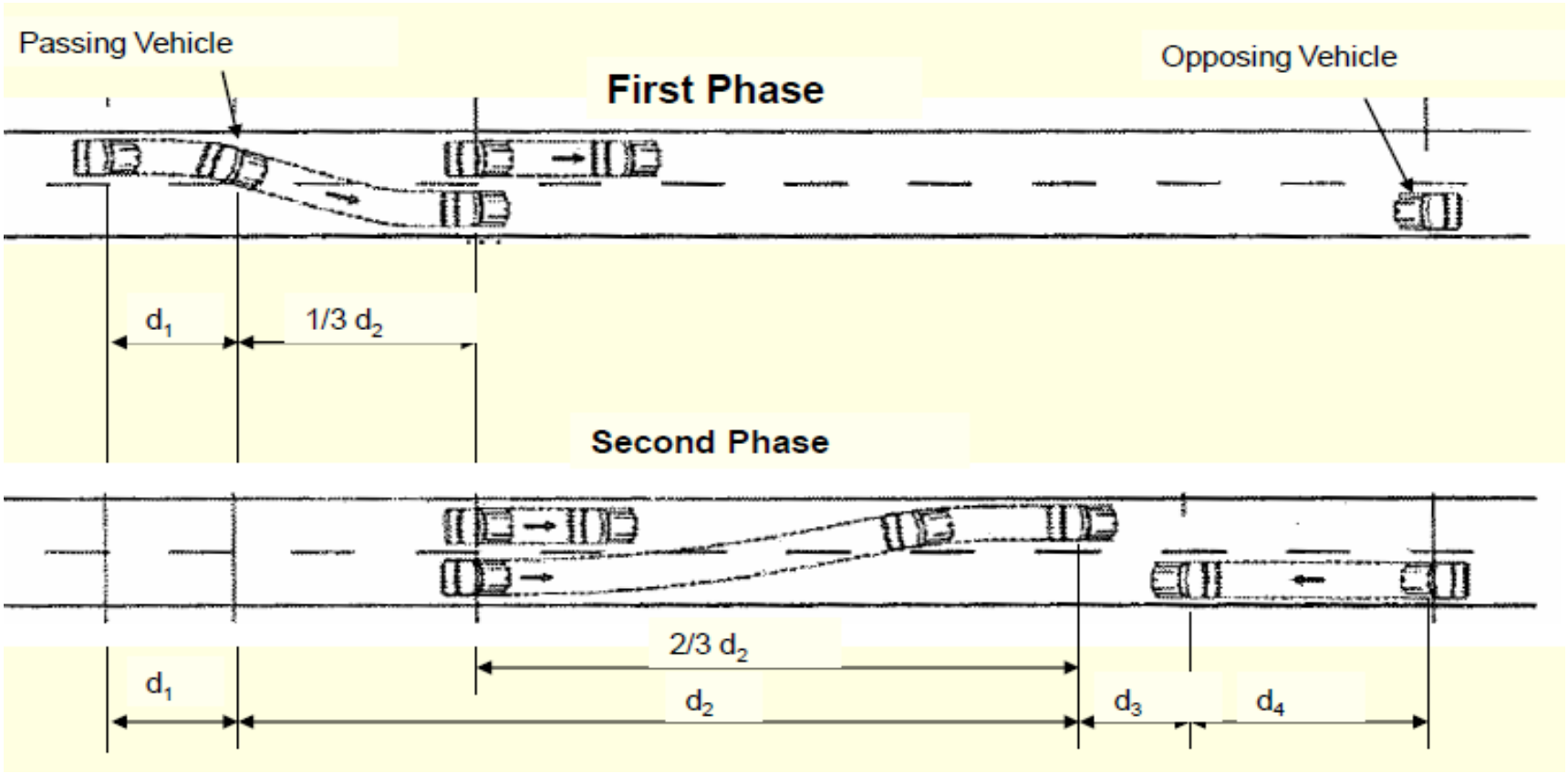


- d(1) = distance traversed during perception and reaction time and during the initial acceleration to the point of encroachment on the right lane
- d(2) = distance traveled while the passing vehicle occupies the right lane

Passing Sight Distance – Two-lane Highways



- **d(3) = distance between the passing vehicle at the end of its maneuver and the opposing vehicle**
- **d(4) = distance traversed by the opposing vehicle for two-thirds of the time the passing vehicle occupies the right lane**

Passing Sight Distance – Two-lane Highways

- $D_{passing} = d_1 + d_2 + d_3 + d_4$

$$d_1 = 1.47 t_1 \left(S - m + \frac{a t_1}{2} \right)$$

d_1 = Distance traveled during P/R time to point where vehicle just enters the right lane

where

t_1 = reaction time, (sec)

S = speed of passing vehicle (mph)

a = acceleration of passing vehicle (mph/s)

m = difference between speeds of passing and passed vehicle

Passing Sight Distance – Two-lane Highways

$$d_2 = 1.47St_2$$

d_2 = distance traveled by vehicle while in right lane

t_2 = time passing vehicle occupies the right lane, (sec)

S = speed of passing vehicle (mph)

d_3 = clearance distance varies from 100 to 300 feet

d_4 = distance traveled by opposing vehicle during passing maneuver

Decision Sight Distance

- SSD are sufficient to allow reasonably competent and alert drivers to come to a hurried stop under ordinary circumstances
- May be inadequate when drivers must make complex or instantaneous decisions, when information is difficult to perceive or when unexpected or unusual maneuvers are required

Decision Sight Distance

- **Decision Sight Distance** is the distance required for a driver to detect an **unexpected or otherwise difficult-to perceive information source** or hazard in a roadway environment that may be **visually cluttered**, recognize the hazard or its potential threat, select an appropriate speed and path, and initiate and complete the required safety maneuver safely and efficiently

Decision Sight Distance

- **AASHTO recommends that decision sight distance be provided :**

- At interchanges or intersection locations where unusual or unexpected maneuvers are required;
- Changes in cross-section such as lane drops and additions, toll plazas, and intense-demand areas where there is substantial “visual noise” from competing information (e.g., control devices, advertising, roadway elements).


Q
A
Answer