Lesson 2
Module 2-2: Fundamentals of Intersection Control and Signal Timing

Objectives:

- Familiarize students with the basic terminologies and concepts of signalized intersections.
- Formally introduce the advantages and disadvantage of the various levels of intersection control.
- Enable student to approximate an appropriate signal timing plan for a single signalized intersection.
- Make student are of the various factors that may affect the signal timing plan a signalized intersection.

Tasks

Quick Recap:

What is transportation?
What is transportation engineering?

Fundamental Terminologies and Concepts

In this portion of this module the instructor will present the following notes, terms and concepts in a creative an informative format. It is recommended and encouraged that the instructions during this portion of the module is supplemented by a handout created from the definitions of the concepts and terminologies presented below.

The Hierarchy of Intersection Control

Level I
Basic road rule - In the absence of control devices the driver on the left must yield to the driver on the right when the vehicle on the right is approaching in a manner that may create an impending hazard.

Level II
Yield and Stop Control – if under Level I control the intersection is unsafe to traverse, some form of Level II control may be used to control the intersection. Forms of this level of signal control include the use of:

- Yield signs
- Two-way stop control
- Four-way stop control

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Factors that may determine whether or not it is appropriate to use this level of control include (Students will be asked to suggest some of these factors):

- high speed roadway
- restricted view of entire intersection
- crash records / number of accidents
- minor street entering (busy) through highway / street
- allow major road with presumed right of way to maintain it given safe operating conditions
- maintain safe operations during merges

**Level III**  Traffic Control Signals – ultimate form of traffic control, assign right-of-way to specifics movements to prevent, reducing the number of conflicting movements. In other words, traffic signals allot right-of-way for vehicles with conflicting movements over time and space.

Factors that may determine whether or not it is appropriate to use this level of control include (Students will be asked to suggest some of these factors):

- all of the above but more severe
- pedestrian volume
- nearby facilities (school, elderly home)
- Crash experience
- Road network and coordinated signalization

**Advantages of Level-III control**
- provide orderly traffic movement
- increase traffic handling capacity of the intersection
- reduce the frequency and severity of certain types of crashes
- they can be coordinated to provide continuous or nearly continuous movement at a definite speed
- they are used to interrupt heavy traffic at intervals to permit other traffic, vehicular or pedestrian, to cross

**Disadvantages of Level-III control**
- excessive delay
- excessive disobedience of the signal indications
- increase use of less adequate routes
- significant increase in the frequency of (rear-end) collisions

**Signalize Intersection Fundamentals**

In this section students will be asked to call upon their experience from the previous day to formulate the definitions of key terms when dealing with a signalized intersection – specifically the components of a cycle.
Terms

Definitions

Cycle
a complete rotation through all of the indications provided ... in our case red → green → yellow → red

Cycle length
the time, in seconds, that is takes to complete one full cycle of all the indications provided

Cycle Components

- **Green** Color → green – movements that have a green light during this interval are allowed. (all other conflicting movements have red indications)
- **Change** Color → yellow – let the drivers on a particular approach realize that they are about to lose the green, it also allows a vehicle that cannot stop safely when the green is withdrawn to legally enter the intersection.
- **Clearance** Color → red (all) – vehicles on each approach are not allowed to enter the intersection but those vehicles that enter the intersection on yellow are allowed to go through before conflicting flows are released
- **Red** Color → red – to prohibit particular movements while other conflicting movements are allowed

Phase
a dedicated movement or sets of movement to flow and safely stopped before the release of conflicting movements at an intersection.

Interval
a period of time during which no signal indication changes

The following exercises are meant to aid in the comprehension of the above terminologies and concepts. The primary method employed to deliver the following exercise is to have the instructor lead a highly interactive discussion, soliciting responses from as many students as possible.

Tasks:

**Question:** How many intervals are there in a two phase cycle?

**Answer:** See below

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Questions: How do traffic engineers how much green time to give a particular phase?

What factors do you think affect the way traffic engineers determine the amount green time to give a particular phase?

Answer (ideally give by Students):

Volume
Speed
Roadway Geometry / topography
Time of day
Queue Length
Distance between intersections

Instructors will prod the student to remember the exercise from the previous day and figure out what is the better criteria to use to calculate the length of the green interval. Instructor will try to solicit from the students that VOLUME is often times the better way to distribute the green time. (The instance of having unequal volume from the previous day’s lesson)

After ensuring that the students understand the above fundamentals, the following section is geared towards instructing and providing students with what is necessary to calculate/determine appropriate signal timings plans for a give circumstance. The first step will have the instructor walk through “Example 1” and explain the 5-step process involved in signal timing plan calculations. Afterwards the associated handout will be given to students for additional practice and reinforcement of the 5-step process for calculations involved in signal timing plans.

Sample Calculation:

<http://www.freeclipartnow.com/transportation/traffic-lights/traffic-light-all.jpg.html>
Example 1:
Consider the following intersection and develop an appropriate signal timing plan given the following information

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Cycle length</td>
<td>60 sec</td>
</tr>
<tr>
<td>Yellow Period</td>
<td>4 sec</td>
</tr>
<tr>
<td>All-Red Period</td>
<td>1 sec</td>
</tr>
</tbody>
</table>

Step 1
Determine the critical lane volume for each direction and the total critical volume.

\[

cv_{EW} = 300 \text{ veh/hr} \\
cv_{NS} = 600 \text{ veh/hr} \\
cv_{TOT} = 900 \text{ veh/hr}
\]

Step 2
Equate the sum of color periods to the cycle length.

E-W - R_{EW} + G_{EW} + Y_{EW} + A_{EW} = 60 sec
N-S - R_{NS} + G_{NS} + Y_{NS} + A_{NS} = 60 sec

\[
G_{EW} + Y_{EW} + A_{EW} + G_{NS} + Y_{NS} + A_{NS} = 60 \text{ sec}
\]

Step 3
Determine the proportion of cycle length to be allotted to each phase/direction (Calculate the length of the green period for each phase/direction)

\[
G = \frac{CV}{CV} \times CL
\]
\[
G_{EW} = \frac{CV_{EW}}{CV_{TOT}} \times CL \Rightarrow \frac{300 \text{veh/hr}}{900 \text{veh/hr}} \times 60 \text{s} = 20 \text{sec}
\]

\[
G_{NS} = \frac{CV_{NS}}{CV_{TOT}} \times CL \Rightarrow \frac{600 \text{veh/hr}}{900 \text{veh/hr}} \times 60 \text{s} = 40 \text{sec}
\]

**Step 4**
Determine the length of the red period using the equations from Step 2

E-W - \( R_{EW} + G_{EW} + Y_{EW} + AR_{EW} = 60 \text{ sec} \)

\[-\]

--- + 20 + 4 + 1 = 60 sec

Therefore: \( R_{EW} = 35 \text{ sec} \)

N-S - \( R_{NS} + G_{NS} + Y_{NS} + AR_{NS} = 60 \text{ sec} \)

\[-\]

--- + 40 + 4 + 1 = 60 sec

Therefore: \( R_{NS} = 15 \text{ sec} \)

**Step 5**
Draw a phase timing diagram to double check results

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Note:
See lesson overview page for PDF for “Exercises in Determining Appropriate Signal Timing Plans”