CE 3201 – Solution to Recitation #2

Braking Distance and Signal Timing

Later in the semester we will work on a project involving the timing of an intersection's traffic signal. Today what we want to look at is how braking distance models are used to determine the yellow (clearance) intervals in a signal timing plan.

A vehicle is travelling at 40 mph and approaching a signalized intersection when the traffic light changes to yellow. The duration of the yellow interval is 3.0 seconds, the driver has a perception/reaction time equal to 1.0 seconds and, when braking, decelerates at a constant rate of 10.0 feet/sec^2.

** **Remember:** When any changes to driving (accelerating/braking) occurs, there is likely a Perception/Reaction Time that needs to be accounted for!

(1) What is the shortest distance the vehicle can be from the intersection and still stop without encroaching on the cross-street? Call this distance d_s.

d1 (for perception reaction) = (58.7)(1.0) = 58.7 ft

d2 (for braking distances) = $(58.7)^2/[2(32.2)((10/32.2) \pm 0)]$ = 172 ft

d1 + d2 = 231 ft

d_s = 231.0 ft.

(2) Now suppose the vehicle is 15 feet long, and the width of the cross-street is 25 feet. What is the farthest distance the vehicle can be from the intersection when the light changes to yellow and still completely clear the intersection before the light changes to red, without accelerating? Call this distance d_c.

Let W = cross-street width, L = vehicle length, t= duration of yellow interval. To successfully clear the intersection d_c must satisfy $W+L+d_c=V_1t$. So,

$d_c = V_1t-W-L$= (58.7)(3.0)-25-15 = 136.1 ft.

** There is no Perception/Reaction Time for this case, as speed stays constant

d_c = 136.1 ft.

(3) When $d_c < d_s$, traffic engineers call the area between d_c and d_s the *dilemma zone.* Suppose the vehicle's front end is exactly in the middle of the dilemma zone when the light changes to yellow. What is the minimum acceleration needed to clear the intersection before the light changes to red? (Assume that the driver's acceleration reaction time is 0.5 seconds)

Midpoint of dilemma zone = (231.0 +136.1)/2 = 183.6 feet from start of cross-street.

Additional distance needed to clear intersection = W+L = 25+15 = 40 feet
Distance covered during reaction time = (0.5)(58.7) = 29.4 feet
So the driver must cover 183.6 + 40 - 29.4 = 194.2 feet, in 3.0 - (0.5) = 2.5 seconds to clear the intersection before the signal turns red. Using

$d = V_1 t + at^2/2 \Rightarrow a = (d - V_1 t) / (t^2/2) = (194.2 - (58.7)(2.5)) / ((2.5)^2/2) =$

** Perception/Reaction Time is applicable here

a = 15.2 ft/s^2

(4) What yellow interval would eliminate the dilemma zone by making $d_c = d_s$?

Remember: d_s is a constant value, as there is no time (t) involved that could be affected by increasing the yellow time.

$d_c = d_s$
$V_1 t - W - L = V_1 t_r + V_1^2/(2a)$
$t = t_r + (W+L)/V_1 + V_1/(2a) = (1.0) + (40/58.7) + (58.7)/[2(10)]$

t = 4.6 seconds (We would use t= 5.0 seconds in our timing.)