Bicycle and Pedestrian Education Program:

Engineering Curriculum Module

Karen Dixon, Ph.D.
Oregon State University

Portland State University
- Center for Urban Studies
- Center for Transportation Studies
- Initiative for Bicycle and Pedestrian Innovation

November 2008
CUS-CTS-08-05
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Portland State University, Portland, Oregon

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OTREC Project 08-126
IBPI Bicycle and Pedestrian Education Program

Summary of Oregon State University Activities

Project Description: The Initiative for Bicycle and Pedestrian Innovation (IBPI) is a joint program between Portland State University (PSU), Oregon State University (OSU), and the University of Oregon to advance bicycle and pedestrian research and education. During the 2007-2008 academic year, Oregon State faculty member, Dr. Karen Dixon, developed and incorporated a bicycle and pedestrian module into the graduate transportation civil engineering class CE 594 – Transportation Facilities Design. This report summarizes the information included in the course, supplemental materials developed from the course, and resulting course assessment.

Overview of Course:

CE 594 – Transportation Facilities Design is a class required for students acquiring a graduate degree in transportation engineering. It introduces common facility design concepts for transportation infrastructure. In the past, this class has included a limited amount of bicycle and pedestrian instruction (often incorporated within larger topics); however, for the Spring 2008 offering the class included an entire module for bicycle and pedestrian design and safety. The syllabus for this course is included at attachment #1. To address ABET requirements, the syllabus must include learning objectives that generally address the focal points of the course. Specific to bicycle and pedestrian issues, one objective (as shown in the syllabus) that at the completion of the course, students should “Understand the concept known as ‘Complete Streets’ (all modes of transportation sharing one facility).” A second objective that included the pedestrian and bicycle initiative was that of traffic calming since the implications of various traffic calming strategies on bicycle and pedestrian travel was directly addressed including how to modify certain traffic calming configurations to make them more bicycle-friendly.

Bicycle and Pedestrian Reading Requirements:

The course had one required reading (by Dan Burden) that students purchased. In addition, they were provided with two supplemental documents. All three of these documents directly addressed bicycle and pedestrian issues. These documents are as follows:


Class Project Assignment:
The bicycle and pedestrian modules lasted a total of two seeks and occurred the second and third week of the term. In addition, a class project followed that required the students to incorporate the bicycle and pedestrian design and safety principles into their project design. A summary of the class project is included as Attachment #2 (see task 3 & 4 in the project description).

In-Class Case Studies:
The BIKESAFE and the PEDSAFE incorporate some case studies that address “innovative” treatments to enhance bicycle and pedestrian operations. During class, the students participated in an active learning exercise where they divided into groups and reviewed two to three case studies. Following their review and critique of the case studies, they presented their case studies to the class for discussion and feedback. They were also instructed that the first exam would include a question about these case studies. A copy of the in-class active learning activity is included as Attachment #3.

Supplemental Handouts and Lecture Notes:
In addition to the required reading, students were provided with supplemental handouts as needed. Students were expected to understand basic bicycle facility design principles including the design of shared-use facilities. Attachment #4 is a supplemental handout provided to the students so that they would know how to design such a facility. It was accompanied by lecture and in-class examples. The source document for this content was the AASHTO Guide for the Development of Bicycle Facilities.

The students also were provided a generally bicycle handout that reviewed the various types of bicycle facilities and included some graphics that demonstrated common design constraints. This handout is included as Attachment #5.

Attachments #6 and #7 are handouts provided for pedestrian specific design and safety issues. They include general pedestrian capacity terms at various critical pedestrian bottleneck locations.

Exam:
Content from the bicycle and pedestrian modules was included in the first class exam and the final exam. Relevant questions from both exams have been extracted and included in Attachment #8.

Animated Movie on Bicycle Safety and Countermeasures:
Though not proposed in the initial course design, when the students were reviewing crash types they seemed to have considerable difficulty visualizing the interactions between the bicycles and the motor vehicles (or bicycles and road characteristics). As a result, Dr. Dixon worked with one of the students to develop a flash movie that can be installed on a class web site so that students can view action-oriented information regarding these specific conflicts. Attachment #9 includes an example of image snap shots from the flash movie. The actual movie is available and is named “bicycle crash types.swf” and requires a Flash reader to view.

Assessment of Bicycle and Pedestrian Knowledge:
Prior to beginning the bicycle and pedestrian modules, the instructor conducted a survey among the students to determine the level of their general knowledge for bicycle and
pedestrian facilities. This in-class survey asked about their general level of knowledge (as they perceived it) in four areas:

- Bicycle Facility Design
- Bicycle Safety and Crash Assessment
- Pedestrian Facility Design
- Pedestrian Safety and Crash Assessment

Since a prerequisite for the class is a basic highway design class, all of the students felt they were well equipped for both of the design elements. During the class, however, the review of designing shared-use facilities demonstrated that the students did not know this information as comprehensively as they initially indicated. All of the students said they had some practical knowledge of bicycle and pedestrian safety but did not know how to assess safety and potential hazards. As a result, the instructor added additional content on this topical area.

At the conclusion of the class, students provided feedback in two ways. First, they were asked to provide written comments about the class with particular attention to the bicycle and pedestrian topics. Second, they rated the class content during the standard class evaluations (this class received an extremely high rating).

Every student provided feedback that the bicycle and pedestrian modules introduced material that they needed to know and had not been exposed to in conventional traffic engineering classes. They also indicated that they had learned several facts about these facilities that they had not given strong consideration to before. One example, a student indicated he often rode his bicycle in a bike lane but frequently did so against traffic or on the sidewalk. Following the safety review of bicycle crash types, he indicated he would no longer ride in this manner.

At the conclusion of the module, we had an in-class discussion about the bicycle and pedestrian topics and several of the students indicated that now that they had a better understanding about bicycle operations (in particular), they thought there should be better enforcement of this transportation mode and even some sort of licensing requirement. This comment was precipitated by discussion regarding the safety assessment of bicycle facilities.
ATTACHMENT #1 – CE 594 Course Syllabus
CE 594 – Transportation Facilities Design  
Spring 2008 (4 credit hours)

Instructors:
Karen Dixon, P.E.  
Room 302 Owen Hall  
Phone: 541-737-6337  
E-mail: karen.dixon@oregonstate.edu

Ida van Schalkwyk  
Room 307 Owen Hall  
Phone: 541-737-8874  
E-mail: idavan@engr.oregonstate.edu

Class Website:  
http://myoregonstate.edu/  
(This is the BlackBoard Login Site)

Lecture Schedule:  
Tuesday  
2:00 p.m. - 4:50 p.m.  
Room 320, Owen Hall

Recitation Schedule:  
Thursday  
2:00 – 3:50 p.m.  
Room 320, Owen Hall

Email:  
Every student must have ENGR and ONID accounts. Read email daily. Note: a class email distribution list will be generated from ENGR accounts. You can “forward” ENGR or ONID to any account. The instructors do not take responsibility for cases where a student’s email bounces (due to a full email inbox or any other reason).

Course Description:  
A project course that focuses on the location and design of transportation facilities and other surface transportation terminals; including current transportation design trends and various interchange designs.

Course Prerequisite:  
CE 392 (also acceptable as a co-requisite)

Text:  
- Streets and Sidewalks, People and Cars by Dan Burden (Dr. Dixon will have these available during the 2nd week of class for a minimal cost)  
- Various Handouts or Linked Documents provided throughout the term

Supplemental References:  
- Highway Engineering by Paul H. Wright & Karen K. Dixon (7th edition),  
Course Outcomes or Objectives:

By the end of the course, you will be able to:

- Understand the basic interchange design principles;
- Understand and implement basic traffic calming and context sensitive design guidelines;
- Understand the concept known as “Complete Streets” (all modes of transportation sharing one facility);
- Recognize and apply basic arterial roadway design techniques (access management, turning radii, intersection sight distance).

Homework:

Homework is instrumental in helping you grasp fundamental concepts and in exposing you to techniques and skills for applying these principles to real-life situations. You may discuss homework problems with your classmates (NOT COPY THEIR SOLUTIONS), but please try to complete all homework on your own initially. Additionally solutions must be developed and submitted independently. For homework activities that require the use of a computer software package, the student may be required to submit his or her input files. It is not appropriate to copy a computer file prepared by someone else and administrative actions will be taken in the event this occurs.

Late homework is not accepted unless specific arrangements are made with the instructors prior to the deadline.

Exams:

There will be two exams during the quarter plus one final exam. The exams must be taken as scheduled. If you MUST miss an exam for an emergency situation, please let the instructors know as soon as possible (prior to the exam). If you oversleep or skip an exam you will not have an opportunity to make it up. If you have a valid (according to the instructors) time conflict and you let her know in advance, there is the possibility of taking an exam at an alternate time.

Class Attendance:

You are expected to attend every class and participate in discussion. If you are not able to make class, notify the instructor before class. If you do miss class, it is your responsibility to find out what was covered and any administrative information that was presented.

Disruptive Behavior:

While the University is a place where the free exchange of ideas and concepts allows for debate and disagreement, all classroom behavior and discourse should reflect the values of respect and civility. Behaviors which are disruptive to the learning environment will not be tolerated. As your instructors, we are dedicated to establishing a learning environment that promotes diversity of race, culture, gender, sexual orientation, and physical disability. Anyone noticing discriminatory behavior in this class, or feeling discriminated against should bring it to the attention of the instructors or other University personnel as appropriate.
Cheating and Student Conduct:
The instructors of this class take the issue of academic honesty very seriously. You are expected to be honest and ethical in your academic work. There is a “zero tolerance” policy in effect for cheating in this class. Any instance in which a student is caught cheating will be handled in strict accordance with the policies outlined at the following website: http://oregonstate.edu/admin/stucon/achon.htm. In order to provide students with a positive learning environment OSU has adopted a pledge of civility, which can be found at http://osu.orst.edu/admin/stucon/index.htm.

Academic dishonesty is defined as an intentional act of deception in one of the following areas:
- **Cheating** - use or attempted use of unauthorized materials, information or study aids
- **Fabrication** - falsification or invention of any information
- **Assisting** - helping another commit an act of academic dishonesty
- **Tampering** - altering or interfering with evaluation instruments and documents
- **Plagiarism** - representing the words or ideas of another person as one's own

When evidence of academic dishonesty comes to one of the instructor's attention, that instructor will document the incident, permit the accused student to provide an explanation, advise the student of possible penalties, and take action. The instructor may impose any academic penalty up to and including an "F" grade in the course after consulting with her department chair and informing the student of the action taken.

Disability:
Accommodations are collaborative efforts between students, faculty and Services for Students with Disabilities (SSD). Students with accommodations approved through SSD are responsible for contacting the faculty member in charge of the course prior to or during the first week of the term to discuss accommodations. Students who believe they are eligible for accommodations but who have not yet obtained approval should contact SSD (737-4098).

Course Evaluation:

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<td>Average of Individual Homework</td>
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<td>Average of Projects</td>
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<td>Final Exam</td>
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## Course Outline and Assignments

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<tr>
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<td>Apr. 1</td>
<td>Course Introduction &amp; Traffic Calming Techniques</td>
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<td>Apr. 3</td>
<td>Traffic Calming Techniques (continued)</td>
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<td>Bicycles &amp; Pedestrians – Traffic Calming Implications</td>
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<td>Apr. 10</td>
<td>Designing for Pedestrians</td>
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<td>Apr. 15</td>
<td>Designing for Bicycles</td>
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<td></td>
<td>Apr. 17</td>
<td>Pedestrian &amp; Bicycle Safety</td>
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<td>4</td>
<td>Apr. 22</td>
<td>Weaving Calculations</td>
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<td>Apr. 24</td>
<td>Interchange and Freeway Issues</td>
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<td>5</td>
<td>Apr. 29</td>
<td>Interchange and Freeway Issues (continued)</td>
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<td>May 1</td>
<td>Gore Design, Spacing, and Ramp Configuration</td>
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<td>May 6</td>
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<td>May 8</td>
<td>Transit Facilities for Roadways</td>
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<td>Site Design: Parking Design</td>
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<td>Site Design: Parking Design (continued), Designing for Different Users (incl. meeting legal requirements when designing for individuals with disabilities)</td>
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<td>Access Management and Road Hierarchy</td>
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<td>May 22</td>
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<td>Access Management (continued): Techniques and Approaches</td>
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Final Exam Schedule: Thursday, June 12, 2008 from 12:00 noon to 1:50 p.m.

### Grading Scheme:

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<td>78.0 – 79.9</td>
<td>C+</td>
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<td>90.0 – 91.9</td>
<td>A-</td>
<td>72.0 - 78.0</td>
<td>C</td>
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<td>88.0 – 89.9</td>
<td>B+</td>
<td>70.0 – 71.9</td>
<td>C-</td>
</tr>
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<td>82.0 - 88.0</td>
<td>B</td>
<td>60.0 - 69.9</td>
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<tr>
<td>80.0 – 81.9</td>
<td>B-</td>
<td>59.9 or lower</td>
<td>F</td>
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ATTACHMENT #2 – CE 594 Traffic Calming Class Project
Due: Thursday, April 24, 2008 at 2:00 p.m.

Note: For this project the class will divide into two teams (one with 3 members and the other with 4 members). You can select your own teams but everyone must participate on one of the two teams. Once you have defined your team, you should submit a team name and a list of the team members to Dr. Dixon (by no later than Thursday, April 10, 2008).

Your company has been hired to review complaints about traffic problems in a residential area in central Corvallis. The neighborhood is bounded to the west by Kings Blvd., to the east by 11th Street, to the south by the one-way Harrison Blvd., and to the north by Buchanan Avenue. The neighborhood is prone to "cut-through" traffic and high speed conditions. Located in the region of this neighborhood are Corvallis High School, Franklin School and Franklin Park. Residents of the neighborhood have contacted the City of Corvallis to request that traffic be “calmed” by the placement of stop signs at every internal intersection.

Your assignment is to assess the neighborhood for potential ways to calm the traffic and improve the region for the property owners using a means other than saturating the neighborhood with stop signs. In addition, you need to evaluate bicycle and pedestrian access and assure that a safe design addresses all users of the facilities. Where feasible, you may wish to improve or add facilities for pedestrians and bicyclists.

You are expected to perform the following tasks:

1. Using the assessment techniques discussed in class, your project team needs to define the boundaries for your study. Be sure these boundaries are clearly defined in your subsequent project report and you provide justification for why you established the specific improvement boundaries. Note: though the project boundaries may be those described above, often traffic conditions on adjacent streets may have a direct affect on the neighborhood you are studying. You should, therefore, evaluate the region to determine where appropriate project boundaries should be located.

2. Evaluate potential traffic calming strategies for your analysis region. To do this, you will need to discuss in your report the pros and cons of each scenario and unique applications and limitations. Be sure to include legal issues that may arise due to implementation of the devices. These must include, but are not limited to, the following:
   - Speed bumps and undulations (humps),
   - Rumble strips,
   - Diagonal diverters,
   - Intersection cul-de-sac,
- Midblock cul-de-sac,
- Semi-diverter,
- Forced-turn channelization,
- Median barrier,
- Traffic circles,
- Roundabouts,
- Time-based exclusions, and
- Chokers.

3. Evaluate pedestrian facilities throughout the neighborhood. Pay particular attention to access crossing streets. Remember the most vulnerable pedestrian is the child! Where feasible, design pedestrian facilities for the neighborhood.

4. Evaluate existing bicycle and future bicycle access and facilities. Be sure to consider the concept of connectivity as well as cyclist destination. Where feasible, design bicycle facilities for the neighborhood.

5. Prepare a report that addresses all issues you feel are critical to traffic calming, pedestrian access, and bicycle access in the neighborhood. Be sure to include sketches and maps of your planned improvements. At a minimum, you should consider the following items when completing your report:
   - Degree of protection from through traffic,
   - Degree of speed reduction,
   - Obstruction to resident access (creating out-of-the-way travel for residents),
   - Obstruction to internal neighborhood circulation, and
   - Obstruction to emergency and service vehicles.

To acquire information about the neighborhood you should visit the region and evaluate the situation personally. Since it is important to determine the extent of cut-thru traffic and associated speeds, you may wish to perform some car following studies in the neighborhood. The attached map depicts the neighborhood boundaries identified previously.
In-class Bike & Pedestrian Case Study Review

From PEDSAFE, “Bridgeport Way Corridor Improvement” Case Study No. 17, pages 153-155

From PEDSAFE, “Large Intersection Solutions” Case Study No. 19, pages 160-161

From PEDSAFE (review the following two case studies):
1. “Illuminated Crosswalk” Case Study No. 25, pages 174-175
2. “Curb Bulbouts with Bicycle Parking” Case Study No. 51, pages 235-236

From BIKESAFE, “Back-in Diagonal Parking with Bike Lanes” Case Study No. 4, pages 157-163

From BIKESAFE, “Crossing an Arterial through an Offset Intersection: Bicycle-Only Center-Turn Lane” Case Study No. 23, pages 230-231

From BIKESAFE, “Innovative Application of the Bike Box” Case Study No. 26, pages 238-241
ATTACHMENT #4 – CE 594 Shared-Use Path Design Handout
Design of Shared Use Facilities

**Design Speed**

A minimum design speed for bicycle facilities is 20 mph (30 km/h). If a downgrade exceeds 4% or where strong prevailing tailwinds exist, a design speed of 30 mph (50 km/h) or more is recommended.

For unpaved paths (that cause the cyclist to move slower) a lower design speed of 15 mph (25 km/h) may be used. If steep downgrades or strong tailwinds exist at the unpaved path, a design speed of 25 mph (40 km/h) can be used.

**Horizontal Alignment**

Bikes lean when cornering/turning to prevent them from falling outward due to centrifugal force. If a bicyclist leans too far the pedal could strike the ground (generally when lean angle from vertical reaches about 25-degrees). Casual bicyclists generally have a maximum lean of 15 to 20-degrees.

Minimum radius of curvature for a lean angle (assumes operator sits reasonably straight in seat) is computed as (U.S. equation for shown):

\[ R = \frac{0.067 \times V^2}{\tan \theta} \]

Where:
- \( R \) = minimum radius (feet)
- \( V \) = Design Speed (mph)
- \( \theta \) = Lean angle from the vertical (degrees)

When lean angle approaches 20-degrees the minimum curvature becomes a function of the superelevation rate of the pathway surface, coefficient of friction between the bike tires and the surface, and the speed of the bike as follows:

\[ R = \frac{V^2}{15 \times \left( \frac{e}{100} + f \right)} \]

Where:
- \( R \) = minimum radius (feet)
\[ V = \text{Design Speed (mph)} \]
\[ e = \text{Rate of superelevation (\%)} \]
\[ f = \text{Coefficient of friction (for shared use facilities this value ranges from approximately 0.31 at 12 mph (20 km/h) to 0.21 at 30 mph (50 km/h). At unpaved surface locations, reduce friction factors by 50\% to provide a margin of safety.} \]

- ADA/PROWAG require cross slopes that do not exceed 2\%, therefore, assume a 2\% maximum cross slope for shared use paths.

- When transitioning a 2\% superelevation, a minimum of a 25-foot transition distance is required between end and beginning of consecutive and reversing horizontal curves.

- If unpaved, friction factors are assumed to be reduced by 50\% to allow a sufficient margin of safety.

- Table 1 assumes a 15-degree lean (using first equation), and Table 2 assumes a 20\% lean and a 2-degree superelevation.

- When a 20-degree lean angle is used, more horizontal space will be taken up by bicyclist so more width needs to be provided.

**Vertical Alignment**

- Grades >5\% are undesirable due to difficulty in climbing and increased descent speeds.

- If necessary to exceed 5\% for short distances, lengths of grades should be restricted to:

<table>
<thead>
<tr>
<th>Grade (%)</th>
<th>Maximum Length (feet)</th>
</tr>
</thead>
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<tr>
<td>5% to 6%</td>
<td>For up to 800'</td>
</tr>
<tr>
<td>7%</td>
<td>For up to 400'</td>
</tr>
<tr>
<td>8%</td>
<td>For up to 300'</td>
</tr>
<tr>
<td>9%</td>
<td>For up to 200'</td>
</tr>
<tr>
<td>10%</td>
<td>For up to 100'</td>
</tr>
<tr>
<td>11+%</td>
<td>For up to 50'</td>
</tr>
</tbody>
</table>

- If crushed stone or unpaved surfaces are used, grades steeper than 3\% are not practical.

- How can excessive grades be mitigated?
  - When using a longer grade, an additional 4' to 6' of width should be considered to permit the slower speed bicyclist to dismount and walk
  - Provide warning signs alerting bicyclists of maximum percent of grade
  - Exceed minimum stopping sight distances
  - Exceed minimum horizontal clearances, recovery area and/or protective bike rails
✓ When possible, use wider path and a series of short switchbacks to help contain the speed of descending bicyclists

**Sight Distance**

- The sight distance is the distance required to bring bicycle to a full controlled stop. This value is a function of:
  - Bicyclist's perception and brake reaction time (often assumed 2.5 seconds)
  - Initial Speed
  - Coefficient of friction between tires and pavement (0.25 often assumed for wet conditions)
  - Braking ability of the bicycle

- The sight distance in the descending direction will control the design (negative grade)

- Table 3 is based on an eye height of 4.5-feet and an object height of 0.0-feet

- Table 4 indicates minimum clearance for lines of obstruction on horizontal curves

- Lateral clearances on horizontal curves should be calculated based on the sum of the stopping sight distances for bicyclists traveling in opposing directions around the curve. If not possible, the path should be widened, have a yellow center line stripe installed, and a "CURVE AHEAD" warning sign constructed on both ends of the curve.
ATTACHMENT #5 – CE 594 Bicycle Facilities Handout
Types of Bicycle Facilities

- Shared Lane -- shared motor vehicle/bicycle use of a "standard" width travel lane
- Wide Outside Lane -- an outside travel lane with a width of at least 14 feet (4.2 meters)
- Bicycle Lane -- a portion of the roadway designated by striping, signing, and/or pavement markings for preferential or exclusive use of bicycles
- Shoulder -- a paved portion of the roadway to the right of the edge stripe designed to serve bicyclists
- Separate Shared Use Path -- a bikeway physically separated from motorized vehicular traffic
- Shared use paths may be used by pedestrians, skaters, wheelchair users, joggers and other non-motorized users.
Figure 13-5. Preemption of walkway width. (Source: Adapted from Ref. 4)
Figure 24. Bike Left-Turn Lane

NOTE:
A bicycle sensitive loop detector is necessary for signalized intersections.
Figure 25. Typical Bicycle/Auto Movement at Intersections of Multilane Streets
ATTACHMENT #6 – CE 594 General Pedestrian Facility Overheads/Notes
Parallel parking.

Pedestrian sight distance and parking restriction needed for

**Figure 9-4.** Pedestrian sight distance and parking restriction needed for parallel parking.
FIGURE 9-6. Pedestrian sight distance and parking restrictions.
Figure 9-7: Pedestrian vision distance and parking restrictions needed for 60 degree angle parking.
EXHIBIT 11-B. PEDESTRIAN WALKWAY LOS

LOS A
Pedestrian Space > 60 ft²/π  Flow Rate ≤ 5 p/min/ft
At a walkway LOS A, pedestrians move in desired paths without altering their movements in response to other pedestrians. Walking speeds are freely selected, and conflicts between pedestrians are unlikely.

LOS B
Pedestrian Space > 40-60 ft²/π  Flow Rate > 5-7 p/min/ft
At LOS B, there is sufficient area for pedestrians to select walking speeds freely, to bypass other pedestrians, and to avoid crossing conflicts. At this level, pedestrians begin to be aware of other pedestrians, and to respond to their presence when selecting a walking path.

LOS C
Pedestrian Space > 24-40 ft²/π  Flow Rate > 7-10 p/min/ft
At LOS C, space is sufficient for normal walking speeds, and for bypassing other pedestrians in primarily unidirectional streams. Reverse-direction or crossing movements can cause minor conflicts, and speeds and flow rate are somewhat lower.

LOS D
Pedestrian Space > 15-24 ft²/π  Flow Rate > 10-15 p/min/ft
At LOS D, freedom to select individual walking speed and to bypass other pedestrians is restricted. Crossing or reverse-flow movements face a high probability of conflict, requiring frequent changes in speed and position. The LOS provides reasonably fluid flow, but friction and interaction between pedestrians is likely.

LOS E
Pedestrian Space > 8-15 ft²/π  Flow Rate > 15-23 p/min/ft
At LOS E, virtually all pedestrians restrict their normal walking speed, frequently adjusting their gait. At the lower range, forward movement is possible only by shuffling. Space is not sufficient for passing slower pedestrians. Cross- or reverse-flow movements are possible only with extreme difficulties. Design volumes approach the limit of walkway capacity, with stoppages and interruptions to flow.

LOS F
Pedestrian Space ≤ 8 ft²/π  Flow Rate varies p/min/ft
At LOS F, all walking speeds are severely restricted, and forward progress is made only by shuffling. There is frequent, unavoidable contact with other pedestrians. Cross- and reverse-flow movements are virtually impossible. Flow is sporadic and unstable. Space is more characteristic of queued pedestrians than of moving pedestrian streams.

Source: Adapted from Fruin (2).
ATTACHMENT #7 – CE 594 Pedestrian Capacity Notes
Types of Pedestrian Facilities

- Walkways and sidewalks: facilities designated exclusively for pedestrians

- Pedestrian Queuing Areas: areas where pedestrians stand temporarily while waiting to be served

- Shared off-street paths: paths physically separated from street traffic. These paths are for pedestrians, bicycles, skateboards, and other non-motorized traffic

- Pedestrian crosswalks: pedestrian crossings at signalized and unsignalized locations

Pedestrian Capacity Terminology

- Pedestrian speed (ft/sec)
- Pedestrian flow rate (p/15 min) or (p/min)
- Pedestrian flow per unit of width (p/min/ft)
- Pedestrian density (p/ft²)
- Pedestrian space (ft²/p)
- Platoon

Pedestrian Walking Speed

0% to 20% elderly: 4.0 ft/s

> 20% elderly: 3.0 ft/s (p. 11-4) or 3.3 ft/s (p. 18-1 of handout)

Uphill grades: reduces speed by 0.5 ft/s (p. 11-4) or 0.3 ft/s (p. 18-1 of handout)
Level of Service (LOS) Notes

- Impeded flow on walkways starts at 530 ft²/p (or roughly 0.5 p/min/ft)

- A capacity of 23 p/min/ft (or 1,380 p/h/ft) is a reasonable value for a pedestrian facility

- Speed is a good indicator of LOS. At speeds of 150 ft/min or less, most pedestrians resort to an unnatural shuffling gait

- Good LOS maintains flow in the minor direction when opposed by a major pedestrian flow

- LOS in platoons is generally one level lower than the average flow criteria (except for LOS A and E which have a wide range of pedestrian flow rates)

Street Corner Time-Space Evaluation

Time-space -- the available time and space for circulation and queuing in the intersection corner during an analysis period

Holding-Area Waiting Times -- the average amount of time a pedestrian must wait at the intersection due to traffic signal delays
Exam Questions included on the Mid-Term and/or Final

**Problem:**

A. Calculate the **required** stopping sight distance for a shared use facility with a design speed of 20 mph, coefficient of friction equal to 0.22, and grade of -2.7%.

B. Calculate the **available** stopping sight distance for a shared use facility with a 110’ long parabolic vertical curve with an approach grade of +1.2% and a departure grade of -2.1%.

C. Calculate the minimum length of a crest vertical curve on a shared use facility with an approach grade of -0.9% and a departure grade of -4.3% if the required stopping sight distance is 250 feet. [Do not forget that the algebraic difference is always a positive value!]

**Problem:**

In class we reviewed several bicycle and pedestrian case studies perceived as “innovative” treatments. One of these case studies discussed a specific application of back-in diagonal parking with bike lanes. Describe the circumstances of the study site (why a unique treatment was needed), the tested treatment configuration, the purpose for using this type of treatment, and the perceived results.

**Problem:**

Your consulting firm has been asked to design a shared use path (for non-motorized vehicles) that is located in a region with periodic extreme terrain. On average the slope of the facility ranges from 4% up to 8%. At locations where there are excessive grades (too steep), you should design mitigation strategies to help accommodate the excessive grades. In class we specifically reviewed five common mitigation strategies for excessive grades. List four of these techniques:

1. __________________________________________
2. __________________________________________
3. __________________________________________
4. __________________________________________
ATTACHMENT #9 – CE 594 “Movie” Created for Web Site – Example Images

Note: This animated bicycle safety movie was created using Adobe Flash and is provided as a flash movie. This requires a reader already available on BlackBoard so this can be directly used on a class website as a supplemental educational tool.
Bicycle Crash Types

Motorist Fails to Yield

Motorist drives through a red light or stop sign without stopping. Motorist could be speeding and unable to stop in time, trying to get through on a yellow, disregarding this signal, or failing to see the signal.
Some General Countermeasures

- Add/Improve Intersection Markings
- Improve Intersection Sight Distance
- Improve Pavement Markings
- Provide Motorist or Bicyclist Education
- Provide Law Enforcement

Motorist Drives Out Midblock: Motorist typically pulls out of a driveway or alleyway and fails to yield to a bicycle located along the roadway or a parallel path or sidewalk. Two thirds of these types of crashes involve a bicyclist riding in the wrong direction.
Some General Countermeasures

- Make Parking Improvements to Increase Sight Distance
- Make Driveway Improvements
- Provide Intersection Treatments for Shared-Use Paths Adjacent to Roadway
- Provide Motorist or Bicyclist Education
- Make Sign Improvements

Motorist Turned or Merged Right into Path of Bicyclist: Motorist turns into the path of a bicyclist traveling in the same direction or hits a bike riding against traffic. This crash type can involve motorists pulling into parking spaces, bus or delivery vehicle pull-overs, or motorists making right turns on red.
Some General Countermeasures

- Reduce Lane Width to Encourage Bicyclists to Take Ownership of Lane (only in low speed areas)
- Provide Bike Lanes or Paved Shoulders
- Implement Turning Restrictions
- Improve Pavement Markings and Signs
- Provide Path Intersection Treatments for Shared-Use Paths Adjacent to the Roadway
- Provide Law Enforcement
- Provide Motorist and/or Bicyclist Education

Non-Motor Vehicle Crashes: Crashes that do not involve motor vehicles and can occur in various ways, including falls from a bike, a collision between two bicycles, a collision between a bike and a pedestrian, or a bicyclist striking an object.
Some General Countermeasures

- Make Roadway Surface Hazard Improvements
- Perform Repetitive and Short-Term Maintenance
- Perform Major Maintenance
- Provide Bicyclist Education
- Institute a Hazard Identification Program