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Traffic Light Problem

1. Problem Statement

When driving to an intersection, all cars go at the speed limit. If the driver wants to continue through the intersection when the light is yellow, they must be able to make it through the intersection while maintaining the speed limit before the light turns to red. If the driver wants to stop, they must be able to stop before reaching the intersection. The goal is to define the necessary variables and utilize them to evaluate a general formula for how long the traffic light needs to stay yellow for.

2. Process:

Our first attempt involved us assuming a lot of different variables and assigning values to everything. We assumed the speed limit was 15 meters per second, that the acceleration while braking was -3 meters per second, and also assigned a length to the intersection. We didn't realize we were supposed to use variables instead of values.

On our second attempt, we created variables for essentially everything, including speed limit (L), acceleration while braking (B), the length the car travels while slowing down to zero m/s (Z), and the length of the intersection (Q). We solved the general formula for how long the traffic light should be yellow, and realized that we get two values for the time, one for how long the car takes to slow down and one for how long it takes for the car to get through the go zone and the intersection. We found that the time for the yellow light must be the max of these two values.

On our third attempt, we added two new values, the length of the car (q) and the reaction time of the driver (R). We solved it out again, but realized that the variable names made it hard to explain to an outside viewer.

On our fourth attempt we used subscripts instead of random letters. For example, L became S_{limit}, R became T_{react}, C became $L_{interesect}$, and more.

In our fifth attempt we further refined it by using V and X as our variables instead of S and L respectively.

3. Solution:

    a. We defined the go zone as everything building up to the light from a point and the stop zone as everything before the go zone. If the front of the car is in the go zone when the light turns yellow, they are allowed to continue driving through the intersection. If the front of the car isn't in the go zone (in the stop zone), they must stop before reaching the intersection.

    b. We defined the speed limit (V_{limit}), braking acceleration (a_{brake}), go zone distance (x_{go}), intersection length ($x_{intersect}$), car length (x_{car}), and reaction time (T_{react}) were all important variables to identify. This is because all the cars' speeds are defined by the speed limit, the braking acceleration needs to be known in order to calculate how long it takes for the car to stop, the go zone distance to know how big the go zone is in order to define how much time the car would take if passing the yellow light, car length because the car still needs to pass its own length in

order to pass the intersection, and reaction time in order to account for the time it takes for a driver to press the brake after seeing the yellow light.

X_{go} = Length (in meters) of the go zone
$X_{intersect}$ = Length (in meters) of the intersect
X_{car} = Length (in meters) of the car
V_{limit} = Speed Limit
T_{React} = Reaction time
T_{yellow} = Time of yellow Light
A_{brake} = Deceleration

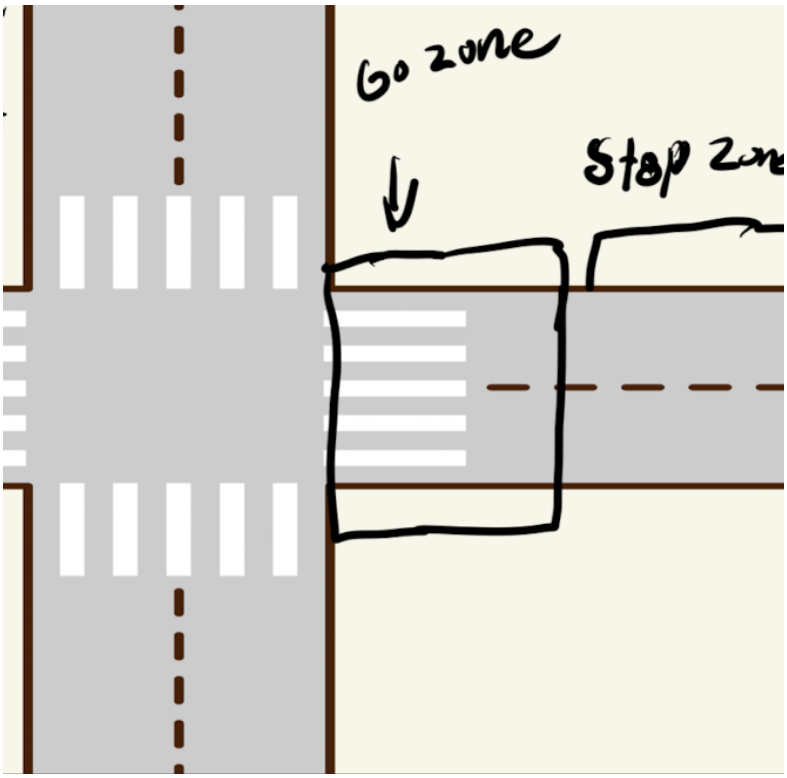
Final Equation

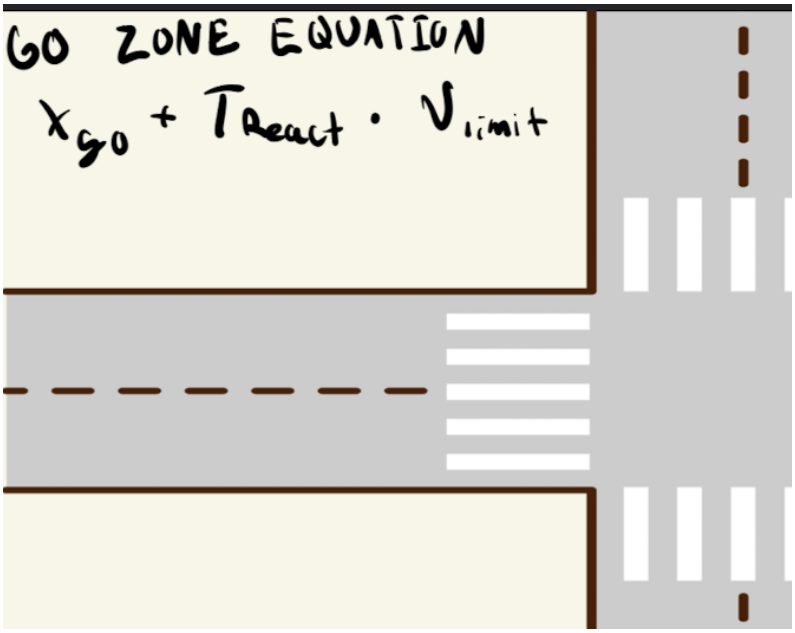
$$\frac{X_{go} + X_{Intersect} + X_{car}}{V_{limit}} + T_{React} \leq T_{yellow}$$

And

$$\frac{-V_{limit}}{A_{brake}} + T_{React} \leq T_{yellow}$$

***Both Conditions Must be Met**





Discussion Questions:

a. For us, the length of the GO zone needed to be long enough such that the car can slow down to 0 m/s from the speed limit within the zone. The STOP zone wasn't relevant to

our model. If the GO zone didn't meet its requirement, it would lead to cars ending up in the intersection, interfering with the traffic because the car couldn't slow down in time.

b.

i. Would make the required yellow light time smaller. It would also make the GO zone larger. It does this through the V_{limit} variable.

ii. If a driver exceeded the speed limit, the GO zone becomes bigger and the yellow light time becomes longer. This happens through the a_{break} variable, as the car wheels would have less friction.

iii. If a driver was driving a truck instead of a car, the yellow light time would increase. It does this through the X_{car} variable.

iv. If a driver was distracted, that would make the GO zone longer, which makes the yellow light time increase. It does this through the T_{react} variable.

c. No it wouldn't be for a plethora of reasons. Firstly, it would encourage drivers to look at the road instead of the light. Also, it would make it more probable that drivers would speed up above the speed limit in order to reach the GO zone in time before the yellow light. This would be dangerous.

d. The timer showing how much time is left before a red light was a bad idea because it would incentivize drivers to go faster to try and make the yellow light before it turns to red, using their own judgement instead of how much time they actually have. This would cause multiple people to exceed the speed limit, while the light is only working in terms of the "ideal" scenario, causing people to not make the yellow light to exceed the GO zone upon stopping, as they could not reach a full stop in time.