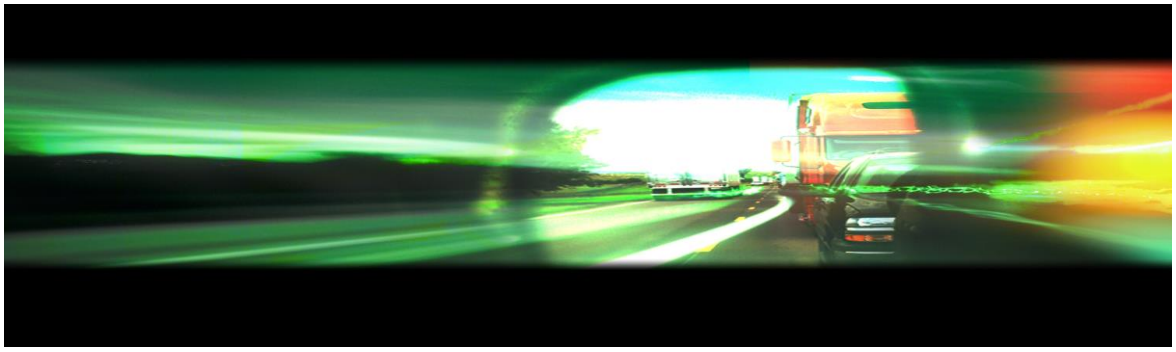
SUSTAINABLE TRANSPORTATION: TECHNOLOGY, ENGINEERING, AND SCIENCE

Summer Camp Instructor's Guide

Final Report



TranLIVE

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16. Abstract This document reproduces the instructor's guide for a ten day transportation engineering summer camp that was held at the University of Idaho in July 2013. The instructor's guide is split into three units: Unit 1: Vehicle Technology, Unit 2: Traffic Engineering and Operations, Unit 3: Transportation Science and Planning. The summer camp was hosted by TRIO Upward Bound. Student participants were low-income, first generation college bound high school students. The goal of the camp was to encourage careers in transportation engineering.		
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FOREWORD

This instructor's guide is intended for a ten day summer camp focused on sustainable transportation. There are three units. The first three days are part of the Vehicle Technology unit. Topics covered during the Vehicle Technology unit include vehicle dynamics, engine design, and emissions and pollutants. The next four days are part of the Traffic Engineering and Operations unit. Topics covered during these days include vehicle detection, coordinated intersections, traffic safety, and geometric highway design. The final three days are part of the Transportation Science and Planning unit. Topics covered during these days include traffic forecasting, bicycle and pedestrian planning, and public transportation.

The daily schedule for the summer camp is split into three sections. The first section is called "Overview and Introduction." The second section is called "Topic Discussion and Example." The third section is called "Activity." The Overview and Introduction, as well as the Topic Discussion and Example are intended to be completed in a classroom and each are designed to be presented as 90 minute lectures. The Activity is intended to be done either in a classroom or as a fieldtrip and should last approximately three hours.

Each section is intended to engage students in a fun and interesting way while still presenting transportation engineering concepts and fundamentals. During each activity, students are required to perform basic calculations, intended to advance their mathematical skills. Throughout the camp, students need to have calculators, pencils, clipboards, and the handouts associated with each section.

2013 Upward Bound Summer Camp

The materials contained in the instructor's guide were first implemented during the summer of 2013 as part of a STEM Access Upward Bound TRIO project. The STEM Access Upward Bound TRIO project prepares high school students for college and post-secondary careers in science, technology, engineering, and math (STEM). The project serves students from low-income, first college generation backgrounds. Students work actively every summer on different STEM research projects to investigate a topic in depth through inquiry. STEM professionals support the research process through hands-on interaction at various field sites and job settings.

The first implementation of this curriculum was used to teach 21 students who were primarily from the Lewiston, Idaho, Clarkston, Washington, and Coeur d'Alene, Idaho area. The students ranged in age from 14 to 18 years old, with grade levels ranging from entering their freshman year of high school to entering their senior year of high school.

After the curriculum was presented, all of the students attending the camp spent ten days in Washington, DC, where they met with congressmen, learned about transportation policy, and experienced the traffic of a large city.

UNIT 1: VEHICLE TECHNOLOGY

Day 1: Vehicle Dynamics

Overview and Introduction

Learning Objectives

- Use algebraic representation
- Calculate values using models
- Solve kinematic problems

Content Outline

1. **When we talk about a vehicle moving, what things would be important to consider?**
    a. How far has the vehicle gone (distance)?
    b. How fast is it going (velocity)?
    c. How quickly is it accelerating or decelerating (acceleration)?
    d. What period of time are we considering (time)?
2. **Mathematically, how would we model this?**
    a. Basic example: How far will a car go in an hour if it travels at 60 mph?
    b. Harder example: What if it traveled 30 mph for 30 minutes and then 60 mph for 30 minutes?
    c. What if we wanted to know speed or acceleration?
3. **Kinematic equations**

$$d = v_0 t + \frac{1}{2} a t^2$$

$$v_f^2 = v_0^2 + 2ad$$

$$v_f = v_0 + at$$

$$d = \frac{v_f + v_0}{2} * t$$

    a. Where:

d = distance (inches, feet, meters, miles, etc…)

t = time (seconds, minutes, hours, etc…)

a = acceleration (feet per second squared, meters per second squared, etc…)

v_0 = starting velocity (feet per second, miles per hour, kilometers per hour, etc…)

v_f = final velocity (feet per second, miles per hour, kilometers per hour, etc…)

4. **Kinematics example problems**

Topic Discussion and Example

Learning Objectives

- Understand frictional forces
- Understand Newton's second law
- Relate Newton's second law and frictional forces to the kinematic equations

Content Outline

1. **Who was Isaac Newton?**
    a. British physicist who lived from 1642-1727
    b. What was Newton famous for?
        i. Discovering gravity (apple falling from tree story)
    c. Also known for developing Newton's three laws
        i. An object at rest stays at rest or an object in motion stays in motion at a constant speed unless acted on by an external force.
        ii. The force applied to an object is equal to the objects mass times the objects acceleration.
        iii. For every action there is an equal and opposite reaction.
2. **Newton's second law**
    a. $\sum F = ma$
    b. Where:
        F = Force exerted on an object
        m = mass of the object
        a = acceleration
3. **For a vehicle, what forces should be included in $\sum F$?**
    a. Forces that move the car
        i. Engine
    b. Forces that resist motion
        i. Drag (greater at high speeds)
        ii. Friction between the road and the tires (dependent on the weight of the vehicle, condition of the tires)
        iii. Internal engine friction (usually minimal)
4. **Newton's second law example**
5. **What is drag?**
    a. Force that resists motion of an object through a fluid (a fluid can be air, water, etc…)

b. $F_D = \frac{1}{2}\rho v^2 C_D A$

c. Where:

F_D = Drag force

ρ = mass density of the fluid

(http://www.denysschen.com/catalogue/density.aspx)

v = speed of the object relative to the fluid

C_D = coefficient of drag

A = reference area

6. **Drag example problems**
7. **What is the friction between the road and the tires (rolling friction)?**
   a. $F_F = C_R F_N$
   b. Where:

F_F = Friction force

C_R = Coefficient of rolling resistance

F_N = Normal force (weight of the vehicle)

8. **Rolling friction example problem**
   a. C_R typically ranges from 0.01 to 0.015 for cars, depending of tire condition
      i. Old tires will have higher values
      ii. New tires will have lower values
9. **Newton's second law example to find frictional forces**

In the afternoon we will go out and measure everything we need to calculate the frictional forces on several vehicles.

Activity

Learning Objectives

- Predict the effects of friction
- Understand that due to error, theoretical values differ from field measurements
- Use friction estimates to approximate the final velocity of a vehicle coasting for a specific distance

The purpose of this activity is to use frictional forces and kinematic equations to estimate the final velocity of a vehicle which has been coasting for a specified distance. The estimated final velocity will then be compared to final velocities measured in the field.

Required Resources

1. Speed gun
2. Stop watch
3. Measuring wheel
4. Vehicles
    a. Small pickup truck
    b. Four door hatchback
    c. Full size van
5. Coefficient of drag tables
6. Internal engine friction tables

Questions to Consider

During the activity, consider the following questions. Be prepared to discuss your answers with the other groups at the end of the activity.

1. How different was the final velocity between the three different runs for your vehicle?
2. Why do you think there was a difference?
3. How different was your calculated final velocity from the final velocity you measured?
4. Why do you think these differences existed?
5. How did your group's final velocity compare to the other groups' values?
6. If you were designing a new car, would you want a high or a low coefficient of drag? Why?
7. If you were designing a new car, would you want a high or a low weight? Why?
8. If you were designing a new car, what would you do to try to limit the drag?
9. What friction force caused the vehicle to decelerate the most?

Tasks

Task 1: Split into four teams and meet with your driver.

1. Small pickup truck
2. Four door hatchback
3. Full size van

Task 2: Using the tables and links provided, determine values for each of the following variables.

1. Area of the front of each vehicle
2. Mass of the car
3. Density of the air (http://www.denysschen.com/catalogue/density.aspx)
4. Current wind speed (http://weather.weatherbug.com/wind-speed-map.html)
5. Internal friction force

Vehicle	Weight (lbs)	Coefficient of Rolling Friction	Coefficient of Drag	Internal Friction Forrce (lb)	Frontal Area (ft^2)
2005 Chevy Malibu Maxx	3459	0.01	0.34	300	28.16
1990 Dodge Ram Van	6010	0.015	0.488	1200	36.27
2000 Toyota Tacoma	2580	0.012	0.44	500	28.63

Task 3: Assuming an initial velocity of 30 mph, calculate your vehicles theoretical final speed after it is allowed to coast for 800 feet. This will require you to use Newton's second law, the rolling friction equation, the drag equation, and the kinematic equations.

Task 4: Designate one group member who will be in charge of recording the data while we are in the field.

Task 5: After you have calculated a theoretical final velocity, verify your calculations with your driver and then walk to the study site.

Task 6: Measure the distance from the starting point to the finish point. Make sure to record the value you measure.

Task 7: Using the provided speed guns, measure your vehicles velocity at the starting point and at the end point. To do this, your driver will accelerate to 30 mph and will then put the car in neutral, allowing it to coast. The driver will coast until the end point. Remember to record the initial and final velocities of the vehicle.

Task 8: Repeat task 7 twice, allowing each team member to use the speed gun at least once.

Task 9: Compare the value of the final velocity of your vehicle which you calculated to the final velocity which you measured. Was your theoretical value higher or lower than your measured value?

Task 10: Compare your vehicle's final velocity to the final velocities of the other vehicles. Was it higher or lower?

Task 11: Answer the questions posed in the Questions to Consider section of the activity.

Day 2: Engine Design

Overview and Introduction

Learning Objectives

- Understand the differences between various types of engines

Content Outline

Yesterday we talked about kinematic equations, the theory that discusses how a vehicle will move. Today we are going to talk about what makes the vehicle move (engines).

1. **What types of engines can you think of?**
    a. 2 stroke
    b. 4 stroke
    c. Rotary
    d. Diesel engine
    e. Hybrid engine
2. **Four stroke engines**
    a. http://www.youtube.com/watch?v=NVBNXK7BAZI
3. **Two stroke engines**
    a. http://www.youtube.com/watch?v=LuCUmQ9FxMU
4. **Rotary engines**
    a. http://www.youtube.com/watch?v=lyItjvs8nvI
    b. http://www.youtube.com/watch?v=Xys2q_uItng
5. **Diesel engines**
    a. http://www.youtube.com/watch?v=PSrIceBDrRM
    b. http://www.youtube.com/watch?v=k3gMTqaNwlE
6. **Hybrid engines**
    a. http://www.youtube.com/watch?v=m2qvGJwTuBo

Topic Discussion and Example

Learning Objectives

- Identify different parts of an engine
- Describe the function of different engine parts

Content Outline

1. **What do you think the most important parts of an engine are?**

For the rest of the hour, we are going to watch a couple videos about some of the key parts of an engine.

2. **General engine components**
    a. http://www.youtube.com/watch?v=saPGX-1qC4M
3. **Clutch**
    a. http://www.youtube.com/watch?v=FfjGohWy-OU
4. **Turbocharger**
    a. http://www.youtube.com/watch?v=vGhlgphrBxA

Activity

Learning Objectives

- Allow students to further familiarize themselves with engine components by observing actual engines in a lab
- Understand what variables impact the power output of an engine
- Visualize how different engine components interact

Purpose

The purpose of this activity is to further familiarize yourself with major components of engines, to understand what variables are most critical in estimating power output, and to visualize how components interact to create an engine cycle.

Required Resources

- Engine lab with different engines with which students can interact

Orientation

Several engines are provided where you can examine engine components and their relationships, recognizing similarities and drawing distinctions between SI and CI engines. This experience will strengthen your ability to reverse engineer how engine systems function based on physical layout. Hands-on exploration with engines and their components is likely to help you construct simple thermo-fluid models in future homework assignments.

Stations

There are a total of four stations that you should visit during the tour of the engine design lab.

Station 1: 4-stroke SI engine (Cadillac 500 CID V8)
Identify the following components on the engine block:

1. Intake manifold
2. Cylinder head
3. Pushrods

4. Exhaust Manifold
5. Starter motor
6. Flywheel
7. Oil pan
8. Carburetor

Station 2: 2-stroke SI engine (Homelite Chainsaw)
Identify the following components:

1. Piston
2. Intake port
3. Exhaust port
4. Carburetor
5. Starter
6. Flywheel/clutch

Answer the following questions:

1. Which ports open first? Which ports open second? Why?
2. Will a 2-stroke engine produce twice as much power as a 4-stroke engine? Why/why not?

Station 3: Cylinder Head (Cadillac 500 CID V8)
Identify the following components on the cylinder head:

1. Spark plug
2. Intake valve
3. Exhaust valve
4. Combustion chamber

Given a ¼" valve lift, what is the cross-sectional area for intake and exhaust into and out of each cylinder? Which area is larger? Why?

Station 4: Turbochargers
Locate the following:

1. Compressor wheel
2. Turbine wheel
3. Bearings
4. Waste gate

Answer the following questions:

1. What limitations surround the selection of boost pressure?
2. How is the waste gate used to control boost pressure?

Other Items of Interest in the Engine Bay

1. YZ250 Engine
2. CFR Engine
3. Eddy Current Dynamometer
4. Water brake Dynamometer
5. Horiba 5 Gas Analyzer
6. Fuel Measurement Cart
7. Dilution Tunnel
8. Flow Bench
9. Yamaha R6 (training engine)

10. Toyota 3S-GTE (training engine)

Discussion Questions

1. What was the most difficult component for you to identify? Why
2. What was the most interesting component to see? Why
3. What engine was the most interesting? Why?
4. Was anything surprising or different than you expected it to be? What was it that surprised you, and why did it surprise you?

Day 3: Emissions and Pollutants

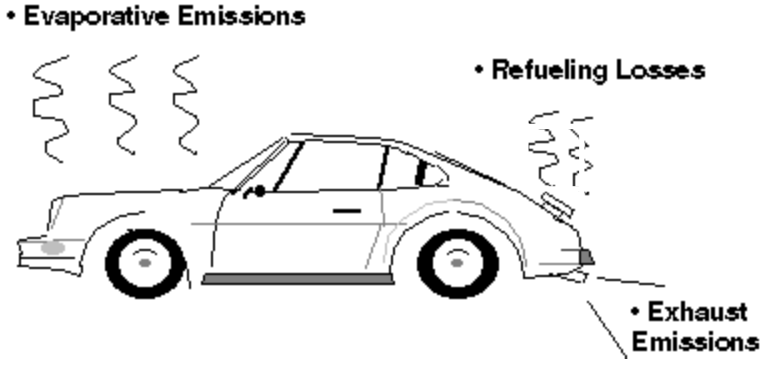
Overview and Introduction

Learning Objectives

- Understand where emissions and pollutants come from
- Conceptualize why emissions and pollutants are important to consider

Content Outline

1. **Introduction**
    a. How noticeable are the effects of pollution?
        i. Bangkok, Thailand with low pollution
        ii. Bangkok, Thailand with high pollution
2. **What are emissions and pollutants?**
    a. Harmful gases which are produced by the engine as the car runs.
3. **Why should we care about emissions and pollutants?**
    a. The World Health Organization estimates that 1.3 million people die each year because of complications due to air pollution. (http://www.egu.eu/news/36/)
    b. Individual vehicles have relatively low emission rates; however, personal automobiles are still the single greatest polluter.
    c. Look at it this way, if I gave one of you a dollar, it wouldn't be a big deal. If I gave all of you a dollar, it would start to get more expensive. If I gave everyone in town a dollar, I would run out of money pretty quick. Similarly, even though one automobile does not create a significant amount of pollutants when the amount of the pollutants from each vehicle are added together, it adds up.
4. **Where do emissions and pollutants come from?**



Source: http://www.epa.gov/otaq/consumer/05-autos.pdf

    a. Two sources of vehicle emissions are fuel evaporation and exhaust emissions.
    b. As we discussed yesterday, vehicles are powered by burning fuel in a combustion engine. Pollution is caused during this process and exits the car as exhaust.

5. **Combustion Process**
    a. Fuel is a mixture of hydrocarbons (compounds which contain hydrogen and carbon atoms).
    b. What's supposed to happen when fuel burns?
        i. In a perfect engine, the oxygen in the air would convert all the hydrogen in the fuel to water and all the carbon in the fuel to carbon dioxide. The nitrogen would remain unaffected.

$$Fuel\ (hydrocarbons) + Air\ (oxyen\ and\ nitrogen) = CO_2 + H_2O + Nitrogen$$

Write this on the board

    c. What actually happens when fuel burns?
        i. In a typical combustion engine, this does not happen, and some of the nitrogen is also affected causing pollutants.

$$Fuel + Air = Unburned\ Hydrocarbons + Nitrogen\ Oxides + Carbon\ Monoxide + Carbon\ Dioxide + H_2O$$

Write this on the board

6. **Looking at the right side of the last equation, five things are being produced by burning fuel.** The only thing produced which isn't a pollutant is water (H_2O), which means that the four main pollutants from combustion engines are:
    a. Hydrocarbons
        i. Emissions which result when fuel molecules in the engine do not burn or burn only partially. Hydrocarbons react in the presence of nitrogen oxides and sunlight to form ground-level ozone, a major component of smog. Ozone irritates the eyes, damages the lungs, and aggravates respiratory problems. It is our most widespread and intractable urban air pollution problem. A number of exhaust hydrocarbons are also toxic, with the potential to cause cancer.
    b. Nitrogen Oxides
        i. Under the high pressure and temperature conditions in an engine, nitrogen and oxygen atoms in the air react to form various nitrogen oxides, collectively known as NO_X. Nitrogen oxides, like hydrocarbons, are precursors to the formation of ozone. They also contribute to the formation of acid rain.
    c. Carbon Monoxide
        i. Carbon Monoxide (CO) is a product of incomplete combustion and occurs when carbon in the fuel is partially oxidized rather than fully oxidized to carbon dioxide (CO_2). Carbon monoxide reduces the flow of oxygen in the bloodstream and is particularly dangerous to a person who has a heart disease.

d. Carbon Dioxide
    i. In recent years, the U.S. has started to consider carbon dioxide as a pollution concern. While carbon dioxide does not directly impact a person's health, it is a "greenhouse gas" which means that it traps the earth's heat and contributes to global warming.
    ii. Note that even if we produced an ideal combustion engine, carbon dioxide would still be a pollutant.

7. Evaporation Pollution

a. In addition to pollution caused by fuel being burned, pollution is also caused by fuel evaporating, causing hydrocarbons to escape the vehicle. This happens in four major ways:
    i. Diurnal
        1. During the day, as the temperature rises, the gas tank in a vehicle will heat up, allowing gasoline vapors which were produced by normal evaporation, to be vented into the atmosphere.
    ii. Running Losses
        1. The hot engine can cause the gasoline to vaporize while the vehicle is running.
    iii. Hot Soak
        1. After the vehicle is turned off, the engine remains hot for a period of time, allowing gasoline evaporation to continue.
    iv. Refueling
        1. Fuel vapors are always present in the gas tank. Whenever you refuel a vehicle, the fuel vapors are forced out of the tank as liquid fuel is pumped in.

8. Where are some of the most polluted cities in the world?

a. Linfen, China
    i. Numerous coal mines in the nearby mountains cause air pollution.
    ii. According to China's State Environmental Protection Agency, Linfen has the worst air quality in the country, which is impressive since nearly ¾ of the most polluted cities in the world are in China.
    iii. People say not to hang your laundry to dry in Linfen because it will turn black before it gets dry.
b. Chernobyl, Russia
    i. Nuclear power plant explosion released significant quantities of radioactive material into the atmosphere.
    ii. Commonly considered to be one of the worst nuclear disasters ever.
c. Beijing, China
    i. Extremely high levels of sulfur dioxide and nitrogen dioxide.

ii. Pollution levels improved in 2008 during the Olympics because government officials banned nearly half of the city's vehicles from being used. After the games, the pollution increased.

d. Mexico City, Mexico
   i. High levels of sulfur dioxide, nitrogen oxides, and carbon monoxide.

9. Where are some of the most polluted cities in the country?

a. Los Angeles
   i. Lots of people, traffic, ports, factories, stagnant weather, and a nearby mountain that traps the pollution causing the smog to be very bad.

b. Phoenix
   i. Topography tends to trap the pollution, making it hard for it to dissipate.

c. Pittsburgh
   i. Coal and steel processing in Pittsburgh and the nearby areas cause significant pollution.

Topic Discussion and Example

Learning Objective

- Estimate the amount of pollution caused by vehicles in the students' hometowns
- Understand that some pollution can be offset by planting more trees

Purpose

Over the last couple decades, the government has begun to push for vehicles to emit fewer gasses. Over the next hour we will look at data trends to determine the success of this. Additionally, we will calculate how much carbon dioxide a vehicle produces in a year.

Tasks

Task 1: In this activity you will compute the amount of carbon dioxide produced in pounds per year by one of the instructor's cars. Assume the following information:

- miles traveled by the car each month = 2700 miles
- gas consumed = 30 miles per gallon
- Carbon Dioxide produced = (20 pounds carbon dioxide/gallon)

Task 2: Based on your results from task three, estimate how many pounds of carbon dioxide would be produced by your hometown. To do this, you must know the population of your hometown. This can be found online. Additionally, you must estimate the number of vehicles per capita. For towns in Idaho, assume that there are 790 vehicles per 1000 people and for Washington, assume that there are 870 vehicles per 1000 people.

Task 3: Calculate the number of trees necessary to offset the amount of carbon dioxide produced by the automobiles in your hometown. To do this, assume that on average, a tree is able to remove 25 pounds of carbon dioxide per year.

Task 4: Calculate the amount of acres of forest necessary to contain the number of trees you calculated in Task 5. Assume that an average forest contains 400 trees per acre.

Activity

Learning Objective

- Research different methods of powering a vehicle
- Use PowerPoint to create a presentation
- Practice public speaking

Required Resources

- Five computers with internet access and PowerPoint

Purpose

The purpose of this activity is to research different fuel types and to present the finding to the rest of the class. This activity was based on the activity found at the following link: http://www.pbs.org/newshour/extra/teachers/lessonplans/science/ethanol_interactive.html

Content Outline

1. **What types of fuel exist?**
    a. Gasoline
    b. Ethanol
    c. Compressed natural gas
    d. Electric
    e. Biodiesel
2. **Each team will research one fuel type, and will present their findings to the class using PowerPoint.**

Tasks

Task 1: Get together with your team and discuss what you already know about your assigned fuel type.

Task 2: Go online to research more information about your fuel type, finding the following information:

1. How is the fuel made?
2. How commonly is the fuel used?
3. Why is it not used more commonly?
4. What pollutants are caused by the fuel? Remember that this could include production of the fuel and well as the consumption of the fuel.

Task 3: Create a PowerPoint presentation that you will share with the class. The presentation should include the following slides:

1. Initial slide with a team name.
2. Introduction slide with your fuel type.
3. One slide addressing each of the questions in task 2.
4. Conclusion slide that discusses your recommendations for the fuel. Should it be used more? Why or why not?

Try to use as little text as possible on your slides and include pictures.

Task 4: Rehearse your presentation with your group members.

Task 5: Give your presentation to the class and answer any questions they may ask.

Task 6: While the other groups are presenting, try to think of question to ask them.

Note: If the class consists of more groups than types of fuel, split the class in half. While the first half researches and presents, the second half of the class can watch *Who Killed the Electric Car?*

UNIT 2: TRAFFIC ENGINEERING AND OPERATIONS

Day 4: Vehicle Detection

Overview and Introduction

Learning Objectives

- Understand the importance of traffic signal detection
- Discuss different types of traffic signal detection
- Observe an operating traffic control cabinet in the field

Required Resources

- Access to an operational traffic control cabinet

Content Outline

1. **What is traffic signal detection?**
2. **How does traffic signal detection work?**
3. **What are common types of traffic signal detection?**
    a. Sonar (sonic)
        i. Detects noises made by the vehicles.
        ii. Struggles to detect quiet vehicles, such as a hybrid.
    b. Infrared
        i. Detects heat put off by a vehicle.
    c. Video
        i. Visually detects when a vehicle arrives.
        ii. Can be hindered by roadway geometry or lighting conditions.
    d. Loop
        i. Uses electromagnetism to detect vehicles.
4. **Why is detection important?**
5. **Where is detection used and what is required for it to work?**
6. **Field trip to observe a traffic control cabinet at an intersection.**
    a. What does a traffic control cabinet do?
    b. What are the key parts of the cabinet?
    c. How do the users, display, detector, and cabinet interact?

Topic Discussion and Example

Learning Objective

- Experiment with magnetism and electromagnets
- Understand the dilemma zone
- Conceptualize ideal loop placement
- Understand how electromagnetism relates to loop detection

Required Resources

- Magnets of varying sizes (at least two per group)
- Metal filings (enough for each group to cover a sheet of paper)
- Motor winding wire (100 feet per group)
- ½ inch diameter 120d nails (must be magnetic)
- Battery charger (used to create the electromagnets)

Content Outline

1. **Basic theory of magnetism**
    a. What is a magnetic field?
    b. Attraction and repulsion.
        i. Use magnets to observe attraction and repulsion
        ii. Use the magnets to determine the location of the poles of a magnet
        iii. Have each group sketch the location of their magnets' poles
        iv. Remind students to be careful if using strong magnets
    c. Lines of flux
        i. Place a sheet of paper over a magnet
        ii. Gently sprinkle metal filings onto the paper
        iii. The metal filings should adhere to the lines of flux
    d. Strength of fields
2. **Electromagnetism**
    a. In a wire
    b. Fields of strength
    c. In a coil
3. **Create an electromagnet**
    a. Wrap the motor winding wire loosely around the nail
    b. Attach the wire to the battery charger
    c. What happens to the wire?
    d. Repeat the process tightly winding the wire around the nail
    e. What was different between the two windings?
4. **Loop Theory**
    a. Operation
    b. Placement
        i. What is the dilemma zone?
        ii. How does the dilemma zone impact loop placement?
    c. Types of loops
    d. How are loop detectors installed?
    e. How commonly are loops used?
    f. Future of loops?

Activity

Learning Objectives

- Understand how electromagnetism relates to loop detection
- Design and test a loop detector

Required Resources

- Loop detection cable
- Example traffic control cabinet which students can use
- Bicycle
- Duct tape

Purpose

The purpose of this activity is to allow students to create a loop detector and to test it using a bicycle. The students can create the loop in any shape they desire.

Tasks

Task 1: Discuss with your group what shape you will make your loop detector into.

Task 2: Estimate how many loops you will make in that shape to allow the detection field to be sufficiently strong.

Task 3: Calculate the amount of loop detector cable necessary to create your desired detection zone.

Task 4: Create your loop, using duct tape to adhere the cable to the floor.

Task 5: Once your loop has been created, connect the loop to the traffic control cabinet.

Task 6: Test your loop by riding a bicycle into the detection zone.

Task 7: Answer the following questions:

- Why did you choose to make the loop into the shape you chose?
- If you were to repeat this activity would you use a different shape?
- Did your loop detect the bicycle? How could you tell when the bicycle was detected?

Day 5: Coordinated Intersections

Overview and Introduction

Learning Objectives

- Understand the difference between actuated and fixed time intersections
- Describe benefits and drawbacks of actuated and fixed time intersections
- Identify when a fixed time intersection would be more applicable than an actuated intersection
- Conceptualize the variables that affect the signal timing of a fixed time intersection

Content Outline

1. **Introduction**
    a. We are going to start talking about intersection operations today.
        i. Why do we care about intersection operations?
        ii. What things do you think are important to consider when we look at the operation of an intersection?
            1. Type of intersection (traffic control)
            2. Performance of the intersection
2. **What type of traffic control do we have at intersections?**
    a. Uncontrolled
    b. Yield Sign
    c. Stop Sign
    d. Roundabout
    e. Traffic Light
        i. *Actuated*
        ii. *Fixed Time*
3. **What is fixed time and how is it different that actuated intersections?**

Replicate this table on the board

Difference	Actuated Intersection	Coordinated Intersection
Cycle Length	Varies based on traffic demand	Always the same
Green Time	Light changes when the demand changes	Always the same
Responds to traffic demands	Yes	No
Can be coordinated with other intersections	No	Yes

In busy areas (21st Street in Lewiston) it's common for intersections to be fixed time so that multiple intersections can be coordinated

4. **What is coordination?**
    a. Getting different intersections to work together so that the time the light turns green at one intersection is dependent on when the light turned green at the previous intersection.
    b. http://www.youtube.com/watch?v=IAg9O16Drmg
    c. http://www.youtube.com/watch?v=Md6UvPWIjwc
5. **Why isn't every intersection coordinated?**
    a. Vehicles spread out the further they go, so if the intersections aren't close, it won't matter that they were coordinated
6. **What do we need to do to be able to coordinate intersections?**
    a. *Travel time* (how long will it take for a platoon to get from one intersection to the next)
    b. *Cycle length* (after a light turns green, how long will it be before it turns green again)
    c. *Green time* (how long is a light green)
    d. *Offset* (how long after one intersection turns green does the next turn green)
7. **How do we determine each of those?**
    a. *Travel time* – basic kinematic equations to determine the amount of time needed to cover the distance (assume constant speed and no time needed for acceleration)
    b. *Cycle length* – critical movement analysis
    c. *Green time* – critical movement analysis
    d. *Offset* – time space diagrams, software such as VISSIM

Topic Discussion and Example

Learning Objectives

- Use Excel
- Estimate offsets in a four intersection network
- Understand how offsets impact traffic progression through a network

Content Outline

1. **What is a time space diagram?**
    a. Plot of a vehicles location (space) on the y-axis versus time on the y-axis
        i. Show example time space diagram
    b. For coordination, it can help estimate offsets
        i. Example showing this
2. **Discuss how a time space diagram is made.**
    a. Using Excel

b. *What needs to be input?* (Done as a discussion, getting feedback from the students about what they think should be included)
    i. *Speed along the road*
    ii. *Spacing between intersections*
    iii. *Cycle length*
    iv. *Green split*
    v. *Platoon length*
    vi. *Offset*
c. How would each input be obtained?
    i. Speed along the road
        1. Taken from existing conditions
    ii. Spacing between intersections
        1. Measured using survey data
        2. Measured using Google Earth
    iii. Cycle length
        1. Obtained from existing design specs
        2. Obtained through field observations
    iv. Green split
        1. Obtained from existing design specs
        2. Obtained through field observations
    v. Platoon length
        1. Field counts of vehicles
    vi. Offset
        1. Selected by the engineer (students) to improve traffic flow

For the rest of the morning we are going to be making our own time space diagrams and will use them to estimate offsets.

3. Given a time space diagram that allows everything to be input.
a. Need to input the information into the Excel sheet
b. Change offsets to pick an optimal offset at each intersection
c. Pick a design objective
    i. Coordinate northbound
    ii. Coordinate southbound
    iii. Coordinate both directions

4. Present results.
a. What was your design objective?
b. What offsets did you select?
c. Why were these offsets the best choice?
d. Did any groups have any questions about their work?

Activity

Learning Objectives

- Estimate offsets in a four intersection network
- Understand how offsets impact traffic progression through a network
- Use level of service to evaluate offset selections

Required Resources

- VISSIM network for a local community
- Computers capable of running VISSIM
- Time space diagram developed in previous activity

Purpose

The purpose of this activity is to evaluate your base network and to choose offsets at each intersection. Your evaluations should be based on the travel time, average delay, and number of stops. The data collected in the base network evaluation will be used to compare to the optimized offset plan. The base network consists of an 80 second cycle length with zero second offsets.

The corridor contains the four following intersections:

- State Highway 8 and Farm Road
- State Highway 8 and Peterson Drive
- State Highway 8 and Line Street
- State Highway 8 and Jackson Street

Tasks

Task 1: You will be given a VISSIM network containing traffic information for each intersection. After opening VISSIM, you must first load the background images. This can be done by completing the following steps:

1. From the dropdown menus at the top of the VISSIM window, select “View”.
2. From the “View” menu, select “Background” and then click “Edit”.
3. A new window should appear. From this window, select “Load…"
4. Select the .bmp file in the new window and then click open.
5. After opening the background image, close the Background Selection window.

Task 2: Click the blue triangle at the top of the screen to begin the simulation. During the initial simulation, make visual observations of the network at each intersection (you can zoom into

different parts of the network using the magnifying glass in the upper left of the screen), and answer the following questions:

1. Are the left turn movements at any of the intersections blocking through traffic?
2. Do the lights seem to be coordinated well? Do the lights turn green after the platoon arrives or before the platoon arrives?
3. Does the queue from one intersection ever spill back into a previous intersection?

Task 3: After completing the visual observations, run the simulation to gather data. The data will automatically be collected as the simulation runs. After the simulation is finished running, the data will be available in the .kna file in the folder where the VISSIM network was stored.

Task 4: Open the .kna file using Excel and delimit the data. To do this, click on the data tab at the top of Excel. Next, select cell A19 and press ctrl+ shift +down arrow, highlighting all of the data. Then click the Text to Columns button. In the new Excel window, select Delimited and then click "Next". After checking the Semicolon box, click the Finish button.

Task 5: Complete the summary tables of the base data which were created in Task 4 by adding the following information:

1. The LOS of each intersection.
2. Identify any movements where the average number of stops is greater than 1.

Task 6: Use the time space diagram which you developed this morning as a starting point to change the offsets in VISSIM for each intersection. This can be done using the following steps:

1. From the signal control drop down menu select “Edit Controllers…”
2. In the top left, highlight the first intersection
3. Click “Edit Signal Groups”
4. In the bottom left, enter a new value in the “Offset” box
5. After changing the offset, click OK in the bottom right of the VISSIM window
6. Repeat steps two through five for the remaining intersections
7. After setting the offsets for each intersection, click OK in the bottom right of the window.

Task 7: Make visual observations of the network at each intersection, and answer the following questions:

1. Are the left turn movements at any of the intersections blocking through traffic?
2. Do the lights seem to be coordinated well? Do the lights turn green after the platoon arrives or before the platoon arrives?
3. Does the queue from one intersection ever spill back into a previous intersection?
4. Does this network look like it is performing better than the base network? Explain why or why not.

Task 8: After completing the visual observations, run the simulation to gather data. The data will automatically be collected at the simulation runs.

Task 9: Using Excel, make a table which summarizes the results of the simulation after updating the offsets, showing the following information:

1. What is the average delay for the network? What was the average delay for each intersection? What is the average delay for each movement at each intersection? What is the LOS of each intersection?
2. What is the travel time for the network?
3. Are there any movements where the average number of stops is greater than one?

Task 10: Compare the new results to the base results. Did the performance of the network improve after updating the offsets?

Task 11: Consider the following questions; be prepared to discuss your answers:

1. How did changing the offset alter the performance of the network?
2. Did you have to prioritize a direction of traffic flow?
    a. How did you choose which direction to prioritize?
    b. Why did you choose this direction over the opposite direction?
3. If you were to do this activity again, what would you do differently?

Day 6: Traffic Safety

Overview and Introduction

Learning Objectives

- Discuss statistics related to traffic safety
- Understand the purpose of crash modification factors
- Understand the factors which affect a driver's ability to stop
- Calculate stopping sight distance

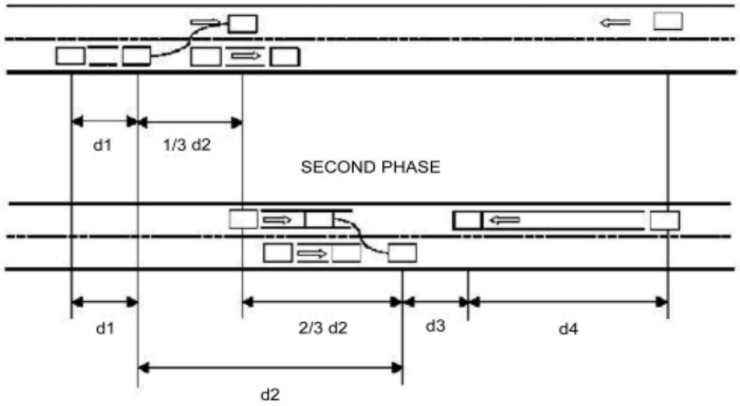
Content Outline

1. **Why is traffic safety important?**
    a. In 2010, there were 32,885 fatal crashes in the U.S.
        i. 2740 per month
        ii. 632 per week
        iii. 90 per day
        iv. One every 16 minutes
2. **Some basic statistics:**
    a. Traffic crashes are the leading cause of teen fatalities, accounting for 38 percent of all teen deaths in the United States.
    b. Everyday more than ten young drivers (age 15-20) are killed in crashes and another 745 are injured.
    c. About 25 percent of crashes killing young drivers involve alcohol.
    d. 39 percent of young male drivers and 26 percent of young female drivers were speeding at the time of their fatal crash.
    e. While young drivers represent six percent of all drivers, they are involved in 16 percent of the crashes.
    f. In 2007, 21 percent of fatal car crashes involving teens between the ages of 16 and 19 were the results of cell phone usage.
    g. http://www.textinganddrivingsafety.com/texting-and-driving-stats/
    h. http://www.youtube.com/watch?v=RrGWhS7x3Nw
3. **Despite our best efforts, can we eliminate crashes?**
    a. Not really because people are easily distracted and don't always follow the rules.
    b. Each person behaves differently when they are driving.
4. **The distance we travel while reacting and stopping is called stopping sight distance**. One common example where this can be seen is in the time it takes us to react to something in the road (person walks into traffic, light changes to red, etc…) and safely stop.
5. **When we are trying to stop, how will our reaction times impact safety?**
    a. Stopping sight distance

b. $SSD = (V)(t) + \frac{V^2}{2a}$ **Write this equation on the board**

c. Where:
V = velocity of the vehicle in feet per second
t = reaction time of the driver in seconds
a = deceleration rate of the driver (assume 11.2 ft/s)

6. **Stopping sight distance example problem**
7. **Passing sight distance**
   a. Four parts to the passing sight distance equation



Source: AASHTO 1994

   b. d_1 is the distance covered while the passing vehicle begins to accelerate and start the passing maneuver
      i. $d_1 = 1.47t_1\left(v - m + \left(\frac{at_1}{2}\right)\right)$

Where:
t_1 = time of the initial maneuver (see table)
a = average acceleration rate of the passing vehicle in mph per second (see table)
v = the average speed of the passing vehicle in mph
m = difference in speeds of the passed vehicle and the passing vehicle in mph
a = acceleration rate of the passing vehicle (see table)

   c. d_2 is the distance traveled while the passing vehicle is driving on the wrong side of the road
      i. $d_2 = 1.47vt_2$

Where:
v = average speed of the passing vehicle in mph (see table)
t_2 = time passing vehicle is in the left lane in seconds (see table)

   d. d_3 is the distance between the passing vehicle and oncoming traffic once the passing vehicle has returned to its lane (see table)

e. d_4 is the distance an oncoming vehicle moves during the passing maneuver
   i. $d_4 = \frac{2}{3}d_2$

f. Passing sight distance is the sum of the four parts
   i. $PSD = d_1 + d_2 + d_3 + d_4$

Passing Sight Distance Variables				
Speed (mph)	30-40	40-50	50-60	60-70
a	1.4	1.43	1.47	1.5
v	34.9	43.8	52.6	62
t1	3.6	4	4.3	4.5
t2	9.3	10	10.7	11.3
d3	100	180	250	300

8. Passing sight distance example

Topic Discussion and Example

Learning Objectives

- Understand the dangers of drinking and driving
- Understand the dangers of texting and driving
- Calculate the affect drinking and texting has on a driver's ability to react and safely stop

Purpose

The purpose of this activity is for students to gain understanding into how texting while driving or driving drunk impacts their ability to stop safely.

At the end of the activity you should be able to answer the following questions:

1. What is your reaction time?
2. How did your reaction time increase when you were talking to someone?
3. How would your reaction time increase if you were texting?
4. How would your reaction time increase if you were drunk?
5. How would your reaction time increase if you were drunk and texting?
6. Why does an increase in reaction time make you a less safe driver?
7. What are some specific examples of times that being able to react quickly is important?

Tasks

Task 1: Split into teams of two.

Task 2: Working with your partner, determine your reaction time using this website http://www.mathsisfun.com/games/reaction-time.html. With your hands in your lap, have your partner start the test. Record the average reaction time which will be shown at the end of the test.

Task 3: Determine how long it would take you to stop without any impairment

Task 4: Determine how long it would take you to stop if you were drinking. Assume that your reaction time increases by a factor of 2.3.

Task 5: Determine how long it would take you to stop if you were texting. Assume that your reaction time increases by a factor of 1.9.

Task 6: Determine how long it would take you to stop if you were texting and drinking. Assume that your reaction time increases by a factor of 4.1.

Activity

Learning Objectives

- Calculate passing sight distance
- Compare distance covered while passing using driver simulator to AASHTO values for passing sight distance

Required Resources

- Driving simulator which models a highway on which drivers have the option to pass slow moving vehicles
- Stop watch

Purpose

The purpose of this activity is to understand the amount of time necessary to safely pass a vehicle on a highway.

Task

Task 1: In teams of four, calculate how much space is necessary to pass a vehicle using the AASHTO passing sight distance equation discussed earlier.

Task 2: Using the University of Idaho's driving simulator, determine how much time it takes each member of your team to pass a vehicle. To do this, one team member should be driving the vehicle, one team member should be timing how long it takes the driver to pass the vehicle, and one team member should record data. The driver should tell their teammates when they are

starting to pass the vehicle. One team member should record the speed the driver is traveling at this point while the other team member should start the timer. After the driver has safely returned to their lane, one team member should record the final speed the driver was traveling, while the other team member should stop the timer. Finally, the time taken should be recorded.

Task 3: Using the kinematic equations you learned during the vehicle dynamics day, determine how far the driver traveled while they were passing the vehicle.

Task 4: Repeat tasks two and three so that each team member has the opportunity to drive.

Task 5: Compare the passing distance calculated in Task 1 to the passing distance of each team member. Was the required passing distance similar? If there were differences, what do you think caused the differences?

Day 7: Geometric Highway Design

Overview and Introduction

Learning Objectives

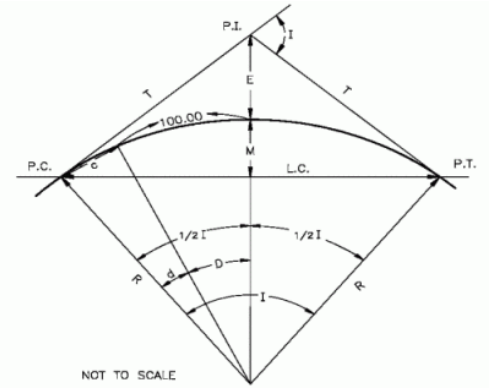
- Understand the fundamental of geometric highway design
- Visualize different variables which affect the geometric design of a highway
- Understand the difference between horizontal and vertical curves

Content Outline

1. **We talked yesterday about safety.** When we design highways, what types of things do we need to consider in our design to make the roads as safe as possible?
    a. Speed limit
    b. Sight distance
    c. Stopping distance
    d. Hills
    e. Corners
    f. Roadway geometry

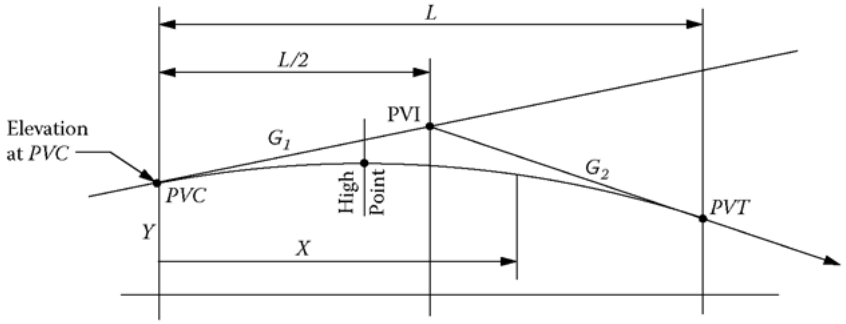
Most of these things can be described by the roadway alignment.

2. **What do you think roadway alignment means?**
    a. Designing where the roads will go
        i. Stationing
        ii. Elevation
3. **Roadway alignment can be described by two broad categories.**
    a. Horizontal alignment
    b. Vertical alignment
4. **Horizontal alignment**



    a. Label each part
        i. *R is the radius*

5. Vertical alignment



a. Label each part
   i. *G_1 is the initial grade of the road in percent*
   ii. *G_2 is the final grade of the road in percent*
   iii. *PVC is the point where the vertical curve starts*
   iv. *PVT is the point where the vertical curve ends*
   v. *PVI is the point where lines tangent to the PVC and PVT intersect*
   vi. *L is the horizontal distance between the PVC and PVT (not affected by elevation changes)*
   vii. *X is the horizontal distance from any point on the curve to the PVC*
   viii. *Y is the elevation at a specific point on the curve*
   ix. *X_{hp} is the distance to the highpoint or low point of the curve*
      1. *Low points are used to determine where drainage is needed*
      2. *Highpoints can be used when checking clearance elevations*

b. Sag vertical curve

c. Crest vertical curve

d. Important Equations
   i. $Y = \left(\frac{G_2 - G_1}{2L}\right)x^2 + G_1 x + Y_{PVC}$
   ii. $Y_{PCV} = Y_{PVI} - \frac{G_1 L}{2}$
   iii. $Y_{PCT} = Y_{PVI} + \frac{G_2 L}{2}$
   iv. $L = X_{PVT} - X_{PVC}$
   v. $L = 2(X_{PVI} - X_{PVC})$
   vi. $X_{hp} = \frac{G_1 L}{(G_1 - G_2)}$

e. Vertical Curve Example 1: For a curve with a PVI at station 46+70 and elevation 853.48 feet, an initial grade of 3%, and a final grade of -2.40%, and a length of 600 feet, determine the stationing and elevation of the PVC, PVT, highpoint, and low point.

6. **World's most dangerous highways**
    a. *Stelvio Pass Road - Italy*
        i. The highest paved mountain pass in the Eastern Alps --and the second highest in the Alps, the Stelvio Pass Road connects the Valtellina with the upper Adige valley and Merano. It is located in the Italian Alps, near Bormio and Sulden, 75 km from Bolzano, close to the Swiss border.
    b. *Trollstigen – Norway*
        i. Nine percent grade (steeper than the Lewiston Grade)
        ii. 11 hairpin turns
        iii. Vehicles over 40 feet are not allowed to drive on the road
    c. *James Dalton Highway – Alaska*
        i. 414 mile gravel road used primarily by oil companies
        ii. Most rental car companies will not allow people to drive on the highway because it is too unsafe
    d. *Sichuan – Tibet Highway – China*
        i. High risk of rockslides and avalanches
        ii. Steep mountains and little guardrails make the passes very unsafe
    e. *Siberian Road to Yakutsk – Russia*
        i. Unpaved highway
        ii. Snowy roads in the winter (winter conditions every month except July and August)
        iii. When the rain comes in the winter, the unpaved road becomes very muddy, causing traffic jams which can be over 1000 vehicles
        iv. People make these traffic jams extra unsafe because they will begin to loot, attack, and kidnap other drivers.
    f. *Guoliang Tunnel Road – China*
        i. The road goes through vertical mountains.
    g. *The Death Road – Bolivia*
        i. The road is very narrow (about ten feet wide). Most roads in America have 12 foot lanes, so they would be at least 24 feet wide.
        ii. It is used by busses and semi-trucks
        iii. It used to be the only route through the mountains; however, an alternate route has now been built. When it was the main road, between 200 and 300 people died on it each year.

Topic Discussion and Example

Learning Objectives

- Understand the fundamental of geometric highway design
- Visualize different variables which affect the geometric design of a highway

- Understand the difference between horizontal and vertical curves
- Work problem relating to horizontal and vertical curves

Content Outline

For the rest of the time we are going to work a couple examples that will help get you ready for the activity this afternoon

1. **Horizontal curve problem**
    a. Example 3.14 from Mannering text
    b. Example 3.16 from Mannering text
2. **Vertical curve problem**
    a. Sag curve: Example 3.2 from Mannering text
    b. Crest curve and stopping sight distance: Problem 3.11 from Mannering text

Activity

Learning Objectives

- Redesign a section of a highway to meet local standards

Purpose

The purpose of this activity is to provide you with the opportunity to design a horizontal curve that meets safety standards for the given design speed.

Required Resources

- Highway design plans that contain a substandard section of roadway
- Ruler
- Compass

Tasks

Task 1: Split into your assigned groups.

Task 2: For the given design speed of 40 mph and superelevation of eight percent, determine what the minimum curve radius should be.

Task 3: For each curve identify the radius and the location of the PC and PT in both stations and feet.

Task 4: For each curve, calculate the tangent length, the location of the PI in both stations and feet, and the total length of the curve.

Task 5: Based on the design plans, identify which curve does not meet the minimum curve radius requirements.

Task 6: Identify a potential realignment for the substandard curve(s) and sketch it onto your map. To do this, do the following steps:

1. Sketch tangent lines for any new curve you are creating.
2. Measure Δ, the angle between the tangent lines using a protractor.
3. Calculate the tangent length using a radius meets the minimum curve radius requirement and your measured value of Δ.
4. Using the tangent length you calculated, determine the locations of the PC and PT by measuring a distance equal to the tangent length from the PI.

Calculate the following information for the new curve(s) on your newly designed road:

1. The locations of the PC, PI, and PT in both feet and stations.
2. The radius of the curve.

Task 7: As a group, be prepared to discuss with the class your answers to the following questions:

1. What issues did you consider when aligning your road?
2. Why did you place the alignment where you did?
3. Were there any other alternative roadway alignments that you considered?
4. Are there any factors that were not included in this activity that should be included when designing a road?

UNIT 3: TRANSPORTATION SCIENCE AND PLANNING

Day 8: Traffic Forecasting

Overview and Introduction

Learning Objectives

- Understand why density is important for transportation planning
- Understand why diversity is important for transportation planning
- Understand why design is important for transportation planning

Content Outline

For the next two days we are going to be talking about transportation planning.

1. **What comes to mind when we talk about transportation planning?**
    a. Traffic forecasting
    b. Bicycles and pedestrians
    c. Traffic calming measures
    d. Alternative transportation modes
2. **As we being to talk about this, there are three things that we should consider. They are called the three d's of transportations planning.**
    a. Density
    b. Diversity
    c. Design
3. **Why is density important for transportation planning?**
    a. In 2008, for the first time ever, more people lived in cities than in rural communities. Additionally, one in six people live in slums. (Klong Toey slum picture, 100,000 people, 0.75mi^2)
    b. It is the opposite of urban sprawl
        i. Discuss urban sprawl
            1. What is it?
            2. Why does it happen?
            3. Why is it bad?
    c. It is easier for a community to provide public transportation to high density areas
    d. Compact high density cities promote walking and biking
        i. Can lower traffic
        ii. Reduces emissions
        iii. Healthier cities
    e. Cities with the highest population density (http://risebd.com/2013/03/09/a-look-into-dhaka-bangladesh-the-most-densely-populated-city-in-the-world/)
        i. Atlanta, Georgia (2,000/mi^2)

ii. Portland, Oregon (3,000/ mi^2)
iii. Vancouver, BC (4,000/ mi^2)
iv. Paris, France (11,000/ mi^2)
v. Jakarta, Indonesia (24,000/ mi^2)
vi. Seoul, South Korea (28,000/ mi^2)
vii. Manila, Philippines (38,000/ mi^2)
viii. Hong Kong, China (62,000/ mi^2)
ix. Karachi, Pakistan (63,000/ mi^2)
x. Mumbai, India (80,000/ mi^2)
xi. Dhaka, Bangladesh (115,000/ mi^2)

f. If the world's population lived in one city, how large would it be?
   i. http://static.persquaremile.com/wp-content/uploads/2011/01/the-worlds-population-concentrated.png

4. **Why is diversity important for transportation planning?**
   a. Mixing land uses encourages walking.
      i. Rather than separating out where people live from where they shop and work, allowing mixed use zoning encourages multimodal transportation.
5. **Why is design important for transportation planning?**
   a. We need to design the roads so that they can be easily accessed by pedestrian and bicycle traffic as well as vehicles.
   b. Engineers designed cul-de-sacs to discourage through traffic; however, this also discouraged people from walking and biking because the trip time significantly increased.

Topic Discussion and Example

Learning Objectives

- Forecast traffic volumes
- Understand exponential growth
- Work with the ITE Trip Generation Manual
- Conceptualize why new developments cause traffic volumes to increase

Content Outline

1. **When a development is being planned, what things do you think need to be considered?**
   a. What is the development?
   b. How big will the development be?
   c. What will the development do to the traffic?
   d. How will the owner of the development pay to offset the increase in traffic?

2. **To estimate the impact of a development, traffic forecasting is used.**
3. **What do you think traffic forecasting does? (What is traffic forecasting?)**
    a. Attempts to answer what the development will do to the current traffic conditions
4. **How do transportation planners forecast traffic?**
    a. Using the trip generation manual
5. **What things are important to know when a transportation planner is forecasting traffic?**
    a. Growth rate for the city
        i. Allows planners to estimate how much traffic would increase if the development was not built due to growth in the city
    b. Land use type and proposed development size
        i. Allows developers to compare the proposed development to similar developments
6. **The increase in traffic (traffic forecasting) is then the sum of the increase in traffic due to the growth of the city and the increase in traffic due to the proposed development.**
7. **Ask students for example land uses (developments) and discuss how you would assess its traffic impact using the trip generation manual.**
    a. Gas station
    b. Casino
    c. Warehouse
    d. Apartments
    e. Residential areas
    f. Hotels
    g. State Parks
    h. Schools
    i. Free standing discount superstore (Costco, Wal-Mart)
8. **How do we estimate the increase in traffic due to the growth of the city?**
    a. $y = a(1 + r)^x$

        y = forecasted traffic flow
        a = current traffic flow
        r = growth rate
        x = number of years we are forecasting for
    b. As an example, let's say that 21st street has a southbound volume of 1200 vehicles per hour. What would the forecasted volume be in fifteen years if the annual growth rate is 4.6 percent and no new developments were added?

        $y = 1200(1 + 0.046)^{15} = 2356$

In the afternoon we will forecast the new Super Wal-Mart's impact on the traffic in Clarkston, Washington.

Activity

Learning Objectives

- Conceptualize why new developments cause traffic volumes to increase
- Use the trip generation manual to calculate the impact of a recent development in a local community
- Discuss potential ways to minimize the impact caused by a new development

Purpose

The purpose of this activity is to better understand traffic forecasting by estimating the impact which a new Super Wal-Mart would have on the PM peak hour traffic during a weekday on Bridge Street in Clarkston, Washington. By the end of this activity, you will be able to forecast traffic if the store was built and compare it to traffic forecasts assuming that a store was not built.

Required Resources

- ITE Trip Generation Manual
- Traffic counts near a proposed development
- Annual traffic growth rate for a local community

Assumptions

As you complete the required tasks, assume the following information:

- Bridge Street currently has a PM peak volume of 2000 vehicles per hour on weekdays
- Clarkson has an annual growth rate of 2.7 percent
- Traffic is to be forecasted for ten years in the future.

Tasks

Task 1: Determine the increase in traffic due to growth in the city.

Task 2: In teams of two, use Google Earth to measure the size of the new Super Wal-Mart (corner of 5th Street and Port Drive).

Task 3: Determine the land use category that a Super Wal-Mart would fall under. Remember that it is a discount superstore and that it is not attached to any other buildings (it is freestanding).

Task 4: Based on the area you measured in Task 2, determine the number of additional trips which will be generated by the new store.

Task 5: Determine the forecasted traffic volume ten years after the store is opened. To do this, use the same equation as you did in Task 1, but the volume from the store should be added into the current volume.

Task 6: Determine the difference in the traffic volume ten years from now if the store is built versus if the store is not built.

Task 7: Make recommendation to the roadway which you think may help to offset the increase in volume. This may include updating the signal timing, adding additional lanes to a road, changing the type of control at an intersection so that it is signalized, or anything else that you can think of. As you come up with recommendations, remember to consider density, diversity, and design.

Task 8: Decide who you think should pay for the improvements based on the difference in traffic volume which you calculated in Task 5. If you think the city would have needed to make the improvements even if the store was not built, it might be reasonable for the developer to pay for less of the improvements. If you think the development was what necessitated the road improvements, then the developer should pay for an increased percentage of the work.

Day 9: Bicycle and Pedestrian Planning

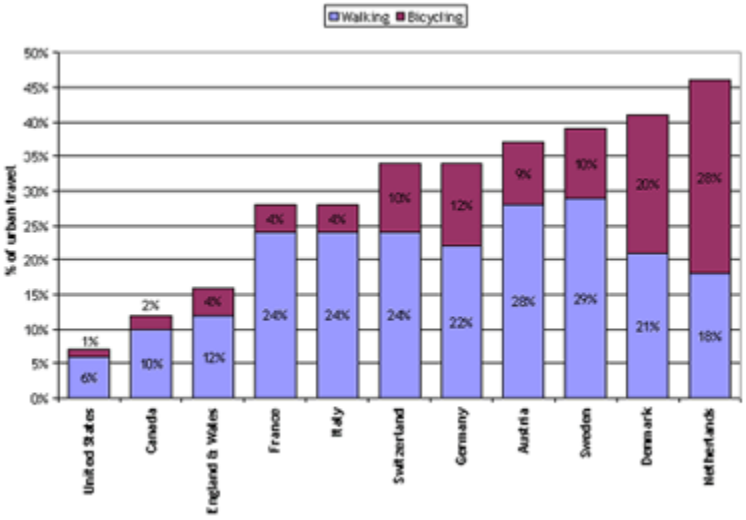
Overview and Introduction

Learning Objectives

- Understand that bicyclists and pedestrians are important to consider
- Contrast the percent of traffic which walks or bikes in the U.S. with other major countries

Content Outline

1. **Over the past several days, everything we have talked about has focused on automobiles.** What other forms of transportation are there?
    a. Walking
    b. Bicycling
2. **How many of you regularly bike or walk places?**
    a. Why or why not? (write student responses on board)
3. **Do you think that Americans bike more or less than other countries?**



Source: http://www.fhwa.dot.gov/publications/research/safety/pedbike/05085/chapt23.cfm

4. **If seven percent of urban travel in American is done by biking or walking while in the Netherlands 46% of urban travel is done by biking or walking, what could transportation planners and engineers do better to encourage more people to bike and walk? (Write student responses on the board)**
    a. Connect transit services to major biking/walking destinations
    b. Increase recreational opportunities
5. **What influences someone's decision to bike or walk?**
    a. Distance/time
    b. Trip barriers
        i. Needing to cross busy intersections
        ii. No bike lanes, or sidewalks, or they are poorly maintained

iii. Safety concerns

c. Destination barriers
   i. Going to a store where you wouldn't be able to carry your purchases home
   ii. Lack of bike facilities (nowhere to lock your bike up)

6. How do the three d's of transportation planning impact biking and walking rates?

a. Density
b. Diversity
c. Design

Topic Discussion and Example

Learning Objectives

- Understand the goal of traffic calming
- Discuss the need for traffic calming
- Discuss the benefits of traffic calming measures
- Discover different traffic calming measures

Content Outline

1. What is a traffic calming?

a. Reducing speeds of vehicles on a road
b. Reducing traffic volumes on a road
c. Basically traffic calming measures get drivers to stay on the main roads rather than side streets

2. Why is there a need for traffic calming?

a. Cut through traffic
   i. Quicker to go through a neighborhood than on the main arterial
   ii. May be due to high volumes on the main street
   iii. May be due to a more direct route on side streets
b. High speeds on neighborhood streets
   i. People may be trying to make time they were delayed on the major street
   ii. Remember how much improvement there was when we set the offsets correctly last Friday? If the timing is poor, wouldn't you be looking for a different route?

3. What are the goals and objectives of traffic calming?

a. Increase safety by slowing vehicle speeds
b. Improve the feel of the streets
c. Make the street more aesthetically pleasing
d. Encourage people to walk or bike

4. **What issues are associated with traffic calming?**
    a. Impact on traffic operations
        i. If we discourage using side streets but don't address the issue which led people to use the side streets, have we really solved anything?
    b. There are no good design standards
    c. Harder access for emergency vehicles
5. **What are different types of traffic calming measures?**
    a. Traffic circles
    b. Curb extensions
    c. Neck down
    d. Diagonal diverter
    e. Truncated diagonal diverter
    f. Chicane
    g. Cul-de-sac
    h. Raised pavement areas
    i. Narrowing streets
    j. Closing segments of streets
    k. Adding texture and visual effects to roadways
    l. Woonerf
    m. Entry treatments
    n. Channelization
    o. Modified intersection design
6. **What of the traffic calming measures we just discussed would you find most beneficial as a pedestrian or as a bicyclist?**
7. **Of the traffic calming measures we just discussed, what would you find most annoying as a driver?**
8. **Who do you think should have priority on the streets, vehicles or non-motorized traffic?** Does it matter where you are?

Activity

Learning Objectives

- Conduct a pedestrian audit for a local community
- Discuss findings from the pedestrian audit
- Recommend potential improvements to increase pedestrian and bicycle friendliness in a local community

Purpose

The purpose of this activity is to conduct a pedestrian audit in a local community. Teams should conduct the audit in an area of town that has high pedestrian volumes. This commonly occurs

downtown or near a university. After completing the audit, students will discuss their thoughts on potential ways to improve the non-motorized transportation services in the community.

Required Resources

- http://katana.hsrc.unc.edu/cms/downloads/walkability_checklist.pdf
- http://www.activelivingresearch.org/files/audit_tool_checklist.pdf

Tasks

Task 1: Read through the two pedestrian audits which have been provided.

Task 2: As a class, walk to the study area.

Task 3: Split into teams of four and with an instructor, complete the audits for the study area.

Task 4: Once you have completed both audits, return to campus.

Task 5: As a class, discuss the following questions:

1. Did you feel like you were able to safely walk around in the study area? Why?
2. What was good about the study area?
3. What was bad about the study area?
4. What did you think could be improved?
5. What would you recommend doing to improve the walkability of the community?

Day 10: Public Transportation

Overview and Introduction

Learning Objectives

- Discuss different types of public transportation
- Understand the benefit of public transit
- Understand the factors that impact transit level of service

Content Outline

1. **So far, we have talked about using cars, bikes, and walking to get around. How else do people travel?**
    a. Ferry
    b. Light rail (train)
    c. Subway
    d. Bus
    e. Airplane
2. **What is the purpose of public transit?**
    a. Relieve congestion on roads
    b. Provide a means for people to move about
3. **Two types of bus routes**
    a. Loop
        i. Drives in a circle
            1. Advantages
            2. Disadvantages
    b. Linear
        i. Drives along a path and then backtracks the path
            1. Advantages
            2. Disadvantages
4. **Transit LOS – Give good and bad examples for each category**
    a. Availability
        i. Service frequency (headway)

Exhibit 3-12
Fixed-Route Service
Frequency LOS

LOS	Avg. Headway (min)	veh/h	Comments
A	<10	>6	Passengers do not need schedules
B	10-14	5-6	Frequent service, passengers consult schedules
C	15-20	3-4	Maximum desirable time to wait if bus/train missed
D	21-30	2	Service unattractive to choice riders
E	31-60	1	Service available during the hour
F	>60	<1	Service unattractive to all riders

Source: TCRP Report 100

        ii. Hours of service

Exhibit 3-13
Fixed-Route Hours of Service LOS

LOS	Hours of Service	Comments
A	19-24	Night or "owl" service provided
B	17-18	Late evening service provided
C	14-16	Early evening service provided
D	12-13	Daytime service provided
E	4-11	Peak hour service only or limited midday service
F	0-3	Very limited or no service

Source: TCRP Report 100

iii. Percentage of transit supportive areas served

Exhibit 3-14
Fixed-Route Service Coverage LOS

LOS	% TSA Covered	Comments
A	90.0-100.0%	Virtually all major origins & destinations served
B	80.0-89.9%	Most major origins & destinations served
C	70.0-79.9%	About ¾ of higher-density areas served
D	60.0-69.9%	About two-thirds of higher-density areas served
E	50.0-59.9%	At least ½ of the higher-density areas served
F	<50.0%	Less than ½ of higher-density areas served

Source: TCRP Report 100

b. Comfort and convenience

i. Expected passenger load (occupancy)

Exhibit 3-26
Fixed-Route Passenger Load LOS

LOS	Load Factor (p/seat)	Standing Passenger Area (ft^2/p)	Standing Passenger Area (m^2/p)	Comments
A	0.00-0.50	>10.8†	>1.00†	No passenger need sit next to another
B	0.51-0.75	8.2-10.8†	0.76-1.00†	Passengers can choose where to sit
C	0.76-1.00	5.5-8.1†	0.51-0.75†	All passengers can sit
D	*1.01-1.25**	3.9-5.4	0.36-0.50	Comfortable standee load for design
E	*1.26-1.50**	2.2-3.8	0.20-0.35	Maximum schedule load
F	*>1.50**	<2.2	<0.20	Crush load

*Approximate value for comparison, for vehicles designed to have most passengers seated. LOS is based on area.
†Used for vehicles designed to have most passengers standing.

Source: TCRP Report 100

ii. On time percentage

Exhibit 3-29
Fixed-Route On-Time Performance LOS

LOS	On-Time Percentage	Comments*
A	95.0-100.0%	1 late transit vehicle every 2 weeks (no transfer)
B	90.0-94.9%	1 late transit vehicle every week (no transfer)
C	85.0-89.9%	3 late transit vehicles every 2 weeks (no transfer)
D	80.0-84.9%	2 late transit vehicles every week (no transfer)
E	75.0-79.9%	1 late transit vehicle every day (with a transfer)
F	<75.0%	1 late transit vehicle at least daily (with a transfer)

NOTE: Applies to routes with a published timetable, particularly to those with headways longer than 10 minutes.
"On-time" is 0 to 5 minutes late, and can be applied to either arrivals or departures, as appropriate for the situation being measured. Early departures are considered on-time only in locations where no passengers would typically board (e.g., toward the end of a route).
*Individual's perspective, based on 5 round trips per week.

Source: TCRP Report 100

iii. Transit-auto travel time

Exhibit 3-31
Fixed-Route Transit-Auto Travel Time LOS

LOS	Travel Time Difference (min)	Comments
A	≤0	Faster by transit than by automobile
B	1-15	About as fast by transit as by automobile
C	16-30	Tolerable for choice riders
D	31-45	Round-trip at least an hour longer by transit
E	46-60	Tedious for all riders; may be best possible in small cities
F	>60	Unacceptable to most riders

Source: TCRP Report 100

Topic Discussion and Example

Learning Objectives

- Calculate the level of service for a bus route in the local community
- Understand that a higher level of service is not always beneficial
- Experience using public transportation

Content Outline

1. **Evaluate a local community's transit system**
    a. http://www.r2transit.com/Downloads/MoscowFixedRouteScheduleEffective12-24-2012.pdf
2. **Split into groups**
    a. Assign each group to a bus route
3. **Have students rank the transit LOS for each category**
    a. Service frequency
        i. How often does the bus come to each stop?
        ii. How long does the bus run each day?
        iii. Percentage of transit supportive areas served
            1. Have GIS map showing transit supportive areas, have students estimate percent served
            2. To save time, or if GIS data is unavailable, this could be estimated or skipped
        iv. Passenger load
            1. Including students
            2. Ignoring students
        v. On time percentage
            1. For each stop was the bus on time, early, or late
        vi. Compare transit auto travel time from the start point to each stop after riding the busses
4. **Discuss findings**
    a. What was the worst level of service category?
    b. How could the level of service be improved for that category?
    c. Would improving the level of service actually benefit the community? Why or why not?

Activity

Learning Objectives

- Design a bus route
- Evaluate the newly designed bus route
- Estimate costs associated with the bus route

Purpose

The purpose of this activity is to construct a bus route in Moscow, Idaho. Your route should stop in areas that are important to the city. At the end of the activity, you should be able to answer the following questions:

1. How many miles does the bus drive each time it completes a route?
2. How much time will it take for the bus to complete one route?
3. How long will the bus operate each day?
4. Why did you choose to stop at each location?
5. What is the level of service of the bus route?

Required Resources

- A map of Moscow which includes a scale and locations of the current bus routes for each group
- Approximately 30 push pins per group
- One ruler per group
- Approximately 20 feet of string

Tasks

Task 1: Each group should pick up a map of Moscow, a box of thumbtacks, a ruler, and 20 feet of string.

Task 2: Discuss with your group where you think the bus route should go to. Remember that this is just one bus route, so it does not need to go everywhere but the route does need to start and stop at the same location.

Task 3: Once you decided which part of town your bus route will serve, decide if you will create a loop route or a linear route.

Task 4: Place pins at each place you would like to design a bus stop.

Task 5: Map your bus route by wrapping string around each pin you placed during Task 4. Additional pins can be used to keep the string on the route the bus will take.

Task 6: Measure the amount of string which was used in the creation of your bus route.

Task 7: Use the scale on the map to determine the distance the bus would drive while completing one route.

Task 8: Assuming a cost of $7.50 per mile the bus drives, estimate the cost of your proposed bus route.

Task 9: Determine the level of service for your proposed bus route. Note that until the bus service is fully operational, some of the level of service parameters will be unknown. Do your best to estimate these anyway.

Task 10: Discuss with your group the answers to the questions posed in the purpose section of the activity. Be prepared to discuss your answers with the other groups.

AFTERWORD

The first implementation of the summer camp was a huge success. In addition to having an extremely fun three weeks, the 21 high school students gained an appreciation and understanding of transportation. These students have a much greater likelihood of entering a career in transportation. Furthermore, they shared and will continue to share their positive experience with friends and family.

This Instructor's Guide was another success. Universities across the country can use this guide to deliver a summer camp. The 10 modular sections can be adapted and improved to fit the needs of any institution. We found the lectures and activities worked really well. The students thoroughly enjoyed the "hands-on" activities. We also found the sequence of topics to exhibit good progression. We did find, however, that by the end of the day, many of the students seemed to be tired and were struggling to pay attention or to focus on the activity. Consequently, we recommend that future delivery would reduce the amount of material covered, allowing the students more free time during the day.

Another lesson we learned was that the required math was too easy for some students and too difficult for others. This may have been particular to our circumstances, but nevertheless, future work could improve this Instructor's Guide to accommodate varying levels of math skills. We also note that the special attention to help students who were weak in math ability was a strain on the delivery of the material. We recommend instructors to be prepared with a plan to deal with individuals who may need special attention.

Our visit to Washington, DC was a wonderful addition to the program. Future work should examine how to incorporate field trips of this type into this Instructor's Guide. Visiting Washington, DC provided the opportunity to meet with congressmen, learn about transportation policy, and experience the traffic of a large city. During this time, the students traveled primarily by walking or riding the metro, which allowed them to experience unfamiliar types of transportation. Additionally, one day was spent biking through the city, which allowed the students to understand why multimodal transportation is important to consider