

**PRAIRIE VIEW A&M UNIVERSITY  
ROY G. PERRY COLLEGE OF ENGINEERING  
DEPARTMENT OF CIVIL & ENVIRONMENTAL ENGINEERING  
3302 TRANSPORTATION ENGINEERING  
SPRING 2022**

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    - Average (Graded original work)**
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**One or Two Page Course Description  
in ABET Format**



**Department of Civil & Environmental Engineering**

**CVEG 3302 – Transportation Engineering**

|                                               |                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|-----------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>CREDIT HOURS</b>                           | 3                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>CONTACT HOURS</b>                          | 5                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>INSTRUCTOR/<br/>COURSE<br/>COORDINATOR</b> | Dr. Kai-Wei Liu, Civil Engineering                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>TEXTBOOK</b>                               | Nicholas J. Garber and Lester A. Hoel, <i>Traffic and Highway Engineering</i> , 5 <sup>th</sup> Edition, Cengage Learning, 2015.                                                                                                                                                                                                                                                                                                         |
| <b>SUPPLEMENTAL<br/>MATERIALS</b>             | Class handouts and representative problems from various sources                                                                                                                                                                                                                                                                                                                                                                          |
| <b>CATALOG<br/>DESCRIPTION</b>                | Principles of transportation engineering. Topics includes basic concepts in the planning, operation, management, and design of air, surface, and water transportation modal facilities; an introduction into the major aspects of regulatory requirements and economics related to transportation issues; and laboratory sessions in the various sub-areas of transportation engineering.                                                |
| <b>PREREQUISITES</b>                          | CHEG 2003 [Economic Analysis and Technical Applications], CVEG 2081 [Survey and Geospatial Concepts], and COMM 1003 [Fundamentals of Speech Communication]                                                                                                                                                                                                                                                                               |
| <b>CO-REQUISITES</b>                          | MATH 2043 [Differential Equations I]                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>DESIGNATION</b>                            | Required                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>COURSE<br/>LEARNING<br/>OUTCOMES/GOALS</b> | (3) ability to communicate effectively with a range of audiences                                                                                                                                                                                                                                                                                                                                                                         |
| <b>TOPICS COVERED</b>                         | <b>I.</b> Introduction<br><b>II.</b> Transportation Systems and Organizations<br><b>III.</b> Traffic Operations<br><b>IV.</b> Geometric Design of Highways<br><b>V.</b> Highway Surveys and Location<br><b>VI.</b> Capacity and Level of Service<br><b>VII.</b> Traffic Engineering<br><b>VIII.</b> Highway Safety<br><b>IX.</b> Traffic Flow<br><b>X.</b> Intersection Design and Control<br><b>XI.</b> Introduction to Pavement Design |

## II ASSESSMENT RESULTS FOR CURRENT ASSESSMENT PERIOD

### Program New ABET Outcomes Assessed in this course

**Outcome 3:** Develop the ability to communicate effectively with a range of audiences

### Assessment Summary of Class Semester Averages for Outcomes: Spring 2022

| Outcomes         | 3                                                                                                                                                                              |
|------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Semester         | Semester Class Average (%)*                                                                                                                                                    |
| Spring 2022      | 79                                                                                                                                                                             |
| Spring 2021      | 85                                                                                                                                                                             |
| Spring 2020      | 74                                                                                                                                                                             |
| Comments on Data | Most students' assignments maintained significant improvement over the semester with the use of course guidelines. However, some students response to the guideline were slow. |

\*Expected Class Average = 70%

# End of Semester Course Assessment Reports Spring 2022

Each summary contains the following Information

## 1. Performance Statistics

- Total number of students in class
- The class average performance (**stated as %**) in each course outcome assessed in this class.
- The acceptable class average for the class in each outcome area as set by your Department.
- Percentage of students who scored below the expected average in each outcome.

## 2. Implementation Summary

- Brief summary of plans implemented during the semester based on last assessment report

## 3. Perceived Problems

- Instructor's **critical evaluation** of perceived problems that affected students' performance. **Realistic problems should be identified throughout the semester and summarized in this section of the report.**

## 4. New Plans for Addressing Problems

- Instructor's plans for addressing the perceived problems the next time the class is taught. **These should be specific enough for another instructor to implement. Most of these should be things that, you, the instructor can implement to help students to improve.**

## 5. Overall Trend over last three assessment periods

- Instructors summary of overall performance trend for each outcome measured over the last three periods.

## 6. Were Expectations Met?

- Answer **YES** if the **class average was above the expected average** and the **stated percentage of students** scored at or above the expected average, else answer NO.

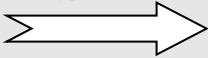
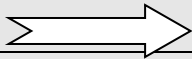
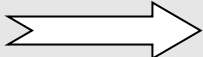
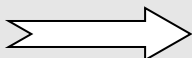
# END OF SEMESTER COURSE OUTCOME ASSESSMENT REPORT

## CVEG 3303-TRANSPORTATION ENGINEERING

### SPRING 2022

**Report Prepared by: Dr. Kai-Wei Liu**

**Report Date: May 20, 2022**

| Semester                             | Analysis Type                                                                                                                                                         | Number of Students                                                                                                                                                                                                                                                                                                                                                                                                                                                               | <b>Outcome 3</b><br>Ability to communicate effectively with a range of audiences |                                                  |               |                                     |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------|---------------|-------------------------------------|
|                                      |                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | Expected Class Average                                                           | Expected Percent of students at or above average | Class Average | % Students meeting Expected Average |
| Spring 2022                          | Direct                                                                                                                                                                | 13*                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 70                                                                               | 70                                               | 79            | 100                                 |
| Spring 2021                          | Direct                                                                                                                                                                | 11*                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 70                                                                               | 70                                               | 85            | 100                                 |
| Spring 2020                          | Direct                                                                                                                                                                | 15*                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | 70                                                                               | 70                                               | 74            | 80                                  |
| <b>Implementation Summary</b>        | Items implemented from previous report or after meeting previous instructor<br>      | The reports along with a formal set of instruction and the classroom lecture have continued to allow students to do well                                                                                                                                                                                                                                                                                                                                                         |                                                                                  |                                                  |               |                                     |
| <b>Perceived Problems</b>            | Perceived problems are directly related to the PC and the sub items under them<br> | There were some lab report scores from students who did not show any improvement during the semester. Some students tend to work on the reports on the due date and make serious mistakes or mix concepts up. Lack of responsibility possibly played a role for some students                                                                                                                                                                                                    |                                                                                  |                                                  |               |                                     |
| <b>Plans for Addressing Problems</b> | Plans for address specific measures to address PC and their sub areas<br>          | The following is recommended for implementation:<br><br>Continue to encourage students to write reports as teamwork. Continue to follow the college guidelines for report preparation with necessary adjustments to fit the lab/field experiments. It might be benefitted to break down the activities into two categories (i.e., learning and developing technical skills, and increasing conceptual knowledge) so that students can gain positive attitudes toward engineering |                                                                                  |                                                  |               |                                     |
| <b>Overall Trend over Periods</b>    | Ascertain if there were improvements over previous semesters<br>                   | Most students' assignments maintained significant improvement over the semester with the use of course guidelines. However, some students response to the guideline were slow.                                                                                                                                                                                                                                                                                                   |                                                                                  |                                                  |               |                                     |
| <b>Were Expectations Met?</b>        |                                                                                                                                                                       | <b>YES</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |                                                                                  |                                                  |               |                                     |

\*Number of students who completed the course

# **TRANSPORTATION ENGINEERING SPRING 2022**

**Title of Assignment: TEST 1**

## **TOPICS COVERED IN TEST 1**

**Test 1 covered the following topics:**

1. Transportation Systems and Organizations
2. Traffic Operations
3. Geometric Design of Highways

**ENGR 3302 – Transportation Engineering**

Mid-term Exam #1

Spring 2022

Total score = 100 pts

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**Academic Integrity**

University students are expected to conduct themselves in accordance with the highest standards of academic honesty. Academic misconduct for which a student is subject to penalty includes all forms of cheating, such as illicit possession of examinations or examination materials, falsification, forgery, complicity or plagiarism. (Plagiarism is the presentation of the work of another as one's own work.) In this class, academic misconduct or complicity in an act of academic misconduct on an assignment or test will result in a failing grade.

I understand that I am bound by the Academic Integrity, specifically for this exam the provisions under Academic Misconduct, Cheating: Intentionally using or attempting to use unauthorized materials, information, notes, study aids or other devices or materials in any academic exercise.

If I violate the Academic Integrity, I understand that I could be subject to any of the Academic Integrity Sanctions provided in accordance with the Honor System Process. These sanctions include academic and educational sanctions as well as expulsion, dismissal, or suspension, and other additional consequences.

I have read the above statement and understand its contents:

Print Name: \_\_\_\_\_ Signature: \_\_\_\_\_

## **INSTRUCTIONS:**

1. Follow directions on each question to the best of your knowledge.
2. Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized and complete).
3. Answer question in space if provided otherwise box your answer.
4. If space is short to work out an answer, then you may continue work on back side or another sheet if needed. Properly label the problem and include a comment on the original question as to inform instructor (i.e. continued on back).
5. If any material other than described above is found in your possession, it could merit exam removal and/or further penalties. This includes looking at someone's exam even for a second or any other form of cheating.
6. Raise hand for any question or inquiry. If instructor is distracted call him, but do not stand.

## True or False

- 1.(10 pts) Color combinations of “black and white” or “black and yellow” are used on roadways because they have been shown to be those to which the eye is most sensitive.
- 2.(10 pts) The three types of vehicle characteristics are static, kinematic, and dynamic. Static characteristics involve the forces that causes the motion of the vehicle.
- 3.(10 pts) Typical cross section for multilane highways consists of travel lanes, shoulders, and medians.

## Multiple Choice (only one correct answer)

- 1.(10 pts) What is the distance between Station 156+21 and 268+74?
  - a.112.53 ft
  - b.11253 ft
  - c.42495 ft
  - d.424.95 ft
- 2.(10 pts) Which of the following is NOT true?
  - a.The width of travel lanes of 9 ft is only for very low volume urban roadways with narrow right-of-way
  - b.Shoulders provide area for vehicles to stop when necessary.
  - c.Medians can be used to separate opposing lanes and provide recovery area for vehicles
  - d.The actual traveling distance of a vehicle before coming to rest is the distance traveled during the braking maneuver
- 3.(10 pts) The design of vertical alignment, sight distance and grades are worst affected by
  - a.Width of the vehicle
  - b.Length of the vehicle
  - c.Speed of the vehicle
  - d.Height of the vehicle



## Calculation

- 1.(10 pts) The gap between two consecutive automobiles (distance between the back of a vehicle and the front of the following vehicle) is 50 ft. At a certain time, the front vehicle is traveling at 60 ft/s and the following vehicle at 44 ft/s. If both vehicles start accelerating at the same time, determine the gap between the two vehicles after 10 sec if the acceleration of the vehicles can be assumed to take the following forms:  $du/dt = 3.4 - 0.075u$  (leading vehicle);  $du/dt = 3.3 - 0.065u$  (following vehicle)
- 2.(10 pts) A toll bridge carries 500 veh/day. The current toll is 50 cents. When the toll is increased by 50 cents, traffic volume decreases by 500 veh/day. Determine the amount of toll that should be charged such that revenue is maximized. How much additional revenue will be received?
- 3.(10 pts) The design speed of a multilane highway is 70 mi/h. Determine the minimum stopping sight distance that should be provided for a roadway with a maximum grade of 5 percent. Note: the term  $a/g$  in the appropriate equation is typically rounded to 0.35 for calculation purposes. Assume perception reaction time = 2.5 sec.
- 4.(10 pts) A car is traveling up a 1.25% grade of a crest curve with a design speed of 40 mph. The descending grade is -2.75%. What is the required length of curve for a stopping sight distance of 305 ft?

**ABOVE AVERAGE**

ENGR 3302 – Transportation Engineering

Mid-term Exam #1      Spring 2022      Total score = 100 pts

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I have read the above statement and understand its contents:

Print Name: Sophie Tulke      Signature: 

**INSTRUCTIONS:**

1. Follow directions on each question to the best of your knowledge.
2. Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized and complete).
3. Answer question in space if provided otherwise box your answer.
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6. Raise hand for any question or inquiry. If instructor is distracted call him, but do not stand.

97.5

### True or False

1. (10 pts) Color combinations of "black and white" or "black and yellow" are used on roadways because they have been shown to be those to which the eye is most sensitive. True
2. (10 pts) The three types of vehicle characteristics are static, kinematic, and dynamic. Static characteristics involve the forces that causes the motion of the vehicle. False ^ kinematic
3. (10 pts) Typical cross section for multilane highways consists of travel lanes, shoulders, and medians. True

### Multiple Choice (only one correct answer)

1. (10 pts) What is the distance between Station 156+21 and 268+74?  
 a. 112.53 ft  
 b. 11253 ft 156 + 21 = 156 x 100 + 21 ft  
 c. 42495 ft 156 + 21 = 15621 ft  
 d. 424.95 ft 268 + 74 = 268 x 100 + 74 = 26874 ft  
 $\frac{26874}{15621} = 11253_{ft}$
2. (10 pts) Which of the following is NOT true?  
 a. The width of travel lanes of 9 ft is only for very low volume urban roadways with narrow right-of-way ✓  
 b. Shoulders provide area for vehicles to stop when necessary. ✓  
 c. Medians can be used to separate opposing lanes and provide recovery area for vehicles ✓  
 d. The actual traveling distance of a vehicle before coming to rest is the distance traveled during the braking maneuver
3. (10 pts) The design of vertical alignment, sight distance and grades are worst affected by  
 a. Width of the vehicle  
 b. Length of the vehicle  
 c. Speed of the vehicle  
 d. Height of the vehicle

### Calculation

1. (10 pts) The gap between two consecutive automobiles (distance between the back of a vehicle and the front of the following vehicle) is 50 ft. At a certain time, the front vehicle is traveling at 60 ft/s and the following vehicle at 44 ft/s. If both vehicles start accelerating at the same time, determine the gap between the two vehicles after 10 sec if the acceleration of the vehicles can be assumed to take the following forms:  $du/dt = \underbrace{3.4}_a - \underbrace{0.075u}_\beta$  (leading vehicle);  $du/dt = 3.3 - 0.065u$  (following vehicle)

$$\begin{aligned} \rightarrow x &= \left( \frac{a}{\beta} \right) t - \frac{a}{\beta^2} (1 - e^{-\beta t}) + \frac{u_0}{\beta} (1 - e^{-\beta t}) \\ &= \left( \frac{3.4}{0.075} \right) \times 10 - \left( \frac{3.4}{(0.075)^2} \right) (1 - e^{-(0.075 \times 10)}) + \frac{60 \text{ ft/s}}{0.075} (1 - e^{-(0.075 \times 10)}) \\ &= 453.3 - 318.9 + 422.11 \\ &= \underline{556.51} = \text{distance traveled by leading vehicle} \end{aligned}$$

$$\begin{aligned} \rightarrow \text{vehicle following} &= \left( \frac{3.3}{0.065} \right) \times 10 - \left( \frac{3.3}{(0.065)^2} \right) (1 - e^{-(0.065 \times 10)}) \\ &\quad + \left( \frac{44 \text{ ft/s}}{0.065} \right) (1 - e^{-(0.065 \times 10)}) \\ &= 501.69 - 373.31 + 323.54 = \underline{451.92 \text{ ft}} \end{aligned}$$

$$\rightarrow \text{gap} = 556.51 \text{ ft} - \cancel{451.92 \text{ ft}} = \boxed{98.59 \text{ ft}}$$

~~457.92~~ - 7.5

2. (10 pts) A toll bridge carries 500 veh/day. The current toll is 50 cents. When the toll is increased by 50 cents, traffic volume decreases by 500 veh/day. Determine the amount of toll that should be charged such that revenue is maximized. How much additional revenue will be received?

$x =$  toll increase

$$V = 500 - x / 50 (500)$$

$$T = 50 + x$$

$$\rightarrow R = (V)(T) = (500 - x / 50 (500)) (50 + x) \quad \leftarrow \text{cancel out}$$

$$= (500 - 10x) (50 + x) = 25,000 - 500x + 500x - 10x^2$$

$$\text{max: } L \rightarrow dR/dx = -20x = 0 \rightarrow 80x = 0 \text{ cents}$$

$$\rightarrow \text{toll for max revenue} = 50 + 0 \text{ cents} = \boxed{50 \text{ cents}}$$

$$\rightarrow AR = (V_{\max} \times T_{\max}) - (V_{\text{current}} \times T_{\text{current}})$$

$$= (500 - (0/50)(500)) (0.5) - (500 \times 0.5)$$

$$= 0 - (500 \times 0.5) = 0 - 250 = -\$250, \text{ loss}$$

$$\boxed{50 \quad 0 \text{ additional revenue}}$$

3. (10 pts) The design speed of a multilane highway is 70 mi/h. Determine the minimum stopping sight distance that should be provided for a roadway with a maximum grade of 5 percent. Note: the term  $a/g$  in the appropriate equation is typically rounded to 0.35 for calculation purposes. Assume perception reaction time = 2.5 sec.

$$SSD = 1.47 vt + \frac{v^2}{30 \left( \frac{a}{g} \pm G \right)}$$

$\swarrow 0.05$ 
 $\nearrow 0.35$  given

$$SSD = (1.47) \left( 70 \frac{\text{mi}}{\text{h}} \right) (2.5 \text{ sec}) + \frac{(70)^2 \text{ mi/h}}{30 (0.35 - 0.05)}$$

$$\text{minimum stopping distance} = 257.25 + 544.4 = \boxed{801.69 \text{ ft}}$$

✓



4. (10 pts) A car is traveling up a 1.25% grade of a crest curve with a design speed of 40 mph. The descending grade is -2.75%. What is the required length of curve for a stopping sight distance of 305 ft?

$$\underline{SSD = 305 \text{ ft}}, \quad \underline{n_1 = 1.25}, \quad \underline{n_2 = -2.75}$$

$$\underline{V = 40 \text{ mph}}, \quad \underline{A = 1.25 - (-2.75) = 4\%}$$

$$\text{for } L > S, \quad L_{\min} = \frac{AS^2}{2158} = \frac{(4)(305^2)}{2158} = 172.43 \text{ ft} \quad \times$$

$$\text{for } S > L, \quad L_{\min} = 2S - \frac{2158}{A} = 2(305) - \frac{2158}{4} = \boxed{70.5 \text{ ft}}$$

→ correct, bc  $305 \text{ ft} > 70.5 \text{ ft}$  ✓ ✓

**AVERAGE**

Omar Haou

**ENGR 3302 – Transportation Engineering**

Mid-term Exam #1

Spring 2022

Total score = 100 pts

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I have read the above statement and understand its contents:

Print Name: Omar Haou Signature: 

**INSTRUCTIONS:**

1. Follow directions on each question to the best of your knowledge.
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6. Raise hand for any question or inquiry. If instructor is distracted call him, but do not stand.

74.5

### True or False

1. (10 pts) Color combinations of "black and white" or "black and yellow" are used on roadways because they have been shown to be those to which the eye is most sensitive. *True*
2. (10 pts) The three types of vehicle characteristics are static, kinematic, and dynamic. Static characteristics involve the forces that causes the motion of the vehicle. *False, static is the weight and size of the vehicle.*
3. (10 pts) Typical cross section for multilane highways consists of travel lanes, shoulders, and medians. *True*

### Multiple Choice (only one correct answer)

1. (10 pts) What is the distance between Station 156+21 and 268+74? = 18621  
☒ a. 112.53 ft  
b. 11253 ft  
c. 42495 ft  
d. 424.95 ft  
$$268.74 - 156.21 = 112.53 \text{ ft}$$
$$26874 - 15621 = 11253 \text{ ft}$$
2. (10 pts) Which of the following is NOT true?
  - a. The width of travel lanes of 9 ft is only for very low volume urban roadways with narrow right-of-way
  - b. Shoulders provide area for vehicles to stop when necessary.
  - c. Medians can be used to separate opposing lanes and provide recovery area for vehicles
  - ☒ d. The actual traveling distance of a vehicle before coming to rest is the distance traveled during the braking maneuver
3. (10 pts) The design of vertical alignment, sight distance and grades are worst affected by
  - ☒ a. Width of the vehicle
  - ☒ b. Length of the vehicle
  - ☒ c. Speed of the vehicle
  - ☒ d. Height of the vehicle

Calculation

1. (10 pts) The gap between two consecutive automobiles (distance between the back of a vehicle and the front of the following vehicle) is 50 ft. At a certain time, the front vehicle is traveling at 60 ft/s and the following vehicle at 44 ft/s. If both vehicles start accelerating at the same time, determine the gap between the two vehicles after 10 sec if the acceleration of the vehicles can be assumed to take the following forms:  $du/dt = 3.4 - 0.075u$  (leading vehicle);  $du/dt = 3.3 - 0.065u$  (following vehicle)

distance between is 50 ft

Front = 60 ft/s

back vehicle is = 44 ft/s

① front vehicle:  $u_t = \left( \frac{a}{B} \right) (1 - e^{-Bt}) + u_0 e^{-Bt}$

$(u_t = \left( \frac{3.4}{0.075} \right) (1 - e^{-0.075(10)}) + (60) e^{-0.075(10)})$

$u_t = 45.3(0.5276) + 28.34$

$u_t = 52.26 \text{ ft/sec}$

$a = 3.4(0.075)(52.26)$

$a = 13.3263 \text{ ft/sec}^2$

②  $u_t = \left( \frac{3.3}{0.065} \right) (1 - e^{-0.065(10)}) + 44 e^{-0.065(10)}$

$u_t = 47.24 \text{ ft/sec}$

$a = 3.3 - 0.065(47.24)$

$a = 0.2294 \text{ ft/sec}^2$

$13.3263 - 0.2294$

Difference = 13.0969  $\text{ft/sec}^2$

2. (10 pts) A toll bridge carries 500 veh/day. The current toll is 50 cents. When the toll is increased by 50 cents, traffic volume decreases by 500 veh/day. Determine the amount of toll that should be charged such that revenue is maximized. How much additional revenue will be received? (a)  
(b)

(a)  $T = 50 + x$   
 $R = \left( 500 - 500 \left( \frac{x}{50} \right) \right) \times (50 + x)$   
 $(500 - 10x) \cdot (50 + x)$   
 $\frac{dR}{dx} 25000 + 500x - 500x - 10x^2$   
 $\frac{dR}{dx} 25000 - 10x^2$   
 $= -20x = 0$   
 $\boxed{x = 0}$  ✓

(b)  $V = 500 - 500 \left( \frac{x}{50} \right)$   
 $V = 500 - 500 \left( \frac{0}{50} \right)$  -2x  
 $V = 500$  vehicles per day  
 $R = V \times T$   
 $R = 500 \times (50 + 0)$   
 $\boxed{R = \$25000}$  per day  
x

3. (10 pts) The design speed of a multilane highway is 70 mi/h. Determine the minimum stopping sight distance that should be provided for a roadway with a maximum grade of 5 percent. Note: the term  $a/g$  in the appropriate equation is typically rounded to 0.35 for calculation purposes. Assume perception reaction time = 2.5 sec.

$$v = 60 \text{ mi/h}$$

$$\text{max grade} = 5\%$$

$$t = 2.5 \text{ sec}$$

$$S = 1.47vt + \frac{v^2}{30\left(\frac{a}{g} \pm G\right)}$$

$$G = \frac{5}{100} = 0.05$$

$$S = (1.47)(70)(2.5) + \frac{70^2}{30(0.35 - 0.05)}$$

$$S = 801.694 \text{ feet}$$



20

S < L  
S > L

- \* 4. (10 pts) A car is traveling up a 1.25% grade of a crest curve with a design speed of 40 mph. The descending grade is -2.75%. What is the required length of curve for a stopping sight distance of 305 ft?

\* 300.6 ft

$$v = 40 \text{ mph}$$

$$SSD = 1.47v \cdot t + \frac{v^2}{30 \left( \frac{a}{32.2} - G \right)}$$

The length of  
the curve is  
300.6 ft.

$$G = G_{\text{rad}}$$

$$1.47(40) \cdot t$$

-8

**BELOW AVERAGE**

ENGR 3302 – Transportation Engineering

Mid-term Exam #1      Spring 2022      Total score = 100 pts

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Print Name: Tyrach Owens      Signature: 

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65

### True or False

1. (10 pts) Color combinations of "black and white" or "black and yellow" are used on roadways because they have been shown to be those to which the eye is most sensitive. True
2. (10 pts) The three types of vehicle characteristics are static, kinematic, and dynamic. Static characteristics involve the forces that causes the motion of the vehicle. True
3. (10 pts) Typical cross section for multilane highways consists of travel lanes, shoulders, and medians. True

### Multiple Choice (only one correct answer)

1. (10 pts) What is the distance between Station 156+21 and 268+74?  
a. 112.53 ft  
b. 11253 ft  
c. 42495 ft  
d. 424.95 ft  
15621 26874
2. (10 pts) Which of the following is NOT true?  
a. The width of travel lanes of 9 ft is only for very low volume urban roadways with narrow right-of-way  
b. Shoulders provide area for vehicles to stop when necessary.  
c. Medians can be used to separate opposing lanes and provide recovery area for vehicles  
d. The actual traveling distance of a vehicle before coming to rest is the distance traveled during the braking maneuver
3. (10 pts) The design of vertical alignment, sight distance and grades are worst affected by  
a. Width of the vehicle  
b. Length of the vehicle  
c. Speed of the vehicle  
d. Height of the vehicle

### Calculation

1. (10 pts) The gap between two consecutive automobiles (distance between the back of a vehicle and the front of the following vehicle) is 50 ft. At a certain time, the front vehicle is traveling at 60 ft/s and the following vehicle at 44 ft/s. If both vehicles start accelerating at the same time, determine the gap between the two vehicles after 10 sec if the acceleration of the vehicles can be assumed to take the following forms:  $du/dt = 3.4 - 0.075u$  (leading vehicle);  $du/dt = 3.3 - 0.065u$  (following vehicle)

$$u_t = (3.4 / 0.075)(1 - e^{(-0.075)(10)}) + 30e^{(-0.075)(10)}$$

$$u_t = 646.3 \text{ ft/s}$$

$$a = du/dt = 3.4 - 0.075u$$

$$= 3.4 - 0.075(646.3)$$

$$= -46.6$$

$$u_t = (3.3 / 0.065)(1 - e^{(-0.065)(10)}) + 30e^{(-0.065)(10)}$$

$$= 819.4$$

$$3.3 - 0.065(819.4)$$

$$= -49.961$$

$$-46.6 - 49.961$$

$$= 3.361 \text{ ft/s}^2$$

$$x = \frac{\alpha}{\beta} t - \frac{\alpha}{\beta^2} (1 - e^{-\beta t}) + \frac{u_0}{\beta} (1 - e^{-\beta t})$$

$$\alpha = 3.4$$

$$\beta = 0.075$$

2. (10 pts) A toll bridge carries 500 veh/day. The current toll is 50 cents. When the toll is increased by 50 cents, traffic volume decreases by 500 veh/day. Determine the amount of toll that should be charged such that revenue is maximized. How much additional revenue will be received?

a)

$$V = 500 - x/50 (500)$$

$$T = 50 + x$$

$$R = [500 - x/50 (500)] (50 + x)$$

$$= 25000 - 10x^2$$

$$\frac{dR}{dx} = 25000 - 20x = 0$$

$$-20x = -25000$$

$$x = 1250$$

b)

$$\Delta R = (V_{max})(T_{max}) - (V_{current})(T_{current})$$

$$= [(500 - (50/50)(500))(2) - (500)(50)]$$

$$= -24000$$

~~\$~~  
-5

3. (10 pts) The design speed of a multilane highway is 70 mi/h. Determine the minimum stopping sight distance that should be provided for a roadway with a maximum grade of 5 percent. Note: the term  $a/g$  in the appropriate equation is typically rounded to 0.35 for calculation purposes. Assume perception reaction time = 2.5 sec.

$$S = 1.47u + \frac{u^2}{30\left(\frac{a}{g} + G\right)}$$

$$S = (1.47)(70)(2.5) + \frac{(70)^2}{30(0.35 - 0.05)}$$

$$S = 306.25 \text{ ft} \quad \times$$

-2/5



4. (10 pts) A car is traveling up a 1.25% grade of a crest curve with a design speed of 40 mph. The descending grade is ~~2~~ 2.75%. What is the required length of curve for a stopping sight distance of 305 ft?

$$A = 0.04 \quad \text{No percent for this equation}$$

$$L_{\min} = \frac{AS^2}{2158} \quad \text{For } S < L = \frac{0.04(305)^2}{2158}$$

$$= 1.72 \text{ ft} \quad \times$$

-2/5

# **TRANSPORTATION ENGINEERING SPRING 2022**

**Title of Assignment: TEST 2**

## **TOPICS COVERED IN TEST 2**

**Test 2 covered the following topics:**

1. Highway Surveys and Location
2. Capacity and Level of Service
3. Traffic Engineering
4. Highway Safety
5. Traffic Flow

ENGR 3302 – Transportation Engineering

Mid-term Exam #2      Spring 2022      Total score = 100 pts

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I have read the above statement and understand its contents:

Print Name: \_\_\_\_\_ Signature: \_\_\_\_\_

## **INSTRUCTIONS:**

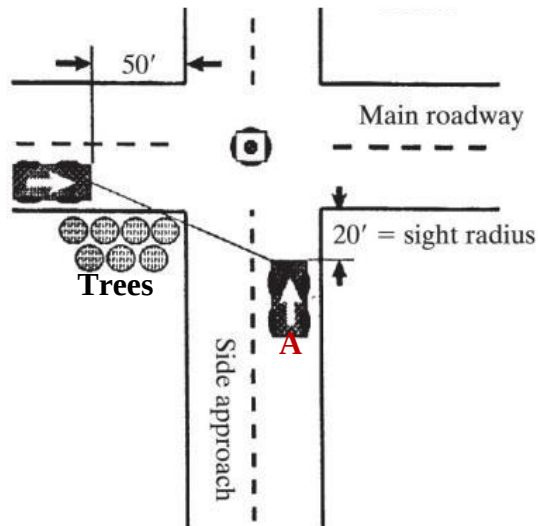
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## True or False

- 1.(10 pts) Vertical curves are parabolic and horizontal curves are circular.
- 2.(10 pts) Level of service (LOS) describes the operating conditions within a traffic stream using density as the quantitative variable and an alphabetic grading system ranging from A to F. At LOS A, breakdown conditions exist and uniform moving flow cannot be maintained.
- 3.(10 pts) In general, there are more steps involved in determining level of service and capacity of two-lane highway than multilane highways.
- 4.(10 pts) The most commonly used format to present and analyze spot speed data is the frequency distribution table.

## Multiple Choice (only one correct answer)

- 1.(10 pts) Which of the following is the most effective way to increase sight radius for the vehicle A?

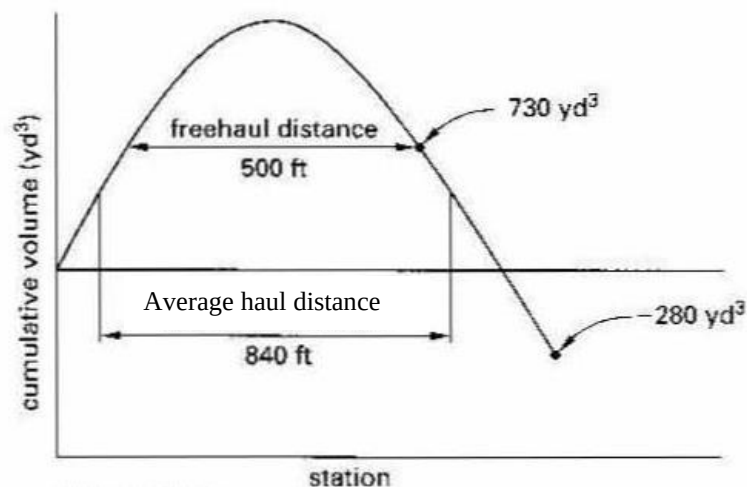


- a. Reduce speed limit
  - b. Increase speed limit
  - c. Remove trees
  - d. Reduce the height of trees
- 2.(10 pts) Which of the following is NOT true?
    - a. Surveying techniques can be split into three categories: ground surveys, remote sensing, and computer graphics
    - b. A crash modification factor is used to compute the expected number of crashes after implementing a safety design on a road or intersection.

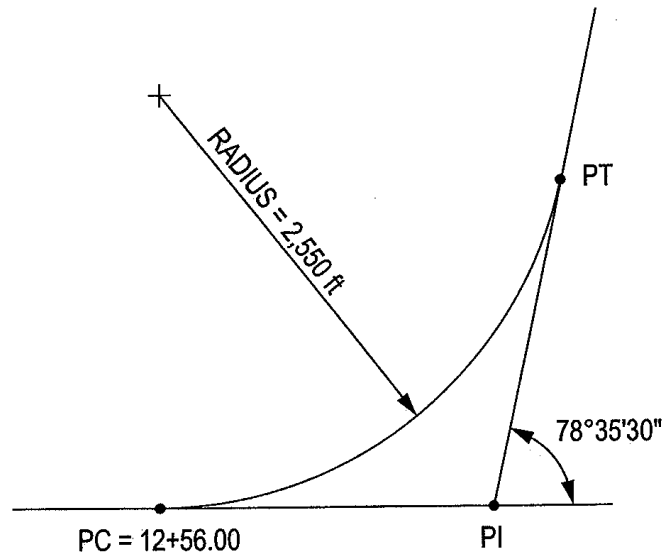
- c. One of the presentation and analysis of traffic volume is graphical intersection summaries. The traffic volume on each route is represented by the width of a band.
- d. The capacity and level of service for multilane highways can be analyzed by applying the procedures developed for basic highway segments.
- 3.(10 pts) A crash modified factor cannot be modified by changing
- access point density
  - the width of lane
  - radius of curvature of roadway curves
  - none of the above

### Calculation

- 1.(10 pts) A highway under construction requires fill and cut based on the ground profile. The following mass diagram indicates the net accumulation of cut and fill between two stations. The maximum distance for which there are no additional hauling charge is 500 ft. The overhaul unit cost is \$9.75 per  $\text{yd}^3$  per station. What is the overhaul cost for the two stations shown?



2.(10 pts) Referring to the horizontal curve shown in the figure below, what is the station of the PI?



3.(10 pts) The speeds in miles per hour, tabulated below were observed with a radar gun. What is the space-mean speed in miles per hour?

60 56 47 48 50

55 51 54 43 38

**ABOVE AVERAGE**



**ENGR 3302 – Transportation Engineering**

Mid-term Exam #2      Spring 2022      Total score = 100 pts

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Print Name: Allyssa Reynolds      Signature: 

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1. Follow directions on each question to the best of your knowledge.
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### True or False

1. (10 pts) Vertical curves are parabolic and horizontal curves are circular. 100

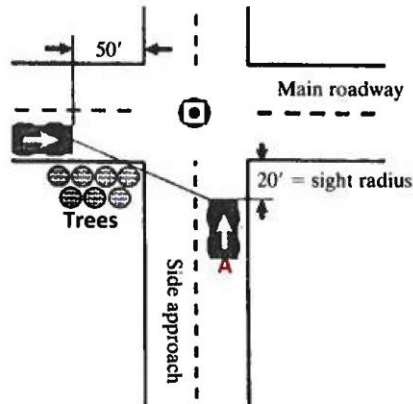
2. (10 pts) Level of service (LOS) describes the operating conditions within a traffic stream using density as the quantitative variable and an alphabetic grading system ranging from A to F. At LOS A, breakdown conditions exist and uniform moving flow cannot be maintained. LOS F

3. (10 pts) In general, there are more steps involved in determining level of service and capacity of two-lane highway than multilane highways. 6 steps

4. (10 pts) The most commonly used format to present and analyze spot speed data is the frequency distribution table. TRUE

### Multiple Choice (only one correct answer)

1. (10 pts) Which of the following is the most effective way to increase sight radius for the vehicle A?



- a. Reduce speed limit
- b. Increase speed limit
- ☒ c. Remove trees
- d. Reduce the height of trees

2. (10 pts) Which of the following is NOT true?

- ☒ a. Surveying techniques can be split into three categories: ground surveys, remote sensing, and computer graphics
- ☒ b. A crash modification factor is used to compute the expected number of crashes after implementing a safety design on a road or intersection.
- ☒ c. One of the presentation and analysis of traffic volume is graphical intersection summaries. The traffic volume on each route is represented by the width of a band.

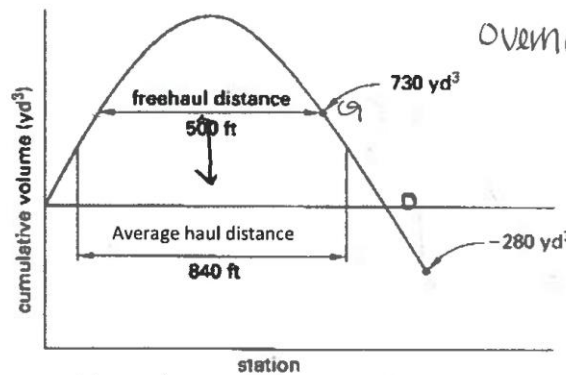
☒ The capacity and level of service for multilane highways can be analyzed by applying the procedures developed for basic highway segments.

3. (10 pts) A crash modified factor cannot be modified by changing

- ☒ access point density
- ☒ the width of lane
- ☒ radius of curvature of roadway curves
- ☐ none of the above

### Calculation

1. (10 pts) A highway under construction requires fill and cut based on the ground profile. The following mass diagram indicates the net accumulation of cut and fill between two stations. The maximum distance for which there are no additional hauling charge is 500 ft. The overhaul unit cost is \$9.75 per yd<sup>3</sup> per station. What is the overhaul cost for the two stations shown?



$$\text{overhaul } \# = \frac{\text{distance}}{100}$$

$$1 \text{ yd} = 3 \text{ ft}$$

$$1 \text{ yd}^3 = 27 \text{ ft}^3$$

$$\# = \frac{1}{2} \ln \left( \frac{\text{area}}{\text{width}} \right)$$

$$= (730 - 280) = 450 \text{ yd}^3$$

Station 1

overhaul

overhaul  $\#$  (avg. haul distance - freehaul distance)

$$= (730 \text{ yd}^3) (840' - 500') \left( \frac{1 \text{ yd}^3}{27 \text{ ft}^3} \right) \times \frac{\$}{\text{yd}^3 \times \text{sta.}} \times \frac{1 \text{ station}}{100 \text{ ft}}$$

$$= 2148,200 \text{ yd}^3 \times \text{ft}$$

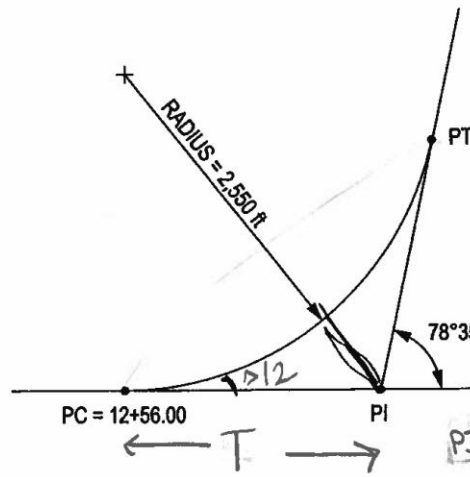
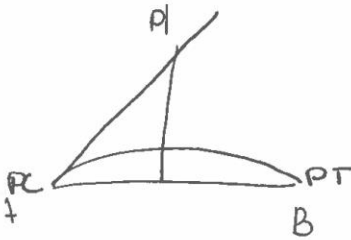
Cost =

$$\frac{\$ 9.75}{\text{yd}^3 \cdot \text{station}} \times 730 \text{ yd}^3 \times \frac{(840' - 500')}{100 \text{ ft}} \cdot \text{station} = \$ 24,199.50$$

$$340/100 = 3.4 \text{ station}$$

(eq. can be used / only requires given info.)

2. (10 pts) Referring to the horizontal curve shown in the figure below, what is the station of the PI?



Find distance between PC & PI.

$$PI = PC + \text{distance}$$

$$R = 2550 \text{ ft}$$

$$L = R(\Delta)(\pi/180)$$

$$= 2550 (78^\circ 35' 30'') (\frac{\pi}{180})$$

$$= 3497.8 \text{ ft}$$

$$PI = \frac{1}{2}(PC - PT)$$

$$= \frac{1}{2}(L)$$

$$= 1748.9 \text{ ft}$$

$$PI = 1256 \text{ ft} + 1748.9 = 3004.9 \text{ ft}$$

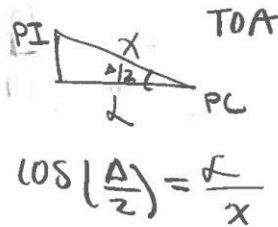
$$= 30+04.9 \text{ sta}$$

$$PI = 1256 + 1748.98$$

$$= 2870.97$$

$$= 28+70.97 \text{ sta}$$

SOH CAH

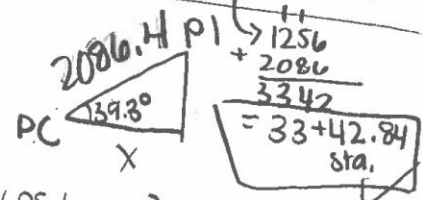


$$\cos(\frac{\Delta}{2}) = \frac{L}{X}$$

$$T = R \tan \frac{\Delta}{2}$$

$$= 2550 \tan(\frac{78.6}{2})$$

$$= 2086.94$$

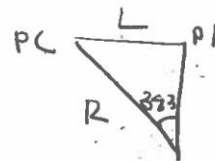


$$\cos(39.3) = \frac{X}{2086.4}$$

$$= 1614.54 \text{ ft}$$

$$\sin(39.3) = \frac{L}{2550}$$

$$L = 1973.3$$



3. (10 pts) The speeds in miles per hour, tabulated below were observed with a radar gun. What is the space-mean speed in miles per hour? Find equation + plot # into eq.

60 56 47 48 50

55 51 54 43 38

$$\begin{aligned}
 \bar{u}_s &= \frac{\# \text{ vehicles}}{\sum \left( \frac{1}{\text{speed}} \right)} \\
 &= \frac{10 \text{ ven}}{\left( \frac{1}{60} \right) + \left( \frac{1}{56} \right) + \frac{1}{47} + \frac{1}{48} + \frac{1}{50} + \frac{1}{55} + \frac{1}{51} + \frac{1}{54} + \frac{1}{43} + \frac{1}{38}} \\
 &= \frac{10 \text{ ven}}{0.203} \\
 &= 49.38 \text{ mph}
 \end{aligned}$$

**AVERAGE**

**ENGR 3302 – Transportation Engineering**

Mid-term Exam #2      Spring 2022      Total score = 100 pts

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I have read the above statement and understand its contents:

Print Name: Daniel Grant      Signature: 



**INSTRUCTIONS:**

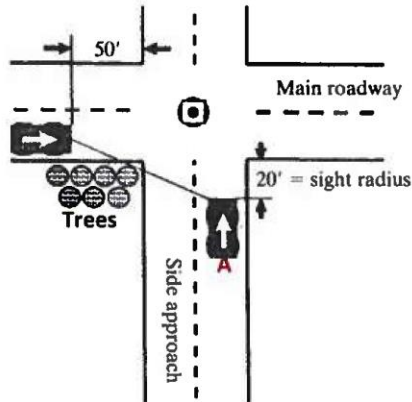
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### True or False

1. (10 pts) Vertical curves are parabolic and horizontal curves are circular. *True*
2. (10 pts) Level of service (LOS) describes the operating conditions within a traffic stream using density as the quantitative variable and an alphabetic grading system ranging from A to F. At LOS A, breakdown conditions exist and uniform moving flow cannot be maintained. *False*
3. (10 pts) In general, there are more steps involved in determining level of service and capacity of two-lane highway than multilane highways. *True*
4. (10 pts) The most commonly used format to present and analyze spot speed data is the frequency distribution table. *True*

### Multiple Choice (only one correct answer)

1. (10 pts) Which of the following is the most effective way to increase sight radius for the vehicle A?



- a. Reduce speed limit
  - b. Increase speed limit
  - ☒ c. Remove trees
  - d. Reduce the height of trees
2. (10 pts) Which of the following is NOT true?
  - ☒ a. Surveying techniques can be split into three categories: ground surveys, remote sensing, and computer graphics
  - ☒ b. A crash modification factor is used to compute the expected number of crashes after implementing a safety design on a road or intersection.
  - ☒ c. One of the presentation and analysis of traffic volume is graphical intersection summaries. The traffic volume on each route is represented by the width of a band.

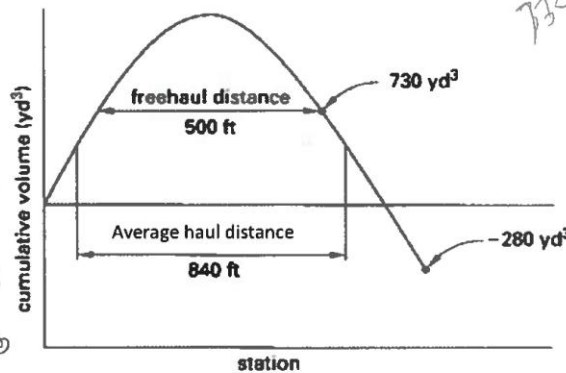
F (d) The capacity and level of service for multilane highways can be analyzed by applying the procedures developed for basic highway segments.

3. (10 pts) A crash modified factor cannot be modified by changing
- access point density
  - the width of lane
  - radius of curvature of roadway curves
  - none of the above

### Calculation

1. (10 pts) A highway under construction requires fill and cut based on the ground profile. The following mass diagram indicates the net accumulation of cut and fill between two stations. The maximum distance for which there are no additional hauling charge is 500 ft. The overhaul unit cost is \$9.75 per  $\text{yd}^3$  per station. What is the overhaul cost for the two stations shown?

$FI = 500 \text{ ft}$   
 $HI = 840 \text{ ft}$   
 $\$9.75 \text{ per } \text{yd}^3 / 100$   
 $2109.75$   
 $\text{unit cost} = 0.975$   
 $2109.75$

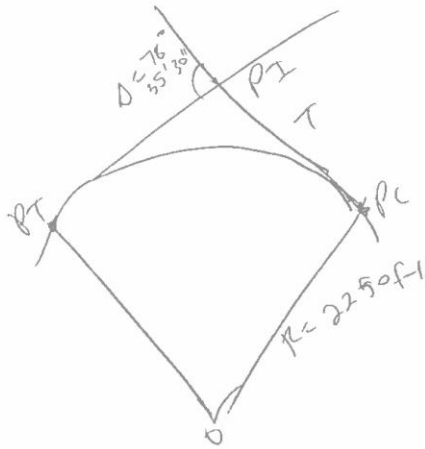
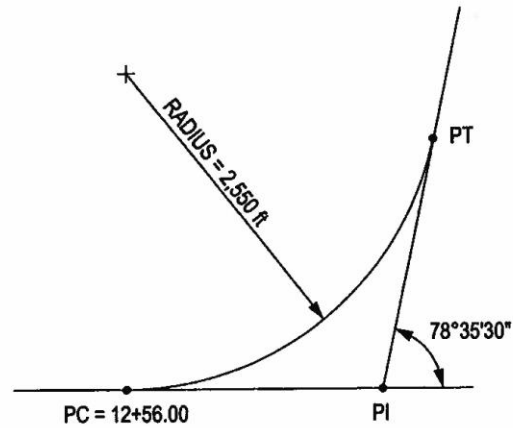


$730 \text{ yd}^3 = 19710$

$280 \text{ yd}^3 = 7560$

8

2. (10 pts) Referring to the horizontal curve shown in the figure below, what is the station of the PI?



$$St. PI = St. PC + \text{tangent length (T)}$$

$$St. P = (12+56) + R \tan \frac{A}{2}$$

$$St. P = (1200+56) + 2250 \times \tan \frac{78^{\circ}35'30''}{2}$$

$$St. P = 3342.84 ft$$

$$St. PI = 33+42.84$$

3. (10 pts) The speeds in miles per hour, tabulated below were observed with a radar gun. What is the space-mean speed in miles per hour?

60 56 47 48 50

55 51 54 43 38

Given speed (mi/hr)

| no. (n) | v (mph) |
|---------|---------|
| 1       | 60      |
| 2       | 56      |
| 3       | 47      |
| 4       | 48      |
| 5       | 50      |
| 6       | 55      |
| 7       | 51      |
| 8       | 54      |
| 9       | 43      |
| 10      | 38      |

No. of Time Speed observed (n) = 10

$$V_{\text{space, mean speed}} = \frac{n}{\sum_{i=1}^n \frac{1}{v_i}}$$

$$Sms = \frac{10}{\frac{1}{38} + \frac{1}{60} + \frac{1}{56} + \frac{1}{47} + \frac{1}{48} + \frac{1}{50} + \frac{1}{55} + \frac{1}{51} + \frac{1}{54} + \frac{1}{43}}$$

$$Sms = \frac{10}{0.2025} = 49.37 \text{ mph} \quad \checkmark$$

**BELOW AVERAGE**

**ENGR 3302 – Transportation Engineering**

Mid-term Exam #2      Spring 2022      Total score = 100 pts

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I have read the above statement and understand its contents:

Print Name: Ariana Mangroo      Signature: 

**INSTRUCTIONS:**

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70

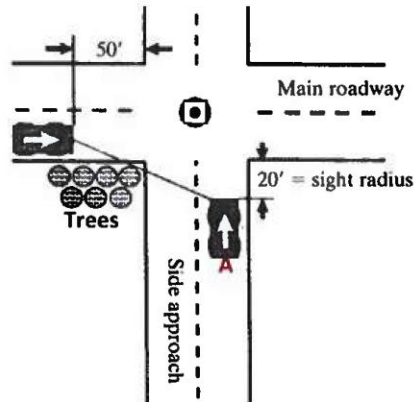
### True or False

1. (10 pts) Vertical curves are parabolic and horizontal curves are circular. True
2. (10 pts) Level of service (LOS) describes the operating conditions within a traffic stream using density as the quantitative variable and an alphabetic grading system ranging from A to F. At LOS A, breakdown conditions exist and uniform moving flow cannot be maintained. False
3. (10 pts) In general, there are more steps involved in determining level of service and capacity of two-lane highway than multilane highways. False
4. (10 pts) The most commonly used format to present and analyze spot speed data is the frequency distribution table. True

10

### Multiple Choice (only one correct answer)

1. (10 pts) Which of the following is the most effective way to increase sight radius for the vehicle A?



- ☐ a. Reduce speed limit
  - ☐ b. Increase speed limit
  - ☒ c. Remove trees
  - ☐ d. Reduce the height of trees
2. (10 pts) Which of the following is NOT true?
  - ☒ a. Surveying techniques can be split into three categories: ground surveys, remote sensing, and computer graphics
  - ☐ b. A crash modification factor is used to compute the expected number of crashes after implementing a safety design on a road or intersection.
  - ☒ c. One of the presentation and analysis of traffic volume is graphical intersection summaries. The traffic volume on each route is represented by the width of a band.

d. The capacity and level of service for multilane highways can be analyzed by applying the procedures developed for basic highway segments.

3. (10 pts) A crash modified factor cannot be modified by changing

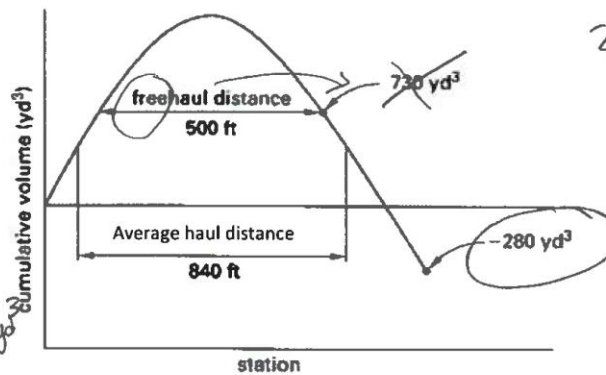
- a. access point density
- b. the width of lane
- c. radius of curvature of roadway curves
- d. none of the above

### Calculation

1. (10 pts) A highway under construction requires fill and cut based on the ground profile. The following mass diagram indicates the net accumulation of cut and fill between two stations. The maximum distance for which there are no additional hauling charge is 500 ft. The overhaul unit cost is \$9.75 per  $\text{yd}^3$  per station. What is the overhaul cost for the two stations shown?

Overhaul  
Cost of  
2 stations  
shown = ?

Overhaul cost  
unit = \$9.75 /  $\text{yd}^3$



$$\begin{aligned}
 & 280 \text{ yd}^3 \times 9.75 \\
 & = 2730 \\
 & = 2730 \text{ yd}^3 \\
 & \times 27 \text{ ft} \\
 & = 73710 \text{ ft}
 \end{aligned}$$

$$\text{Overhaul cost} = \text{overhaul unit cost} \times \text{overhaul cost}$$

$$\text{Overhaul cost} = (73710 \text{ ft}) \times (840 \text{ ft} - 500 \text{ ft})$$

$$\text{Overhaul cost} = (73710 \text{ ft}) \times (340)$$

$$\text{Overhaul cost} = 25061400 \text{ ft}$$

mph

3. (10 pts) The speeds in miles per hour, tabulated below were observed with a radar gun. What is the space-mean speed in miles per hour?

60 56 47 48 50

55 51 54 43 38

$$\frac{10}{\left(\frac{1}{60} + \frac{1}{56} + \frac{1}{47} + \frac{1}{48} + \frac{1}{50} + \frac{1}{55} + \frac{1}{51} + \frac{1}{54} + \frac{1}{43} + \frac{1}{38}\right)}$$

$$\Rightarrow \frac{10}{.2025135219} = \boxed{49.379 \text{ mph}}$$

# **TRANSPORTATION ENGINEERING SPRING 2022**

**Title of Assignment: FINAL EXAM**

## **TOPICS COVERED IN FINAL EXAM**

**Test 3 covered the following topics:**

1. Traffic Flow
2. Intersection Design and Control
3. Introduction to Pavement Design

ENGR 3302 – Transportation Engineering

Final Exam      Spring 2022      Total score = 90 pts

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I have read the above statement and understand its contents:

Print Name: \_\_\_\_\_ Signature: \_\_\_\_\_

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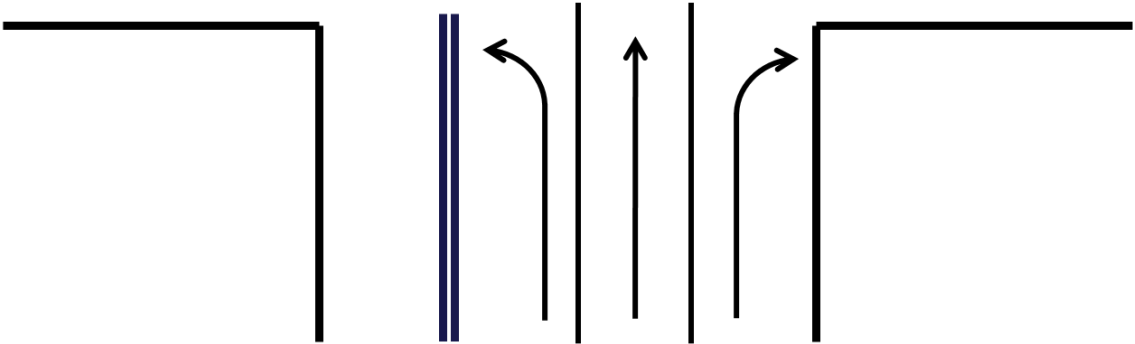
## TaskStream

Completion of TaskStream.

## True or False

- 1.(10 pts) We decide the thickness of the top layer for a flexible pavement and the thickness of the top three layers for a rigid pavement.
- 2.(10 pts) Signal delay could be reduced by adjusting the phase pattern and phase lengths by time of day.
- 3.(10 pts.) A traffic engineer should design a dilemma zone for an intersection.

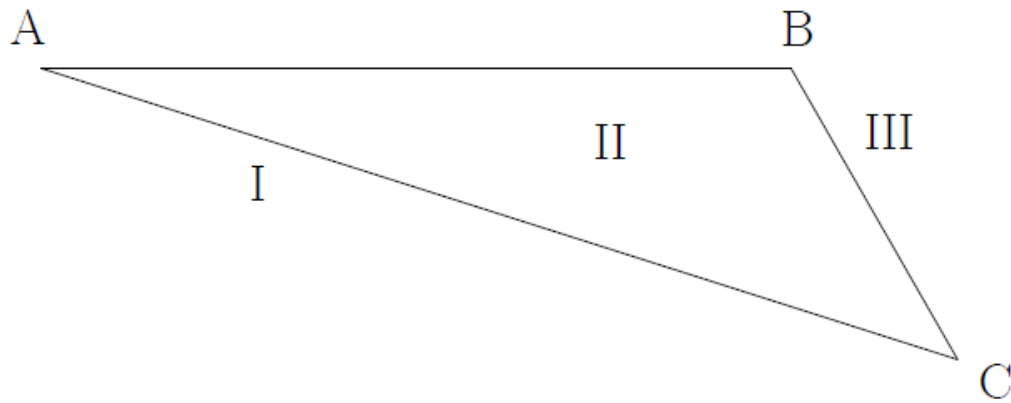
## Multiple Choice (only one correct answer)

- 1.(10 pts) On an intersection, there are three phases. For each phase, the light is yellow for 5 seconds. The light is green for 13 seconds for phase 1, 15 seconds for phase 2 and 14 seconds for phase 3. Which of the following is the total cycle length of this intersection?
  - a.47 seconds
  - b.57 seconds
  - c.52 seconds
  - d.42 seconds
- 2.(10 pts) Which of the following is NOT true?
  - a.Flexible pavement is easier to repair than rigid pavement.
  - b.Flexible pavement is less durable than rigid pavement.
  - c.Rigid pavement has higher unit price per ft<sup>2</sup> than flexible pavement.
  - d.In extreme hot weather, rigid pavement tends to become softer than flexible pavement.
- 3.(10 pts) What is the number of lane group of the following approach?

- a.1
- b.2
- c.3
- d.4

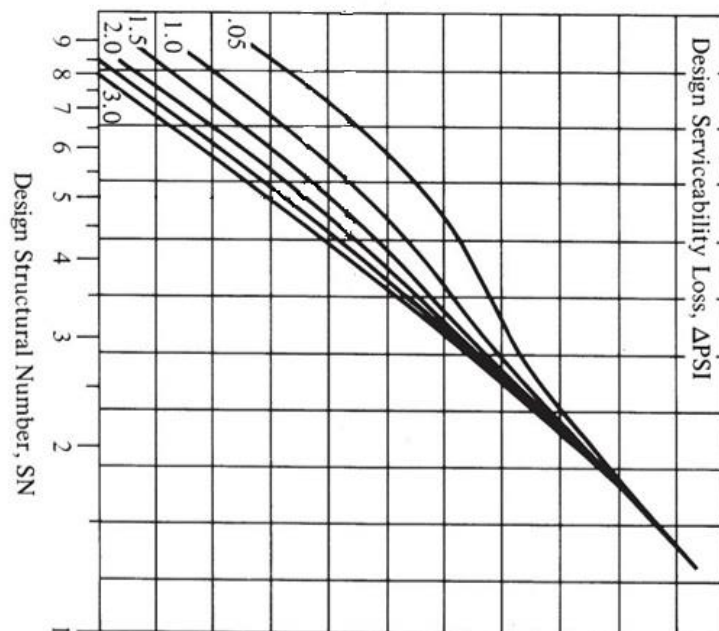
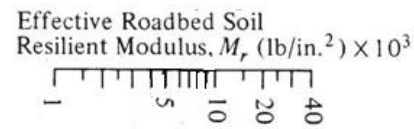
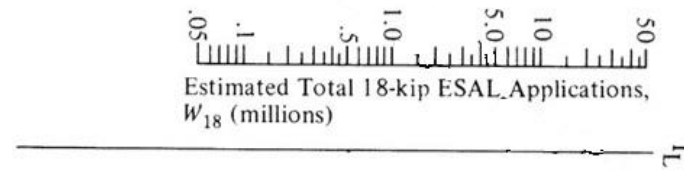
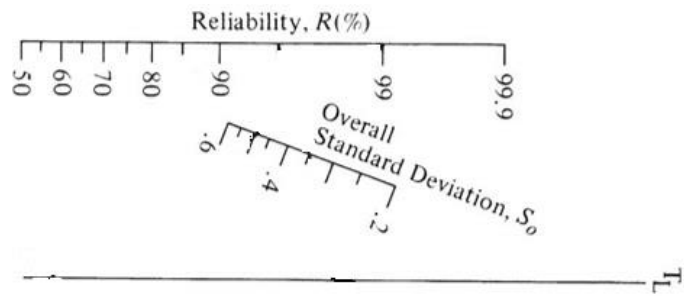
## Calculation

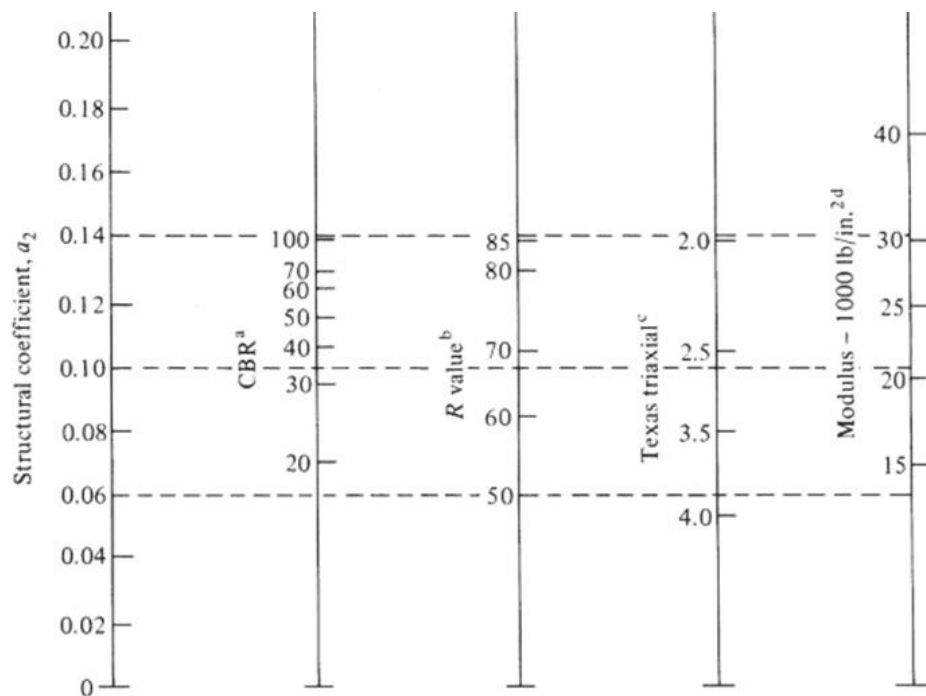
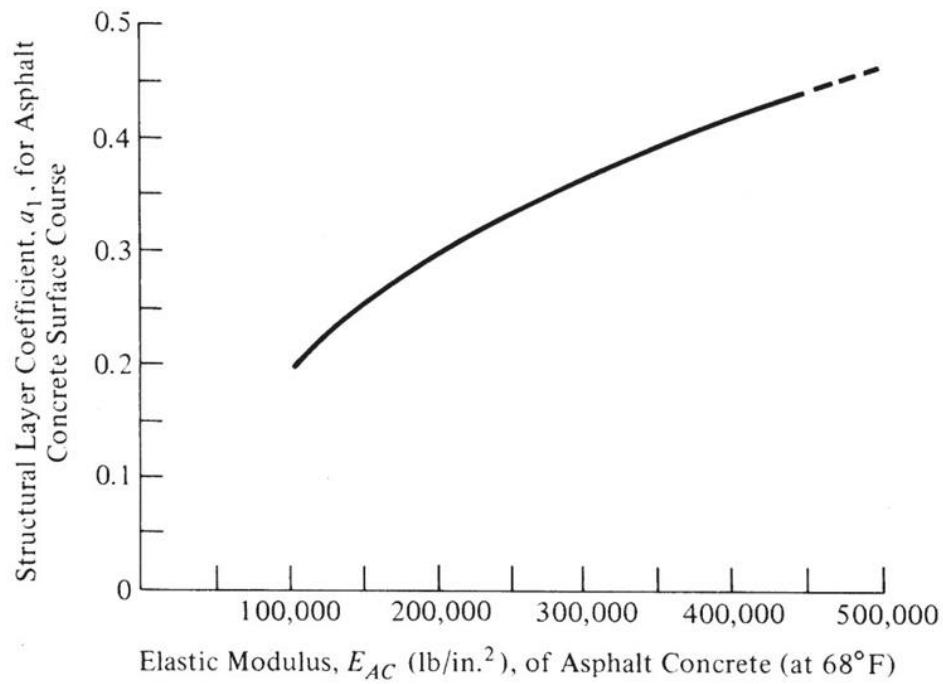
1. (10 pts.) The figure below shows a portion of the shockwave diagram created by an incident. In Region I, the volume is 800 vehicles per hour and the density is 25 vehicles per mile; in Region II, the volume is 500 vehicles per hour and the density is 100 vehicles per mile; and in Region III, the volume is 1100 vehicles per hour and the density is 70 vehicles per mile. What are the speeds of shockwaves I-II and II-III?





2. (20 pts) An interstate 8-lane highway pavement composed of an asphalt surface course, a base course, and a sand-gravel subbase is to be designed for an average annual daily traffic volume of 12000 with the following vehicle distribution: 50% passenger cars (1000 lb/axle), 33% 2-axle single unit trucks (6000 lb/axle), and 17% 3-axle single unit trucks (10,000 lb/axle). A growth rate of 4%, design period of 20 years, and predicting 45% of traffic are on the design lane. Equivalency factors for passenger cars, 2-axle single-unit trucks, and 3-axle single-unit trucks are 0.00002, 0.010, and 0.088. The quality of drainage is considered fair because water can be removed from the pavement within a week. However, there is a large amount of precipitation, so more than 25% of the time the pavement will be exposed to moisture level approaching saturation. Use a reliability level of 99%, a standard deviation of 0.35, a design serviceability loss of 2.0, resilient modulus of 15000 psi for subgrade, resilient modulus of 400000 psi for asphalt concrete, resilient modulus of 20000 psi for base course, resilient modulus of 15000 psi for subbase course to determine a suitable pavement structure by applying AASHTO design method.



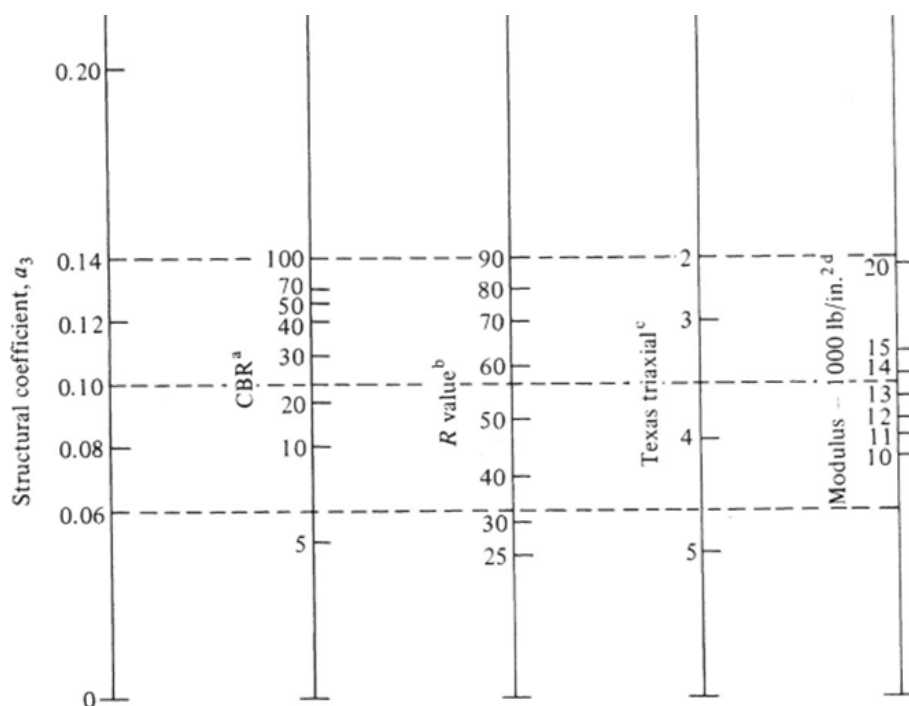


<sup>a</sup> Scale derived by averaging correlations obtained from Illinois.

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**Table 19.7** Definition of Drainage Quality

| <i>Quality of Drainage</i> | <i>Water Removed Within*</i> |
|----------------------------|------------------------------|
| Excellent                  | 2 hours                      |
| Good                       | 1 day                        |
| Fair                       | 1 week                       |
| Poor                       | 1 month                      |
| Very poor                  | (water will not drain)       |

\*Time required to drain the base layer to 50% saturation.

SOURCE: Based on *AASHTO Guide for Design of Pavement Structures*, 1993, AASHTO, Washington, D.C.

**Table 19.8** Recommended  $m_i$  Values

| <i>Quality of Drainage</i> | <i>Percent of Time Pavement Structure Is Exposed to Moisture Levels Approaching Saturation</i> |                |                 |                         |
|----------------------------|------------------------------------------------------------------------------------------------|----------------|-----------------|-------------------------|
|                            | <i>Less Than 1%</i>                                                                            | <i>1 to 5%</i> | <i>5 to 25%</i> | <i>Greater Than 25%</i> |
| Excellent                  | 1.40–1.35                                                                                      | 1.35–1.30      | 1.30–1.20       | 1.20                    |
| Good                       | 1.35–1.25                                                                                      | 1.25–1.15      | 1.15–1.00       | 1.00                    |
| Fair                       | 1.25–1.15                                                                                      | 1.15–1.05      | 1.00–0.80       | 0.80                    |
| Poor                       | 1.15–1.05                                                                                      | 1.05–0.80      | 0.80–0.60       | 0.60                    |
| Very poor                  | 1.05–0.95                                                                                      | 0.95–0.75      | 0.75–0.40       | 0.40                    |

SOURCE: Based on *AASHTO Guide for Design of Pavement Structures*, 1993, AASHTO, Washington, D.C.

**ABOVE AVERAGE**

**ENGR 3302 – Transportation Engineering**

Final Exam      Spring 2022      Total score = 90 pts

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Print Name: Allyssa meynolds      Signature: 

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8/90

## TaskStream

Completion of TaskStream.

### True or False

- (10 pts) We decide the thickness of the top layer for a flexible pavement and the thickness of the top three layers for a rigid pavement. FALSE ✓
- (10 pts) Signal delay could be reduced by adjusting the phase pattern and phase lengths by time of day. TRUE ✓

- (10 pts.) A traffic engineer should design a dilemma zone for an intersection. FALSE ✓

### Multiple Choice (only one correct answer)

- (10 pts) On an intersection, there are three phases. For each phase, the light is yellow for 5 seconds. The light is green for 13 seconds for phase 1, 15 seconds for phase 2 and 14 seconds for phase 3. Which of the following is the total cycle length of this intersection?

- ☒ 47 seconds
- ☐ 57 seconds
- ☐ 52 seconds
- ☐ 42 seconds

cycle length = time required for all intervals to occur.

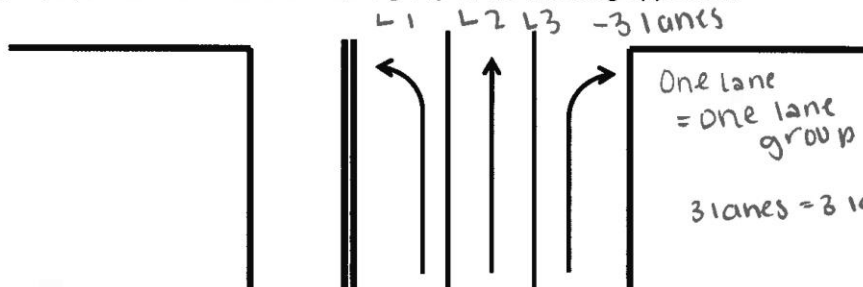
$5(3) + 13 + 15 + 14$

↑  
3 phases total

- (10 pts) Which of the following is NOT true? ✓

- ☐ Flexible pavement is easier to repair than rigid pavement. TRUE
- ☐ Flexible pavement is less durable than rigid pavement. TRUE
- ☒ Rigid pavement has higher unit price per ft<sup>2</sup> than flexible pavement. TRUE
- ☐ In extreme hot weather, rigid pavement tends to become softer than flexible pavement. FALSE

- (10 pts) What is the number of lane group of the following approach?



- a. 1
- b. 2
- ☒ c. 3
- d. 4



# Calculation

1. (10 pts.) The figure below shows a portion of the shockwave diagram created by an incident. In Region I, the volume is 800 vehicles per hour and the density is 25 vehicles per mile; in Region II, the volume is 500 vehicles per hour and the density is 100 vehicles per mile; and in Region III, the volume is 1100 vehicles per hour and the density is 70 vehicles per mile. What are the speeds of shockwaves I-II and II-III?

$$\frac{\text{veh}}{\text{hr}} \times \frac{\text{mile}}{\text{veh}} = \text{mph}$$

$$q = UK$$

$$800 = 32 K \quad K = 25$$

I

$$q_{max} = \frac{U_f K_j}{4}$$

$$q_1 = 800 \frac{\text{veh}}{\text{hr}}$$

$$1100 = \frac{(32) K_j}{4} \Rightarrow K_j = 137.5 \frac{\text{veh}}{\text{mi}}$$

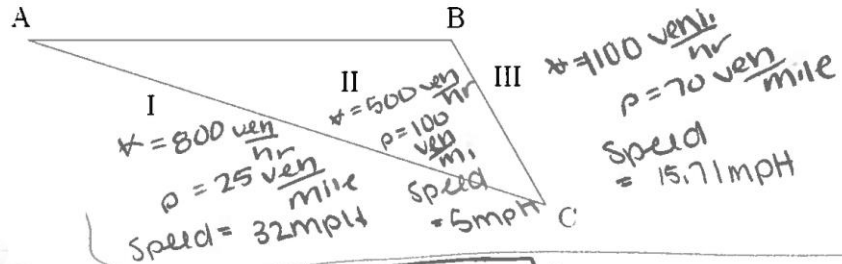
$$\begin{aligned} \text{I} - \text{II} \\ &= \frac{q_1 - q_2}{K_1 - K_2} = \frac{800 - 500}{24.36 - 137.5} = \\ &= \frac{300}{-113.14} = -2.65 \text{ mi/hr} \end{aligned}$$

$$U_{II} = \phi \Rightarrow -7.1 \text{ mph}$$

$$\text{II} - \text{III}$$

$$\frac{(q_{II} - q_{III})}{K_{II} - K_{III}} = \frac{(500 - 1100)}{(137.5 - 68.75)} = \frac{-600}{68.75} = -8.73 \text{ mi/hr}$$

$$\text{if } q_{II} = \phi \Rightarrow -16 \text{ mph}$$



$$\begin{aligned} u_1 &= U_f (1 + \sqrt{1 - q_1 / q_{max}}) / 2 \\ &= 32 (1 + \sqrt{1 - 800 / 1100}) / 2 \\ &= 24.36 \text{ mph} \end{aligned}$$

$$\text{II} \quad u_2 = \phi, \quad K_2 = K_j = 137.5 \frac{\text{veh}}{\text{mi}}, \quad q_2 = 500 \frac{\text{veh}}{\text{hr}}$$

$$\begin{aligned} \text{III} \quad q_3 &= 1100 \frac{\text{veh}}{\text{hr}} \\ K_3 &= \frac{K_j}{2} = \frac{137.5}{2} = 68.75 \frac{\text{veh}}{\text{mi}} \end{aligned}$$

-5

WORK CONT'D ON BACK OF  
THIS PAGE!

- FLEXIBLE

2. (20 pts) An interstate 8-lane highway pavement composed of an asphalt surface course, a base course, and a sand-gravel subbase is to be designed for an average annual daily traffic volume of 12000 with the following vehicle distribution: 50% passenger cars (1000 lb/axle), 33% 2-axle single unit trucks (6000 lb/axle), and 17% 3-axle single unit trucks (10,000 lb/axle). A growth rate of 4%, design period of 20 years, and predicting 45% of traffic are on the design lane. Equivalency factors for passenger cars, 2-axle single unit trucks, and 3-axle single unit trucks are 0.00002, 0.010, and 0.088. The quality of drainage is considered fair because water can be removed from the pavement within a week. However, there is a large amount of precipitation, so more than 25% of the time the pavement will be exposed to moisture level approaching saturation. Use a reliability level of 99%, a standard deviation of 0.35, a design serviceability loss of 2.0, resilient modulus of 15000 psi for subgrade, resilient modulus of 40000 psi for asphalt concrete, resilient modulus of 40000 psi for base course, resilient modulus of 20000 psi for subbase course to determine a suitable pavement structure by applying AASHTO design method. (Please use figures and/or tables on the following pages and show your work)

$$ESAL_i = F_d(Grn) (365 \times AADT) N_i F_E$$

$$AADT = 12,000 \quad Grn = \frac{[1 + r]^n - 1}{r}$$

$$Mr_4 = 15,000 \text{ lb/in}^2 \text{ (subgrade)}$$

$$Mr_3 = 20,000 \text{ lb/in}^2 \text{ (subbase)}$$

$$Mr_2 = 40,000 \text{ lb/in}^2 \text{ (base)}$$

$$Mr_1 = 400,000 \text{ lb/in}^2 \text{ (asphalt concrete)}$$

$$S_0 = 0.35$$

$$R = 99\%$$

$$P_i - P_T = 2$$

$$50\% \text{ 2-axle (1000 lb/axle) } , 0.00002$$

$$33\% \text{ 2-axle (6000 lb/axle) } , 0.010$$

$$17\% \text{ 3-axle (10,000 lb/axle) } , 0.088$$

$$F = 4.90$$

$$\text{period} = 20 \text{ yrs}$$

$$45\% \text{ on design lane}$$

$$8 \text{ lanes total}$$

$$ESAL_{2\text{-axle p.c.}} = (45/100) \left[ \left( 1 + \frac{4}{100} \right)^{20} - 1 \right] \times (365 \times 12,000 \times 0.5) (2) (0.00002)$$

$$= 0.45 (29.79) \left( \frac{4}{100} \right) (4 \times 10^{-5})$$

$$= 1174.32$$

$$ESAL_{2\text{-axle truck}} = (45/100) \left[ \left( 1 + \frac{4}{100} \right)^{20} - 1 \right] \times (365 \times 0.33 \times 12,000) (2) (0.010)$$

$$= 0.45 (29.79) \left( \frac{4}{100} \right) (445,100) (2) (0.010)$$

$$= 3.88 \times 10^5$$

$$ESAL_{3\text{-axle truck}} = (45/100) \left[ \left( 1 + \frac{4}{100} \right)^{20} - 1 \right] \times (365 \times 0.17 \times 12,000) (3) (0.088)$$

$$= 0.45 (29.79) \left( \frac{4}{100} \right) (744,100) (3) (0.088)$$

$$= 2.11 \times 10^6$$

$$\text{Total ESAL} = 3.03 \times 10^6$$

$$ESAL = 3.03 \times 10^6$$

$$D_1 = \frac{SN_1}{a_1} = \frac{2.51}{0.4} = 6.275 \quad \boxed{7 \text{ in}}$$

$$SN_1 = 2.51$$

use  $Mr_2$

$$L_{40,000}$$

use  $Mr_3$   
 $\approx 20,000$

$$SN_2 = a_1 D_1 + a_2 D_2 m_2$$

$$3.2 = (0.4)(7) + (0.172)(D_2)(0.8)$$

$$D_2 = 2.907$$

$$\boxed{= 3 \text{ in}}$$

check min. thickness requirement!

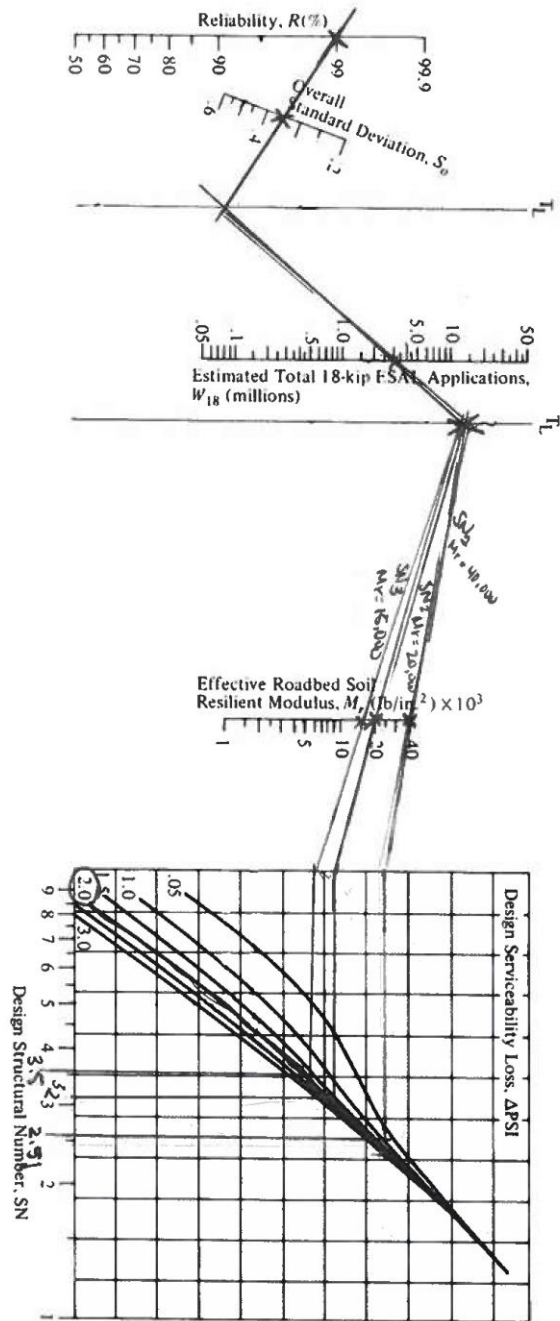
$$SN_3 = (0.4)(7) + (0.172)(3)(0.8) + (0.145)(D_3)(0.8)$$

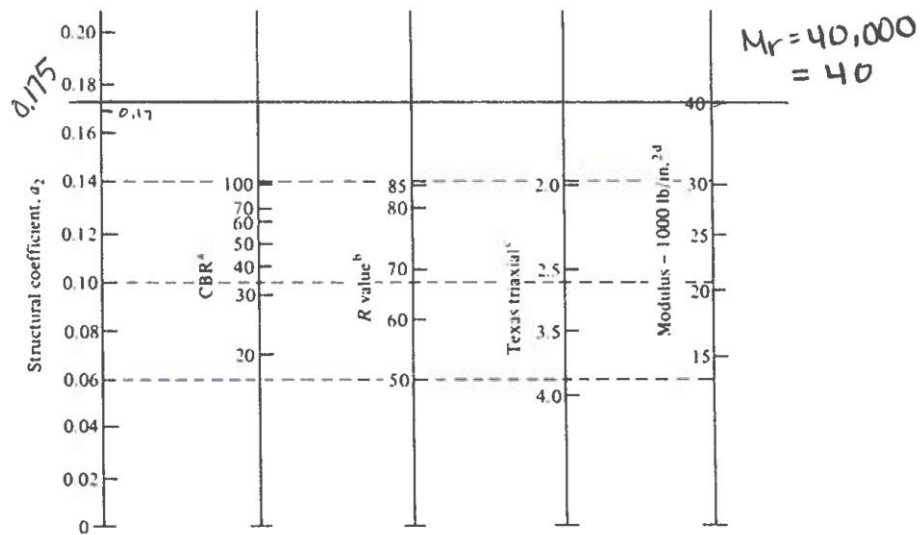
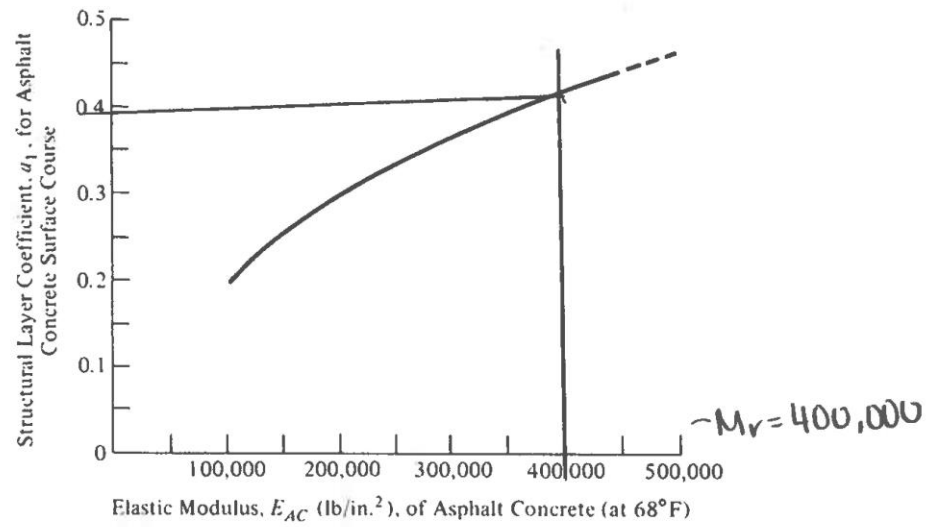
$$3.5 = 2.8 + 0.413 + 0.116(D_3)$$

$$\frac{0.287}{0.116} = 2.46$$

$$\boxed{= 3 \text{ in}}$$

-4



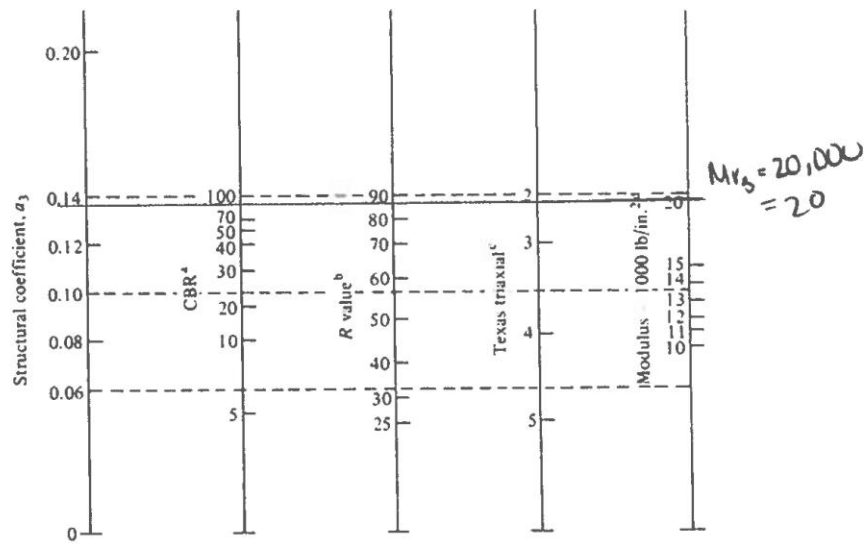


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**Table 19.7** Definition of Drainage Quality

| Quality of Drainage | Water Removed Within*  |
|---------------------|------------------------|
| Excellent           | 2 hours                |
| Good                | 1 day                  |
| Fair                | 1 week                 |
| Poor                | 1 month                |
| Very poor           | (water will not drain) |

\*Time required to drain the base layer to 50% saturation.

SOURCE: Based on AASHTO Guide for Design of Pavement Structures, 1993, AASHTO, Washington, D.C.

**Table 19.8** Recommended  $m_1$  Values

| Quality of Drainage | Percent of Time Pavement Structure Is Exposed to Moisture Levels Approaching Saturation |           |           |                  |
|---------------------|-----------------------------------------------------------------------------------------|-----------|-----------|------------------|
|                     | Less Than 1%                                                                            | 1 to 5%   | 5 to 25%  | Greater Than 25% |
| Excellent           | 1.40–1.35                                                                               | 1.35–1.30 | 1.30–1.20 | 1.20             |
| Good                | 1.35–1.25                                                                               | 1.25–1.15 | 1.15–1.00 | 1.00             |
| Fair                | 1.25–1.15                                                                               | 1.15–1.05 | 1.00–0.80 | 0.80             |
| Poor                | 1.15–1.05                                                                               | 1.05–0.80 | 0.80–0.60 | 0.60             |
| Very poor           | 1.05–0.95                                                                               | 0.95–0.75 | 0.75–0.40 | 0.40             |

SOURCE: Based on AASHTO Guide for Design of Pavement Structures, 1993, AASHTO, Washington, D.C.

**AVERAGE**



**ENGR 3302 – Transportation Engineering**

Final Exam      Spring 2022      Total score = 90 pts

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**Academic Integrity**

University students are expected to conduct themselves in accordance with the highest standards of academic honesty. Academic misconduct for which a student is subject to penalty includes all forms of cheating, such as illicit possession of examinations or examination materials, falsification, forgery, complicity or plagiarism. (Plagiarism is the presentation of the work of another as one's own work.) In this class, academic misconduct or complicity in an act of academic misconduct on an assignment or test will result in a failing grade.

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If I violate the Academic Integrity, I understand that I could be subject to any of the Academic Integrity Sanctions provided in accordance with the Honor System Process. These sanctions include academic and educational sanctions as well as expulsion, dismissal, or suspension, and other additional consequences.

I have read the above statement and understand its contents:

Print Name: Tyrrah Owens      Signature: 



**INSTRUCTIONS:**

1. Follow directions on each question to the best of your knowledge.
2. Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized and complete).
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5. Raise hand for any question or inquiry. If instructor is distracted call him, but do not stand.

65/90

### TaskStream

Completion of TaskStream.

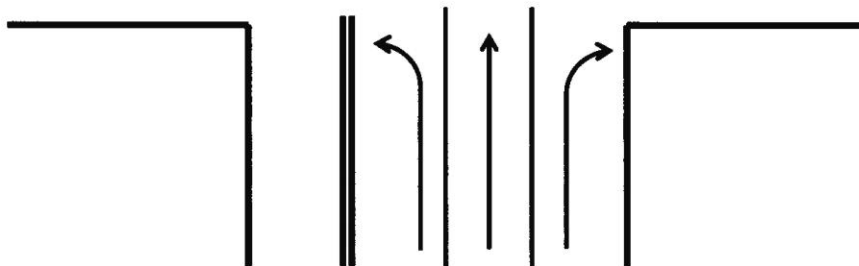
### True or False

1. (10 pts) We decide the thickness of the top layer for a flexible pavement and the thickness of the top three layers for a rigid pavement. **F** ✓
2. (10 pts) Signal delay could be reduced by adjusting the phase pattern and phase lengths by time of day. **T** ✓
3. (10 pts.) A traffic engineer should design a dilemma zone for an intersection. **F** ✓

### Multiple Choice (only one correct answer)

1. (10 pts) On an intersection, there are three phases. For each phase, the light is yellow for 5 seconds. The light is green for 13 seconds for phase 1, 15 seconds for phase 2 and 14 seconds for phase 3. Which of the following is the total cycle length of this intersection?  
-10 ✓  
  - a. 47 seconds
  - b. 57 seconds
  - c. 52 seconds
  - d. 42 seconds

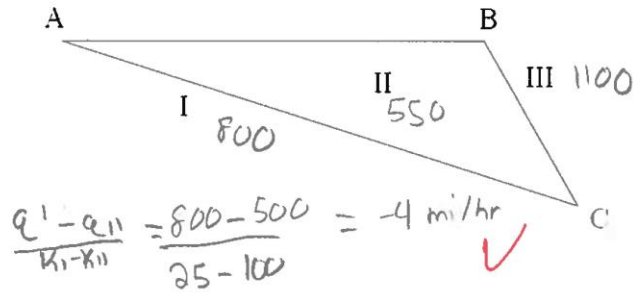
Handwritten calculation:  $5 + 13 + 15 + 14 = 47$
2. (10 pts) Which of the following is NOT true?  
  - a. Flexible pavement is easier to repair than rigid pavement.
  - b. Flexible pavement is less durable than rigid pavement.
  - c. Rigid pavement has higher unit price per ft<sup>2</sup> than flexible pavement.
  - d. In extreme hot weather, rigid pavement tends to become softer than flexible pavement. ✓
3. (10 pts) What is the number of lane group of the following approach?



- a. 1
- b. 2
- c. 3 ✓
- d. 4

### Calculation

1. (10 pts.) The figure below shows a portion of the shockwave diagram created by an incident. In Region I, the volume is 800 vehicles per hour and the density is 25 vehicles per mile; in Region II, the volume is 500 vehicles per hour and the density is 100 vehicles per mile; and in Region III, the volume is 1100 vehicles per hour and the density is 70 vehicles per mile. What are the speeds of shockwaves I-II and II-III?



$$\frac{q_I - q_{II}}{k_I - k_{II}} = \frac{800 - 500}{25 - 100} = -4 \text{ mi/hr} \quad \checkmark$$

$$\frac{q_{II} - q_{III}}{k_{II} - k_{III}} = \frac{500 - 1100}{100 - 70} = -20 \text{ mi/hr} \quad \checkmark$$

2. (20 pts) An interstate 8-lane highway pavement composed of an asphalt surface course, a base course, and a sand-gravel subbase is to be designed for an average annual daily traffic volume of 12000 with the following vehicle distribution: 50% passenger cars (1000 lb/axle), 33% 2-axle single unit trucks (6000 lb/axle), and 17% 3-axle single unit trucks (10,000 lb/axle). A growth rate of 4%, design period of 20 years, and predicting 45% of traffic are on the design lane. Equivalency factors for passenger cars, 2-axle single-unit trucks, and 3-axle single-unit trucks are 0.00002, 0.010, and 0.088. The quality of drainage is considered fair because water can be removed from the pavement within a week. However, there is a large amount of precipitation, so more than 25% of the time the pavement will be exposed to moisture level approaching saturation. Use a reliability level of 99%, a standard deviation of 0.35, a design serviceability loss of 2.0, resilient modulus of 15000 psi for subgrade, resilient modulus of 400000 psi for asphalt concrete, resilient modulus of 40000 psi for base course, resilient modulus of 20000 psi for subbase course to determine a suitable pavement structure by applying AASHTO design method. (Please use figures and/or tables on the following pages and show your work)

$$ESAL = F_d G_{rn} (365 \times AADT)^{0.45} \sum (P_i)^{0.45} (W_{Ti})^{0.75} (F_i)^{0.5} (E_i)^{0.5}$$

ESAL 2-axle truck:  $(0.45)(29.78)(6000)(0.33)(365)(2)(0.008)$

ESAL 3-axle truck:  $(0.45)(29.78)(6000)(0.17)(365)(3)(0.027)$

$$ESAL = 3.6 \times 10^4$$

We know  $M_R$  for base course = 40,000 psi  
Using this value in Figure 19.8 we obtain:

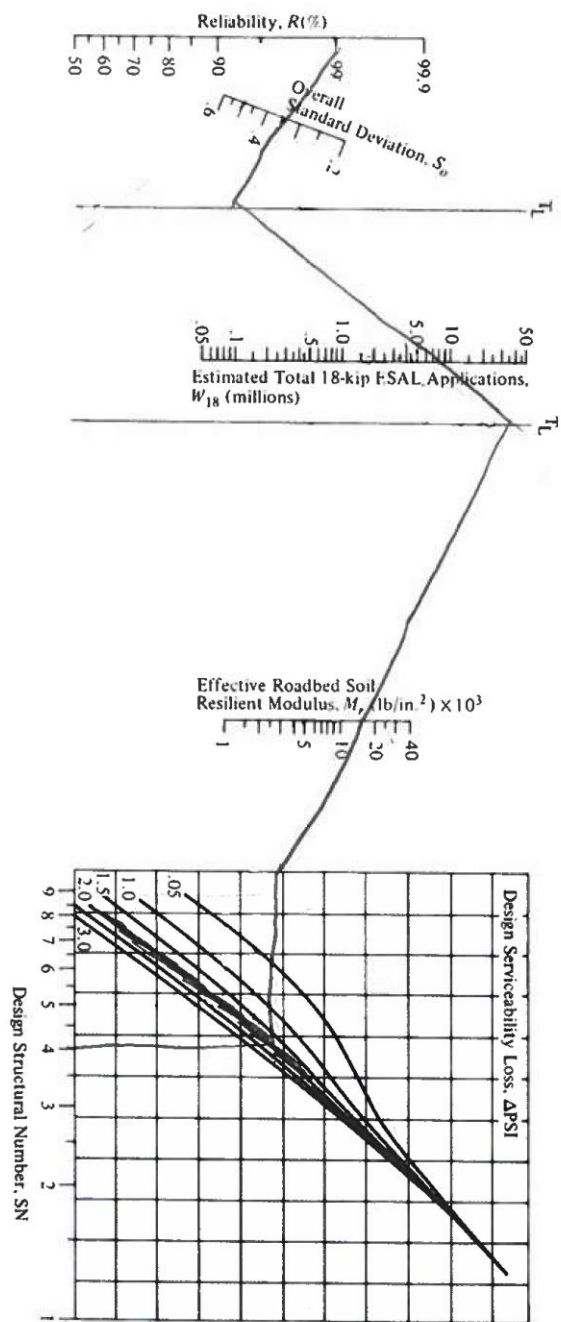
$$SN = 4$$

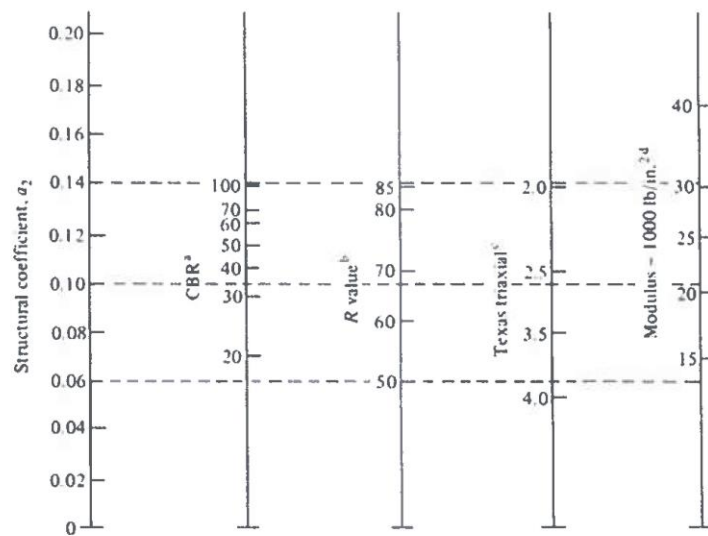
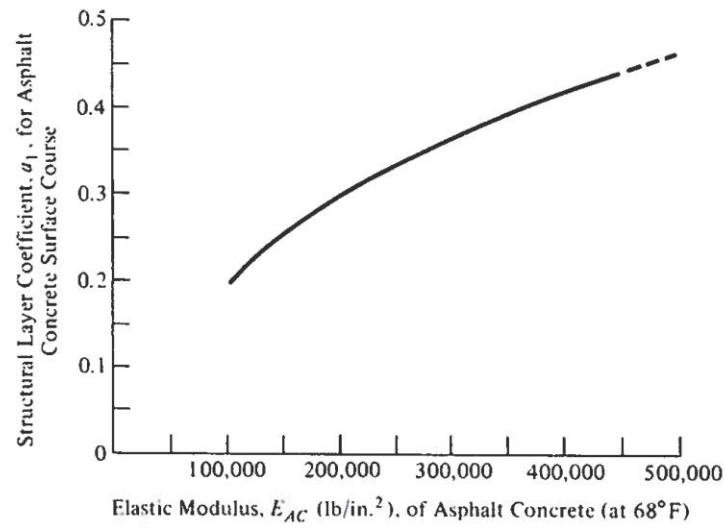
$D_1$

$D_2$  ?

$D_3$

-15



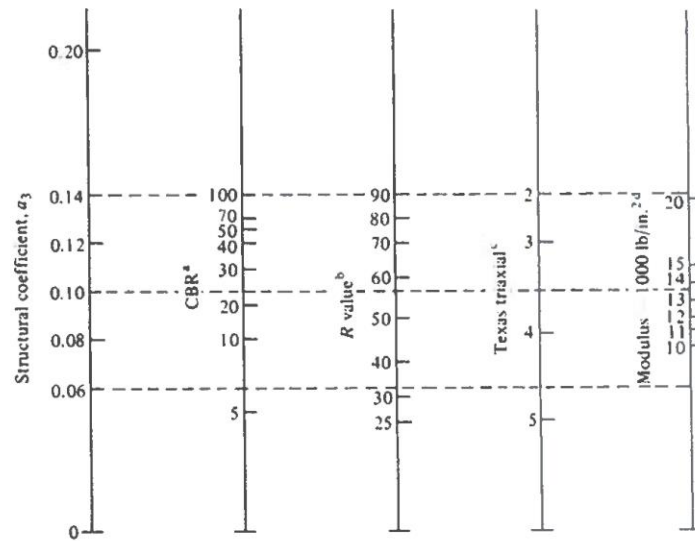


<sup>a</sup>Scale derived by averaging correlations obtained from Illinois.

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**Table 19.7** Definition of Drainage Quality

| Quality of Drainage | Water Removed Within*  |
|---------------------|------------------------|
| Excellent           | 2 hours                |
| Good                | 1 day                  |
| Fair                | 1 week                 |
| Poor                | 1 month                |
| Very poor           | (water will not drain) |

\*Time required to drain the base layer to 50% saturation.

SOURCE: Based on *AASHTO Guide for Design of Pavement Structures*, 1993, AASHTO, Washington, D.C.

**Table 19.8** Recommended  $m_1$  Values

| Quality of Drainage | Percent of Time Pavement Structure Is Exposed to Moisture Levels Approaching Saturation |           |           |                  |
|---------------------|-----------------------------------------------------------------------------------------|-----------|-----------|------------------|
|                     | Less Than 1%                                                                            | 1 to 5%   | 5 to 25%  | Greater Than 25% |
| Excellent           | 1.40–1.35                                                                               | 1.35–1.30 | 1.30–1.20 | 1.20             |
| Good                | 1.35–1.25                                                                               | 1.25–1.15 | 1.15–1.00 | 1.00             |
| Fair                | 1.25–1.15                                                                               | 1.15–1.05 | 1.00–0.80 | 0.80             |
| Poor                | 1.15–1.05                                                                               | 1.05–0.80 | 0.80–0.60 | 0.60             |
| Very poor           | 1.05–0.95                                                                               | 0.95–0.75 | 0.75–0.40 | 0.40             |

SOURCE: Based on *AASHTO Guide for Design of Pavement Structures*, 1993, AASHTO, Washington, D.C.

**BELOW AVERAGE**



**ENGR 3302 – Transportation Engineering**

Final Exam      Spring 2022      Total score = 90 pts

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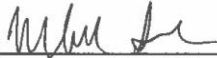
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Print Name: Marshall Johnson      Signature: 

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55/90

### TaskStream

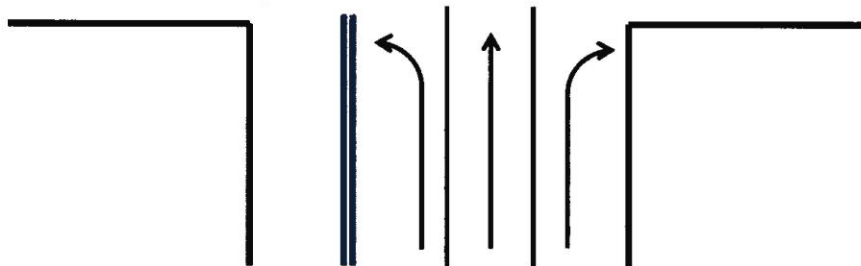
Completion of TaskStream.

### True or False

- F. 1. (10 pts) We decide the thickness of the top layer for a flexible pavement and the thickness of the top three layers for a rigid pavement.
- F. 2. (10 pts) Signal delay could be reduced by adjusting the phase pattern and phase lengths by time of day.
- T. 3. (10 pts.) A traffic engineer should design a dilemma zone for an intersection.

### Multiple Choice (only one correct answer)

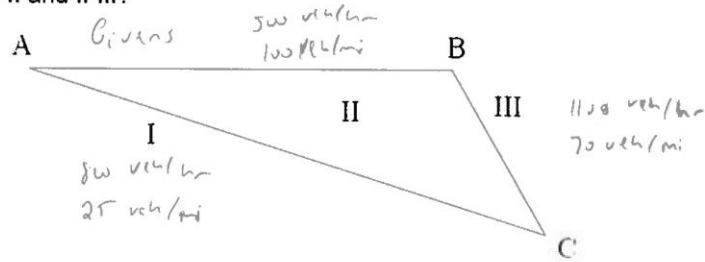
- 20
1. (10 pts) On an intersection, there are three phases. For each phase, the light is yellow for 5 seconds. The light is green for 13 seconds for phase 1, 15 seconds for phase 2 and 14 seconds for phase 3. Which of the following is the total cycle length of this intersection?
- $(13 + 5) + (15 + 5) + (14 + 5) = 57 \text{ seconds}$
- a. 47 seconds  
b. 57 seconds  
c. 52 seconds  
d. 42 seconds
2. (10 pts) Which of the following is NOT true?
- a. Flexible pavement is easier to repair than rigid pavement. T  
b. Flexible pavement is less durable than rigid pavement. T  
c. Rigid pavement has higher unit price per ft<sup>2</sup> than flexible pavement. T  
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- a. 1  
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### Calculation

1. (10 pts.) The figure below shows a portion of the shockwave diagram created by an incident. In Region I, the volume is 800 vehicles per hour and the density is 25 vehicles per mile; in Region II, the volume is 500 vehicles per hour and the density is 100 vehicles per mile; and in Region III, the volume is 1100 vehicles per hour and the density is 70 vehicles per mile. What are the speeds of shockwaves I-II and II-III?



Find:

Speed of shockwaves I-II & II-III

$$\begin{aligned}
 u_{I-II} &= \frac{q_A - q_B}{k_A - k_B} \\
 &= \frac{800 - 500}{25 - 100} \text{ veh/hr} \\
 &= \boxed{-4 \text{ mph}} \quad \checkmark
 \end{aligned}$$

$$\begin{aligned}
 u_{II-III} &= \frac{q_B - q_C}{k_B - k_C} \\
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Passenger car (1000 lb/axle) = 50%  $\rightarrow$  Eq. factors 0.00002

2-axle (6000 lb/axle) = 33%  $\rightarrow$  0.010

3-axle (10,000 lb/axle) = 17%  $\rightarrow$  0.088

4% growth rate (29.78)

20 year period

45% traffic (0.45)

2-axle

$ESAL = f_s G_H AADT \cdot 365 \cdot N_i$

$= 0.45(29.78)(12,000)(.33)(365)(2)(0.010) \Rightarrow 387316.108$

$\Rightarrow 3.87 \times 10^6$

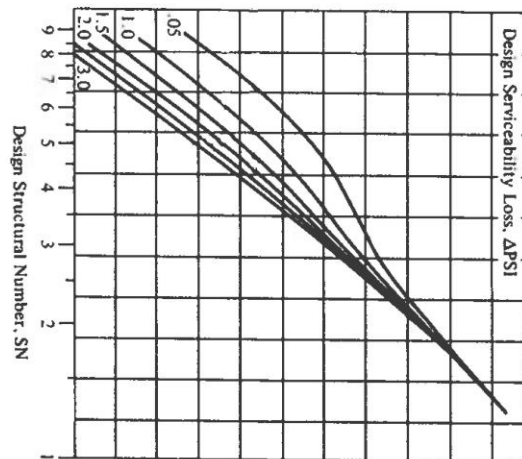
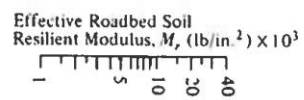
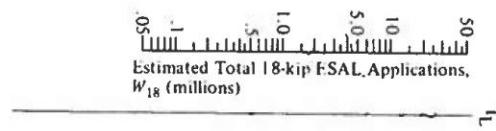
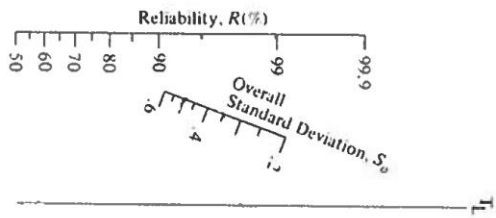
3-axle

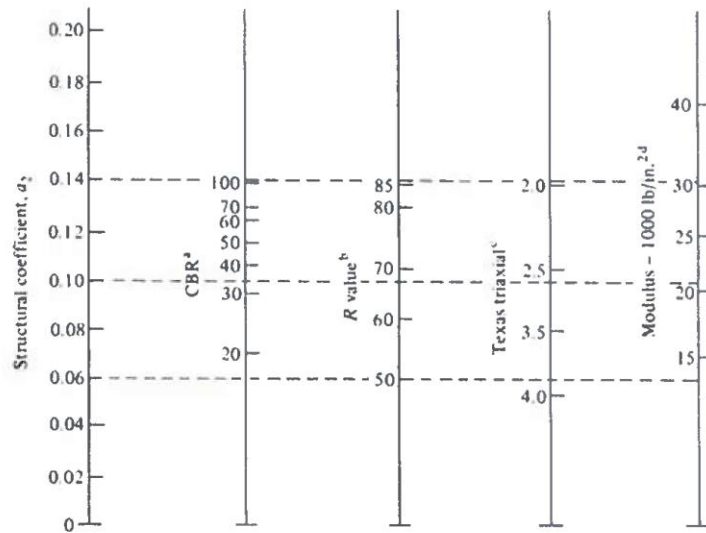
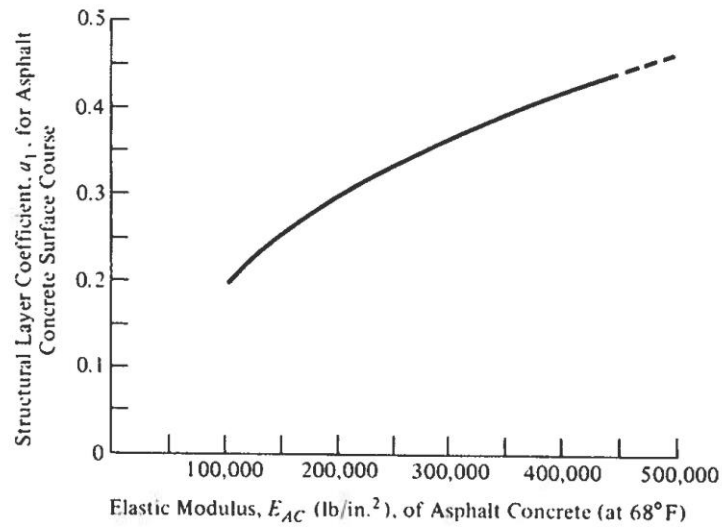
$ESAL = 0.45(29.78)(12,000)(.17)(365)(3)(0.088) \Rightarrow 2.63 \times 10^6$

Total ESAL =  $3.87 \times 10^6 + 2.63 \times 10^6 \Rightarrow 3.017 \times 10^6$  ✓

$D_1, D_2, D_3 ?$

-15



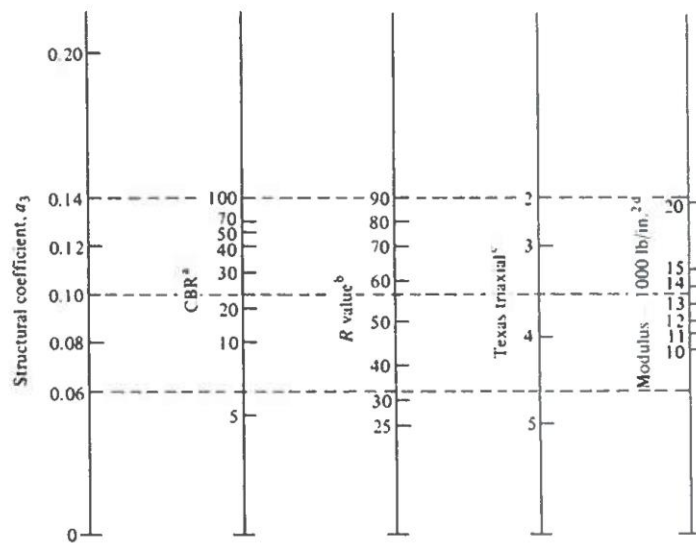


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| Excellent           | 1.40–1.35                                                                               | 1.35–1.30 | 1.30–1.20 | 1.20             |
| Good                | 1.35–1.25                                                                               | 1.25–1.15 | 1.15–1.00 | 1.00             |
| Fair                | 1.25–1.15                                                                               | 1.15–1.05 | 1.00–0.80 | 0.80             |
| Poor                | 1.15–1.05                                                                               | 1.05–0.80 | 0.80–0.60 | 0.60             |
| Very poor           | 1.05–0.95                                                                               | 0.95–0.75 | 0.75–0.40 | 0.40             |

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**TRANSPORTATION ENGINEERING  
SPRING 2022**

**HOMEWORK 1**

**TOPICS COVERED IN HOMEWORK 1**

**1. Traffic Operations**

## CVEG 3302 Transportation Engineering, Spring 2022

### Homework Assignment #1

**Due Date: Thursday, February 03, 2022 (in classroom)**

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

1. A toll bridge carries 6,000 veh/day. The current toll is \$3.50/vehicle. Studies have shown that for each increase in toll of 50 cents, the traffic volume will decrease by 500 veh/day. It is desired to increase the toll to a point where revenue will be maximized. (60 pts)
  - a) Write the expression for travel demand on the bridge, related to toll increase and current volume.
  - b) Determine toll charge to maximize revenues.
  - c) Determine traffic in veh/day after toll increase.
  - d) Determine total revenue increase with new toll.
2. Consideration is being given to increasing the toll on a bridge now carrying 4500 veh/day. The current toll is \$1.25/veh. It has been found from past experience that the daily traffic volume will decrease by 400 veh/day for each 25¢ increase in toll. Therefore, if  $x$  is the increase in toll in cents/veh, the volume equation for veh/day is  $V = 4500 - 400 (x / 25)$ , and the new toll/veh would be  $T = 125 + x$ . In order to maximize revenues, (a) what would the new toll charge be per vehicle (10 pts) and (b) what would the traffic in veh/day be after the toll increase? (30 pts)
3. An individual is planning to take an 600-mile trip between two large cities. Three possibilities exist: air, rail, or auto. The person is willing to pay \$25 for every hour saved in making the trip. The trip by air costs \$450 and travel time is 6 hrs, by rail the cost is \$400 and travel time is 10 hrs, and by auto the cost is \$250 and travel time is 15 hrs. Which mode is the best choice if cost is the only consideration? (10 pts)

**ABOVE AVERAGE**



**Civil Engineering Department**

**Prairie View A&M University**

**CVEG 3302(P01): Transportation Engineering**

**Homework**

**Spring 2022**

**Homework 1**

**Assigned Date**

**January 27, 2022**

**Completed by**

**Allyssa Reynolds**

**Submitted by**

**Allyssa Reynolds**

**On**

**February 3, 2022**

**To**

**Dr. Liu**



**Civil Engineering Department**

**Prairie View A&M University**

**CVEG 3302(P01): Transportation Engineering**

**Homework**

**Spring 2022**

**Homework 1**

**Assigned Date**

**January 27, 2022**

**Completed by**

**Allyssa Reynolds**

**Submitted by**

**Allyssa Reynolds**

**On**

**February 3, 2022**

**To**

**Dr. Liu**

## Problem 1

A toll bridge carries 6,000 vehicles/day. The current toll is \$3.50/vehicle. Studies have shown that for each increase in toll 50 cents, the traffic volume will decrease by 500 vehicles/day. It is desired to increase the toll to a point where revenue will be maximized.

a) Write the expression for travel demand on the bridge, related to toll increase and current volume.

$$x = \text{toll increase in cents}$$

$$V = 6000 - \frac{x}{50}(500) \Rightarrow 6000 - 10x$$

$$T = \$3.50 + x$$

$$\text{Travel Demand: } 6000 - 10x = V$$

b) Determine toll charge to maximize revenues.

$$\begin{aligned} \text{Revenue} &= \text{toll} \times \text{volume} \\ &= (6000 - 10x)(\$3.50 + x) \\ &= 2100,000 + 6000x - 3500x - 10x^2 \\ &= -10x^2 + 2500x + 2,100,000 \end{aligned}$$

For max value of  $x$ , compute first deriv.

$$\begin{aligned} (-10x^2 + 2500x + 2,100,000)' \\ &= -20x + 2500 \\ \frac{2500}{20} &= \frac{2500}{20} \\ x &= 125 \end{aligned}$$

$$T = 3.50 + 1.25 = 4.75 \quad \therefore \$4.75 \text{ is the toll charge to maximize revenues}$$

c) Determine traffic in vehicles/day after toll increase.

$$\begin{aligned} T &= 3.50 + x \\ 3.50 + 1.25 &= 4.75 \end{aligned}$$

$$\begin{aligned} V &= 6000 - 10x \\ &= 6000 - 10(125) \\ &= 6000 - 1250 \\ &= 4750 \end{aligned}$$

$\therefore$  traffic will be 4750 vehicles/day after toll increases

d) Determine the total revenue increase w/new toll.

$$\text{New Toll} = 3.50 + 1.25 = 4.75 \text{ or } \$4.75$$

$$\begin{aligned} \text{Additional Revenue} &= (V_{\text{max}})(T_{\text{max}}) - (V_{\text{current}})(T_{\text{current}}) \\ &= (6000 - \frac{125}{50}(500))(4.75) - (6000)(3.5) \end{aligned}$$

$$\begin{aligned} &= (4.75)(4750) - 21,000 \\ &= \$22,562.5 - 21,000 \\ &= \$1562.5 \end{aligned}$$

The toll will gain an additional revenue increase of \$1562.5 per day. Thus, the total revenue will be \$22,562.5 per day.

## Problem 2)

Consideration is being given to increasing the toll on a bridge now carrying 4500 veh/day. The current toll is \$1.25/veh. It has been found from past experience that the daily traffic volume will decrease by 400 veh/day for each 25¢ increase in toll. ∴, if  $x$  is the increase in toll in cents/veh, the volume equation for veh/day is  $V = 4500 - 400(x/25)$ . The new toll/veh would be  $T = 125 + x$ . In order to maximize revenues,

(a) what would the new toll charge be per vehicle?

$$\text{Given: } V = 4500 - \frac{x}{25}(400)$$

$$T = 125 + x$$

$$\begin{aligned} \text{Revenue} &= (\text{toll})(\text{volume}) \\ &= (4500 - 16x)(125 + x) \\ &= 562,500 + 4500x - 2000x - 16x^2 \\ &= -16x^2 + 2500x + 562,500 \end{aligned}$$

max value of  $x$ :

$$\begin{aligned} &(-16x^2 + 2500x + 562,500)' \\ &= -32x + 2500 \\ &\quad \frac{32x}{32} = \frac{2500}{32} \\ &\quad x = 78.125 \end{aligned}$$

$$T = 125 + 78.125 = 203.125$$

∴ the new toll charge per vehicle would be \$2.03. ✓

b) What would the traffic be veh/day be after the toll increases?

$$V = 4500 - \frac{x}{25}(400)$$

$$\text{New toll} = 1.25 + 0.78 = 2.03$$

$$V = 4500 - \frac{2.03}{25}(400)$$

$$= 4467.52 \text{ veh/day}$$

∴ the traffic will be 4468 veh/day after the toll increases. ✓



## Problem 3)

An individual is planning to take an 600-mile trip between two large cities. Three possibilities exist: air, rail, or auto.

The person is willing to pay \$25 for every hour saved in making the trip. The person is willing to pay \$25 for every hour saved.

| Mode | Cost  | Time (hr) |
|------|-------|-----------|
| Air  | \$450 | 6         |
| Rail | \$400 | 10        |
| Auto | \$250 | 15        |

Which mode is the best choice if only cost is considered?

$$\text{Air} = 450 + 6(25) = 450 + 150 = \$600$$

$$\text{Auto} = 250 + 15(25) = 250 + 375 = \$625$$

$$\text{Rail} = 400 + 10(25) = 400 + 250 = \$650$$

Air is the best option because it is the cheapest option.





**AVERAGE**

Sophie Tuke  
HW 1

80

$$(1) a - V = (\text{Vehicles carried by toll}) \left( \frac{\text{increase in toll cost}}{\text{increase in toll cost}} \right) (x')$$

$$= (6000) \left( \frac{x}{50} \right) (500)$$

$$= \boxed{6000 - \frac{x}{50} (500)}$$

$$b - R = VT = (6000 - \frac{x}{50} (500)) (350 + x)$$

$$= (6000 - 10x) (350 + x)$$

$$= 2,100,000 + 2500x - 10x^2$$

$$d/dt (2,100,000 + 2500x - 10x^2) = 0$$

$$2500 - 20x = 0 \quad x = 125 \text{ cents}$$

$$T = 350 + x = 350 + 125 = 475 \text{ cents} = \boxed{\$4.75}$$

$$c - V = 6000 - \left( \frac{125}{50} \right) (500) = \boxed{4750 \text{ vehicles/day}}$$

$$d - R = V_{\max} \times T_{\max} = 4750 \frac{\text{veh}}{\text{d}} \times \$4.75 = \boxed{\$22,562.50}$$

$$(2) R = V \times T = (4500 - 400 \times \frac{x}{40}) (1.25 + x)$$

$$= 562500 - 4500x - 1250x - 10x^2$$

$$d/dx (562500 - 4500x - 1250x - 10x^2) = 0$$

$$\text{after new toll increase: } V = 4500 - 400 \times \frac{160}{40} = 1900 \text{ veh/d}$$

$$T_{\max} = 1.25 + 1.60 = 2.85 \text{ cents} \Rightarrow \$2.85$$

$$R = V_{\max} T_{\max} - V_{\text{current}} T_{\text{current}}$$

$$= (1900 \times 2.85) - (4500 \times 1.25)$$

$$= \boxed{\$1265}$$

the increase of revenue is not provided in (d)

$$(2) V = 4,500 - \frac{x}{25} (400)$$

$$\hookrightarrow R = V \times T = (4500 - \frac{x}{25} \times 400) (125 + x)$$

$$R = (562,500 - 2,500x - 16x^2)$$

$$dR/dT = 2500 - 32x = 0 \rightarrow x = 2500/32 = 78 \text{ ¢}$$

$$T = 125 + x = 125 + 78 = 203 \text{ ¢} = \boxed{\$2.03}$$

$$\text{Traffic volume} = V = 4500 - \frac{78}{25} (400)$$

$$= 4500 - 1248$$

$$= \boxed{3252 \text{ veh/day}}$$

$$(3) \text{ a — } \$25/\text{hr} \quad \text{cost} = 600 + (25 \times 8) = \$800$$

$$\text{rail cost} = 450 + (25 \times 16) = \$850$$

Auto was smartest choice

~~not~~ calculation is not correct

**BELOW AVERAGE  
(NO DATA)**

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**HOMEWORK 2**

**TOPICS COVERED IN HOMEWORK 2**

**1. Transportation Operations**

**CVEG 3302 Transportation Engineering, Spring 2022**  
**Homework Assignment #2**

**Due Date: Thursday, February 10, 2022 (on Canvas)**

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

1. What are the four principal modes for passenger transportation? Which of these modes accounts for the largest passenger-miles? Which mode accounts for the lowest? (30 pts)
2. (a) What color combinations are used for general warning signs (e.g., advance railroad crossing signs)? (b) Why are these combinations used? (20 pts)
3. A driver with a perception-reaction time of 2.5 sec is driving at 65 mi/h when he/she observes that an accident has blocked the road ahead. Determine the distance the vehicle would move before the driver could activate the brakes. (Hint: the vehicle will continue to move at 65 mi/h during the perception-reaction time of 2.5 sec.) (20 pts)
4. A 5-axle truck traveling on an interstate highway has the following axle characteristics: Distance between the first set of tandem axles and the back set of tandem axles = 48 ft. Determine the overall gross weight of the truck. (30 pts)

**ABOVE AVERAGE**



**Civil Engineering Department**

**Prairie View A&M University**

**CVEG 3302(P01): Transportation Engineering**

**Homework**

**Spring 2022**

**Homework 2**

**Assigned Date**

**January 3, 2022**

**Completed by**

**Allyssa Reynolds**

**Submitted by**

**Allyssa Reynolds**

**On**

**February 10, 2022**

**To**

**Dr. Liu**



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**CVEG 3302 Transportation Engineering, Spring 2022**

**Homework Assignment #2**

**Due Date: Thursday, February 10, 2022 (on Canvas)**

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

1. What are the four principal modes for passenger transportation? Which of these modes accounts for the largest passenger-miles? Which mode accounts for the lowest? (30 pts)
2. (a) What color combinations are used for general warning signs (e.g., advance railroad crossing signs)? (b) Why are these combinations used? (20 pts)
3. A driver with a perception-reaction time of 2.5 sec is driving at 65 mi/h when he/she observes that an accident has blocked the road ahead. Determine the distance the vehicle would move before the driver could activate the brakes. (Hint: the vehicle will continue to move at 65 mi/h during the perception-reaction time of 2.5 sec.) (20 pts)
4. A 5-axle truck traveling on an interstate highway has the following axle characteristics: Distance between the first set of tandem axles and the back set of tandem axles = 48 ft. Determine the overall gross weight of the truck. (30 pts)

Problem 1)

What are the 4 principal modes for passenger transportation? Which of these modes accounts for the largest passenger-miles? Which mode accounts for the lowest?

The 4 principal modes for passenger transportation are:

- 1) Automobile
- 2) Bus
- 3) Railway
- 4) Airway ✓

Automobile accounts for the largest passenger-miles.

Railway accounts for the lowest passenger-miles.

Problem 2)

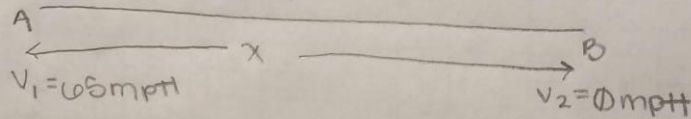
What color combinations are used for general warning signs (e.g., advance railroad crossing signs)? (b) Why are these combinations used?

(a) Black + white, and black + yellow are the color combinations used for general warning signs. ✓

(b) These combinations are used because the eye is more sensitive to this combination. ✓

Problem 3)

A driver with a perception-reaction time of 2.5 sec is driving at 65 mph when he/she observes that an accident has blocked the road ahead. Determine the distance the vehicle would move before the driver could alternate the brakes.

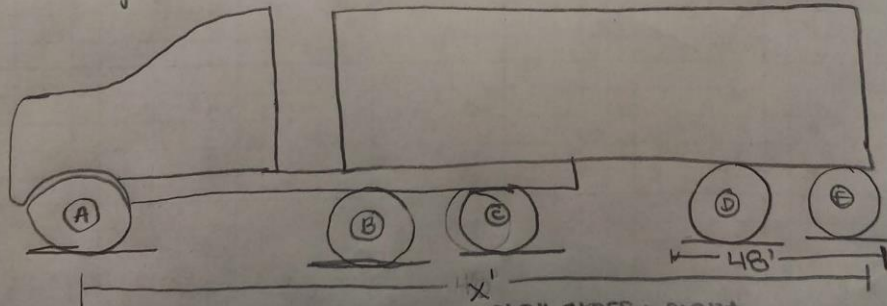


$$\text{Distance (d)} = \text{velocity} \times \text{time}$$

$$= \frac{65 \text{ miles}}{\text{hr}} \times \frac{1 \text{ hr}}{60 \text{ min}} \times \frac{1 \text{ min}}{60 \text{ s}} \times \frac{2.5 \text{ s}}{1} =$$

$= 0.045 \text{ miles}$   
 $\therefore$  the distance the vehicle would move is 0.045 miles. ✓

Problem 4) A 5-axle truck traveling on an interstate highway has the following axle characteristics: Distance between the first set of tandem axles + the back set of tandem axles = 48 ft. Determine the overall gross weight of the truck.



$$W = 500 \left[ \frac{LN}{N-1} + 12N + 36 \right]$$

$$= 500 \left[ \frac{(48)(5)}{4} + 12(5) + 36 \right] = 80,000 \text{ lb} \quad \checkmark$$

W: overall gross weight

N: # of axles in group

L: extreme spacing of any group of 2 or more consecutive axles (ft).

**AVERAGE  
(NO DATA)**

**BELOW AVERAGE  
(NO DATA)**

□

□

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**HOMEWORK 3**

**TOPICS COVERED IN HOMEWORK 3**

**1. Geometric Design of Highways**

**CVEG 3302 Transportation Engineering, Spring 2022**  
**Homework Assignment #3**

**Due Date: Thursday, February 17, 2022 (on Canvas)**

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

1. The design speed of a multilane highway is 60 mi/h. Determine (a) the minimum stopping sight distance (SSD) that should be provided for a level roadway, and (b) the minimum SSD that should be provided for a roadway with a maximum grade of 7 percent. [Since this roadway has a maximum grade of 7 percent,  $G = -0.07$ . The downgrade (negative) case provides the most conservative (higher) value for design.] Note: the term  $a/g$  in the appropriate equation is typically rounded to 0.35 for calculation purposes. Assume perception reaction time = 2.5 sec. (30 pts)
2. The acceleration of a vehicle can be expressed as:  $du/dt = 3.6 - 0.06u$ . If the vehicle speed,  $u$ , is 30 ft/sec at time  $T_0$ , determine acceleration after 4 seconds. (15 pts)
3. Determine the horsepower developed by a passenger car traveling at a speed of 50 mi/h on an upgrade of 5% with a smooth pavement. The weight of the car is 3500 lb and the cross-sectional area of the car is 40 ft<sup>2</sup>. (40 pts)
4. What is the distance required to stop an average passenger car when brakes are applied on a 3.3% downgrade if that vehicle was originally traveling at 35 mi/h? (15 pts)



**ABOVE AVERAGE**



**Civil Engineering Department**

**Prairie View A&M University**

**CVEG 3302(P01): Transportation Engineering**

**Homework**

**Spring 2022**

**Homework 3**

**Assigned Date**

**February 10, 2022**

**Completed by**

**Allyssa Reynolds**

**Submitted by**

**Allyssa Reynolds**

**On**

**February 17, 2022**

**To**

**Dr. Liu**

**CVEG 3302 Transportation Engineering, Spring 2022**

**Homework Assignment #3**

**Due Date: Thursday, February 17, 2022 (on Canvas)**

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

1. The design speed of a multilane highway is 60 mi/h. Determine (a) the minimum stopping sight distance (SSD) that should be provided for a level roadway, and (b) the minimum SSD that should be provided for a roadway with a maximum grade of 7 percent. [Since this roadway has a maximum grade of 7 percent,  $G = -0.07$ . The downgrade (negative) case provides the most conservative (higher) value for design.] Note: the term  $a/g$  in the appropriate equation is typically rounded to 0.35 for calculation purposes. Assume perception reaction time = 2.5 sec. (30 pts)
2. The acceleration of a vehicle can be expressed as:  $du/dt = 3.6 - 0.06u$ . If the vehicle speed,  $u$ , is 30 ft/sec at time  $T_0$ , determine acceleration after 4 seconds. (15 pts)
3. Determine the horsepower developed by a passenger car traveling at a speed of 50 mi/h on an upgrade of 5% with a smooth pavement. The weight of the car is 3500 lb and the cross-sectional area of the car is 40 ft<sup>2</sup>. (40 pts)
4. What is the distance required to stop an average passenger car when brakes are applied on a 3.3% downgrade if that vehicle was originally traveling at 35 mi/h? (15 pts)

# Homework 03

CVEG 3302 (201)  
Transportation Engineering

Allyssa Reynolds

## Problem 1)

Design speed of a multi-lane highway is 60 mi/hr. Determine:  
(a) min. stopping sight distance (SSD) that should be provided for  
a level roadway.  $f_f$  rounded to 0.35. Assume  $t = 2.5$  s.

$$SSD = \text{lag distance} + \text{braking distance}$$

$$= 1.47 u t + \frac{u^2}{30 (f_f \pm G)}$$

$$= (1.47)(60)(2.5) + \frac{60^2}{30 (0.35 \pm 0)}$$

$$= 220.5 + 342.86$$

$$= 563.36 \text{ ft}$$

(b) min. SSD that should be provided for a roadway w/ a  
maximum grade of 7%  
 $G = -0.07$

$$SSD = 1.47 u t + \frac{u^2}{30 (f_f \pm G)}$$

$$= 1.47 (60)(2.5) + \frac{60^2}{30 (0.35 - 0.07)}$$

$$= 220.5 + 428.57$$

$$= 649.07 \text{ ft}$$

$$SSD = 1.47 u t + \frac{u^2}{30 (f_f \pm G)}$$

$$= 1.47 (60)(2.5) + \frac{60^2}{30 (0.35 - 0.07)}$$

$$= 220.5 + 285.71$$

$$= 506.21 \text{ ft}$$

## Problem 2)

The acc. of a vehicle can be expressed as:  $\frac{du}{dt} = 3.6 - 0.06u$ .

If the vehicle speed,  $u$ , is 30 ft/s at time  $T_0$ , determine acceleration  
after 4 seconds.

$$\alpha = 3.6$$

$$\beta = 0.06$$

$$u_t = \frac{\alpha}{\beta} (1 - e^{-\beta t}) + u_0 e^{-\beta t}$$

$$\frac{du}{dt} = \alpha - \beta u_t$$

$$u_t = \frac{3.6}{0.06} (1 - e^{-0.06(4)}) + 30 e^{-0.06(4)}$$

$$= 60 (0.2134) + 23.6$$

$$= 36.4$$

$$\frac{du}{dt} = 3.6 - (0.06)(36.4)$$

$$\frac{du}{dt} = 1.416 \text{ ft/s}$$

$$\therefore a = 1.416 \text{ ft/s}$$

Homework 03

CVE63302 P(01)  
Transportation  
Engineering

Allyssa Reynolds

Problem 3)

Determine the horsepower developed by a passenger car traveling at a speed of 50 mi/hr on an upgrade 5% w/ a smooth pavement. The weight of the car is 3500 lb & cross-sectional area of the car is 40 ft<sup>2</sup>.

Air Resistance

$$P = 0.076 W V^2 \quad \rho = 32.2$$

$$C_D = 0.4$$

$$A = 40 \text{ ft}^2$$

$$R_a = 0.5 \left( \frac{2.15 C_D A V^2}{g} \right) \quad V = 50$$

$$= 0.5 \left( \frac{2.15 (0.076 W) (0.4) (40) (50)^2}{32.2} \right)$$

$$= 0.5 (204.58)$$

$$= 102.31 \text{ lb}$$

Grade Resistance

$$R_g = \text{Weight} \times \text{grade}$$

$$= 3500 (0.05)$$

$$= 175 \text{ lb}$$

Rolling Resistance

$$R_r = (C_{rs} + 2.15 C_{rw} V^2) W$$

$$= (0.012 + 2.15 (0.65 \times 10^{-4}) (50)^2) (3500)$$

$$= 54.231 \text{ lb}$$

Horsepower Delivered

$$P = \frac{1.47 R_{g \text{ sum}}}{550}$$

$$550$$

$$= \frac{1.47 (102.3 + 175 + 54.23) (50)}{550}$$

$$550$$

$$= 44.30 \text{ hp}$$

$\therefore$  the horsepower developed is 44.30 hp.



**AVERAGE  
(NO DATA)**

**BELOW AVERAGE  
(NO DATA)**

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**HOMEWORK 4**

**TOPICS COVERED IN HOMEWORK 4**

**1. Geometric Design of Highways**

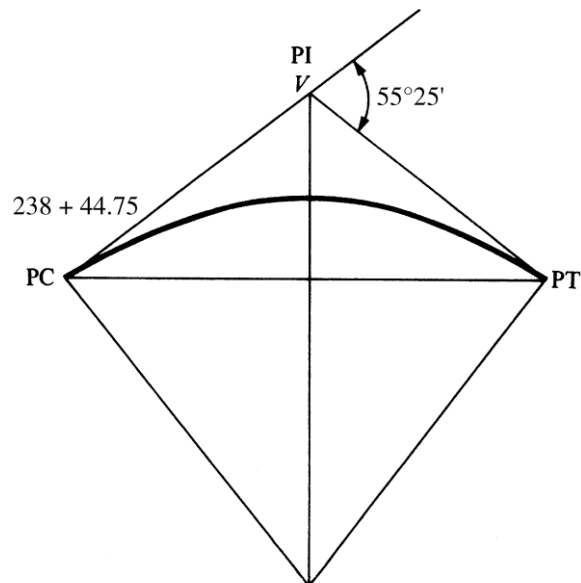


**CVEG 3302 Transportation Engineering, Spring 2022**  
**Homework Assignment #4**

**Due Date: Thursday, March 10, 2022 (on Canvas)**

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

1. (70 pts.) A crest vertical curve connects a +4.44% grade and a -6.87% grade. The PVI is at station 43+50.00 at an elevation of 1240.00 ft. The design speed is 30 mi/h and the length of the vertical curve is 214.89 ft. Determine: (a) The station of the BVC, (b) The elevation of the BVC, (c) The station of the EVC, (d) The elevation of the EVC, (e) The station of the high point, (f) The elevation of the high point, (g) The elevation of station 44+23.23
2. (30 pts.) The intersection angle of a 4° curve is  $55^{\circ}25'$ , and the PC is located at station 238+44.75. Determine (a) the length of the curve, (b) the station of the PT, (c) the deflection angles, and (d) the chord lengths for setting out the curve at whole stations from the PC.



**ABOVE AVERAGE**

CVEG 3302 PM

HW # 4

Hunter Rodgers

①

$$A = |4.44 - (-6.87)|$$

$$Y = 1240 \text{ ft}$$

100

$$A = 11.31\%$$

$$G_1 = 4.44$$

$$G_2 = -6.87$$

$$L = 214.89$$

$$\begin{aligned} \text{a) Station BVC} &= \text{Sta @ } 1240 \text{ ft} - \frac{L}{2} \\ &= 43 + 50.00 - \frac{214.89}{2} \\ &= 43 + 50.00 - 107.445 \\ &= 42 + 42.55 \end{aligned}$$

$$\begin{aligned} \text{b) Elevation @ BVC} &= Y - \frac{G_1 \times L}{200} \\ &= 1240 \text{ ft} - \frac{(4.44)(214.89)}{200} \\ &= 1240 \text{ ft} - 4.771 \\ &= 1235.23 \text{ ft} \end{aligned}$$

$$\begin{aligned} \text{c) Station @ EVC} &= \text{Sta @ } 1240 \text{ ft} + \frac{L}{2} \\ &= 43 + 50.00 + \frac{214.89}{2} \\ &= 44 + 57.45 \end{aligned}$$

$$\begin{aligned} \text{d) Elevation @ EVC} &= Y + \frac{G_2 \times L}{200} \\ &= 1240 \text{ ft} + \frac{(-6.87)(214.89)}{200} \\ &= 1232.62 \text{ ft} \end{aligned}$$

$$e) \quad X_{\text{high}} = \frac{L G_1}{(G_1 - G_2)} \quad \text{or} \quad \frac{L G_1}{A}$$

$$= \frac{(214.89)(4.44)}{(4.44 - -6.87)}$$

$$X_{\text{high}} = \underline{84.36 \text{ ft}}$$

$$= \text{Station@ BVC} + X_{\text{high}}$$

$$= (42 + 42.55) + 84.36 \text{ ft}$$

$$= \boxed{43 + 26.91}$$

$$f) \quad Y_{\text{high}} = \frac{L G_1^2}{200(G_1 - G_2)}$$

$$Y_{\text{high}} = \frac{214.89 (4.44)^2}{200(11.31)}$$

$$Y_{\text{high}} = \underline{1.87 \text{ ft}}$$

$$= \text{Elevation of BVC} + Y_{\text{high}}$$

$$1235.23 + 1.87$$

$$= \boxed{1237.1 \text{ ft}}$$



$$h) \text{ Tangent Elevation} = \text{Elevation of BVC} + \frac{G \cdot X}{100}$$

@ 44+23.23

$$\begin{aligned} \text{Tangent Ele} &= 1235.23 + \frac{4.44 \cdot 180.68}{100} \\ &= 1243.25 \text{ ft} \end{aligned}$$

$$\begin{aligned} Y &= \frac{Ax^2}{200L} \\ &= \frac{11.31(180.68)^2}{200(214.89)} = \underline{8.59 \text{ ft}} \end{aligned}$$

$$\text{Elev of } (44+23.23) = \text{Elev of BVC} - \text{offset}$$

$$= 1243.25 - 8.59$$

$$\boxed{= 1234.66 \text{ ft}}$$

$$\textcircled{2} \quad \text{Radius of curve} = \frac{5729.6}{D} = \frac{5729.6}{4} = \underline{1432.4 \text{ ft}}$$

$$a) \text{ Length of Curve} = \frac{R \Delta \pi}{180} = \frac{(1432.4)(55.4167 \pi)}{180}$$

$$= \underline{1385.42 \text{ ft}}$$

$$\begin{array}{c} 55^\circ 25' \\ \downarrow \\ 55.4167 \end{array}$$

$$b) \text{ Station of PT} = \text{PC station} + \text{Length of Curve}$$

$$\begin{aligned} &= 238 + 44.75 + 1385.42 \\ &= \underline{252 + 30.17} \end{aligned}$$

$$d) 239 - (238 + 44.75) = \underline{55.25 \text{ ft}}$$

**AVERAGE**

75

$$(1) A = 4.44 - (-6.87) = 11.31'$$

$$a) L = 19 \times 11.31 = 214.89 \text{ ft}$$

$$b) (43 + 50) - \frac{214.89}{2} = (42 + 42.55)$$

$$c) \frac{1240 - 4.44 \times 214.89}{200} = 1,235.23 \text{ ft}$$

$$d) (43 + 50) + \frac{214.89}{2} = (44 + 57.45)$$

$$e) \frac{1,240 + -6.87 \times 214.89}{200} = 1,232.62 \text{ ft}$$

$$f) \frac{214.89 \times 4.44}{(4.44 - (-6.87))} = 84.36 \text{ ft}$$

$$\rightarrow (42 + 42.55) + 84.36 = (43 + 26.91)$$

$$g) Y_{\text{high}} = \frac{214.89 \times 4.44}{200 (4.44 - (-6.87))} = 1.87 \text{ ft}$$

$$\rightarrow 1,235.23 + 1.87 = 1,237.1 \text{ ft}$$

cg) "



$$(2) \text{ radius} = \frac{1719}{4} = 429.8 \text{ m}$$

$$\text{Length curve} = \frac{(429.8)(55.4167)\pi}{180} = 415.7\text{m} \times$$

$$= (13 + 25.63) \text{ Station}$$

Station at PT =  $(238 + 13.43) + (13 + 25.63)$   
 $= (252 + 9.06)$  Station

distance between

PT and first section:  $(239+00) - (238+13.43) = 16.57m$

$$SI = \frac{16.57}{415.7} + \frac{55.4117}{1000} = 2.210\%$$

deflection angle =  $\frac{\delta l}{2} = 1.105'' = 1^{\circ} 6' 18''$

↳ distance between

last station in PT (2 :  $(252 + 9.05) - (252 + 00) = 9.05m$

$$S_2 = 9.05 \times 85.4164 = 773.7$$

deflection angle =  $1.206' / 2 = 0.603^\circ$

[illegible]

**BELOW AVERAGE  
(NO DATA)**

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**HOMEWORK 5**

**TOPICS COVERED IN HOMEWORK 5**

- 1. Geometric Design of Highways**
- 2. Highway Surveys and Location**

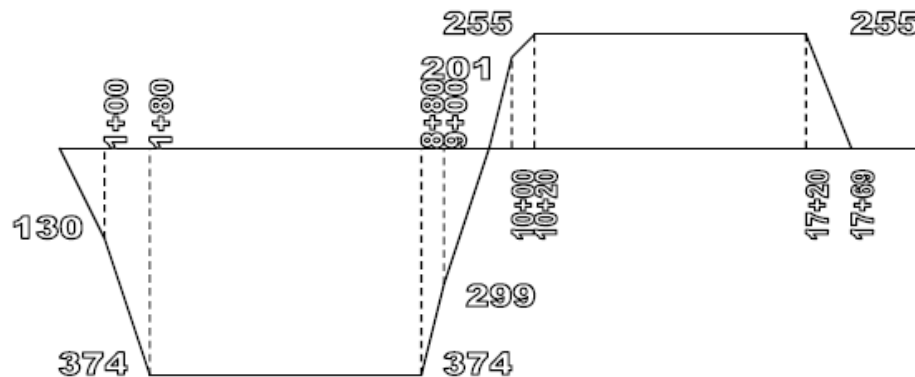
## CVEG 3302 Transportation Engineering, Spring 2022

### Homework Assignment #5

Due Date: Friday, March 25, 2022 (on Canvas)

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

3. (50 pts.) Given a sag vertical curve connecting a  $-1.5\%$  grade with a  $+2.5\%$  grade on a rural arterial highway with a length of the curve of 724 ft, compute the elevation of the curve at 100 ft stations if the grades intersect at station (475+00) at an elevation of 300.00 ft. Identify the station and elevation of the low point.
4. (50 pts.) Using the mass diagram given below, determine the total overhaul cost if the free haul is 700 ft and the overhaul cost is \$10 per cubic yard station. Stations of the free haul lines are 1 + 80 and 8 + 80 and 10 + 20 and 17 + 20.



Practice Problems (**NOT** to be graded)

- A crest vertical curve connects a  $+4.90\%$  grade and a  $-1.85\%$  grade. The PVI is at station 77+00.00 at an elevation of 770.00 ft. The design speed is 60 mi/h. The length of the vertical curve is 1019.25 ft. Determine: (a) The station of the BVC, (b) The elevation of the BVC, (c) The station of the EVC, (d) The elevation of the EVC, (e) The station of the high point, (f) The elevation of the high point, (g) The elevation of station 75+30.00
- Determine the minimum length of a sag vertical curve if the grades are  $-4\%$  and  $+2\%$ . Design speed is 70 mi/h. State assumptions used. Consider the following criteria: stopping sight distance, comfort, and general appearance.

**ABOVE AVERAGE**

$$\textcircled{1} \quad G_1 = -1.5\%$$

$$G_2 = +2.5\%$$

$$y = ax^2 + bx + c$$

$$a = \frac{g_2 - g_1}{2L} = \frac{2.5 + 1.5}{2 \times 7.24} = \underline{0.276}$$

$$b = G_1$$

$$c = 300 + \frac{1.5 \times 724}{200} = \underline{305.43 \text{ ft}}$$

$$y = 0.276x^2 - 1.5x + 305.43 \quad \left( \begin{array}{l} \text{Station} \\ \text{elevation} \end{array} \right)$$

$$47138 + \frac{1.5 \times 724}{4} =$$

$$47138 + 271.5 = 47409.5$$

$$\frac{271.5}{100} = 2.715 =$$

$$y = 0.276 \cdot 2.715^2 - 1.5 \cdot 2.715 + 305.43$$

$$\underline{y = 303.391 \text{ ft}}$$



| Station | x    | elevation |
|---------|------|-----------|
| 471+38  | 0    | 305.43    |
| 472+00  | 0.62 | 304.60    |
| 473+00  | 1.62 | 303.72    |
| 474+00  | 2.62 | 303.94    |
| 475+00  | 3.62 | 303.62    |
| 476+00  | 4.62 | 304.39    |
| 477+00  | 5.62 | 305.72    |
| 478+00  | 6.62 | 307.59    |

②

$$\frac{(1)1+80}{100} = \left( \frac{\frac{100}{2} + 80}{100} \right) (130) + \left( \frac{\frac{80}{2}}{100} \right) (374 - 130)$$

$$(1.3)(130) + (.4)(244) \\ = \underline{266.6 \text{ yd}^3 - \text{station}}$$

$$\frac{266.6 \text{ yd}^3}{374 \text{ yd}^3} = \underline{0.713 - \text{station}}$$

$$\frac{(2)8+80}{100} = \left( \frac{\frac{63}{2} + 20}{100} \right) (299) + \left( \frac{\frac{20}{2}}{100} \right) (374 - 299)$$

$$(.515)(299) + (.1)(75)$$

$$153.985 + 7.5$$

$$= \underline{161.485 \text{ yd}^3}$$

$$\frac{161.485 \text{ yd}^3}{374 \text{ yd}^3} = \underline{0.432 - \text{station}}$$

$$\text{Overhaul cost} = (1 + 2)(374 \text{ yd}^3) \left( \frac{\text{overhaul cost}}{\text{per CY}} \right) \\ = (0.713 + 0.432)(374 \text{ yd}^3) (\$10 / \text{yd}^3)$$

$$= \$4,282.3 \quad \text{X}$$



$$\begin{aligned}
 10+20 &= \left( \frac{\frac{37}{2} + 20}{100} \right) (201) + \left( \frac{\frac{20}{2}}{100} \right) (255 - 201) \\
 &= 77.385 + 5.4 \\
 &= \underline{82.785 \text{ yd}^3}
 \end{aligned}$$

$$\frac{82.785 \text{ yd}^3}{255 \text{ yd}^3} = \underline{0.325 \text{ station}}$$

$$\begin{aligned}
 17+20 &= \left( \frac{\frac{49}{2}}{100} \right) (255) \\
 &= \underline{62.475 \text{ yd}^3}
 \end{aligned}$$

$$\frac{62.475 \text{ yd}^3}{255 \text{ yd}^3} = \underline{0.245 \text{ station}}$$

$$\begin{aligned}
 \text{Overhaul cost} &= (3 + 4) (255 \text{ yd}^3) \left( \frac{\text{overhaul cost}}{\text{per CY}} \right) \\
 &= (0.325 + 0.245) (255 \text{ yd}^3) (\$10 / \text{yd}^3) \\
 &= \underline{\$1,453.5}
 \end{aligned}$$

**AVERAGE  
(NO DATA)**

**BELOW AVERAGE**

CNEG 3302

HW 5

Maurice B. H.

Question 1 Given initial grade  $g_1 = 1.25\%$   
 final grade  $g_2 = -2.75\%$   
 $V = 65 \text{ MPH}$

$$SSD = 645$$

$$A = 191 - 327 \quad 1.25 - (-2.75) = A = 4\%$$

$$t_{min} = \frac{AS^2}{200(WA + \sqrt{A})^2}$$

$$H_1 = 35 \text{ ft} \quad H_2 = 2.0 \text{ ft}$$

$$L_{min} = \frac{4(95)^2}{200(2.5 + \sqrt{2.0})^2}$$

$$L_{min} = 771.023$$

50

Question 2

BVC = station 300 ft elevation -  $\frac{L}{2}$

475+00 = station @ 300 ft elevation and 724 ft PCL

$$BVC = (475+00) - \frac{724}{2} = (471+38)$$

$$BVC = 471+38$$

$$(475+00) + \frac{724}{2} = (478+62) \approx FVC$$

$$BVC = y - \frac{G_1 x}{200}$$

$$BVC = 300 - \frac{1.3 \times 724}{200} = 305.93 \text{ ft}$$

$$y = \frac{Ax^2}{200L} \quad y = \frac{4 \times 62^2}{200 \times 724} = 0.11 \text{ ft}$$

$$305.5 + 0.11 = 305.61 \text{ ft}$$

Curve Elevation



# Question 2 cont

| Station | Distance from BVC (x) Ft | Tangent Elevation (ft) | Offset | Curve elevation (tangent elevation + offset) (ft) |
|---------|--------------------------|------------------------|--------|---------------------------------------------------|
| 471.38  | 0                        | 305.43                 | 0      | 305.43                                            |
| 472.00  | 62                       | 304.5                  | 0.11   | 304.61                                            |
| 473     | 122                      | 303                    | 0.73   | 303.27                                            |
| 474     | 182                      | 301.5                  | 1.9    | 303.4                                             |
| 475     | 242                      | 300                    | 3.62   | 303.62                                            |
| 476     | 302                      | 298.5                  | 5.9    | 304.4                                             |
| 477     | 362                      | 297                    | 8.73   | 305.73                                            |
| 478     | 422                      | 295.5                  | 12.11  | 307.61                                            |
| 478.62  | 482                      | 294.57                 | 14.48  | 309.05                                            |

$$y_{10w} = \frac{L G_1^2}{200(G_1 - G_2)}$$

$$y_{10w} = \frac{724 \times (1.5)^2}{200(-1.5 - 2.5)}$$

$$= -2.24 \text{ ft}$$

$$305.43 - 2.24 = 303.19 \text{ ft}$$

$$y_{10w} = \frac{L G_2^2}{200(G_1 - G_2)}$$

$$x_{10w} = \frac{-724 \times 1.5}{(1.5 - 2.5)} = 271.5 \text{ off}$$

question 2 was missing. The question 2 you provided is question 1.

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**HOMEWORK 6**

**TOPICS COVERED IN HOMEWORK 6**

**1. Traffic Engineering**

## CVEG 3302 Transportation Engineering, Spring 2022

### Homework Assignment #6

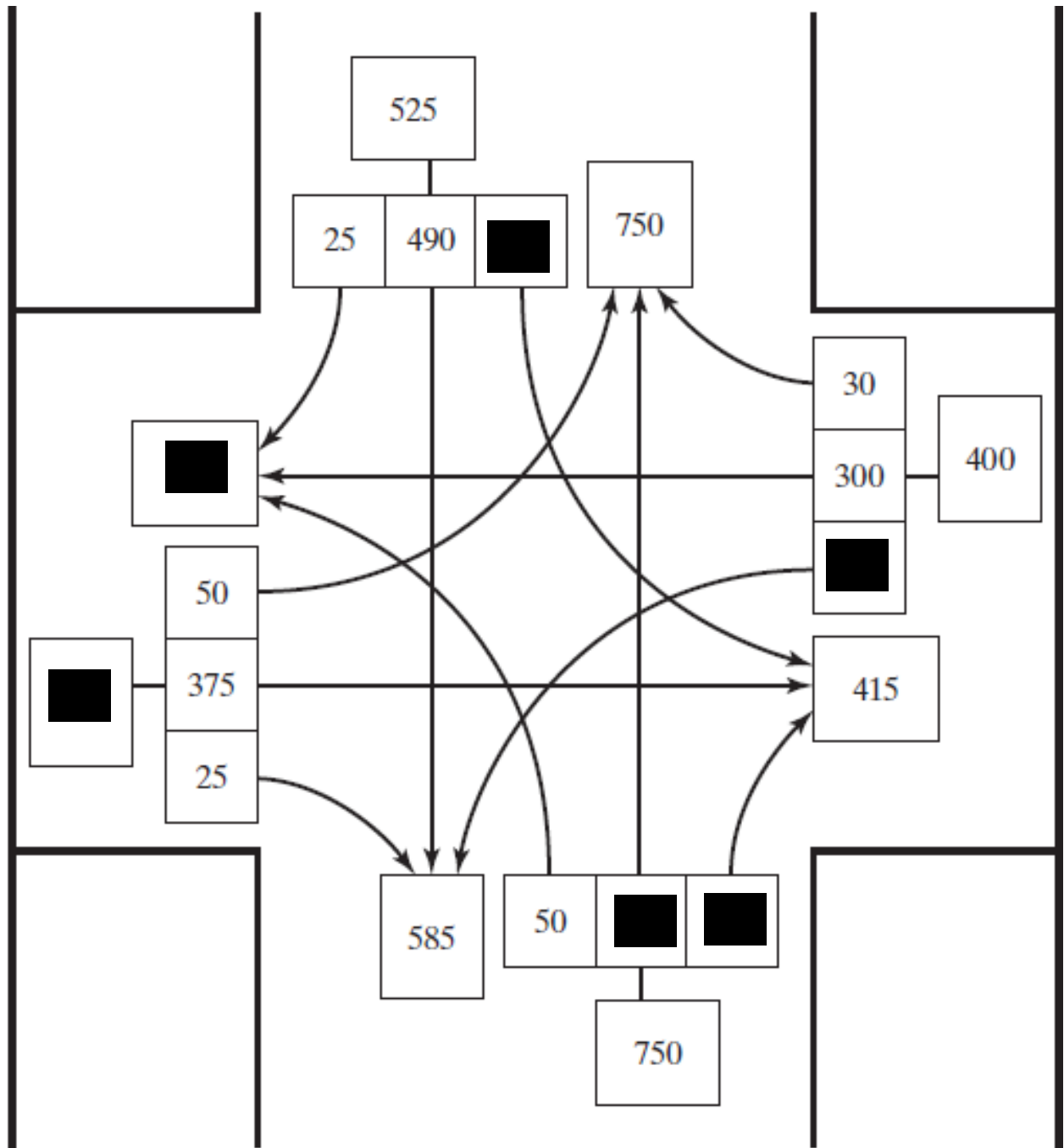
**Due Date: Saturday, April 2, 2022 (on Canvas)**

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

- 1.(80 pts.) Using the data below, develop cumulative percentage distribution for the data and determine (a) average speed, (b) 85th-percentile speed, (c) 15th-percentile speed, and (d) median speed.

| <i>Car No.</i> | <i>Speed<br/>(mi/h)</i> | <i>Car No.</i> | <i>Speed<br/>(mi/h)</i> | <i>Car No.</i> | <i>Speed<br/>(mi/h)</i> | <i>Car No.</i> | <i>Speed<br/>(mi/h)</i> |
|----------------|-------------------------|----------------|-------------------------|----------------|-------------------------|----------------|-------------------------|
| 1              | 35.1                    | 23             | 46.1                    | 45             | 47.8                    | 67             | 56.0                    |
| 2              | 44.0                    | 24             | 54.2                    | 46             | 47.1                    | 68             | 49.1                    |
| 3              | 45.8                    | 25             | 52.3                    | 47             | 34.8                    | 69             | 49.2                    |
| 4              | 44.3                    | 26             | 57.3                    | 48             | 52.4                    | 70             | 56.4                    |
| 5              | 36.3                    | 27             | 46.8                    | 49             | 49.1                    | 71             | 48.5                    |
| 6              | 54.0                    | 28             | 57.8                    | 50             | 37.1                    | 72             | 45.4                    |
| 7              | 42.1                    | 29             | 36.8                    | 51             | 65.0                    | 73             | 48.6                    |
| 8              | 50.1                    | 30             | 55.8                    | 52             | 49.5                    | 74             | 52.0                    |
| 9              | 51.8                    | 31             | 43.3                    | 53             | 52.2                    | 75             | 49.8                    |
| 10             | 50.8                    | 32             | 55.3                    | 54             | 48.4                    | 76             | 63.4                    |
| 11             | 38.3                    | 33             | 39.0                    | 55             | 42.8                    | 77             | 60.1                    |
| 12             | 44.6                    | 34             | 53.7                    | 56             | 49.5                    | 78             | 48.8                    |
| 13             | 45.2                    | 35             | 40.8                    | 57             | 48.6                    | 79             | 52.1                    |
| 14             | 41.1                    | 36             | 54.5                    | 58             | 41.2                    | 80             | 48.7                    |
| 15             | 55.1                    | 37             | 51.6                    | 59             | 48.0                    | 81             | 61.8                    |
| 16             | 50.2                    | 38             | 51.7                    | 60             | 58.0                    | 82             | 56.6                    |
| 17             | 54.3                    | 39             | 50.3                    | 61             | 49.0                    | 83             | 48.2                    |
| 18             | 45.4                    | 40             | 59.8                    | 62             | 41.8                    | 84             | 62.1                    |
| 19             | 55.2                    | 41             | 40.3                    | 63             | 48.3                    | 85             | 53.3                    |
| 20             | 45.7                    | 42             | 55.1                    | 64             | 45.9                    | 86             | 53.4                    |
| 21             | 54.1                    | 43             | 45.0                    | 65             | 44.7                    |                |                         |
| 22             | 54.0                    | 44             | 48.3                    | 66             | 49.5                    |                |                         |

2.(20 pts.) Below is a graphic intersection summary diagram that allows simple entry of data on a predesigned graphic form. Please identify the values in all black boxes.





**ABOVE AVERAGE  
(NO DATA)**

**AVERAGE**

**CVEG 3302 Transportation Engineering, Spring 2022**

**Homework Assignment #6**

**Due Date: Saturday, April 2, 2022 (on Canvas)**

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

1. (80 pts.) Using the data below, develop cumulative percentage distribution for the data and determine (a) average speed, (b) 85th-percentile speed, (c) 15th-percentile speed, and (d) median speed.

| <i>Car No.</i> | <i>Speed<br/>(mi/h)</i> | <i>Car No.</i> | <i>Speed<br/>(mi/h)</i> | <i>Car No.</i> | <i>Speed<br/>(mi/h)</i> | <i>Car No.</i> | <i>Speed<br/>(mi/h)</i> |
|----------------|-------------------------|----------------|-------------------------|----------------|-------------------------|----------------|-------------------------|
| 1              | 35.1                    | 23             | 46.1                    | 45             | 47.8                    | 67             | 56.0                    |
| 2              | 44.0                    | 24             | 54.2                    | 46             | 47.1                    | 68             | 49.1                    |
| 3              | 45.8                    | 25             | 52.3                    | 47             | 34.8                    | 69             | 49.2                    |
| 4              | 44.3                    | 26             | 57.3                    | 48             | 52.4                    | 70             | 56.4                    |
| 5              | 36.3                    | 27             | 46.8                    | 49             | 49.1                    | 71             | 48.5                    |
| 6              | 54.0                    | 28             | 57.8                    | 50             | 37.1                    | 72             | 45.4                    |
| 7              | 42.1                    | 29             | 36.8                    | 51             | 65.0                    | 73             | 48.6                    |
| 8              | 50.1                    | 30             | 55.8                    | 52             | 49.5                    | 74             | 52.0                    |
| 9              | 51.8                    | 31             | 43.3                    | 53             | 52.2                    | 75             | 49.8                    |
| 10             | 50.8                    | 32             | 55.3                    | 54             | 48.4                    | 76             | 63.4                    |
| 11             | 38.3                    | 33             | 39.0                    | 55             | 42.8                    | 77             | 60.1                    |
| 12             | 44.6                    | 34             | 53.7                    | 56             | 49.5                    | 78             | 48.8                    |
| 13             | 45.2                    | 35             | 40.8                    | 57             | 48.6                    | 79             | 52.1                    |
| 14             | 41.1                    | 36             | 54.5                    | 58             | 41.2                    | 80             | 48.7                    |
| 15             | 55.1                    | 37             | 51.6                    | 59             | 48.0                    | 81             | 61.8                    |
| 16             | 50.2                    | 38             | 51.7                    | 60             | 58.0                    | 82             | 56.6                    |
| 17             | 54.3                    | 39             | 50.3                    | 61             | 49.0                    | 83             | 48.2                    |
| 18             | 45.4                    | 40             | 59.8                    | 62             | 41.8                    | 84             | 62.1                    |
| 19             | 55.2                    | 41             | 40.3                    | 63             | 48.3                    | 85             | 53.3                    |
| 20             | 45.7                    | 42             | 55.1                    | 64             | 45.9                    | 86             | 53.4                    |
| 21             | 54.1                    | 43             | 45.0                    | 65             | 44.7                    |                |                         |
| 22             | 54.0                    | 44             | 48.3                    | 66             | 49.5                    |                |                         |

$$(a) \text{ Average Speed} = \frac{T_s}{\# \text{ of cars}}$$

80

$$\Rightarrow \frac{4195.7}{86} = \boxed{48.787 \text{ mi/hr}}$$

(b) 85th percentile speed:

$$\frac{53 + 55 - 53}{86.1 - 73.3} \times (85 - 73.3)$$

$$\Rightarrow \boxed{54.8 \text{ mi/hr}}$$

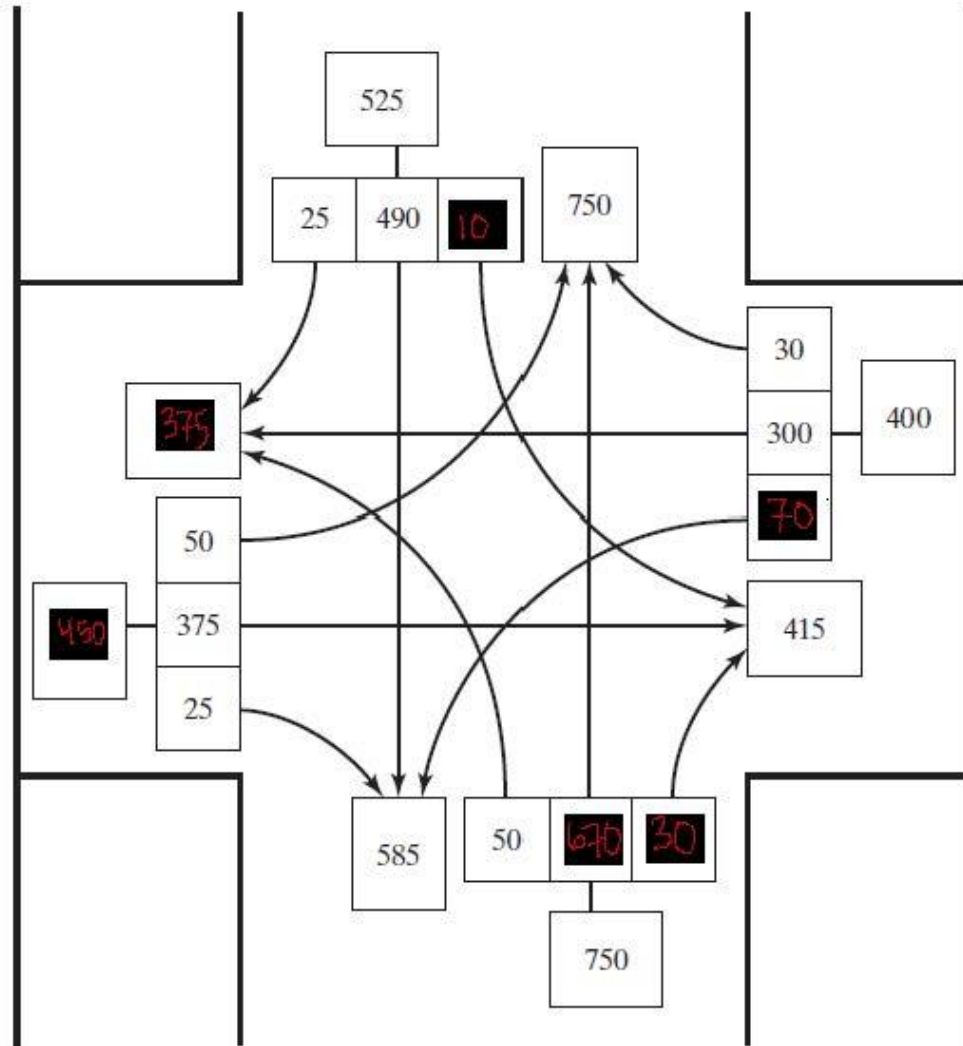
(c) 15th percentile speed:

$$41 + \frac{43 - 41}{17.4 - 13.9} (15 - 13.9) \Rightarrow \boxed{41.63 \text{ mi/hr}}$$

(d)

$$\frac{49 + 51 - 49}{19.75 - 9} (50 - 9) \Rightarrow \boxed{61.148 \text{ mi/hr}}$$

2. (20 pts.) Below is a graphic intersection summary diagram that allows simple entry of data on a predesigned graphic form. Please identify the values in all black boxes.



**BELOW AVERAGE**

maunicebette HW #6

CVF 63302

maunicebette HW #6

CVF 63302

Problem 1

| Speed Range (mi/hr) | Mid Speed (mi/hr) | Frequency | Frequency | Calc Freq |
|---------------------|-------------------|-----------|-----------|-----------|
| 33-35               | 34                | 1         | 1.17      | 1.17      |
| 35-37               | 36                | 3         | 3.44      | 4.66      |
| 37-39               | 38                | 2         | 2.32      | 6.98      |
| 39-41               | 40                | 4         | 4.65      | 11.63     |
| 41-43               | 42                | 5         | 5.81      | 17.44     |
| 43-45               | 44                | 4         | 4.65      | 22.09     |
| 45-47               | 46                | 9         | 10.46     | 32.55     |
| 47-49               | 48                | 12        | 13.96     | 46.51     |
| 49-51               | 50                | 12        | 13.96     | 60.47     |
| 51-53               | 52                | ↓         | 9.30      | 69.77     |
| 53-55               | 54                | 8         | 10.46     | 80.23     |
| 55-57               | 56                | 9         | 9.30      | 89.53     |
| 57-59               | 58                | 8         | 3.44      | 93.07     |
| 59-61               | 60                | 3         | 2.32      | 95.39     |
| 61-63               | 62                | 2         | 2.32      | 97.66     |
| 63-65               | 64                | 2         | 1.17      | 98.83     |
| 65-67               | 66                | 1         | 1.17      | 100       |
|                     |                   | 86        | 100       |           |

(A) Avg Speed =  $\frac{\sum F \times MS}{\sum F} = \frac{4218}{86} = 49.05 \text{ mi/hr}$

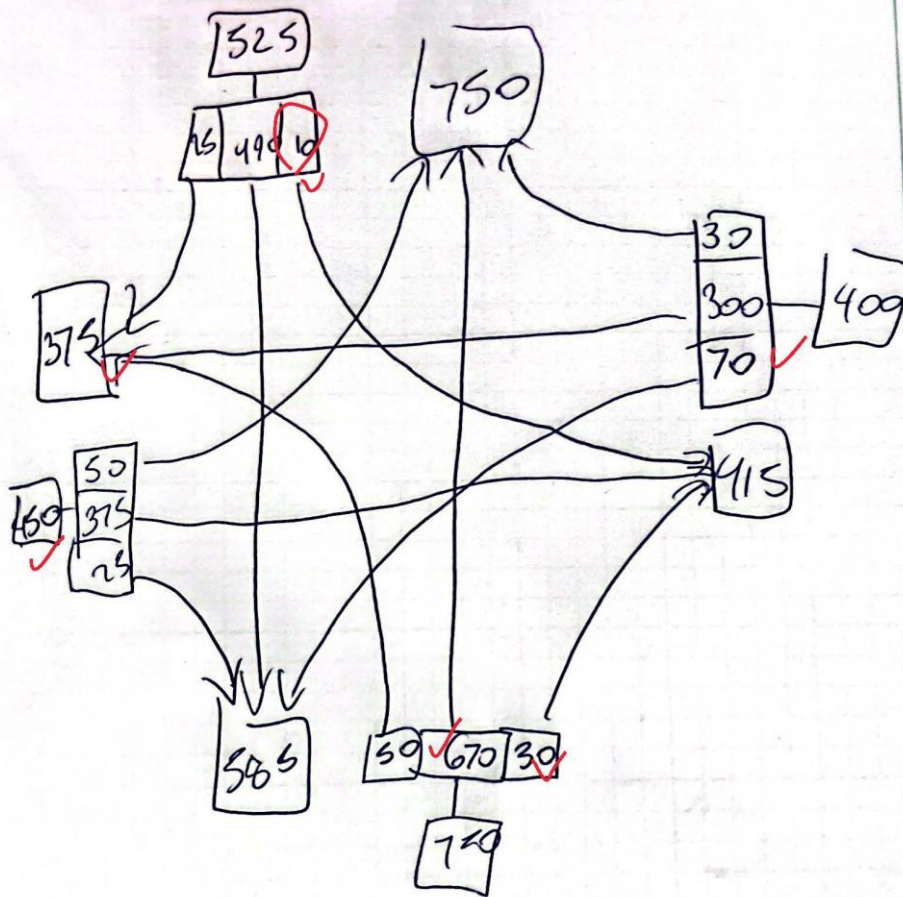
(B) 65th Percentile Speed =  $54 + \frac{56-54}{89.55-80.23} \times (85-80.23) = 55.03$

(C) 15th Percentile Speed =  $40 + \frac{42-40}{17.44-11.63} \times (15-11.63) = 41.16 \text{ mi/hr}$

(D) Median Speed = 50th Percentile Speed =  $48 + \frac{50-48}{60.47-46.51} \times (50-46.51) = 50.5 \text{ mi/hr}$



## Problem 2





**TRANSPORTATION ENGINEERING  
SPRING 2022**

**HOMEWORK 7**

**TOPICS COVERED IN HOMEWORK 7**

**1. Intersection Design and Control**

## CVEG 3302 Transportation Engineering, Spring 2022

### Homework Assignment #7

**Due Date: Thursday, April 22, 2022 (on Canvas)**

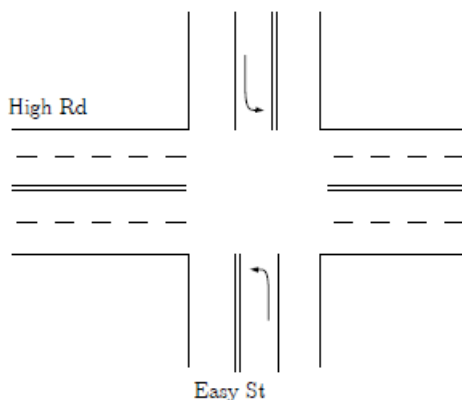
**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

1. (50 pts.) Consider a roadway with (max.) capacity 2000 veh/hr and free-flow speed 40 mph. Initially, the flow is 1000 veh/hr and uncongested. A traffic signal is red for 45 seconds, causing several shockwaves. (a) sketch a time-space diagram, indicating all the shockwaves which are formed; (b) calculate the speed of each shockwave from your diagram. Hints:

$$q_{max} = \frac{u_f k_j}{4}$$

$$k = k_j \left( 1 - \frac{u}{u_f} \right), \quad u = \frac{u_f}{2} + \frac{u_f \sqrt{1 - q/q_{max}}}{2}, \quad u_{AB} = \frac{q_A - q_B}{k_A - k_B}$$

2. (50 pts.) Consider the intersection given below. Lanes are 11 feet wide on Easy Street and 13 feet wide on High Road. Assume a one-second PIJR time. For the north- and southbound direction, there are no heavy vehicles so the design vehicle is 12 ft long and has a deceleration rate of 20 ft/s<sup>2</sup>. For the east- and westbound directions, the design vehicle is 25 ft long and has a deceleration rate of 10 ft/s<sup>2</sup>. The speed limit for all approaches is 30 mph. Calculate the minimum safe clearance time for each approach.



**ABOVE AVERAGE**

Allyssa Reynolds Homework 07 Submission

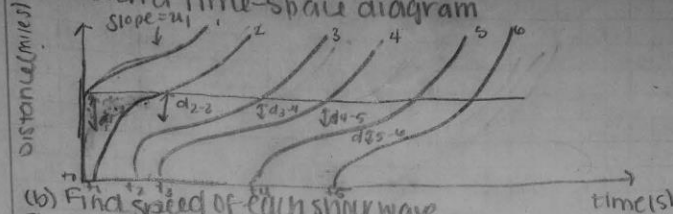
4/22/2022

Transportation Engineer CVEG 3302P01

## Problem 1

Consider a roadway w/ max capacity 2000 ven/hr + free-flow speed is 40 mph. Initially, the flow is 1000 ven/hr and unobstructed. A traffic signal is red for 45s, causing several shockwaves.

(a) Sketch a time-space diagram



(b) Find speed of each shockwave.

$$q_{\max} = \frac{u_f k_j}{4}, \quad k_j = \frac{q_{\max}}{u_f}$$

$$= \frac{4(2000)}{40} = 200 \text{ ven/hr}$$

$$u_{AB} = \frac{q_A - q_B}{k_A - k_B}$$

$$u_1 = \frac{u_f (1 + \sqrt{1 - q/q_{\max}})}{2}$$

$$= \frac{40 (1 + \sqrt{1 - 1000/2000})}{2}$$

$$= 34.14 \text{ mi/hr}$$

$$k_1 = k_j \left(1 - \frac{u_1}{u_f}\right)$$

$$= 200 \left(1 - \frac{34.14}{40}\right)$$

$$k_1 = 29.3 \text{ ven/mi}$$

@ Region 1  
 $q = 1000 \text{ ven/hr}$   
 $k = 29.3 \text{ ven/mi}$

@ Region 2  
 $q = 0 \text{ ven/hr}$   
 $k = 200 \text{ ven/mi}$

@ Region 3  
 $q = 2000 \text{ ven/hr}$   
 $k = \frac{k_j}{2} = 100 \text{ ven/mi}$

@ Region 4  
 $q = 0 \text{ ven/hr}$   
 $k = 0 \text{ ven/mi}$

## Speeds

$$u_{1,2} = \frac{1000 - 0}{29.3 - 100} = -5.85 \text{ mi/hr}$$

$$u_{2,3} = \frac{1000 - 2000}{29.3 - 100} = 14.14 \text{ mi/hr}$$

$$u_{1,4} = \frac{1000 - 0}{29.3 - 0} = 34.13 \text{ mi/hr}$$

$$u_{2,4} = \frac{0 - 2000}{200 - 100} = -20 \text{ mi/hr}$$

$$u_{2,4} = \frac{0 - 0}{200 - 0} = 0 \text{ mi/hr}$$

$$u_{3,4} = \frac{2000 - 0}{100 - 0} = 20 \text{ mi/hr}$$

CIVE 3302 P01

Homework 07

Allyssa Reynolds

2/2

Safety clearance

Easy Street:

Lane width = 11 ft

No heavy vehicles

Design length = 12 ft

Deceleration = 20 ft/s<sup>2</sup> = a

High Rd:

Lane width = 13 ft

Design vehicle = 25 ft

Deceleration = 10 ft/s<sup>2</sup>

PIR = 1 second

Easy Street

$$C \geq \frac{S + \frac{u}{2a} + \frac{W + L}{U}}{2(-a)}$$

$$\geq 1 + \frac{44.1}{2(-20)} + \frac{(11+12)}{44.1} = 2.625$$

$$C \geq 2.625$$

$$30 \text{ mph} = 30(1.47) = 44.1 \text{ ft/s}$$

answers are not correct due to the use of  
wrong unit

High Rd

$$C \geq \frac{S + \frac{u}{2a} + \frac{W + L}{U}}{2(-a)}$$

$$\geq 1 + \frac{44.1}{2(-10)} + \frac{(13+25)}{44.1} = 4.075$$

$$C \geq 4.075$$

**AVERAGE**

CVEG 3302

MAURICE BETH'S

4/21/22 HW# 7

Problem 1

Cap = 2000 veh/hr

free flow speed = 40

flow is 1000 veh/hr

initially

(A)

↑  
space

→ time



79

$$K_f = \frac{q_{max}}{u_f}$$

$u_f = 40 \text{ mi/hr}$

$q_{max} = 2000$

$$K_f = \frac{q_{max}}{u_f} = \frac{2000}{40} = 50 \text{ veh/mi}$$

Region 1  $q_1 = 1000$

$$u_f (1 + \sqrt{1 - \frac{q_{max}}{q_1}}) = \frac{40 (1 + \sqrt{1 - \frac{1000}{2000}})}{2} = 34.14 \text{ mi/hr}$$

$$K_1 = K_f = 200 (1 - \frac{34.14}{40}) = 29.3 \text{ veh/mi}$$

Region 2

$u_2 = u_f = 40$

$K_2 = K_f = 200 \text{ veh/mi}$

$q_2 = 0 \text{ veh/hr}$

Region 3

$q_3 = 2000$

$$K_3 = K_f / 2 = \frac{200}{2} = 100 \text{ veh/mi}$$

Region 4  $q_4 = 0$   $K_4 = 0$



CVF 63302

Maurice Betti's

4/22/22 / CV63302

$$u_{1-2} = \frac{q_1 - q_2}{K_1 - K_2} = \frac{1000 - 0}{39.14 - 200} = -6.029 \text{ mi/hr}$$

ve indicates shock wave move upstream

$$u_{1-3} = \frac{q_1 - q_3}{K_1 - K_3} = \frac{1000 - 2000}{39.14 - 100} = 15.18 \text{ mi/hr}$$

ve sign indicates shock wave move downstream

$$u_{1-4} = \frac{q_1 - q_4}{K_1 - K_4} = \frac{1000 - 0}{39.14 - 0} = 29.24 \text{ mi/hr}$$

downward or downstream

$$u_{2-3} = \frac{q_2 - q_3}{K_2 - K_3} = \frac{0 - 2000}{100 - 100} = -20 \text{ upstream}$$

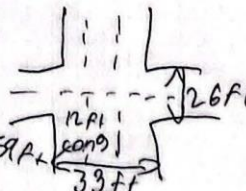
$$u_{2-4} = \frac{q_2 - q_4}{K_2 - K_4} = \frac{0 - 0}{100 - 0} = 0, \text{ stationary}$$

$$u_{3-4} = \frac{q_3 - q_4}{K_3 - K_4} = \frac{2000 - 0}{100 - 0} = 20 \text{ mi/hr downstream}$$

$$\text{Shockwave } 1-2 = -6.029 \text{ mi/hr}$$

Problem 2

$$S = q_4 + \frac{1}{2} a t^2$$

$$= 99 \times 1 + \frac{1}{2} \times 10 \times 1 = 99 \text{ ft}$$


$$\text{Clearance time} = \frac{54 + 12 + 26}{99} = 2.0909 \text{ Sec}$$

$$\text{For east & West bound direct } \Rightarrow S = 99 + \frac{1}{2} a t^2$$

$$99 \times 1 + \frac{1}{2} \times 10 = 99 \text{ ft}$$

$$\text{Clearance time} = \frac{99 + 25 + 33}{99} = 2.932 \text{ Sec}$$

**BELOW AVERAGE  
(NO DATA)**

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**HOMEWORK 8**

**TOPICS COVERED IN HOMEWORK 8**

**1. Introduction to Pavement Design**

## CVEG 3302 Transportation Engineering, Spring 2022

### Homework Assignment #8

**Due Date: Saturday, April 30, 2022 (on Canvas)**

**Full credit given if you answer each question correctly, show work, and the work can be followed (neat, organized, and complete)**

1. (40 pts.) We are building a 6-lane highway. The estimate AADT is 6000 vehicles with the following vehicle distribution

Passenger cars (1000 lb/axle) = 60%  
2-axle single-unit trucks (5000 lb/axle) = 30%  
3-axle single-unit trucks (7000 lb/axle) = 10%

With a growth rate of 5%, design period of 20 years, and predicting 45% of traffic to be on the design lane, what is the total EASL loading?

(The equivalency factors for passenger cars, 2-axle single-unit trucks, and 3-axle single-unit trucks are 0.00002, 0.008, and 0.027, respectively.)

2. (60 pts.) We are designing a flexible pavement for a highway using the AASHTO method to carry a design EASL of  $2 \times 10^6$ . It is estimated that it takes about a week for water to drain from within the pavement and the pavement structure will be exposed to moisture levels approaching saturation for 30% of the time. Use a reliability level of 99%, a standard deviation of 0.49, a design serviceability loss of 2.0, resilient modulus of 9000 lb/in<sup>2</sup> for subgrade, resilient modulus of 450000 lb/in<sup>2</sup> for asphalt concrete, CBR value of 100 for base course, resilient modulus of 31000 lb/in<sup>2</sup> for base course, CBR value of 22 for subbase course, resilient modulus of 13500 lb/in<sup>2</sup> for subbase course to determine a suitable pavement structure.

**ABOVE AVERAGE**

①

Passenger

100

$$\begin{aligned}
 EASL &= S_d G_{rn} (365 \times AADT_i) N_i F_{Ei} \\
 &= .45 \times \frac{(1+.04)^{20} - 1}{.04} (365 \times 6000 \times .6) (2 \times .00002) \\
 &= .45 \times 29.78 (1314000) (.00004) \\
 &= 13.401 (52.56) \\
 &= 704.4 \quad \checkmark \quad \text{can be ignored!}
 \end{aligned}$$

2-axle

$$\begin{aligned}
 &= .45 \times \frac{(1+.04)^{20} - 1}{.04} (365 \times 6000 \times .3) (2 \times .008) \\
 &= .45 \times 29.78 (657000) (.016) \\
 &= 13.401 (10512) \\
 &= 140871.3 \quad \checkmark
 \end{aligned}$$

3-axle

$$\begin{aligned}
 &= .45 \times \frac{(1+.04)^{20} - 1}{.04} (365 \times 6000 \times .1) (3 \times .027) \\
 &= .45 \times 29.78 (219000) (.081) \\
 &= 13.401 (17739) \\
 &= 237720.3 \quad \checkmark
 \end{aligned}$$

$$\begin{aligned}
 \Sigma EASL &= 704.4 + 140,871.3 + 237,720.3 \\
 &= 379,296 \quad \checkmark
 \end{aligned}$$



(2)

$$EASL = 2 \times 10^6$$

$$R = 99\%$$

$$S_o = 0.49$$

$$M_{r1} = 450,000 \text{ psi}$$

$$M_{r2} = 31,000 \text{ psi}$$

$$M_{r3} = 13,500 \text{ psi}$$

$$M_{r4} = 9,000 \text{ psi}$$

$$CB_{r2} = 100$$

$$CB_{r3} = 32$$

$$\Delta P = 2$$

Quality of Drainage

= Fair

$$m = 30\%$$

Sol

$$SN_1 = 2.6 = a_1 D_1 = \frac{2.6}{a_1} = \frac{2.6}{.44} = 5.9 = \boxed{6''}$$

$$SN_2 = a_1 D_1 + a_2 D_2 m_2 = 0.44 \times 6'' + 0.14 D_2 \times 0.8 = 3.8$$

$$D_2 = 10.36'' = \boxed{11''}$$

$$SN_3 = a_1 D_1 + a_2 D_2 m_2 + a_3 D_3 m_3$$

$$= 0.44 \times 6'' + (0.14)(11'')(0.8) + 0.1 D_3 (0.8)$$

$$= 4.4$$

$$D_3 = 5.2'' = \boxed{6''}$$

**AVERAGE**



1)

$$ESAL = \sum_d \times G_{jt} \times AADT_i \times 365 \times N_i \times F_{E_i}$$

Axle 2:

$$ESAL = 0.40 \times 33.06 \times 6000 \times 365 \times 2 \times 0.00626 \times 30\%$$

$$ESAL = 1.0877 \times 10^5$$

Axle 3:

$$ESAL = 0.40 \times 33.06 \times 6000 \times 365 \times 3 \times 0.0224 \times 10\%$$

$$ESAL = 1.946 \times 10^5$$

$$\text{Total ESAL} = ESAL_{\text{Axle 2}} + ESAL_{\text{Axle 3}}$$

$$\text{Total ESAL} = 1.0877 \times 10^5 + 1.946 \times 10^5$$

$$\Rightarrow \boxed{3.0337 \times 10^5}$$

75

2) Reliability level  $(R) = 99\%$  (85-99.9)

Standard deviation  $(S_o) = 0.49$

Initial  $PSI = 4.6$

Terminal  $PSI = 2.5$

$$\Delta PSI = 4.6 - 2.5 = 2$$

Modulus of subgrade = 9000  $PSI$

Resilient value A asphalt = 450,000  $PSI$

CBR of base = 100

CBR of subbase = 22

Resilient Modulus subbase = 13500  $PSI$

- Draw line joining Reliability level = 99% to  $G S_o = 0.49$  & extend line to  $TL$ , where it intersects at A.
- From A, draw a line to  $ES_2 = 7 \times 10^6$  & extend this line to Second  $TL$ , where it intersects at B.
- From B, Draw a line to subgrade modulus = 9000  $PSI$  and extend line to design serviceability after to line intersecting at C.
- Draw horizontal line From point C to  $\Delta PSI$  curve of 1.6 at point D
- Project vertical line from point D to  $SN = 5.3$

- given resilient modulus of 450,000
- from elastic chart  $a_1 = 0.44$
- the resilient modulus of base is 31000 psi
- from chart  $a_2 = 0.18$
- The resilient modulus of subbase is 13500 psi
- from chart  $a_3 = 0.14$
- Drainage Coefficient = 1.10
- $SN = a_1 D_1 + a_2 D_2 M_2 + a_3 D_3 M_3$   
 $SN \Rightarrow 5.3$
- consider resilient modulus subbase = 13500 psi
- $SNL = 3.6$
- consider resilient modulus base = 31000 psi
- $SNL = 2.8$
- $D_1 = \frac{2.8}{0.44} = 6.36 \Rightarrow 8 \text{ in}$  thickness of asphalt
- $SN_1 = a_1 \times D_1 = 0.44 \times 8 = 3.52$
- $D_2 = \frac{SN_2 - SN_1}{a_2 M_2} \Rightarrow 0.404$  w/ ~~4 in~~ thickness
- $D_3 = \frac{SN_3 - SN_2}{a_3 M_3} \Rightarrow 6.215 \text{ in} \approx 6.5 \text{ in}$  thick
- $SN_3 = (0.14 \times 6.5 \times 1.10) + 4.312 = 4.84 \approx 4.8$   
 $\Rightarrow 5.313$

**BELOW AVERAGE  
(NO DATA)**

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**LAB 1**

**TOPICS COVERED IN LAB 1**

**1. Transportation Systems and Organizations**

## **CVEG 3302 Transportation Engineering, Spring 2022**

### **Lab Assignment #1**

**Due Date: Thursday, February 03, 2022 (in classroom)**

Prepare a 6-10 minutes presentation and one page summary for the following organizations. The presentation should at least include (i) the type of organization, (ii) its purpose, and (iii) its members and constituency. Each group will be assigned one organization.

Organizations:

AAR: Association of American Railroads

AASHTO: American Association of State Highway and Transportation Officials

APTA: American Public Transportation Association

FHWA: Federal Highway Administration

TRB: Transportation Research Board

Example:

AAA: American Automobile Association. It is a not-for-profit, fully tax-paying corporation. It is a federation of affiliated motor clubs with more than 1,100 offices in the U.S. and Canada. AAA provides services to its members such as travel, automotive, insurance, financial, and discounts. It has over 53 million members in the United States and Canada. Each AAA club is an independent, not-for-profit organization, chartered and incorporated in its own state and controlled by its own Board of Directors.

**ABOVE AVERAGE**

**LAB 1**  
**GROUP #** 1

| CRITERIA                            | Maximum Points | Points Awarded |
|-------------------------------------|----------------|----------------|
| Type of Organization                | 15             | 15             |
| Organization Purpose                | 15             | 15             |
| Members and Constituency            | 15             | 15             |
| Presentation Time (6-10 minutes)    | 5              | 5              |
| <b>Presentation Structure</b>       |                |                |
| Introduction, Body, Conclusion      | 5              | 4              |
| Not Wordy                           | 5              | 5              |
| Graphics and Colors                 | 5              | 3              |
| Q/A section                         | 5              | 5              |
| <b>Presenters</b>                   |                |                |
| Connect with Audience               | 5              | 5              |
| Bad Habits (e.g., hands in pockets) | 5              | 3              |
| Dress Appropriately                 | 5              | 5              |
| Read from Slides                    | 5              | 4              |
| Speak Clearly                       | 5              | 5              |
| Confidence and Enthusiasm           | 5              | 3              |
| <b>TOTAL</b>                        |                | 94             |

**Suggestions:**



**LAB 1**  
**GROUP #** 1

| CRITERIA                            | Maximum Points | Points Awarded |
|-------------------------------------|----------------|----------------|
| Type of Organization                | 15             | 15             |
| Organization Purpose                | 15             | 15             |
| Members and Constituency            | 15             | 15             |
| Presentation Time (6-10 minutes)    | 5              | 3              |
| <b>Presentation Structure</b>       |                |                |
| Introduction, Body, Conclusion      | 5              | 2              |
| Not Wordy                           | 5              | 2              |
| Graphics and Colors                 | 5              | 5              |
| Q/A section                         | 5              | 5              |
| <b>Presenters</b>                   |                |                |
| Connect with Audience               | 5              | 4              |
| Bad Habits (e.g., hands in pockets) | 5              | 3              |
| Dress Appropriately                 | 5              | 5              |
| Read from Slides                    | 5              | 2              |
| Speak Clearly                       | 5              | 4              |
| Confidence and Enthusiasm           | 5              | 4              |
| <b>TOTAL</b>                        |                | <b>84</b>      |

**Suggestions:**

**LAB 1**  
**GROUP #** 1

| CRITERIA                            | Maximum Points | Points Awarded |
|-------------------------------------|----------------|----------------|
| Type of Organization                | 15             | 15             |
| Organization Purpose                | 15             | 15             |
| Members and Constituency            | 15             | 15             |
| Presentation Time (6-10 minutes)    | 5              | 5              |
| <b>Presentation Structure</b>       |                |                |
| Introduction, Body, Conclusion      | 5              | 5              |
| Not Wordy                           | 5              | 4              |
| Graphics and Colors                 | 5              | 5              |
| Q/A section                         | 5              | 5              |
| <b>Presenters</b>                   |                |                |
| Connect with Audience               | 5              | 5              |
| Bad Habits (e.g., hands in pockets) | 5              | 5              |
| Dress Appropriately                 | 5              | 5              |
| Read from Slides                    | 5              | 5              |
| Speak Clearly                       | 5              | 5              |
| Confidence and Enthusiasm           | 5              | 5              |
| <b>TOTAL</b>                        |                | 99             |

**Suggestions:**

**LAB 1**  
**GROUP #** 1

| CRITERIA                            | Maximum Points | Points Awarded |
|-------------------------------------|----------------|----------------|
| Type of Organization                | 15             | 15             |
| Organization Purpose                | 15             | 15             |
| Members and Constituency            | 15             | 15             |
| Presentation Time (6-10 minutes)    | 5              | 5              |
| <b>Presentation Structure</b>       |                | 5              |
| Introduction, Body, Conclusion      | 5              | 5              |
| Not Wordy                           | 5              | 5              |
| Graphics and Colors                 | 5              | 5              |
| Q/A section                         | 5              |                |
| <b>Presenters</b>                   |                |                |
| Connect with Audience               | 5              | 5              |
| Bad Habits (e.g., hands in pockets) | 5              | 5              |
| Dress Appropriately                 | 5              | 5              |
| Read from Slides                    | 5              | 5              |
| Speak Clearly                       | 5              | 5              |
| Confidence and Enthusiasm           | 5              | 5              |
| <b>TOTAL</b>                        |                | 100            |

**Suggestions:**

**LAB 1**  
**GROUP #** AASHTO (1)

| CRITERIA                            | Maximum Points | Points Awarded |
|-------------------------------------|----------------|----------------|
| Type of Organization                | 15             | 15             |
| Organization Purpose                | 15             | 15             |
| Members and Constituency            | 15             | 15             |
| Presentation Time (6-10 minutes)    | 5              | 5              |
| <b>Presentation Structure</b>       |                |                |
| Introduction, Body, Conclusion      | 5              | 5              |
| Not Wordy                           | 5              | 5              |
| Graphics and Colors                 | 5              | 5              |
| Q/A section                         | 5              | 5              |
| <b>Presenters</b>                   |                |                |
| Connect with Audience               | 5              | 3              |
| Bad Habits (e.g., hands in pockets) | 5              | 3              |
| Dress Appropriately                 | 5              | 5              |
| Read from Slides                    | 5              | 5              |
| Speak Clearly                       | 5              | 5              |
| Confidence and Enthusiasm           | 5              | 4              |
| <b>TOTAL</b>                        |                | <b>93</b>      |

**Suggestions:**

**LAB 1**  
**GROUP #**   1  

| CRITERIA                            | Maximum Points | Points Awarded |
|-------------------------------------|----------------|----------------|
| Type of Organization                | 15             | 15             |
| Organization Purpose                | 15             | 15             |
| Members and Constituency            | 15             | 15             |
| Presentation Time (6-10 minutes)    | 5              | 5              |
| <b>Presentation Structure</b>       |                |                |
| Introduction, Body, Conclusion      | 5              | 5              |
| Not Wordy                           | 5              | 5              |
| Graphics and Colors                 | 5              | 2              |
| Q/A section                         | 5              | 5              |
| <b>Presenters</b>                   |                |                |
| Connect with Audience               | 5              | 4              |
| Bad Habits (e.g., hands in pockets) | 5              | 5              |
| Dress Appropriately                 | 5              | 5              |
| Read from Slides                    | 5              | 4              |
| Speak Clearly                       | 5              | 5              |
| Confidence and Enthusiasm           | 5              | 4              |
| <b>TOTAL</b>                        |                | 94             |

**Suggestions:** More graphics

**LAB 1**  
**GROUP #** 1

| CRITERIA                            | Maximum Points | Points Awarded |
|-------------------------------------|----------------|----------------|
| Type of Organization                | 15             | 15             |
| Organization Purpose                | 15             | 15             |
| Members and Constituency            | 15             | 15             |
| Presentation Time (6-10 minutes)    | 5              | 5              |
| <b>Presentation Structure</b>       |                |                |
| Introduction, Body, Conclusion      | 5              | 5              |
| Not Wordy                           | 5              | 5              |
| Graphics and Colors                 | 5              | 5              |
| Q/A section                         | 5              | 5              |
| <b>Presenters</b>                   |                |                |
| Connect with Audience               | 5              | 5              |
| Bad Habits (e.g., hands in pockets) | 5              | 5              |
| Dress Appropriately                 | 5              | 5              |
| Read from Slides                    | 5              | 5              |
| Speak Clearly                       | 5              | 5              |
| Confidence and Enthusiasm           | 5              | 5              |
| <b>TOTAL</b>                        |                | 100            |

**Suggestions:**

**LAB 1**  
**GROUP #**   1  

| <b>CRITERIA</b>                         | <b>Maximum Points</b> | <b>Points Awarded</b> |
|-----------------------------------------|-----------------------|-----------------------|
| <b>Type of Organization</b>             | 15                    | 15                    |
| <b>Organization Purpose</b>             | 15                    | 15                    |
| <b>Members and Constituency</b>         | 15                    | 15                    |
| <b>Presentation Time (6-10 minutes)</b> | 5                     | 5                     |
| <b>Presentation Structure</b>           |                       |                       |
| Introduction, Body, Conclusion          | 5                     | 5                     |
| Not Wordy                               | 5                     | 5                     |
| Graphics and Colors                     | 5                     | 4                     |
| Q/A section                             | 5                     | 5                     |
| <b>Presenters</b>                       |                       |                       |
| Connect with Audience                   | 5                     | 4                     |
| Bad Habits (e.g., hands in pockets)     | 5                     | 5                     |
| Dress Appropriately                     | 5                     | 4                     |
| Read from Slides                        | 5                     | 4                     |
| Speak Clearly                           | 5                     | 5                     |
| Confidence and Enthusiasm               | 5                     | 4                     |
| <b>TOTAL</b>                            |                       | <b>95</b>             |

**Suggestions:**

**LAB 1**  
**GROUP #** 1

| CRITERIA                            | Maximum Points | Points Awarded |
|-------------------------------------|----------------|----------------|
| Type of Organization                | 15             | 15             |
| Organization Purpose                | 15             | 15             |
| Members and Constituency            | 15             | 15             |
| Presentation Time (6-10 minutes)    | 5              | 5              |
| <b>Presentation Structure</b>       |                |                |
| Introduction, Body, Conclusion      | 5              | 5              |
| Not Wordy                           | 5              | 5              |
| Graphics and Colors                 | 5              | 5              |
| Q/A section                         | 5              | 5              |
| <b>Presenters</b>                   |                |                |
| Connect with Audience               | 5              | 5              |
| Bad Habits (e.g., hands in pockets) | 5              | 5              |
| Dress Appropriately                 | 5              | 5              |
| Read from Slides                    | 5              | 3              |
| Speak Clearly                       | 5              | 5              |
| Confidence and Enthusiasm           | 5              | 3              |
| <b>TOTAL</b>                        |                | 96             |

**Suggestions:** speak a little louder



**LAB 1**  
**GROUP #** 1

| CRITERIA                            | Maximum Points | Points Awarded |
|-------------------------------------|----------------|----------------|
| Type of Organization                | 15             | 15             |
| Organization Purpose                | 15             | 15             |
| Members and Constituency            | 15             | 15             |
| Presentation Time (6-10 minutes)    | 5              | 5              |
| <b>Presentation Structure</b>       |                |                |
| Introduction, Body, Conclusion      | 5              | 18             |
| Not Wordy                           | 5              |                |
| Graphics and Colors                 | 5              |                |
| Q/A section                         | 5              |                |
| <b>Presenters</b>                   |                |                |
| Connect with Audience               | 5              | 4              |
| Bad Habits (e.g., hands in pockets) | 5              | 3              |
| Dress Appropriately                 | 5              | 5              |
| Read from Slides                    | 5              | 4              |
| Speak Clearly                       | 5              | 5              |
| Confidence and Enthusiasm           | 5              | 4              |
| <b>TOTAL</b>                        |                | <b>93</b>      |

**Suggestions:**



**Civil Engineering Department**  
**Prairie View A&M University**  
**CVEG 3302(P01): Transportation Engineering**  
**Laboratory Assignment**

**Spring 2022**

**Lab 01 - One Page Summary of AASHTO**

**Assigned Date**

**January 3, 2022**

**Completed by**

**Denia Leroy, Hunter Rodgers, and Allyssa Reynolds**

**Submitted by**

**Allyssa Reynolds**

**On**

**February 9, 2022**

**To**

**Dr. Liu**

### **Summary of AASHTO: American Association of State Highway and Transportation Officials**

The American Association of State Highway and Transportation Officials is a non-profit organization and a non-partisan association. AASHTO was first established on December 12, 1914, by highway officials.

This organization aims to issue/establish standards, protocols, and procedures for various areas within Civil Engineering. These areas are related to the different modes of transportation, including air, highways, rail, and more. This organization, also known as AASHTO, works with federal and state governments to establish these standards. This ensures uniformity within Civil Engineering practices across all federal and state levels.

AASHTO has an executive committee of 12 members including the President, Vice President, Secretary-Treasurer, and two board members from each of the four regional associations. These regions include the north, south, east, and west. As of 2016, AASHTO has an estimate of 134 members.

*Traffic and Highway Engineering* provides context on seven different categories of organizations involved within transportation. AASHTO best fits the fourth category. According to *Traffic and Highway Engineering*, "State and local agencies and authorities responsible for the planning, design, construction, and maintenance of transportation facilities such as roads and airports." AASHTO best fits this criterion, as the organization works with both state and federal agencies to establish standards needed for the different parts of the construction process. Examples of this include planning, design, and construction.

**Citations:**

Garber, Nicholas J, and Lester A. Hoel. Traffic and Highway Engineering. St. Paul: West Pub. Co, 2015. Print.

Organization: AASHTO Structure, Strategic Plan, and More.  
<https://www.transportation.org/home/organization/>.

Weingroff, Richard F. Celebrating A Century of Cooperation | FHWA Lock U.S. Department of Transportation United States Department of Transportation. 1 Oct. 2014, [highways.dot.gov/public-roads/septemberoctober-2014/celebrating-century-cooperation#:~:text=Here%20is%20where%20it%20all,State%20Highway%20and%20Transportation%20Officials.](https://highways.dot.gov/public-roads/septemberoctober-2014/celebrating-century-cooperation#:~:text=Here%20is%20where%20it%20all,State%20Highway%20and%20Transportation%20Officials.)

# AASHTO: American Association of State Highway and Transportation Officials

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Group 1: Hunter Rodgers, Denia Leroy, and Allyssa Reynolds



## Introduction

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### AASHTO: American Association of State Highway and Transportation Officials

- Civil Engineering organization
- Focus on all modes of transportation
  - Rail
  - Highway
  - Air



## AASHTO: History (General Overview)

| 1   Established                                                                                                                                                                | 2   Founder                                                                                                                                                                                               | 3   Members                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| <ul style="list-style-type: none"><li>• December 12, 1914.</li><li>• American Association of State Highway Officials.</li><li>• Washington D.C.</li><li>• 16 states.</li></ul> | <ul style="list-style-type: none"><li>• Late 1800s, private organizations created quality roads.</li><li>• Logan Page, director of OPR.</li><li>• Limited to state highway officials and staff.</li></ul> | <ul style="list-style-type: none"><li>• 19 members</li><li>• 130+ members</li><li>• Road officials</li></ul> |

## AASHTO: Type of Organization

---

- Association, works and construction
- It is a nonprofit organization, nonpartisan association
- It includes public and private members in the highway and transportation department across the U.S., the District of Columbia, and Puerto Rico

## AASHTO: Purpose of Organization

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- Foster the development, operation, and maintenance of an integrated national transportation system.
- They work to educate the public and key decision makers about the critical role that transportation plays in securing a good quality of life and sound economy for our nation

## AASHTO: Members and Constituency of Organization

---

- AASHTO has an executive committee made up of 12 members
  - The President
  - The Vice President
  - The Secretary - Treasurer
  - Two board members from each of the four Regional Associations
  - The immediate past- president will serve as an ex- officio member,
- The executive committee also includes the AASHTO Executive Director as an ex officio, non voting member



## AASHTO: Members and Constituency of Organization

---

- AASHTO has eight regional representatives
  - Region 1- Northeast Association of State Highway and Transportation Officials ( NASTO)
  - Region 2- Southern Association of State Highway and Transportation Officials (SASHTO)
  - Region 3- Mid America Association of State Highway and Transportation Officials (MAASTO)
  - Region 4- Western Association of State Highway and Transportation Officials (WASHTO)

## AASHTO: Members and Constituency of Organization

---

|                     |                                                                                                                                                                                              |
|---------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Region I (NASTO)    | Composed of Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New Jersey, New York, Pennsylvania, Rhode Island, Vermont, and the District of Columbia.                   |
| Region II (SASHTO)  | Composed of Alabama, Arkansas, Florida, Georgia, Kentucky, Louisiana, Mississippi, North Carolina, Puerto Rico, South Carolina, Tennessee, Virginia, and West Virginia.                      |
| Region III (MAASTO) | Composed of Illinois, Indiana, Iowa, Kansas, Michigan, Minnesota, Missouri, Ohio, and Wisconsin.                                                                                             |
| Region IV (WASHTO)  | Composed of Alaska, Arizona, California, Colorado, Hawaii, Idaho, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, and Wyoming. |



## Summary

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- AASHTO focuses on all modes of transportation.
- Provides standards, protocols, and procedures for different areas in Civil Engineering.
- Has an extensive history, dating back to 1914.
- Qualified representation for each region within the U.S. is an important aspect.

## Question/Answers



# References

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Garber, Nicholas J, and Lester A. Hoel. Traffic and Highway Engineering. St. Paul: West Pub. Co, 2015. Print.

Organization: AASHTO Structure, Strategic Plan and More. <https://www.transportation.org/home/organization/>.

Weingroff, Richard F. Celebrating A Century of Cooperation | FHWA Lock U.S. Department of Transportation United States Department of Transportation. 1 Oct. 2014,

[highways.dot.gov/public-roads/septemberoctober-2014/celebrating-century-cooperation#:~:text=Here%20is%20where%20it%20all,State%20Highway%20and%20Transportation%20Officials](https://www.fhwa.dot.gov/public-roads/septemberoctober-2014/celebrating-century-cooperation#:~:text=Here%20is%20where%20it%20all,State%20Highway%20and%20Transportation%20Officials).

**AVERAGE  
(NO DATA)**

**BELOW AVERAGE  
(NO DATA)**

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**LAB 2**

**TOPICS COVERED IN LAB 2**

**1. Traffic Operations**

**CIVIL ENGINEERING DEPARTMENT  
PRAIRE VIEW A&M UNIVERSITY**

## Lab #2

### TRAFFIC SPOT SPEED STUDIES

Due 3/3/2022 (Canvas)

## Objectives

To conduct a spot speed study on PVAMU campus and to statistically analyze the obtained data for a speed limit recommendation.

## Background

In order to estimate network travel times, establish speed limits, advisory speeds, determine design criteria as well as evaluate facility performance, vehicular speed data is frequently collected. Site selection is important to ensure reliable data. Spot speed data will be collected and the analysis will evaluate average speed along with standard deviation.

## Procedures

After the selection of a street, conduct a spot speed study of vehicles. Record the time, traveling distance, direction, weather and surface conditions of the site. The categories of vehicles being sampled include autos (including pick-up trucks), buses, and trucks. Record the number of vehicles traveling at their respective speeds. A sample of at least 20 vehicles is required but a larger sample is recommended for a more throughout analysis. Avoid alerting motorists the presence of a spot speed study to prevent inaccurate samples caused by distractions.

## Reporting Requirements

Use the lab report format for this lab write up. In addition to meeting the requirements for the lab report, please answer the following questions in the discussion section of your lab report.

- What is the average speed of vehicles?
- What is the standard deviation of these measurements?
- Comparison of the average speed with the speed limit and provide suggestions (if any)

What is the SSD for the average speed and the speed limit on level roads? Provide any suggestions according to the SSD comparison. (Table 3.4)

**ABOVE AVERAGE**

**LAB 2**  
**GROUP # \_\_\_\_1\_\_\_\_**

| <b>CRITERIA</b>                                                                                                                                                          | <b>Maximum Points</b> | <b>Points Awarded</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| <b>1. TITLE PAGE</b><br>Includes the title of the report, the authors and team number, and date.                                                                         | <b>5</b>              | 5                     |
| <b>2. TABLE OF CONTENTS</b><br>Includes all sections of the report, figures, tables, and appendices with corresponding page numbers.                                     | <b>5</b>              | 5                     |
| <b>3. ABSTRACT</b><br>Summarizes what was done, what was found, and its importance                                                                                       | <b>10</b>             | 10                    |
| <b>4. INTRODUCTION</b><br>Includes motivation, general summary, definitions, theory, and background.                                                                     | <b>10</b>             | 10                    |
| <b>5. PROCEDURE</b><br>Describes the procedure step-by-step.                                                                                                             | <b>10</b>             | 6                     |
| <b>6. RESULTS</b>                                                                                                                                                        | <b>40</b>             |                       |
| Average speed of vehicles                                                                                                                                                | 8                     | 8                     |
| Standard deviation of measurements                                                                                                                                       | 8                     | 8                     |
| Comparison of the average speed with the speed limit and provide suggestions                                                                                             | 8                     | 8                     |
| SSD for the average speed and the speed limit on level roads                                                                                                             | 8                     | 8                     |
| SSD comparison                                                                                                                                                           | 8                     | 8                     |
| <b>7. DISCUSSION</b><br>Analysis of the results based on the reporting requirements. Problems encountered during the procedure and effects on the results are discussed. | <b>10</b>             | 10                    |
| <b>8. CONCLUSIONS</b><br>Summary of the analysis results, lessons, and recommendations.                                                                                  | <b>10</b>             | 7                     |
| <b>TOTAL</b>                                                                                                                                                             |                       | <b>93</b>             |

**Suggestions:**

1. Titles of tables were not provided. When a table is listed in the content, it needs to be shown after the paragraph.
2. Tested results need to be shown in the results and discussion section.
3. Procedures should not be just a bullet form.
4. Please provide recommendations for future improvement and/or future research



Prairie View A&M University  
College of Engineering  
Department of Civil & Environmental Engineering



CVEG 3302 P01 Transportation Engineering  
LABORATORY REPORT ON  
“Traffic Spot Speed Studies”

Conducted on  
February 24th, 2022

Submitted by: Group 1  
Denia Leroy  
Allyssa Reynolds  
Hunter Rodgers

On  
March 3rd, 2022  
To  
Dr. Lui

## Table of Contents

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| Abstract.....               | 3 |
| Introduction.....           | 3 |
| Experimental Procedure..... | 3 |
| Results .....               | 4 |
| Discussion.....             | 4 |
| Conclusion.....             | 5 |
| Appendices .....            | 6 |
| References.....             | 7 |

## Abstract

The purpose of this experiment is to conduct a spot speed study on a selected street on PVAMU campus. The students conducting the procedure found that the current speed limit is acceptable for the roadway being tested. It's important to conduct this type of study, so engineers can collect and analyze the average speed among vehicles such as cars, pick up trucks, buses, and trucks for establishing proper speed limits along main highways and streets.

## Introduction

Speed is a very important aspect of traffic engineering because it deals with the safety and comfortability of drivers on the road. Speed is measured for a wide range of traffic analyses by engineers. A spot speed study is an instantaneous speed of a vehicle at a specified location. There are different measurements used to determine the spot speed as accurately as possible such as the enoscope, radar, and direct measurement of time.

This experiment closely studies the average speed of randomly selected cars traveling down a selected site to determine the sustainability of the set speed limit. To determine the appropriate roadway speed limit many factors have to be considered such as weather, traveling distance, road conditions, and direction.

The objective of the traffic spot speed study is to calculate the average speed among all the vehicles considered for the experiment, standard deviation, and stopping sight distance (SSD). The stopping sight is defined as the minimum sight distance required for a driver to stop a vehicle after seeing an object in the path of the vehicle without hitting an object.

## Experimental Procedure

1. Select street to conduct spot speed study of vehicles
2. Record the time, traveling distance, direction, weather and surface conditions of the site
3. Record a sample of at least 20 vehicles
4. Avoid alerting motorists the presence of a spot speed study to prevent inaccurate samples caused by distractions

## Results

**Table 1.0:**

| Car No. | Speed (ft/s) | Speed (mph) |
|---------|--------------|-------------|
| 1       | 27.49        | 18.75       |
| 2       | 24.95        | 17.01       |
| 3       | 25.44        | 17.35       |
| 4       | 26.24        | 17.89       |
| 5       | 23.96        | 16.34       |
| 6       | 28.32        | 19.31       |
| 7       | 19.03        | 12.97       |
| 8       | 18.52        | 12.63       |
| 9       | 27.04        | 18.43       |
| 10      | 20.46        | 13.95       |
| 11      | 26.43        | 18.02       |
| 12      | 26.13        | 17.82       |
| 13      | 14.95        | 10.19       |
| 14      | 28.80        | 19.64       |
| 15      | 30.36        | 20.70       |
| 16      | 30.12        | 20.54       |
| 17      | 16.53        | 11.27       |
| 18      | 24.05        | 16.40       |
| 19      | 29.60        | 20.18       |
| 20      | 28.74        | 19.59       |
| 21      | 25.65        | 17.49       |
| Average | 24.90        | 16.97       |

Table 1 represents each car's speed over the distance of 0.071 miles and the average speed of 21 cars total.

## Results and Discussion

There were numerous parameters identified during this experiment, including the individual and average speed of the vehicles, the standard deviation of the individual speeds, the stopping sight distance from the average speed, and the suitability of the current speed limit.

The average speed of the vehicles found was 24.90 feet per second (ft/s) or 16.97 miles per hour (mph), as provided from Table 1.0. The standard deviation obtained was 3.07. The percentage variance of the actual and average speed limit was 15.15%, as the speed limit of the leveled roadway is 20 mph. This means there was a slight variance between the actual and average speed limits. This variance allowed us to determine that the current speed limit is adequate for the traffic flow and roadway conditions. The stopping sight distance, SSD, was determined to be

0.017 miles for the average speed, and 0.021 miles for the actual speed. The variance between the two showed a 19.05% difference, showing the current speed limit is acceptable.

There were various problems/errors identified while conducting this experiment. One error identified was human error. Due to the road length observed, the time it took for the cars to reach the total distance of 0.071 miles may have been incorrect. This is due to human sight, as group members struggled to identify the starting and stopping points consistently. This could have been avoided by choosing a shorter distance to observe. Another error identified was a systematic error. The road observed was a high traffic area, so the car's speed significantly decreased as the road became crowded. This caused some of the results to be incorrect, as the experimental conditions were altered. This could have been avoided by choosing a roadway with moderate traffic flow.

## Conclusion

All objectives were met. The average speed determined was 16.97 mph over a distance of 0.071 miles. When compared to the current speed limit of 20 mph, we believe the current speed limit is adequate for the roadway. Other parameters were determined, such as the stopping sight distance (SSD), standard deviation, and errors identified within the experiment. One significant error that occurred was systematic, as the heavy traffic flow directly impacted the speed of each vehicle. This caused our investigation to be conducted under unregular conditions, providing inaccurate information.

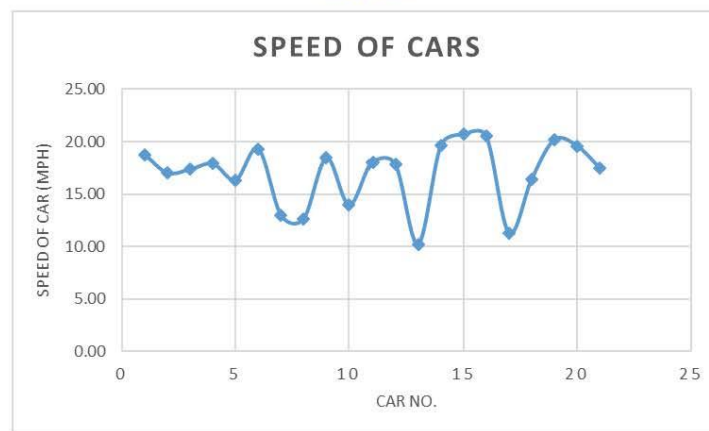
## Appendices

Table 2.0:

| Car No. | Distance (ft) | Distance (miles) | Time (s) | Time (hr) | Speed (ft/s) | Speed (mph) |
|---------|---------------|------------------|----------|-----------|--------------|-------------|
| 1       | 375           | 0.071            | 13.64    | 0.0038    | 27.49        | 18.75       |
| 2       | 375           | 0.071            | 15.03    | 0.0042    | 24.95        | 17.01       |
| 3       | 375           | 0.071            | 14.74    | 0.0041    | 25.44        | 17.35       |
| 4       | 375           | 0.071            | 14.29    | 0.0040    | 26.24        | 17.89       |
| 5       | 375           | 0.071            | 15.65    | 0.0043    | 23.96        | 16.34       |
| 6       | 375           | 0.071            | 13.24    | 0.0037    | 28.32        | 19.31       |
| 7       | 375           | 0.071            | 19.71    | 0.0055    | 19.03        | 12.97       |
| 8       | 375           | 0.071            | 20.25    | 0.0056    | 18.52        | 12.63       |
| 9       | 375           | 0.071            | 13.87    | 0.0039    | 27.04        | 18.43       |
| 10      | 375           | 0.071            | 18.33    | 0.0051    | 20.46        | 13.95       |
| 11      | 375           | 0.071            | 14.19    | 0.0039    | 26.43        | 18.02       |
| 12      | 375           | 0.071            | 14.35    | 0.0040    | 26.13        | 17.82       |
| 13      | 375           | 0.071            | 25.08    | 0.0070    | 14.95        | 10.19       |
| 14      | 375           | 0.071            | 13.02    | 0.0036    | 28.80        | 19.64       |
| 15      | 375           | 0.071            | 12.35    | 0.0034    | 30.36        | 20.70       |
| 16      | 375           | 0.071            | 12.45    | 0.0035    | 30.12        | 20.54       |
| 17      | 375           | 0.071            | 22.69    | 0.0063    | 16.53        | 11.27       |
| 18      | 375           | 0.071            | 15.59    | 0.0043    | 24.05        | 16.40       |
| 19      | 375           | 0.071            | 12.67    | 0.0035    | 29.60        | 20.18       |
| 20      | 375           | 0.071            | 13.05    | 0.0036    | 28.74        | 19.59       |
| 21      | 375           | 0.071            | 14.62    | 0.0041    | 25.65        | 17.49       |
| Average |               |                  | 15.66    | 0.0043    | 24.90        | 16.97       |

Table 2.0 reflects the average speed of each vehicle over a distance of 0.071 miles.

Graph 1.0:



Graph 1 is a graphical representation of each car's speed over a distance of 0.071 miles.

**Equation 1: Conversion of feet to miles**

$$\text{Distance in miles} = \frac{x \text{ (ft)}}{5280}$$

**Equation 1a: Sample Calculation of Equation 1**

$$\text{Distance} = \frac{x \text{ (ft)}}{5280} = \frac{375 \text{ ft}}{5280} = 0.071 \text{ miles}$$

**Equation 2: Conversion of ft/s to miles/hour**

$$\text{Speed} = \frac{x \text{ (ft)}}{\text{time (s)}} = \frac{\frac{x \text{ (ft)}}{5280}}{\text{time (s)} \cdot 60 \left( \frac{\text{min}}{\text{sec}} \right)}$$

**Equation 2a: Sample Calculation of Equation 2**

$$\text{Speed} = \frac{\frac{x \text{ (ft)}}{5280}}{\text{time (s)} \cdot 60 \left( \frac{\text{min}}{\text{sec}} \right)} = \frac{\frac{375}{5280}}{13.64 \cdot 60} = 18.745 \text{ miles per hour}$$

**Equation 3: Stopping Sight Distance (SSD)**

$$SSD = 1.47 \cdot u \cdot PRT + \frac{u^2}{30 \left( \frac{a}{g} - 32.2 \right)}$$

**Equation 3a: Sample Calculation of Equation 3**

$$SSD = 1.47 \cdot 16.97 \cdot 2.5 + \frac{16.97^2}{30 \left( \frac{11.2}{32.2} - 32.2 \right)} = 38.33 \text{ ft} = 0.017 \text{ miles}$$

**Equation 4: Percentage Variance**

$$\frac{|\text{actual value} - \text{expected value}|}{\text{expected value}} \cdot 100$$

**Equation 5: Standard Deviation**

$$\sigma = \sqrt{\frac{\sum (x_i - \mu)^2}{N}}$$

**Equation 6: Average**

$$\frac{x+y}{2}$$

**Equation 6a: Sample Calculation of Equation 3**

$$\frac{10+10}{2} = 10$$

## Reference

1. "Methods and Practices for Setting Speed Limits: An Informational Report - Safety | Federal Highway Administration." *Dot.gov*, 2009, [safety.fhwa.dot.gov/speedmgt/ref\\_mats/fhwasal2004/](https://safety.fhwa.dot.gov/speedmgt/ref_mats/fhwasal2004/).
2. <https://www.engineeringenotes.com/transportation-engineering/traffic-engineering/spot-speed-studies-in-traffic-engineering-endoscope-measurement-and-methods/48389>

**AVERAGE**

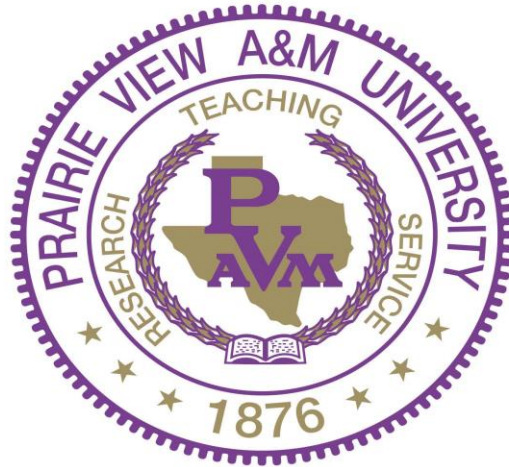


**LAB 2**  
**GROUP #   2**

| <b>CRITERIA</b>                                                                                                                                                          | <b>Maximum Points</b> | <b>Points Awarded</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| <b>1. TITLE PAGE</b><br>Includes the title of the report, the authors and team number, and date.                                                                         | <b>5</b>              | 3                     |
| <b>2. TABLE OF CONTENTS</b><br>Includes all sections of the report, figures, tables, and appendices with corresponding page numbers.                                     | <b>5</b>              | 5                     |
| <b>3. ABSTRACT</b><br>Summarizes what was done, what was found, and its importance                                                                                       | <b>10</b>             | 7                     |
| <b>4. INTRODUCTION</b><br>Includes motivation, general summary, definitions, theory, and background.                                                                     | <b>10</b>             | 8                     |
| <b>5. PROCEDURE</b><br>Describes the procedure step-by-step.                                                                                                             | <b>10</b>             | 6                     |
| <b>6. RESULTS</b>                                                                                                                                                        | <b>40</b>             |                       |
| Average speed of vehicles                                                                                                                                                | 8                     | 8                     |
| Standard deviation of measurements                                                                                                                                       | 8                     | 8                     |
| Comparison of the average speed with the speed limit and provide suggestions                                                                                             | 8                     | 6                     |
| SSD for the average speed and the speed limit on level roads                                                                                                             | 8                     | 4                     |
| SSD comparison                                                                                                                                                           | 8                     | 4                     |
| <b>7. DISCUSSION</b><br>Analysis of the results based on the reporting requirements. Problems encountered during the procedure and effects on the results are discussed. | <b>10</b>             | 6                     |
| <b>8. CONCLUSIONS</b><br>Summary of the analysis results, lessons, and recommendations.                                                                                  | <b>10</b>             | 10                    |
| <b>TOTAL</b>                                                                                                                                                             |                       | <b>75</b>             |

**Suggestions:**

1. Please provide correct group #.
2. "what was found" needs to be provided in Abstract
3. Background information is needed in Introduction
4. Procedures should not be just a bullet form.
5. Titles of tables were not provided. When a table is listed in the content, it needs to be shown after the paragraph.
6. The required questions need to be answered in the section of discussion and should be addressed in a paragraph. There are two speed limit values (24 mph and 25 mph) in the report.
7. Unit of SSD was not provided in tables. SSD comparison was not provided.



Course Name: CVEG 3302 P01 Transportation Engineering

Laboratory Report #1: Traffic Spot Speed Studies

Submitted by Group 1: Ariana Mangroo, Marshall Johnson, Omar Hajo

Submitted On: March 3, 2022

Submitted to: Kai-Wei Victor Liu



## **Table of Contents**

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### **Abstract**

The purpose of this experiment was to conduct a spot speed study on Prairie View A&M University campus. The experiment was conducted by using our cell phones to measure the distance between two light posts. The total distance traveled per car and the amount of time it took the car to reach one light post to the next was used to calculate the speed of the car. The experiment resulted in students being able to calculate the average speed of twenty cars going

### **Introduction**

Traffic spot speed studies help to determine the speed limit of a road factoring in networking time and other matters. There are three different kinds of methods in this study: the stopwatch method, radar meter method, and the pneumatic road tube method. These matters include advisory speeds, determine design criteria, and evaluate facility performance. For this lab we were instructed to calculate the acceleration of 20 vehicles using your surroundings. After each car data was being recorded.

### **Experimental Procedure**

1. Select a street where vehicles pass frequently
2. Select two points where you will analyze vehicles passing
3. Use measure app on iPhone to specify exact distance for the two points
4. Record spot speed for at least 20 vehicles
5. Record the time, direction, weather, and surface conditions of the site.
6. Avoid alerting individuals in the speed test that you are conducting one so that the recordings will not be tampered by fear
7. Answer the following:
  - a. What is the average speed of vehicle?

$$Acceleration = \frac{Distance}{Time} m/s^2$$

- b. What is the standard deviation of these measurements?

$$\sigma = \sqrt{\frac{\sum(x_i - \mu)^2}{N}}$$

- c. Comparison of the average speed with the speed limit and provide suggestions (if any)
- d. What is the SSD for the average speed and the speed limit on level roads? Provide any suggestions according to the SSD comparison

$$1.47\mu * t + \frac{\mu^2}{30\left(\frac{a}{32.2}\right) - g}$$

## Results

Table 1

| Vehicles | Distance(feet) | Time (sec) | Average Speed (m/s) | Standard Deviation | Average of the Average Speed | SSD for the Average Speed | SSD for the 20 Mph |
|----------|----------------|------------|---------------------|--------------------|------------------------------|---------------------------|--------------------|
| 1        | 78             | 2.18       |                     |                    |                              |                           |                    |
| 2        | 78             | 2.05       |                     |                    |                              |                           |                    |
| 3        | 78             | 2.01       |                     |                    |                              |                           |                    |
| 4        | 78             | 1.68       |                     |                    |                              |                           |                    |
| 5        | 78             | 1.8        |                     |                    |                              |                           |                    |
| 6        | 78             | 2.01       |                     |                    |                              |                           |                    |
| 7        | 78             | 2.1        |                     |                    |                              |                           |                    |
| 8        | 78             | 1.95       |                     |                    |                              |                           |                    |
| 9        | 78             | 3.28       |                     |                    |                              |                           |                    |
| 10       | 78             | 2.66       |                     |                    |                              |                           |                    |
| 11       | 78             | 1.81       |                     |                    |                              |                           |                    |
| 12       | 78             | 2.8        |                     |                    |                              |                           |                    |
| 13       | 78             | 2.85       |                     |                    |                              |                           |                    |
| 14       | 78             | 2.56       |                     |                    |                              |                           |                    |
| 15       | 78             | 2.53       |                     |                    |                              |                           |                    |
| 16       | 78             | 2.53       |                     |                    |                              |                           |                    |
| 17       | 78             | 2.78       |                     |                    |                              |                           |                    |
| 18       | 78             | 1.91       |                     |                    |                              |                           |                    |
| 19       | 78             | 2.5        |                     |                    |                              |                           |                    |
| 20       | 78             | 2.91       |                     |                    |                              |                           |                    |

Table 2

| Vehicles | Distance(feet) | Time (sec) | Average Speed (m/s <sup>2</sup> ) | Standard Deviation | Average of the Average Speed | SSD for the Average Speed | SSD for the 20 Mph |
|----------|----------------|------------|-----------------------------------|--------------------|------------------------------|---------------------------|--------------------|
| 1        | 78             | 2.18       | 36                                | 6.55               | 34.43983924                  | 239.56                    |                    |
| 2        | 78             | 2.05       | 38                                |                    |                              | 252.89                    |                    |
| 3        | 78             | 2.01       | 39                                |                    |                              | 260.99                    |                    |
| 4        | 78             | 1.68       | 46                                |                    |                              | 316.98                    |                    |
| 5        | 78             | 1.8        | 43                                |                    |                              | 290.97                    |                    |
| 6        | 78             | 2.01       | 39                                |                    |                              | 260.99                    |                    |
| 7        | 78             | 2.1        | 37                                |                    |                              | 245.41                    |                    |
| 8        | 78             | 1.95       | 40                                |                    |                              | 267.99                    |                    |
| 9        | 78             | 3.28       | 24                                |                    |                              | 170.92                    |                    |
| 10       | 78             | 2.66       | 29                                |                    |                              | 193.99                    |                    |
| 11       | 78             | 1.81       | 43                                |                    |                              | 291.6                     |                    |
| 12       | 78             | 2.8        | 28                                |                    |                              | 190.4                     |                    |
| 13       | 78             | 2.85       | 27                                |                    |                              | 182.979                   |                    |
| 14       | 78             | 2.56       | 30                                |                    |                              | 199.145                   |                    |
| 15       | 78             | 2.53       | 31                                |                    |                              | 207.4                     |                    |
| 16       | 78             | 2.53       | 31                                |                    |                              | 207.4                     |                    |
| 17       | 78             | 2.78       | 28                                |                    |                              | 189.6                     |                    |
| 18       | 78             | 1.91       | 41                                |                    |                              | 276.21                    |                    |
| 19       | 78             | 2.5        | 31                                |                    |                              | 206.02                    |                    |
| 20       | 78             | 2.91       | 27                                |                    |                              | 185.36                    |                    |
|          |                |            |                                   |                    | average                      | 231.8402                  | 111.83             |

### Discussions

After completing the traffic speed test, the results have been observed and the test objective has been met. The distance used for this lab was taken from one light pole to another, which was 78 ft, remained constant for the whole experiment. The time was taken for the vehicle to get from point A to point B and was divided by the distance to get the average speed during that journey. After finding all speeds of the vehicles, the average of all speeds found was 34.34 mph. The standard deviation calculated was 6.55 and the average SSD for the average speed was 231.84 ft.

### **Conclusion**

With completion of the experiment, we concluded that it was a success. The tables show that many cars went above the speed limit of 24 mph with only one vehicle going under the limit at 24 mph and the highest speed being 46 mph. Taking these readings helped to gain a visual and better understanding of how fast vehicles move on Prairie View's campus

### **Recommendation**

On average, most vehicles were moving around 10mph above the speed limit. While it is important to keep people happy by not making the speed limit too low or putting an excess of speed bumps, it is also important to keep people safe. To maintain both, the speed limit should be increased from 25 mph to 30 mph. This will provide vehicles more leeway to drive at a comfortable speed while also being safe. Speed bumps should not be needed.

## **Reference**

Class PowerPoints



## **Appendix**

### **Appendix A**

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### **Appendix B**

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### **Appendix C**

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### **Appendix D**

**Experimental Procedure: Pages 3-4**

### **Appendix E**

**Results: Pages 4-5**

### **Appendix F**

**Discussion: Page 5**

### **Appendix G**

**Conclusion: Page 6**

### **Appendix H**

**Recommendation: 6**

### **Appendix I**

**Reference: Page 7**

**BELOW AVERAGE  
(NO DATA)**

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**LAB 3**

**TOPICS COVERED IN LAB 3**

1. Highway Surveys and Location

**CIVIL ENGINEERING DEPARTMENT  
PRAIRE VIEW A&M UNIVERSITY**

### Lab 3

#### Highway Earthwork Volumes, Mass Diagram, and Cost

Due 3/24/2022 (Canvas)

A roadway section is 2000 ft long (20 stations). The cut and fill volumes are to be computed between each station. Table below lists the station numbers (column 1) and lists the end area values ( $\text{ft}^2$ ) between each station that are in cut (column 2) and that are in fill (column 3). Material in a fill section will consolidate (known as shrinkage), and for this road section, is 10 percent.

| <i>End Area (<math>\text{ft}^2</math>)</i> |            |             |
|--------------------------------------------|------------|-------------|
| <i>1</i>                                   | <i>2</i>   | <i>3</i>    |
| <i>Station</i>                             | <i>Cut</i> | <i>Fill</i> |
| 0                                          | 3          | 18          |
| 1                                          | 2          | 50          |
| 2                                          | 2          | 97          |
| 3                                          | 4          | 130         |
| 4                                          | 8          | 51          |
| 5                                          | 40         | 45          |
| 6                                          | 45         | 20          |
| 7                                          | 80         | 5           |
| 8                                          | 122        | 2           |
| 9                                          | 130        | 0           |
| 10                                         | 140        | 0           |
| 11                                         | 100        | 3           |
| 12                                         | 80         | 30          |
| 13                                         | 75         | 20          |
| 14                                         | 50         | 50          |
| 15                                         | 20         | 80          |
| 16                                         | 10         | 100         |
| 17                                         | 0          | 120         |
| 18                                         | 3          | 120         |
| 19                                         | 40         | 50          |
| 20                                         | 30         | 30          |

Please show detail calculation for the followings:

- Compute Fill and Cut Volumes and Mass Diagram Ordinate
- Develop a plot of Mass Diagram

The limit of profitable haul distance is 600 ft and the free haul distance is 300 ft. The overhaul price is \$10 per CY-ft. Compute overhaul cost using the developed Mass Diagram.

ABOVE AVERAGE

Prairie View A&M University  
College of Engineering  
Department of Civil & Environmental Engineering



CVEG 3302 P01 Transportation Engineering  
LABORATORY REPORT ON  
“Highway Earthwork Volumes, Mass Diagrams, and Cost”

Conducted on  
March 10th, 2022

Submitted by: Group 1  
Allyssa Reynolds  
Hunter Rodgers  
Denia Leroy

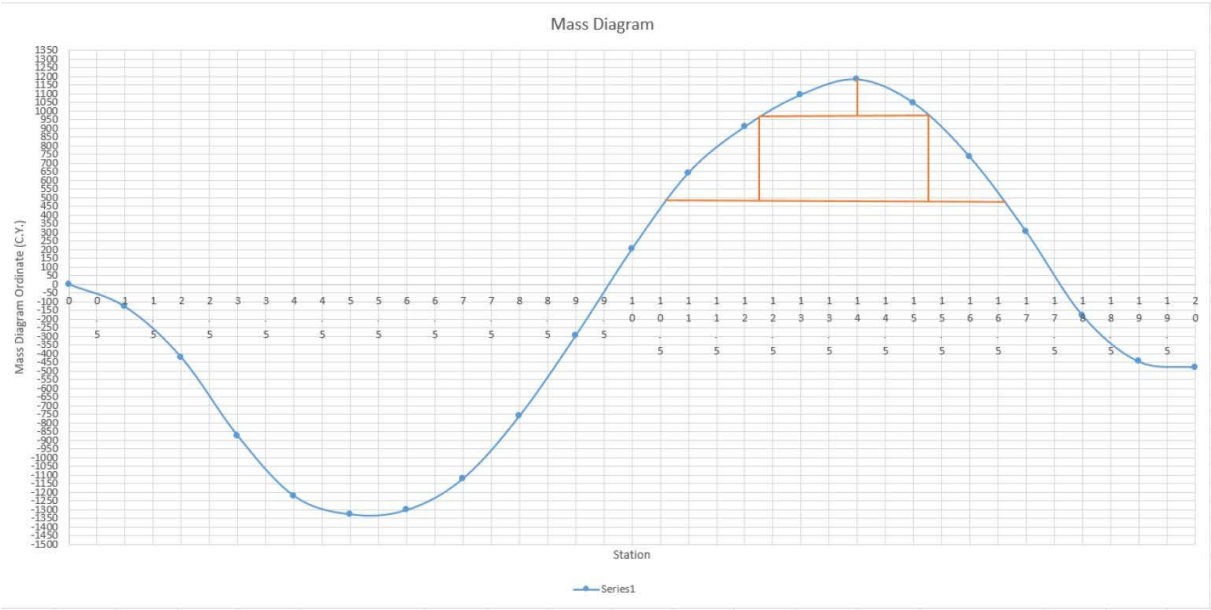
On  
March 24, 2022  
To  
Dr. Lui

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| References.....             |   |



# Results and Discussion



**Table 1: Mass Ordinate Diagram**

Used for overhaul calculations.

| Overhaul Calculation         |                |      |           |
|------------------------------|----------------|------|-----------|
| Given                        | Overhaul Price | \$10 | per CY*FT |
| First Overhaul Station (ft)  | 1052           |      |           |
| Second Overhaul Station (ft) | 1225           |      |           |
| Total Distance (ft)          | 173            |      |           |
| Volume (CY)                  | 470            | CY   |           |
| Total Cost                   | \$813,100.00   |      |           |
| Third Overhaul Station (ft)  | 1525           |      |           |
| Fourth Overhaul Station (ft) | 1652           |      |           |
| Total Distance (ft)          | 127            |      |           |
| Volume (CY)                  | 470            | CY   |           |
| Total Cost                   | \$596,900.00   |      |           |
| Total Overhaul Cost          | \$1,410,000.00 |      |           |

**Table 2: Overhaul Cost Analysis**

Table used to determine the total overhaul cost.

## Conclusion

In Conclusion the cut and fill volumes were successfully computed between each station to develop a mass diagram with a shrinkage of 10%. It can be observed on the mass diagram two major curves representing the amount of cut and fill areas that needs to be removed or added for the highway earthwork. Where the total overhaul cost of \$1,410,000 was determined from the mass diagram plot. This experiment really helped give knowledge on the process contractors and inspectors have to take in order to build highways successfully.

## Appendices

## References

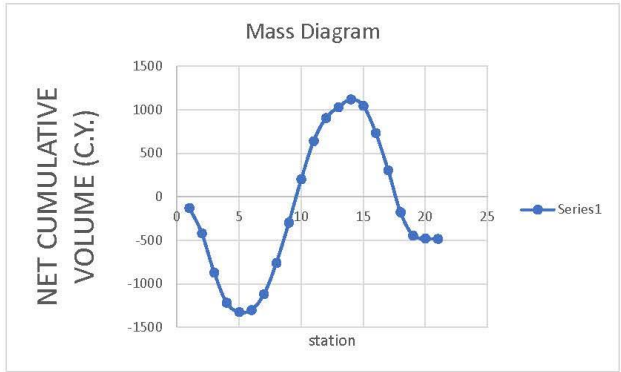
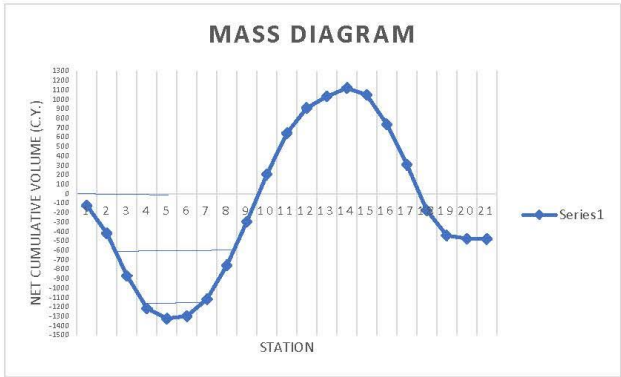
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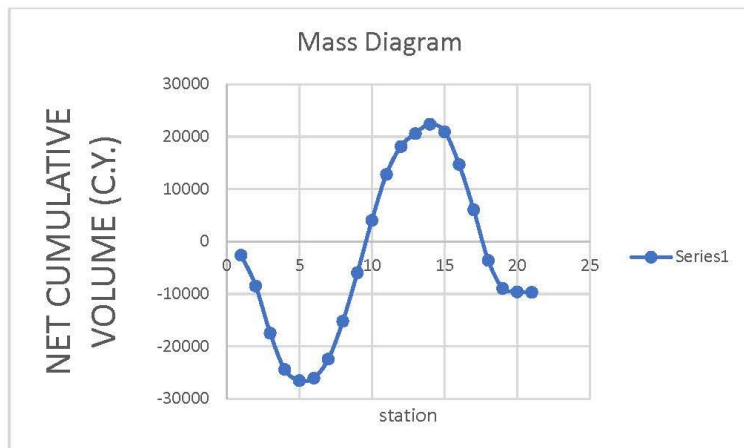
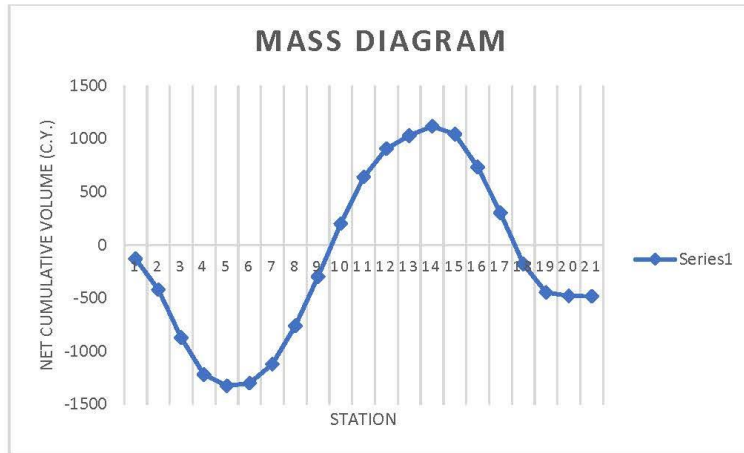
-Mass-Diagrams-moved2.pdf.

**AVERAGE  
(NO DATA)**

**BELOW AVERAGE**

| station | total cut (ft^2) | total fill (ft^2)) | total cut vol (yd) | total fill vol (Yd) | shrinkage 10% | adjusted fill (yd) | mass diagram ordinate |
|---------|------------------|--------------------|--------------------|---------------------|---------------|--------------------|-----------------------|
| 0       | 3                | 18                 | 9.259259259        | 125.9259259         | 12.59259259   | 138.5185185        | -129.2592593          |
| 1       | 2                | 50                 | 7.407407407        | 272.2222222         | 27.22222222   | 299.4444444        | -421.2962963          |
| 2       | 2                | 97                 | 11.11111111        | 420.3703704         | 42.03703704   | 462.4074074        | -872.5925926          |
| 3       | 4                | 130                | 22.22222222        | 335.1851852         | 33.51851852   | 368.7037037        | -1219.074074          |
| 4       | 8                | 51                 | 88.88888889        | 177.7777778         | 17.77777778   | 195.5555556        | -1325.740741          |
| 5       | 40               | 45                 | 157.4074074        | 120.3703704         | 12.03703704   | 132.4074074        | -1300.740741          |
| 6       | 45               | 20                 | 231.4814815        | 46.2962963          | 4.62962963    | 50.92592593        | -1120.185185          |
| 7       | 80               | 5                  | 374.0740741        | 12.96296296         | 1.296296296   | 14.25925926        | -760.3703704          |
| 8       | 122              | 2                  | 466.6666667        | 3.703703704         | 0.37037037    | 4.074074074        | -297.7777778          |
| 9       | 130              | 0                  | 500                | 0                   | 0             | 0                  | 202.2222222           |
| 10      | 140              | 0                  | 444.4444444        | 5.555555556         | 0.555555556   | 6.111111111        | 640.5555556           |
| 11      | 100              | 3                  | 333.3333333        | 61.11111111         | 6.111111111   | 67.22222222        | 906.6666667           |
| 12      | 80               | 30                 | 287.037037         | 148.1481481         | 14.81481481   | 162.962963         | 1030.740741           |
| 13      | 75               | 50                 | 231.4814815        | 129.6296296         | 12.96296296   | 142.5925926        | 1119.62963            |
| 14      | 50               | 20                 | 129.6296296        | 185.1851852         | 18.51851852   | 203.7037037        | 1045.555556           |
| 15      | 20               | 80                 | 55.55555556        | 333.3333333         | 33.33333333   | 366.6666667        | 734.4444444           |
| 16      | 10               | 100                | 18.51851852        | 407.4074074         | 40.74074074   | 448.1481481        | 304.8148148           |
| 17      | 0                | 120                | 5.555555556        | 444.4444444         | 44.44444444   | 488.8888889        | -178.5185185          |
| 18      | 3                | 120                | 79.62962963        | 314.8148148         | 31.48148148   | 346.2962963        | -445.1851852          |
| 19      | 40               | 50                 | 129.6296296        | 148.1481481         | 14.81481481   | 162.962963         | -478.5185185          |
| 20      | 30               | 30                 | 55.55555556        | 55.55555556         | 5.555555556   | 61.11111111        | -484.0740741          |





### **Part C**

Total cost= overhaul cost x overhaul volume x overhaul station

$$600 * (500 - 300) = 120,000$$

$$120000 * 10 = 1,200,000$$

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**LAB 4**

**TOPICS COVERED IN LAB 4**

**1. Capacity and Level of Service**

**CIVIL ENGINEERING DEPARTMENT  
PRAIRE VIEW A&M UNIVERSITY**

## Lab #4

### Capacity and Level of Service (LOS) Analysis

Due 4/1/2022 (Canvas)

Use the lab report format for this lab write up.

The number of vehicles on our highways increases every year, and transportation engineers are often faced with the challenge of designing modifications to existing facilities that will service the increased demand. As part of this work, the engineers must evaluate the capacity of the existing and proposed systems. In addition, engineers are often required to justify the expense of modifying or adding facilities by looking at the current and potential levels of service.

Traffic engineers use capacity and level of service analyses to:

- Determine the number and width of lanes needed for new facilities or for expanding existing facilities.
- Assess service levels and operational characteristics of existing facilities that are being considered for upgrading.
- Identify traffic and roadway changes needed for new developments.
- Provide base values for determining changes in fuel consumption, air pollutant emissions, road-user costs, and noise associated with proposed roadway changes.

Our Department of Transportation (DOT) has been given funding for the construction of a new urban freeway to relieve the congestion on the existing freeway that extends through the downtown section of our community. Your supervisor has given you the task of determining the *free-flow speed*, *density*, and *level of service* for this urban freeway segment. This existing freeway has the following characteristics:

- Demand volume: 4000 veh/h
- PHF=0.92
- Terrain: Level
- Number of lanes: 3 in each direction
- Lane width: 11ft
- Lateral clearance: 3ft
- Ramp density: 4 Diamond interchanges spaced 1.5 mi apart
- Heavy vehicles in traffic stream during the peak hour: None
- Driver population: Commuters and familiar drivers



**ABOVE AVERAGE**

**LAB 2**  
**GROUP # \_\_\_\_ 1 \_\_\_\_**

| <b>CRITERIA</b>                                                                                                                                                          | <b>Maximum Points</b> | <b>Points Awarded</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| <b>1. TITLE PAGE</b><br>Includes the title of the report, the authors and team number, and date.                                                                         | <b>2</b>              | 2                     |
| <b>2. TABLE OF CONTENTS</b><br>Includes all sections of the report, figures, tables, and appendices with corresponding page numbers.                                     | <b>3</b>              | 3                     |
| <b>3. ABSTRACT</b><br>Summarizes what was done, what was found, and its importance                                                                                       | <b>10</b>             | 10                    |
| <b>4. INTRODUCTION</b><br>Includes motivation, general summary, definitions, theory, and background.                                                                     | <b>10</b>             | 10                    |
| <b>5. PROCEDURE</b><br>Describes the procedure step-by-step.                                                                                                             | <b>10</b>             | 5                     |
| <b>6. RESULTS</b>                                                                                                                                                        | <b>45</b>             |                       |
| free-flow speed                                                                                                                                                          | 15                    | 14                    |
| density                                                                                                                                                                  | 15                    | 14                    |
| level of service                                                                                                                                                         | 15                    | 15                    |
| <b>7. DISCUSSION</b><br>Analysis of the results based on the reporting requirements. Problems encountered during the procedure and effects on the results are discussed. | <b>10</b>             | 10                    |
| <b>8. CONCLUSIONS</b><br>Summary of the analysis results, lessons, and recommendations.                                                                                  | <b>10</b>             | 10                    |
| <b>TOTAL</b>                                                                                                                                                             |                       | <b>93</b>             |

**Suggestions:**

1. In a report, we normally include sentences instead of bullets to describe procedures. Please also include the available data (e.g., a table form) in this section
2. Should we change figure 1 to Table 1 since it is in a table form? Please also include units in figure 1 even though units have been mentioned in the following paragraph.
3. Table/figure should be placed after paragraph instead of after section title.

Prairie View A&M University  
College of Engineering  
Department of Civil & Environmental Engineering



CVEG 3302 P01 Transportation Engineering  
LABORATORY REPORT ON  
"Capacity and Level of Service (LOS) Analysis"

Conducted on  
March 24th, 2022

Submitted by: Group 1  
Allyssa Reynolds  
Hunter Rodgers  
Denia Leroy

On  
April 1, 2022  
To  
Dr. Lui

## Table of Contents

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| Abstract.....               | 3 |
| Introduction.....           | 3 |
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## Abstract

The purpose of the Capacity and Level of Service Analysis was to determine the free-flow speed, density, and level of service of an urban freeway segment. As the population within Houston has continually risen each decade, the capacity of roadways has been observed. Understanding the capacity of roadways helps in numerous ways, including allowing individuals to reach their destinations on time and preventing accidents and car crashes. Thus, this experiment was essential as it would aid in developing methods to alleviate congestion on the designated freeway. The density from this roadway was determined to be: 22.31 pc/mi/ln. The free-flow speed of the freeway was: 62.87 mph, and rounded up to 65 mph. The level of service of this freeway was: C. The results obtained indicate that the freeway has mildly/noticeably congestion, and thus methods to alleviate this congestion should be observed.

## Introduction

Within Transportation Engineering, it is necessary to understand and determine the free-flow speed, density, and level of service of all roadways. Since there are thousands of roads across the United States, states have implemented government agencies to handle any tasks relating to transportation. Within Texas, the Texas Department of Transportation is tasked with developing, planning, maintaining, and more for all roadways owned by the state of Texas. In this study, the capacity and overall quality of a given urban freeway segment were observed to aid in TXDot's goal to alleviate congestion in highly congested roadways. Density is the volume of cars per hour per lane. Free-flow speed is the ideal speed a vehicle can maintain without undergoing disruptions due to other vehicles on the same roadway. The level of service is a measurement of the quality of flow (Garber, et. al, 2020). All three parameters have been determined within this study and should be used to aid in finding innovative solutions to alleviate congestion.

## Experimental Procedure

- Specify Input Data (Includes: demand volume, number and width of lanes, right-side lateral clearance, total ramp density, percent of heavy vehicles, terrain, and composition of the driver population)
- Compute the free flow speed
- Select a free flow speed curve
- Adjust the demand volume
- Estimate speed and density
- Determine LOS

## Results and Discussion

| Density | Free-Flow Speed | Level of Service |
|---------|-----------------|------------------|
| 22.31   | 65              | C                |

**Figure 1.0** represents the results for density, free-flow speed, and level of service.

The density from this roadway was determined to be: 22.31 pc/mi/ln. The free-flow speed of the freeway was: 62.87 mph, and rounded up to 65 mph. The level of service of this freeway was: C. Although free-flow speed was calculated to be 62.87 mph, the value had to be rounded to 65 mph to fulfill the conditions for the comparison of the adjusted demand flow rate and breakpoint. As the level of service was determined to be C, this reflects the quality of the flow of the freeway. Thus, many speeds of vehicles are observed to be the free-flow speed, and the freeway is nearing its capacity. For drivers, this means they will have to take more precautions when switching lanes and may not be able to switch lanes as often. Unfortunately, if a blockage occurred, there may be greater traffic and a longer travel time for drivers to reach their destination. Due to this rating, it is recommended that solutions be found to alleviate this mild congestion.

## Conclusion

In conclusion, the objective of the lab was met. Using the existing freeways characteristics, the free flow speed, density, and level of service were able to be accurately determined. The values can be found in Figure 1.0. By looking at the determined level of service, we are able to justify the expense of modifying the facilities.

## Reference

Garber, Nicholas J, Lester A. Hoel, and Raju Sarkar. *Traffic and Highway Engineering*. 2020.  
Print.

## Appendices

**Sample Calculation 1:** Find the Adjustment Factor for Heavy Vehicles

$$f_{HV} = \frac{1}{1 + (\text{truck proportion})(\text{Passenger car equivalent of truck} - 1) + (\text{RV proportion})(\text{PCE of RV} - 1)}$$

$$= \frac{1}{1 + (0) + (0)} = 1$$

**Sample Calculation 2:** Find the Demand Flow Rate

$$v_p = \frac{\text{Demand Volumes}}{(\text{peak hour factor})(\text{number of lanes in one direction})(\text{adjustment factor for unfamiliar drivers})(\text{adjustment factor for heavy vehicles})}$$

$$= \frac{4000}{(0.92)(3)(1)(1)} = 1449.28 \text{ pc/h/ln}$$

**Sample Calculation 3:** Find the Free-Flow Speed

$$FFS = 75.4 - f_{LW} - f_{LC} - 3.22TRD^{0.84}$$

$$= 75.4 - 11 - 3 - 3.22(1.5)^{0.84} = 62.87 \text{ mph}$$

**Sample Calculation 4:** Find the Estimated Speed

$$S_{BP-65} = 65 - 0.00001418(v_p - 1400)^2$$

$$= 65 - 0.00001418(1449.28 - 1400)^2 = 64.97 \text{ mph}$$

**Sample Calculation 5:** Find the Density

$$D = \frac{v_p}{S}$$

$$= \frac{1149.28}{64.97} = 22.31 \text{ pc/mi/ln}$$



**AVERAGE**

**LAB 4**  
**GROUP # \_\_\_\_2\_\_\_\_**

| <b>CRITERIA</b>                                                                                                                                                          | <b>Maximum Points</b> | <b>Points Awarded</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| <b>1. TITLE PAGE</b><br>Includes the title of the report, the authors and team number, and date.                                                                         | <b>2</b>              | 1                     |
| <b>2. TABLE OF CONTENTS</b><br>Includes all sections of the report, figures, tables, and appendices with corresponding page numbers.                                     | <b>3</b>              | 3                     |
| <b>3. ABSTRACT</b><br>Summarizes what was done, what was found, and its importance                                                                                       | <b>10</b>             | 10                    |
| <b>4. INTRODUCTION</b><br>Includes motivation, general summary, definitions, theory, and background.                                                                     | <b>10</b>             | 10                    |
| <b>5. PROCEDURE</b><br>Describes the procedure step-by-step.                                                                                                             | <b>10</b>             | 2                     |
| <b>6. RESULTS</b>                                                                                                                                                        | <b>45</b>             |                       |
| free-flow speed                                                                                                                                                          | 15                    | 10                    |
| density                                                                                                                                                                  | 15                    | 10                    |
| level of service                                                                                                                                                         | 15                    | 15                    |
| <b>7. DISCUSSION</b><br>Analysis of the results based on the reporting requirements. Problems encountered during the procedure and effects on the results are discussed. | <b>10</b>             | 5                     |
| <b>8. CONCLUSIONS</b><br>Summary of the analysis results, lessons, and recommendations.                                                                                  | <b>10</b>             | 6                     |
| <b>TOTAL</b>                                                                                                                                                             |                       | <b>72</b>             |

**Suggestions:**

1. Team number was missing.
2. Graph 1 to 3 are not related to procedures in this report.
3. We need to describe procedures in sentences instead of bullets. What is Table 1 in the section of procedures? Equation # needs to be mentioned in paragraph.
4. Table title needs to be placed above the table. Equations are not related to procedures.
5. The value of free flow speed in the result and discussion section does not match with the value listed in abstract. The value of density in discussion does not match with the value in abstract.
6. Unit was missing in the discussion section. The unit of demand flow was not correct.
7. The summary of the analysis results was not provided in the conclusion.



Capacity and Level of Service

Ariana Mangroo

Marshall Johnson

Omar Hajo

4/1/2022

## **TABLE OF CONTENT**

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| <b>INTRODUCTION</b>               | <b>3</b>    |
| <b>EXPERIMENTAL PROCEDURE</b>     | <b>4-6</b>  |
| <b>RESULTS</b>                    | <b>7</b>    |
| <b>DISCUSSIONS</b>                | <b>7</b>    |
| <b>CONCLUSION/RECOMMENDATIONS</b> | <b>8</b>    |
| <b>REFERENCES</b>                 | <b>8</b>    |
| <b>APPENDICES</b>                 | <b>9-10</b> |

## **ABSTRACT**

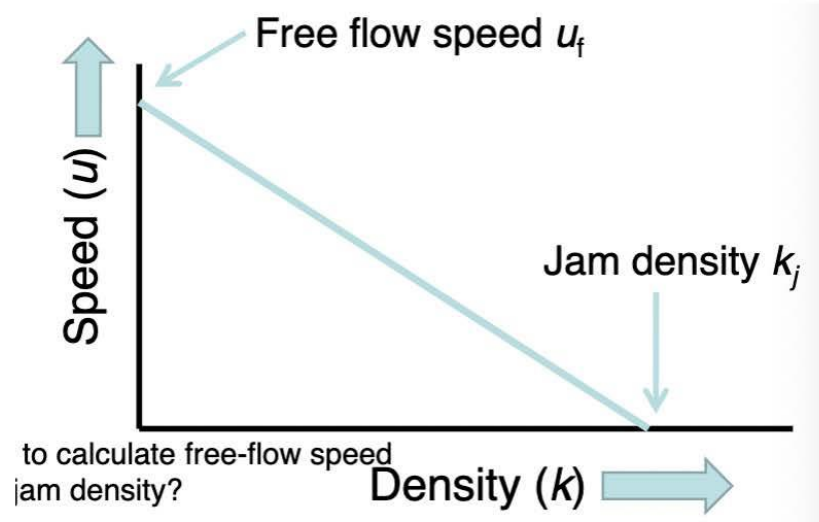
This lab aims to analyze the capacity and level of service (LOS) for the Texas Department of Transportation (TxDOT). The funding was given by this company to develop and construct a new freeway in hopes to decrease the congestion in the greater area of Houston that extends to downtown. After carefully analyzing the capacity and level of service the results show that the free flow of speed is  $54.4 \frac{mi}{h}$  the density is 24.15 pc/h/ln and the level of service is C. The results of this lab are important because it allows TxDOT to have a greater understanding of the population of people they can accommodate and the quality of the current operating traffic system.

## **INTRODUCTION**

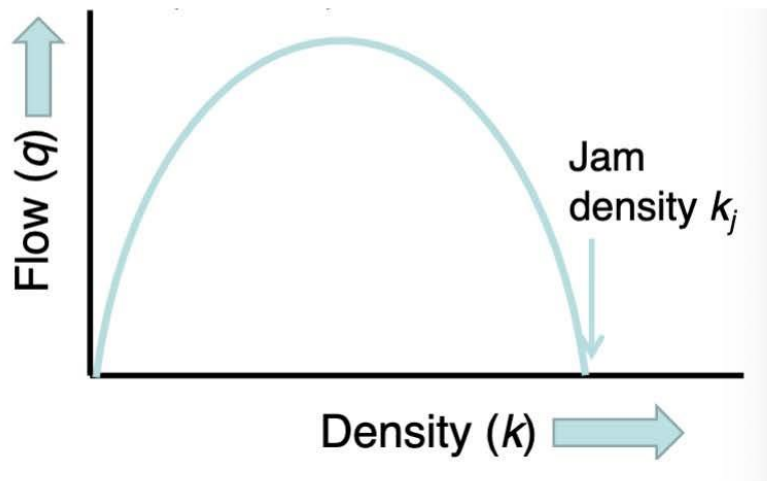
The amount of people that relocate on a day-to-day basis is only increasing as the years pass. The result of this migration has a large effect on traffic engineers and how they will go about making sure the roads will accommodate this change. The method that helps these engineers that we are focusing on for the purpose of this lab is known as capacity and level of service. When describing capacity, the best way to understand it is as being “the maximum number of vehicles, passengers, or the like, per unit time, which can be accommodated under given conditions with a reasonable expectation of occurrence” (Tom V. Mathew, K V Krishna Rao, May 3, 2007) [1]. Level of service aims to answer, “how good is the present traffic situation on a given facility” (Tom V. Mathew, K V Krishna Rao, May 3, 2007) [2].

## EXPERIMENTAL PROCEDURE

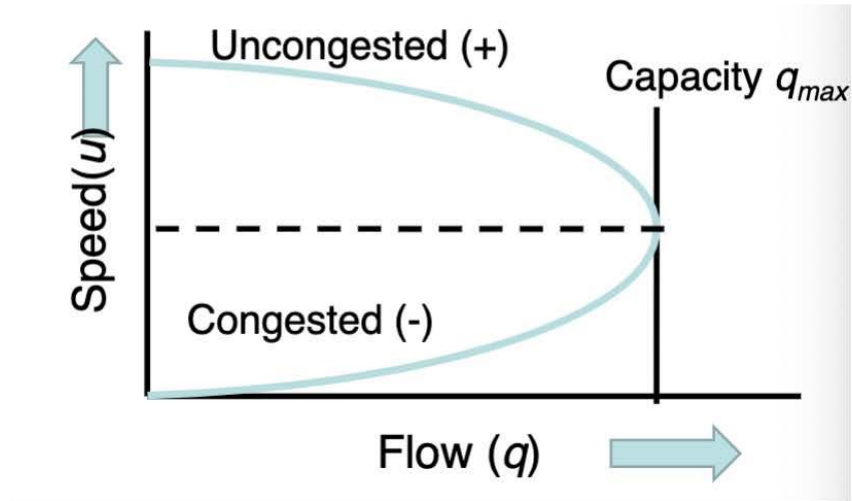
Visual representation:



Graph 1: Speed VS Density



Graph 2: Flow VS Density



Graph 3: Speed VS Flow

Given:

1. Demand Volume:  $4000 \frac{veh}{h}$
2. PHF=0.92
3. Terrain: Level
4. Number of lanes: 3 in each direction
5. Lane width: 11ft
6. Later clearance: 3ft
7. Ramp density: 4 Diamond interchanges spaced 1.5 mi apart
8. Heavy Vehicles in traffic stream during the peak hour: None
9. Driver population: Commuters and familiar drivers

Find:

1. Free-flow speed
2. Density
3. Level of service

Equations:

Free-flow speed

[1]

$$FFS = 75.4 - f_{LW} - f_{LC} - 3.22TRD^{0.84}$$

Where,

$f_{LW}$  = adjustment for lane width

$f_{LC}$  = adjustment for right – side lateral clearance

TRD= Total ramp density (ramps/mi)

Demand Flow

[2]

$$V_p = \frac{V}{PHF * N * f_{Hv} * f_p}$$

Where,

$V_p$  = Deman flow rate under base conditions

PHF= Peak hour factor

N= Number of lanes in analysis direction

$f_{Hv}$  = Adjustment factor for presence of heavy vehicles in traffic stream

$f_p$  = adjustment factor for unfamiliar driver populations, for regular users it is 1

Mean Speed

[3]

$$S = FFS - \left[ \frac{1}{9} (7FFS - 340) \left( \frac{V_p + 30FFS - 3,400}{40FFS - 1,700} \right)^{2.6} \right]$$

where,

$S$  = Mean speed of traffic stream under base conditions ( $\frac{mi}{h}$ )

Density

[4]

$$D = \frac{V_p}{S}$$

Lable of Service

Table 1



## RESULTS

**Table B-1**  
**1994 HCM Level of Service Criteria for Basic Freeway Sections**

| LOS | 70 mph<br>Free-Flow Speed          |                             |                             |                              | 65 mph<br>Free-Flow Speed          |                             |                             |                              | 60 mph<br>Free-Flow Speed          |                             |                             |                              |
|-----|------------------------------------|-----------------------------|-----------------------------|------------------------------|------------------------------------|-----------------------------|-----------------------------|------------------------------|------------------------------------|-----------------------------|-----------------------------|------------------------------|
|     | Density <sup>a</sup><br>(pc/mi/ln) | Speed <sup>b</sup><br>(mph) | Maximum <sup>c</sup><br>V/C | MSF <sup>d</sup><br>(pcphpl) | Density <sup>a</sup><br>(pc/mi/ln) | Speed <sup>b</sup><br>(mph) | Maximum <sup>c</sup><br>V/C | MSF <sup>d</sup><br>(pcphpl) | Density <sup>a</sup><br>(pc/mi/ln) | Speed <sup>b</sup><br>(mph) | Maximum <sup>c</sup><br>V/C | MSF <sup>d</sup><br>(pcphpl) |
| A   | ≤ 10.0                             | ≥ 70.0                      | 0.318/0.304                 | 700                          | ≤ 10.0                             | ≥ 65.0                      | 0.295/0.283                 | 650                          | ≤ 10.0                             | 60.0                        | 0.272/0.261                 | 600                          |
| B   | ≤ 16.0                             | ≥ 70.0                      | 0.509/0.487                 | 1,120                        | ≤ 16.0                             | ≥ 65.0                      | 0.473/0.457                 | 1,040                        | ≤ 16.0                             | 60.0                        | 0.436/0.412                 | 960                          |
| C   | ≤ 24.0                             | ≥ 68.5                      | 0.747/0.715                 | 1,644                        | ≤ 24.0                             | ≥ 64.5                      | 0.704/0.673                 | 1,548                        | ≤ 24.0                             | 60.0                        | 0.655/0.626                 | 1,440                        |
| D   | ≤ 32.0                             | ≥ 63.0                      | 0.916/0.876                 | 2,015                        | ≤ 32.0                             | ≥ 61.0                      | 0.887/0.849                 | 1,952                        | ≤ 32.0                             | 57.0                        | 0.829/0.793                 | 1,824                        |
| E   | ≤ 36.7/39.7                        | ≥ 60.0/58.0                 | 1.000                       | 2,200/2,300                  | ≤ 39.3/43.4                        | ≥ 56.0/53.0                 | 1.000                       | 2,200/2,300                  | ≤ 41.5/46.0                        | 53.0/50.0                   | 1.000                       | 2,200/2,300                  |
| F   | Variable                           | Variable                    | Variable                    | Variable                     | Variable                           | Variable                    | Variable                    | Variable                     | Variable                           | Variable                    | Variable                    | Variable                     |

**Table 1: Level of Service Criteria for Basic Freeway Sections**

The information gathered by the Texas Department of Transportation is what was used to determine the section at which the construction will fall under. The result that was analyzed was that the road will fall under the level of service C. The supervisor asked to find the following values, the free flow speed which was  $54.1 \frac{mi}{h}$ , and the density which was 24.15 pc/h/ln.

## DISCUSSIONS

The free flow speed, which is the average speed of a sample of vehicles in a set section, calculated is 54.1. With that being said, the free flow speed is sufficient for the highway. The demand flow is 1449.3 pc/h/ln<sup>3</sup>. Since the mean speed is, the value meets the requirements for the roadway given. Traffic density is calculated to be 4.15 pc/h/ln. The Level of Service is a measurement that shows the quality of traffic service for vehicles. Overall, the Level of Service (LOS) is C.

## **CONCLUSIONS AND RECOMMENDATIONS**

In conclusion, the capacity and level of service involve the evaluation of how capable a road section can carry traffic. We did this by using a set of procedures to determine the maximum flow of traffic that a section of a highway will carry under prevailing roadway traffic and control conditions. We considered the Base Conditions, Free- Flow Speed (FFS), Flow Rates Beyond the Breakpoint, and the Level of Service. The capacity analysis helps us understand how much traffic a given transportation facility can accommodate. The level of service tries to answer how good the present traffic situation is on a given facility.

## **REFERENCES**

- [1-2] *Capacity and Level of Service - Priodeep's Home*. <https://priodeep.weebly.com/uploads/6/5/4/9/65495087/lec-35.pdf>.
- [3] *Appendix B Traffic Level of Service ... - California*. [https://ccag.ca.gov/wp-content/uploads/2014/07/cmp\\_2005\\_Appendix\\_B.pdf](https://ccag.ca.gov/wp-content/uploads/2014/07/cmp_2005_Appendix_B.pdf).

## APPENDICES

Given:

1. Demand Volume:  $4000 \frac{veh}{h}$
2. PHF=0.92
3. Terrain: Level
4. Number of lanes: 3 in each direction
5. Lane width: 11ft
6. Later clearance: 3ft
7. Ramp density: 4 Diamond interchanges spaced 1.5 mi apart
8. Heavy Vehicles in traffic stream during the peak hour: None
9. Driver population: Commuters and familiar drivers

Free flow speed

$$FFS = 75.4 - f_{LW} - f_{LC} - 3.22TRD^{0.84}$$

$$FFS = 75.4 - 11 (ft) - 3 (ft) - 3.22 * \frac{4}{1.5}^{0.84}$$

$$FFS = 54.1 \frac{mi}{h}$$

Demand Flow

$$V_p = \frac{V}{PHF * N * f_{Hv} * f_p}$$

$$V_p = \frac{4000 \frac{veh}{h}}{0.92 * 3 * 1 * 1}$$

$$V_p = 1449.3 \text{ pc/h/ln3}$$

Mean Speed

$$S = FFS - \left[ \frac{1}{9} (7FFS - 340) \left( \frac{V_p + 30FFS - 3,400}{40FFS - 1,700} \right)^{2.6} \right]$$

$$S = 54.4 - \left[ \frac{1}{9} (7 * 54.4 - 340) \left( \frac{1449.3 + 30 * 54.4 - 3,400}{40 * 54.4 - 1,700} \right)^{2.6} \right]$$

$$S = 55.9 \frac{mi}{h}$$

Density

$$D = \frac{V_p}{S}$$

$$D = \frac{1449.3}{55.9}$$

$$D = \mathbf{24.15 \text{ pc/h/ln}}$$

Level of service

According to the “level of service criteria for Multilane Highways” (Appendix B traffic Level of service) [3] the level of service is **C**.

**BELOW AVERAGE**

**LAB 4**  
**GROUP #   3**

| <b>CRITERIA</b>                                                                                                                                                          | <b>Maximum Points</b> | <b>Points Awarded</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| <b>1. TITLE PAGE</b><br>Includes the title of the report, the authors and team number, and date.                                                                         | <b>2</b>              | 2                     |
| <b>2. TABLE OF CONTENTS</b><br>Includes all sections of the report, figures, tables, and appendices with corresponding page numbers.                                     | <b>3</b>              | 3                     |
| <b>3. ABSTRACT</b><br>Summarizes what was done, what was found, and its importance                                                                                       | <b>10</b>             | 4                     |
| <b>4. INTRODUCTION</b><br>Includes motivation, general summary, definitions, theory, and background.                                                                     | <b>10</b>             | 0                     |
| <b>5. PROCEDURE</b><br>Describes the procedure step-by-step.                                                                                                             | <b>10</b>             | 5                     |
| <b>6. RESULTS</b>                                                                                                                                                        | <b>45</b>             |                       |
| free-flow speed                                                                                                                                                          | 15                    | 10                    |
| density                                                                                                                                                                  | 15                    | 10                    |
| level of service                                                                                                                                                         | 15                    | 10                    |
| <b>7. DISCUSSION</b><br>Analysis of the results based on the reporting requirements. Problems encountered during the procedure and effects on the results are discussed. | <b>10</b>             | 6                     |
| <b>8. CONCLUSIONS</b><br>Summary of the analysis results, lessons, and recommendations.                                                                                  | <b>10</b>             | 10                    |
| <b>TOTAL</b>                                                                                                                                                             |                       | <b>60</b>             |

**Suggestions:**

1. This report needs editing. The margins were misaligning.
2. We need paragraph / sentences in abstract. What was done and what was found were not provided in abstract.
3. The information provided in introduction is not related to this course.
4. Please use paragraph / sentences to describe step-by-step procedure.
5. Table needs to have a title. Equations do not appear in the file. Units were missing.
6. Units were missing in the discussion.

Prairie View A&M University  
College of Engineering  
Department of Civil & Environmental Engineering



CVEG 3302 P01 Transportation Engineering

**LABORATORY REPORT**  
**Capacity and Level of Service (LOS) Analysis**

Conducted on: March 24th, 2022

Submitted by: Group #3

Trinity Scott

Noah Smith

Sophie Tuke

Maurice Bettis

Submitted on: April 1st, 2022

Submitted to Dr. Liu

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## **Abstract**

In this experiment, our objective was to see capacity and level of service analyses to:

- Determine the number and width of lanes needed for new facilities or for expanding existing facilities.
- Assess service levels and operational characteristics of existing facilities that are being considered for up
- Identify traffic and roadway changes needed for new developments.
- Provide base values for determining changes in fuel consumption, air pollutant emissions, road user costs

roadway changes.

To accomplish these we had to find the free flow speed density and level of service for this urban freeway s

Free flow speed is  $75.4 - f_{LW} - f_{LC} - 3.22TRD^{0.84}$

Density is  $\frac{VP}{\text{Breaking point}}$

And level of service is density > demand

The data gathered in this experiment evaluation is key to making the road way a safer and a more healthier Environment.

## **Introduction**

In order to complete this lab, we needed a fundamental grasp of capacitor capacitance. When the potential energy in an electrostatic field is stored in a capacitor (two parallel isolated conductors). This potential energy can be put to use in the form of work. Additionally, throughout this potential energy storage, capacitance develops. The measured charge that may be held per volt is known as capacitance. The form of the plates, the substance between them, and finally the spacing between them all affect capacitance. The voltages of the capacitor's capacitance are also determined by parallel and series circuits. The capacitance of each capacitor in a parallel circuit may be put together to determine the overall capacitance of the circuit. The capacitors in a series circuit behave as if the plate area is unchanged but the distance between them is doubled. As a result, the overall capacitance is half of the individual capacitors' value. When a capacitor is able to charge, an RC circuit can be formed.

## **Objective**

The objective of this experiment is to see how the operational analysis procedure for estimating speed, and density, determining LOS for basic highway segments works.

**Procedure**

Found by using AASHTO

1. Specify input data
2. Compute the free-flow speed
3. Select a free-flow speed curve
4. Adjust demand value
5. Estimate speed and density
6. Determine LOS

## Data/Results

Demand Volume: 4000 veh/ht

PHF: 0.92

Number of lanes: 3 in each direction

Lateral Clearance: 3ft

Ramp density: 4 diamond interchanges spaced 1.5 mil apart

Lane width: 11ft

Driver Population: Commuters and familiar drivers

| Demand volume | PHF  | Terrain | Number of lanes   | Lane width | Lateral clearance | Ramp density         |        |                |                                |  |
|---------------|------|---------|-------------------|------------|-------------------|----------------------|--------|----------------|--------------------------------|--|
| veh/h         |      | Level   | in each direction | ft         | ft                | diamond interchanges | spaced | Heavy vehicles | Driver population              |  |
| 4000          | 0.92 |         | 3                 | 11         | 3                 | 4                    | 1.5    | none           | commuters and familiar drivers |  |
| FFS           | fHV  | Vp      | TRD               | Breakpoint | Density           | LOS                  |        |                |                                |  |
| 69            | 1    | 1449    | 1.33              | 69.3       | 20.9              | C                    |        |                |                                |  |

$$TRD = \frac{\text{Ramp interchange} * \text{number of interchanges}}{\text{mi}}$$

$$TRD = \frac{2 * 4}{6} = 1.33$$

$$FFS = 75.4 - f_{LW} - f_{LC} - 3.22 TRD^{0.84}$$

$$FFS = 75.4 - 1.9 - 1.2 - (3.22 * 1.33)^{0.84} = 68.2$$

$$f_{HV} = \frac{1}{1 + P_T(E_T - 1) + P_R(E_R - 1)}$$

$$f_{HV} = \frac{1}{1 + 0 * (1.5 - 1) + (0 * (1.2 - 1))} = 1$$

$$V_p = \frac{V}{(PHF)(N)(f_p)(f_{HV})}$$

$$VP = \frac{4000}{(0.92)(3)(1.00)(1.00)} = 1449.3$$

$$S = \text{Breaking point} = 70 - 0.0000116 * (V_p - 1200)^2$$

$$S = 70 - 0.0000116 * (1449 - 1200)^2 = 69.3$$

$$\text{Density} = \frac{VP}{\text{Breaking point}}$$

$$\text{Density} = \frac{1449}{69.3} = 20.9$$

$$Los > 18 - 26$$

## **Discussion**

In this report, TRD, the total number of ramp findings, were found to be 1.33. This was given, but is generally measured 3 miles upstream and 3 miles downstreams of the midpoint of a section of a roadway. This exemplified that it was a generally flat roadway.

The FFS, free flow speed, is the general speed that is desired by drivers if there were no vehicles accompanied on the road. This is a great measure to determine traffic flow, and in this lab report, the FFS equaled 68.2, which is generally high.

The fHV, heavy vehicle adjustment factor, was only found to be 1. This coincided with the given statement that there were no heavy vehicles present during the peak hour of traffic flow.

Along with these calculations, the VP, flow rate, and the S, breaking point, were also calculated in order to determine all the qualitative characteristics of LOS, Level of Service, of the highway.

In transportation engineering, this measure is generally taken to analyze roadways and its traffic flow, and determine the quality levels of traffic based on performance measures such as vehicle speed, density, and the congestion of traffic in order to produce optimal transportation flow.

## **Conclusion/Recommendations**

Based on the data collected and analyzed from traffic volume study of the commuters and familiar drivers, the traffic volume observed in the given location can be considered under LOS C. This type of Level of Service has restricted flow that remains stable, but has significant interactions with other vehicles in a traffic stream. A driver notices general lowering in ease and flow while driving at this stage of LOS. It is not the most efficient method for flow of traffic, so, for future matters, it can be made easier for drivers by, for example, adding lanes. This can give more room for drivers to drive through, and thus, eases the volume of traffic and increases flow. This experiment exemplified the methods to which organizations such as the Department of Transportation take in order to organize roadways and freeways, and help large cities, such as Houston, better operate and get from place to place.

**TRANSPORTATION ENGINEERING  
SPRING 2022**

**LAB 5**

**TOPICS COVERED IN LAB 5**

1. Intersection Design and Control

**CIVIL ENGINEERING DEPARTMENT  
PRAIRE VIEW A&M UNIVERSITY**

## Lab #5

### Signal Analysis

Due 4/29/2022

Use the lab report format for this lab write up.

The city of Prairie View has hired your engineering firm to try to improve their signals. Most signals use more or less the same timing throughout the day, but delay could be reduced by adjusting the phase pattern and phase lengths by time of day. So, here are the tasks you must complete:

1. Choose a signalized intersection in Prairie View, obtain turning movement volumes for all approaches, for 15 minutes (sometime between 7:30 AM and 7:30 PM if a weekday, or between noon and 8:00 PM if a weekend), and record the current signal phasing pattern, and the length of the green, yellow, and all-red time for each phase.
2. Calculate the delay for each lane group, each approach, and the intersection as a whole.
3. Improve the signal's design by changing the phasing pattern and/or durations of green, yellow, and all-red time.

You might need the following information as well:

- Use a design vehicle 20 feet long and with a braking rate of  $11.2 \text{ ft/s}^2$ .
- Assume 1 second of PIJR time.
- In the interest of safety, you can calculate intersection width and lane width from Google Maps or Google Earth, even if the resulting measurements are a little fuzzy.
- When measuring the lengths of green, yellow, and all-red time for current conditions, it is a good idea to take several measurements and average them.
- One possible way to make the measurement of the current conditions is to have one person timing signal phases with a stopwatch, and two others recording the turning movements.

Upload your answers to the above tasks in word file, along with any supporting documents (e.g., spreadsheets).

**Please don't go to the city of Prairie View telling them that your professor says their signals are poorly timed. It takes more than just fifteen minutes of measurements on one day to properly design a signal.**

**ABOVE AVERAGE**

**LAB 5**  
**GROUP # \_\_\_\_1\_\_\_\_**

| <b>CRITERIA</b>                                                                                                                                                          | <b>Maximum Points</b> | <b>Points Awarded</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| <b>1. TITLE PAGE</b><br>Includes the title of the report, the authors and team number, and date.                                                                         | <b>2</b>              | 2                     |
| <b>2. TABLE OF CONTENTS</b><br>Includes all sections of the report, figures, tables, and appendices with corresponding page numbers.                                     | <b>3</b>              | 3                     |
| <b>3. ABSTRACT</b><br>Summarizes what was done, what was found, and its importance                                                                                       | <b>5</b>              | 2                     |
| <b>4. INTRODUCTION</b><br>Includes motivation, general summary, definitions, theory, and background.                                                                     | <b>5</b>              | 5                     |
| <b>5. PROCEDURE</b><br>Describes the procedure step-by-step.                                                                                                             | <b>5</b>              | 3                     |
| <b>6. RESULTS</b>                                                                                                                                                        | <b>55</b>             |                       |
| turning movement volumes for all approaches                                                                                                                              | 10                    | 10                    |
| record the current signal phasing pattern                                                                                                                                | 10                    | 10                    |
| length of the green, yellow, and all-red time for each phase                                                                                                             | 10                    | 10                    |
| delay for each lane group, each approach, and the intersection as a whole                                                                                                | 15                    | 15                    |
| Improve the signal's design                                                                                                                                              | 10                    | 10                    |
| <b>7. DISCUSSION</b><br>Analysis of the results based on the reporting requirements. Problems encountered during the procedure and effects on the results are discussed. | <b>10</b>             | 6                     |
| <b>8. CONCLUSIONS</b><br>Summary of the analysis results, lessons, and recommendations.                                                                                  | <b>10</b>             | 6                     |
| <b>9. AUTHOR CONTRIBUTIONS</b>                                                                                                                                           | <b>5</b>              | 5                     |
| <b>TOTAL</b>                                                                                                                                                             |                       | <b>87</b>             |

**Suggestions:**

1. A brief summary of results should be shown in Abstract.
2. Please provide some sentences before the bullets in the section of procedure.
3. Title of table should be placed above the table. Once a table is referred in a paragraph, the table should be listed after the paragraph.
4. It is not clear which design was chosen. In Abstract and Results and Discussion, it states Design 1 was chosen; however, it shows Design 2 was chosen in Conclusion.



Prairie View A&M University  
College of Engineering  
Department of Civil & Environmental Engineering



CVEG 3302 P01 Transportation Engineering  
LABORATORY REPORT ON  
"Signal Analysis"

Conducted on  
April 24th, 2022

Submitted by: Group 1  
Allyssa Reynolds  
Hunter Rodgers

On  
April 30th, 2022  
To  
Dr. Lui

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## Abstract

The purpose of this experiment is to analyze a signalized intersection in Prairie View. After conducting an analysis on the selected intersection, the lab group decided that we will choose Design 1 to improve the signals. Design 1 has a lower cycle length, allows the public to access the intersection quicker, and reduces public opposition. It is important to conduct this type of study because retiming traffic signals can improve traffic safety and a cities quality of life.

## Introduction

Traffic signals have a significant role in our roadway systems. They are supposed to help move traffic safely and in a timely manner. Signalized intersections could have insufficient timing which can affect traffic flow. To improve traffic flow, we must adjust the cycle length if needed. Cycle length is defined as the time required for all intervals to occur. The capacity at a signalized intersection is defined as the maximum rate of flow for the subject lane group that can go through the intersection under signalized conditions. Capacity is given in units of vehicles/hour but is based on the flow during a 15 minute time period. The cycle length is defined as the time required for all intervals to occur. The objective of the signal analysis study is to examine the signalized intersection, and to improve the signals design.

## Experimental Procedure

- Select a signalized intersection in Prairie View
- Obtain turning movement volumes for all approaches for 15 min
- Record the current signal phasing pattern and length of the green, yellow, and all-red time for each phase

## Tabular Results

| Phase | Design 1      |                | Cycle Length, s |
|-------|---------------|----------------|-----------------|
|       | Green Time, s | Yellow Time, s |                 |
| 1     | 13            | 10.5           | 71.5            |
| 2     | 16            | 32             | 71.5            |

Table 1.0 reflects Design 1 green time, yellow time, and cycle length for each phase.

## Results and Discussion

The original signal cycle for the PVAMU four-way intersection was as follows: 37.01s, 35.03s, 32.06s, and 27.13s. The green time observed for the four-way junction was: 14.76s, 17.82s, 8.28s, and 10.45s. The yellow time observed for the four-way intersection was as follows: 3.66s, 3.56s, 3.34s, 3.01s. The vehicle volume observed was vehicle/15 minutes and converted to vehicle/hour by multiplying the original volume by 60 and a factor of 15. The following volume was observed for the left lane only: 420 veh/hr, 180 veh/hr, 780 veh/hr, and 900 veh/hr. The following volume was observed for the combined lane: 1980 veh/hr, 2340 veh/hr, and 480 veh/hr. The length of the east-west bound intersection was observed to be 321.04 feet. The length of the north-south bound intersection was observed to be 250.63 feet. Both measurements were obtained using the google maps feature to develop and analyze a line.

The delay observed for the original traffic configuration is as follows for the delay: 22.58s and 7.08s for Phases I and II. The average delay observed for each intersection is 7.66s, 2.52s, 2.59s, and 3.30s for intersections 1-4. The average delay observed for each junction is 2.59s, 0.90s, 0.27s, and 0.64s for intersections 1-4, respectively.

During this laboratory, two designs were developed to optimize the final design choice. For Design 1, two phases were observed. The speed limit for all roadways were observed to be 35 mph. The ratio of design volume to saturation flow was determined to be 0.017 and 0.021 for  $Y_1$  and  $Y_2$  respectively. The saturation flow was assumed to be 1900 pcphpl, as this is a standard value. Phase I included both lanes for vehicles driving west and east bound. Phase II included both lanes for vehicles driving north and south bound. Phase II held a critical value of 0.021. The yellow time was found to be 10.5s for Phase I, and 32s for Phase II. The cycle length was

determined to be 71.5s. The green time was determined to be 13s for Phase I, and 16s for Phase II.

For Design 2, three phases were observed. The speed limit for all roadways were observed to be 35 mph. The ratio of design volume to saturation flow was determined to be 0.007, 0.017, and 0.021 for  $Y_1$ ,  $Y_2$ ,  $Y_3$  respectively. The saturation flow was assumed to be 1900 pcphpl, as this is a standard value. Phase I included only one lane for vehicles driving westbound. Phase II included only one lane for vehicles driving eastbound. Phase III included both lanes for vehicles driving north and south bound. Phase III held a critical value of 0.021. The yellow time was found to be 10.5s for Phase I, 10.5s for Phase II, and 32s for Phase III. The cycle length was determined to be 88.5s. The green time was determined to be 5.5s for Phase I, 13.5s for Phase II, and 16.5s for Phase III. This design was the most optimized choice not only due to its delay observed, but due to its capacity to allow more vehicles to pass for a longer period.

Specific data for Design 1 and 2 can be found near the end of Appendix A. Raw data for Design can be found in both Appendix A and B.

Design 1 was chosen as the most optimized solution due to it's lower cycle length time. Having a shorter cycle length would allow the public to access the intersection quicker, and reduce public opposition for the configuration. As Design 1 was selected, the original configuration of the intersection remained the same.

#### Sources of Error

There were numerous errors observed during this experiment. This source of error was a personal error. As the intersection cycle was being evaluated, multiple readings were not taken for each traffic signal. Thus, the data obtained may not have been accurate. This could have been avoided by conducting multiple timings for each intersection and taking the average.

## Conclusion

Two designs were developed to improve the signal's design. Design 2 was the most optimized solution due to its shorter cycle length. The configuration of the intersection didn't due to choosing this design. Sources of error identified within the experiment include personal error, as multiple timings for each intersection were not obtained. Recommendations include completing the experiment in duplicates to obtain accurate readings and expanding the project for daily traffic volume and cycle length observations. This would provide an opportunity for a more optimized design to be developed.

## Author Contributions

The authors confirm their contribution to the report as follows: written narrative/report: Hunter Rodgers, Allyssa Reynolds; abstract and introduction: Hunter Rodgers; experimental procedure: Hunter Rodgers; analysis and interpretation of results: Allyssa Reynolds; conclusion: Allyssa Reynolds; All authors reviewed the results and approved the final version of the report.

## References

Garber, Nicholas J, and Lester A. Hoel. Traffic and Highway Engineering. St. Paul: West Pub. Co, 2015. Print.

## Appendix A

| Intersection | Green Time, s | Yellow Time, s | Red Time, s | Overall Time, s |
|--------------|---------------|----------------|-------------|-----------------|
| 1            | 14.76         | 3.66           | 18.59       | 37.01           |
| 2            | 17.82         | 3.56           | 13.65       | 35.03           |
| 3            | 8.28          | 3.34           | 20.44       | 32.06           |
| 4            | 10.45         | 3.01           | 13.67       | 27.13           |

**Table 1.0** reflects the readings obtained from the intersection analysis.

| Intersection | (Left-Lane) | (Straight/Right Lane) | (Left-Lane)<br>Phase 1     | (Straight/Right Lane)<br>Phase 2 |
|--------------|-------------|-----------------------|----------------------------|----------------------------------|
|              | Phase 1     | Phase 2               | Vehicle Volume, qi, veh/hr | Vehicle Volume, qi, veh/hr       |
| 1.00         | 7.00        | 33.00                 | 420.00                     | 1980.00                          |
| 2.00         | 3.00        | 39.00                 | 180.00                     | 2340.00                          |
| 3.00         | 13.00       | -                     | 780.00                     |                                  |
| 4.00         | 15.00       | 8.00                  | 900.00                     | 480.00                           |

**Table 2.0** reflects the vehicle volume obtained from the intersection analysis.

| Intersection | Length, m | Length, ft |
|--------------|-----------|------------|
| 1            | 97.85     | 321.04     |
| 2            | 76.39     | 250.63     |
| 3            | 76.39     | 250.63     |
| 4            | 97.85     | 321.04     |

**Table 3.0** reflects the length of each intersection.

| Design 2 |               |                |                 |
|----------|---------------|----------------|-----------------|
| Phase    | Green Time, s | Yellow Time, s | Cycle Length, s |
| 1        | 5.5           | 10.5           | 88.5            |
| 2        | 13.5          | 10.5           | 88.5            |
| 3        | 16.5          | 32             | 88.5            |

**Table 4.0** reflects Design 2 green time, yellow time, and cycle length for each phase.

|         | Lane Group | Capacity, Ci | Degree of Saturation, Xi |
|---------|------------|--------------|--------------------------|
| Phase 1 | 1.00       | 633.79       | 0.66                     |
|         | 2.00       |              | 3.12                     |
|         | 3.00       |              | 1.23                     |
| Phase 2 | 1.00       | 1728.22      | 0.52                     |
|         | 2.00       |              | 0.28                     |
|         | 3.00       |              | 0.10                     |
|         | 4.00       |              | 1.35                     |

**Table 5.0** represents the degree of saturation and capacity found from raw calculations.

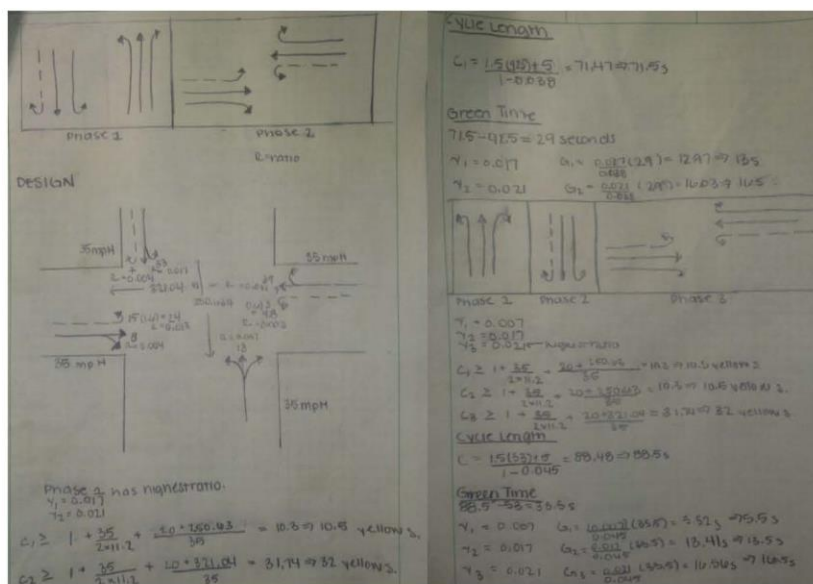
|                            |            |             |             |  |               |      |             |
|----------------------------|------------|-------------|-------------|--|---------------|------|-------------|
|                            |            | Total Delay |             |  |               |      |             |
| Phase 1                    | Lane Group |             |             |  | Average Delay |      |             |
|                            | 1.00       |             |             |  | Intersection  | da   | di*qi       |
|                            | 2.00       | 22.58       |             |  | 1.00          | 7.66 | 54197.73669 |
|                            | 3.00       |             |             |  | 2.00          | 2.52 | 17841.65413 |
| Phase 2                    | 1.00       |             |             |  | 3.00          | 2.49 | 17614.26443 |
|                            | 2.00       | 7.08        |             |  | 4.00          | 3.30 | 23364.07089 |
|                            | 3.00       |             |             |  |               |      |             |
|                            | 4.00       |             |             |  |               |      |             |
| Average Intersection Delay |            |             |             |  |               |      |             |
| Intersection               |            | d           | da*qa       |  |               |      |             |
| 1.00                       |            | 2.59        | 18372.11413 |  |               |      |             |
| 2.00                       |            | 0.90        | 6350.419267 |  |               |      |             |
| 3.00                       |            | 0.27        | 1940.554555 |  |               |      |             |
| 4.00                       |            | 0.64        | 4554.013817 |  |               |      |             |

Tables 6.0-9.0 represent the total delay, average delay, and average intersection delay results found for the original traffic configuration.

|         | Original      |       |         |                   |      |
|---------|---------------|-------|---------|-------------------|------|
|         | Uniform Delay |       |         | Incremental Delay |      |
| Phase 1 | Lane Group    |       | Phase 1 | Lane Group        |      |
|         | 1.00          |       |         | 1.00              |      |
|         | 2.00          | 17.05 |         | 2.00              | 5.53 |
|         | 3.00          |       |         | 3.00              |      |
| Phase 2 | 1.00          |       | Phase 2 | 1.00              |      |
|         | 2.00          |       |         | 2.00              | 0.12 |
|         | 3.00          | 6.96  |         | 3.00              |      |
|         | 4.00          |       |         | 4.00              |      |

**Table 10.0** reflects the uniform delay and incremental delay used for the total delay, average delay, and average intersection delay results for the original configuration.

## Appendix B



**Figures 1.0 and 2.0** reflect Design 1 and 2 configurations and how the yellow time, green time, and cycle length were obtained.



**AVERAGE**

**LAB 5**  
**GROUP # \_\_\_\_3\_\_\_\_**

| <b>CRITERIA</b>                                                                                                                                                          | <b>Maximum Points</b> | <b>Points Awarded</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| <b>1. TITLE PAGE</b><br>Includes the title of the report, the authors and team number, and date.                                                                         | <b>2</b>              | 2                     |
| <b>2. TABLE OF CONTENTS</b><br>Includes all sections of the report, figures, tables, and appendices with corresponding page numbers.                                     | <b>3</b>              | 3                     |
| <b>3. ABSTRACT</b><br>Summarizes what was done, what was found, and its importance                                                                                       | <b>5</b>              | 4                     |
| <b>4. INTRODUCTION</b><br>Includes motivation, general summary, definitions, theory, and background.                                                                     | <b>5</b>              | 3                     |
| <b>5. PROCEDURE</b><br>Describes the procedure step-by-step.                                                                                                             | <b>5</b>              | 3                     |
| <b>6. RESULTS</b>                                                                                                                                                        | <b>55</b>             |                       |
| turning movement volumes for all approaches                                                                                                                              | 10                    | 10                    |
| record the current signal phasing pattern                                                                                                                                | 10                    | 5                     |
| length of the green, yellow, and all-red time for each phase                                                                                                             | 10                    | 10                    |
| delay for each lane group, each approach, and the intersection as a whole                                                                                                | 15                    | 10                    |
| Improve the signal's design                                                                                                                                              | 10                    | 0                     |
| <b>7. DISCUSSION</b><br>Analysis of the results based on the reporting requirements. Problems encountered during the procedure and effects on the results are discussed. | <b>10</b>             | 10                    |
| <b>8. CONCLUSIONS</b><br>Summary of the analysis results, lessons, and recommendations.                                                                                  | <b>10</b>             | 10                    |
| <b>9. AUTHOR CONTRIBUTIONS</b>                                                                                                                                           | <b>5</b>              | 5                     |
| <b>TOTAL</b>                                                                                                                                                             |                       | <b>75</b>             |

**Suggestions:**

1. "what was found" is missing in Abstract. The information shown in Introduction is a general description. Please provide more precise information.
2. Please provide some sentences before the bullets in the section of procedure. Please add titles for pictures and tables. Please explain each phase. The calculation should be listed in Appendix and equations can be listed in Results.
3. Improvement of the signal's design is not provided. If no improvement is needed, a sentence to declare it is necessary.

Prairie View A&M University  
College of Engineering  
Department of Civil & Environmental Engineering



CVEG 3302 P01 Transportation Engineering

## LABORATORY REPORT #5

### **Signal Analysis**

Conducted on: April 28th, 2022

Submitted by: Group #3

Trinity Scott

Noah Smith

Sophie Tuke

Maurice Bettis

Submitted on: April 30th, 2022

Submitted to Dr. Liu

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## Abstract

Signal Analysis focuses on the estimation of delays and queue lengths from signals at individual and sequenced intersections. It is an important performance measure that actually accounts for a part of the intersection Level of Service (LOS), and helps to determine adequate lane lengths, as signals can easily influence traffic flow. In this lab, the University Drive and Owens Road intersection in Prairie View, Texas was analyzed for delay, for each lane group, and further interpreted to determine improvements for signal design. Using the given parameters, the traffic signals were timed and analyzed, and the traffic flow was also taken into account in order to determine accurate measures for the intersection in Prairie View, Texas.

## Introduction

When properly placed and conducted, traffic signals are key in creating a safe and efficient roadway environment for the flow of vehicles. Traffic signals support transportation engineers in controlling traffic in a safe and organized system. They assist vehicles on the roadway by organizing movement in an orderly fashion, reducing travel times based on signal timing amounts, and improving the amount of traffic that an intersection can handle, due to the coordination. Without traffic signals, cars would have no organized manner to drive on the roadways. It would cause a lot of traffic backup on roads, delays in travel times, no organized travel flow system, and likely result in more crashes on the road. Signal Analysis is fundamental in ensuring that vehicles are moving in the most efficient manner on the roadways. Better traffic signals save time, amount of vehicle backup on the road, and promote structure and better flow.

#### Experimental Procedure

1. Choose a signalized intersection in Prairie View, Tx and obtain turning movement volumes for all approaches, for 15 minutes
2. Record the current signal phasing pattern, and the length of the green, yellow, and all-red time for each phase.
3. Calculate the delay for each lane group, each approach, and the intersection as a whole
4. Improve the signals design by changing the phasing pattern and/or durations of green, yellow, and all-red time

## Results

Our results were taken at the intersection of University Drive and Owens Road, at the front of Prairie View University, in Prairie View, Texas on April 28, 2022 around 4:20 pm.

### University Drive & Owens Road/FM 1098 *Northbound* Analysis (photo referenced from Google Maps)



| Signal Analysis          | Amount of Vehicles in Flow | Time of Signal |
|--------------------------|----------------------------|----------------|
| 1. Left Turn Green Light | 4 vehicles                 | 15.16 seconds  |
| 2. Green Light           | 6 vehicles                 | 29.45 seconds  |
| 3. Green Light           | 7 vehicles                 | 29.71 seconds  |
| 4. Green Light           | 6 vehicles                 | 29.42 seconds  |
| 5. Yellow Light          | 1 vehicle                  | 3.31 seconds   |
| 6. Red Light             | -                          | 31.3 seconds   |
| 7. Red Light             | -                          | 28.18 seconds  |

### University Drive & Owens Road/FM 1098 *Southbound* Analysis (photo referenced from Google Maps)



| Signal Analysis | Amount of Vehicles in Flow |
|-----------------|----------------------------|
|-----------------|----------------------------|



|                  |            |
|------------------|------------|
| 8. Green Light   | 7 vehicles |
| 9. Green Light   | 4 vehicles |
| 10. Green Light  | 6 vehicles |
| 11. Yellow Light | -          |
| 12. Red Light    | -          |
| 13. Red Light    | -          |

**Owens Road/FM 1098 & University Drive *East bound* Analysis (photo referenced from Google Maps)**



| Signal Analysis  | Amount of Vehicles in Flow | Time of Signal |
|------------------|----------------------------|----------------|
| 14. Green Light  | 4                          | 12.17 seconds  |
| 15. Green Light  | 2                          | 19.78 seconds  |
| 16. Green Light  | 3                          | 19.29 seconds  |
| 17. Yellow Light | -                          | 2.55 seconds   |
| 18. YellowLight  | -                          | 3 seconds      |
| 19. Red Light    | -                          | 31.02 seconds  |

**University Drive & Owens Road/FM 1098 *Westbound* Analysis (photo referenced from Google Maps)**



| Signal Analysis | Amount of Vehicles in Flow |
|-----------------|----------------------------|
| 20. Green Light | 4                          |
| 21. Green Light | 5                          |

|                  |   |
|------------------|---|
| 22. Green Light  | 7 |
| 23. Yellow Light | - |
| 24. Yellow Light | - |
| 25. Red Light    | - |

| Delay 1     | Delay 2     | Lane group  | Approach    | intersection |
|-------------|-------------|-------------|-------------|--------------|
| 26.05       | 24.68       | 50.73       | 26.05019231 | 50.72970146  |
| 26.05019231 | 16.45275304 | 42.50294534 | 26.05019231 | 42.50294534  |
| 26.05019231 | 14.10235975 | 40.15255205 | 26.05019231 | 40.15255205  |
| 26.05019231 | 16.45275304 | 42.50294534 | 26.05019231 | 42.50294534  |
| 26.05019231 | 14.10235975 | 40.15255205 | 26.05019231 | 40.15255205  |
| 26.05019231 | 24.67912955 | 50.72932186 | 26.05019231 | 50.72932186  |
| 26.05019231 | 16.45275304 | 42.50294534 | 26.05019231 | 42.50294534  |
| 26.05019231 | 24.67912955 | 50.72932186 | 26.05019231 | 50.72932186  |
| 26.05019231 | 49.35825911 | 75.40845142 | 26.05019231 | 75.40845142  |
| 26.05019231 | 32.90550607 | 58.95569838 | 26.05019231 | 58.95569838  |
| 26.05019231 | 24.67912955 | 50.72932186 | 26.05019231 | 50.72932186  |
| 26.05019231 | 19.74330364 | 45.79349595 | 26.05019231 | 45.79349595  |
| 26.05019231 | 14.10235975 | 40.15255205 | 26.05019231 | 40.15255205  |

Sample calculation

Delay 1 =  $(0.5 * 52.10038462 * (1 - (15.16/52.1003))) / (1 - (1 * (15.16/52.1003)))$

=26.05

Delay 2 =  $(900 * 0.25) * ((1 - 1) + \text{SQRT}((1 - 1)^2) + (8 * 0.5 * 1 * 1) / (145.87 * 0.25))$

=24.68

Lane group = 26.05 + 24.68 = 50.73

Approach =  $(26.05/106)/106 = 26.05$

Intersection =  $(50.73/338.65)/338.65 = 50.73$

Based on the calculations as well as accident reports. The bulk amount of incidents on this street was not caused by the signal timing. They were caused by pedestrians not using the cross walk. The only time that would be the left turn green time going East bound because the red time is a lot longer than green meaning cars would have to speed to make it to the light before it changes phases.

### Discussion

In this lab, we were tasked with calculating the delay for each lane group, approach, intersection as a whole. After evaluating the calculations, the overall objective was to improve the signal by designing either the phasing pattern differently, the duration of the green, yellow, and red times, or a mix of both. After taking these calculations, we came to the first delay of 26.05 seconds and a second delay of 24.68 seconds, and the lane group ended up being 50.73 seconds, the final approach ending up being 26.05 seconds and the delay of the intersection being 50.73 seconds.

### Conclusion

The objective of this lab experiment was completed successfully. Students were able to go out and provide and collect data in order to create a signal analysis and better the design of signal. The primary purpose of the analysis is to find the delays, and calculate the lane groups, intersections and approaches. These findings are associated with the requirements that intersections should meet. Recommendations for the lab conduction going forward would be to probably just give different data to the groups for calculating and maybe just have the students take a picture of an intersection and use it as if the data was collected from that certain place. Due to Prairie View being a small town and not having the best or many places to collect data it was kind of difficult to get accurate information.

#### Author contribution

Author of abstract : sophie tuke

Author of introduction : sophie tuke

Author of Experimental procedure : trinity scott

Author of Results : noah smith and maurice bettis

Author of discussion : maurice bettis

Author of conclusion : trinity scott



**BELOW AVERAGE**

**LAB 5**  
**GROUP # \_\_\_\_\_2\_\_\_\_\_**

| <b>CRITERIA</b>                                                                                                                                                          | <b>Maximum Points</b> | <b>Points Awarded</b> |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|
| <b>1. TITLE PAGE</b><br>Includes the title of the report, the authors and team number, and date.                                                                         | <b>2</b>              | 1                     |
| <b>2. TABLE OF CONTENTS</b><br>Includes all sections of the report, figures, tables, and appendices with corresponding page numbers.                                     | <b>3</b>              | 3                     |
| <b>3. ABSTRACT</b><br>Summarizes what was done, what was found, and its importance                                                                                       | <b>5</b>              | 1                     |
| <b>4. INTRODUCTION</b><br>Includes motivation, general summary, definitions, theory, and background.                                                                     | <b>5</b>              | 1                     |
| <b>5. PROCEDURE</b><br>Describes the procedure step-by-step.                                                                                                             | <b>5</b>              | 2                     |
| <b>6. RESULTS</b>                                                                                                                                                        | <b>55</b>             |                       |
| turning movement volumes for all approaches                                                                                                                              | 10                    | 5                     |
| record the current signal phasing pattern                                                                                                                                | 10                    | 5                     |
| length of the green, yellow, and all-red time for each phase                                                                                                             | 10                    | 8                     |
| delay for each lane group, each approach, and the intersection as a whole                                                                                                | 15                    | 8                     |
| Improve the signal's design                                                                                                                                              | 10                    | 0                     |
| <b>7. DISCUSSION</b><br>Analysis of the results based on the reporting requirements. Problems encountered during the procedure and effects on the results are discussed. | <b>10</b>             | 8                     |
| <b>8. CONCLUSIONS</b><br>Summary of the analysis results, lessons, and recommendations.                                                                                  | <b>10</b>             | 8                     |
| <b>9. AUTHOR CONTRIBUTIONS</b>                                                                                                                                           | <b>5</b>              | 0                     |
| <b>TOTAL</b>                                                                                                                                                             |                       | <b>50</b>             |

**Suggestions:**

1. Title of the report and group number are missing. The purpose of this lab mentioned in Abstract is not correct. The information shown in Introduction does not relate to this lab.
2. Please provide some sentences before the bullets in the section of procedure. The procedure is not correct. The data shown in Results needs editing (e.g., what is "1.08.98"?).
3. Please explain "phase 1". Title of table is missing. Once a table is referred in a paragraph, the table should be listed after the paragraph.
4. Some reporting requirements are missing.



Lab 5

Signal Analysis

Professor Kai Wei

Ariana Mangroo

Marshall Johnson

Omar Hajo

April 30, 2022



## TABLE OF CONTENT

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#### Abstract:

The purpose of the signal analysis lab is to measure the power of spectrums of both known and unknown signals. A spectrum analyzer is the tool used to measure the magnitude of an input signal versus frequency within the full frequency range of the instrument. Driving signals are important because it is meant to warn the drivers of the changes in the road ahead. For curved roads the radius is measured. Another thing you have to take into consideration is the elevation that the curve is. The way that surveyors measure the length of the curve is in google maps. The procedure is to create a circle on google maps and make the circle fit the length of the curve. The radius of the circle is given and that will determine the length of the curve. The length time it takes for a car to go along the curve determines the speed which is used to calculate the speed limits on the road. This can also help determine the signal analysis to let engineers know if the road needs construction or not.

#### Introduction

Signal Analysis involves the ability to collect and understand sensitive information sent by various signals. We determine signal analysis in order to extract meaningful information processes, assessments, characterization and the understanding of mechanics. This can predict whether or not the signal will need to be altered over time or not. Most signals would need to be altered over time due to wear and tear of the roads by weather. This is a way engineers use theoretical techniques and algorithms to fix traffic signals.

#### Experimental procedure

1. Pick a signalized intersection on PVAMU and observe the turning movement.
2. Observe for 15 minutes during the day and time each turning car with a stopwatch.
3. Record the data after each turn for 15 minutes.
4. Find the intersection of google maps to find out the radius of the curve.
5. Calculate the signal phasing pattern.

6. Record results for each turn taken.

Results:

Light 1: Green= 8.68

yellow = 3.49

```
red = 1.08.98
```

Light 2: Green = 20.70

Yellow= 2.14

Red= 58.97

Light 3: green= 6.11

yellow= 3.51

red= 17.7

## Discussion

In this lab, we were tasked with calculating the delay for each lane group, approach, and intersection as a whole. After evaluating the calculations, the overall objective was to improve the signal by designing either the phasing pattern differently, the duration of the green, yellow, and red times, or a mix of both. After taking these calculations, we came up with a uniform delay of 1.72, an incremental delay of 5.46, and a total delay of 7.19.

|         |               |             |          |            |                   |  |  |             |          |
|---------|---------------|-------------|----------|------------|-------------------|--|--|-------------|----------|
|         | Green Time    | Yellow Time | Red Time | Total time |                   |  |  |             |          |
| 1       | 8.68          | 3.49        | 68.98    | 81.15      |                   |  |  |             |          |
| 2       | 20.7          | 2.14        | 58.97    | 81.81      |                   |  |  |             |          |
| 3       | 6.11          | 3.51        | 17.7     | 27.32      |                   |  |  |             |          |
|         | 11.83         |             |          | 63.42667   |                   |  |  |             |          |
|         |               |             | 633.79   | 0.66       |                   |  |  |             |          |
|         |               |             |          |            |                   |  |  |             |          |
|         | Uniform Delay |             |          |            | Incremental Delay |  |  | Total Delay |          |
|         | 1             |             |          | 1          |                   |  |  | 1           |          |
| phase 1 | 2             | 1.722111776 |          | 2          | 5.464265          |  |  | 2           | 7.186377 |
|         | 3             |             |          | 3          |                   |  |  | 3           |          |

## Conclusion

As a whole, this experiment was done successfully. We were able to find the uniform, incremental, and total delay. Although some difficulties were presented, we were able to learn from this and expand our knowledge on traffic light design, delay, and how each value affects one another.