Traffic Engineering, 4th Edition
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Solutions to Problems in Chapter 2

Problem 2-1

The driver continues to travel at 60 mi/h while taking his foot from the accelerator to the brake. Therefore, the vehicle will travel:

$$d_r = 1.47\,S\,t = 1.47 * 60 * 3.5 = 308.7 \;\; ft$$

before the driver's foot hits the brake.

Problem 2-2

When the driver first sees the overturned truck, he will continue to move at 65 mi/h during his reaction time. During this time, the vehicle will travel 1.47*65*t feet, or 95.5t ft. Thus, the distance available for braking is 350 – 95.5t feet. This is the distance that is available for deceleration before the vehicle hits the overturned truck. The formula for braking distance is:

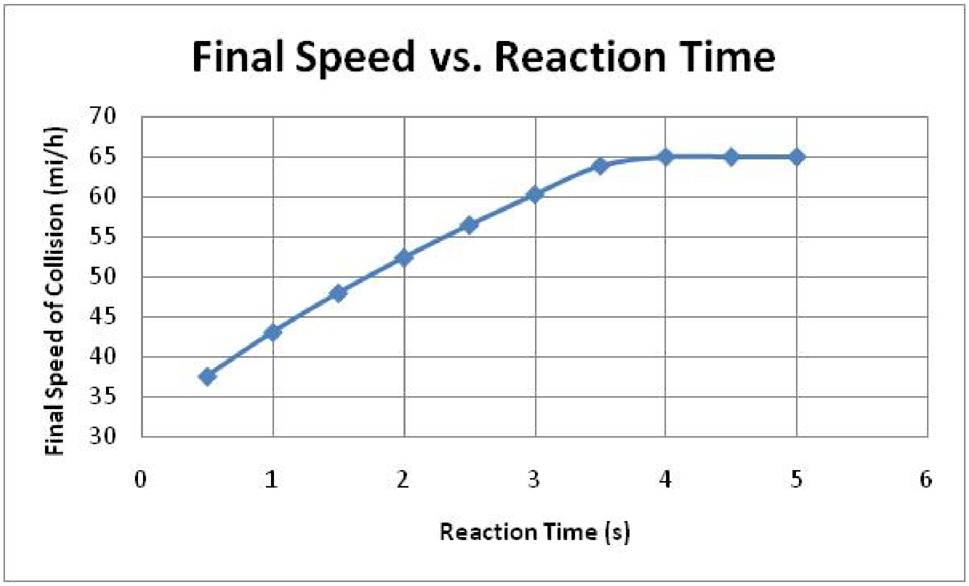
$$d_b = \frac{S_i^2 - S_f^2}{30(F \pm 0.01G)}$$

In this case, the initial speed (S_i) is 65 mi/h. The friction factor, F, is related to the deceleration rate, and is computed by dividing the deceleration rate by the deceleration rate due to gravity, or 10/32.2 = 0.31. The grade is level, i.e., G = 0. The braking distance is 350 – 95.5t. Therefore:

$$350 - 95.5t = \frac{65^2 - S_f^2}{30(0.31)} = \frac{4225 - S_f^2}{9.3}$$

This equation is solved for various values of t from 0.50 to 5.00 s. Note that at the point where the reaction distance becomes more than 350 ft, the final speed is a constant 60 mi/h, and the braking distance is essentially "0."

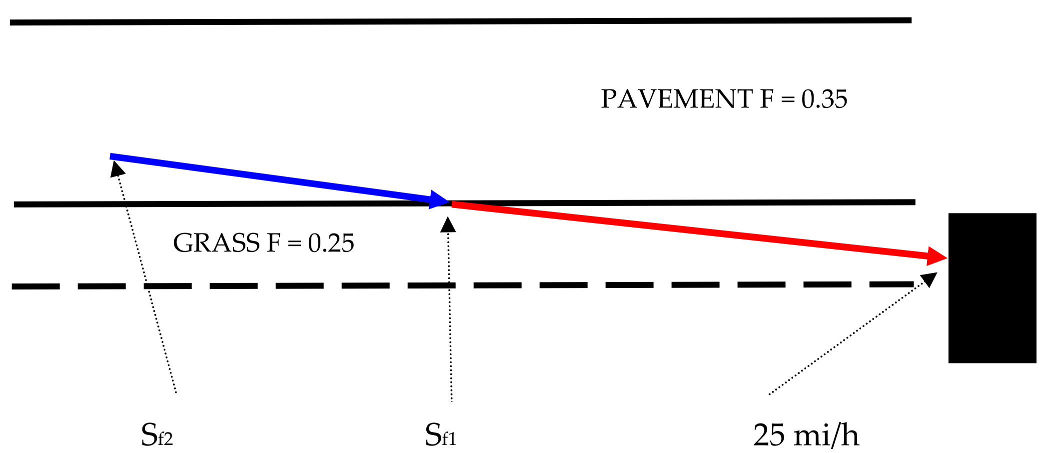
Reaction Time (s)	Reaction Distance (ft)	Braking Distance (ft)	Final Speed (mi/h)
0.5	47.8	302.2	37.6
1.0	95.6	254.5	43.1
1.5	143.3	206.7	48.0
2.0	191.1	158.9	52.4
2.5	238.9	111.1	56.5
3.0	286.7	63.4	60.3
3.5	334.4	15.6	63.9
4.0	382.2	0.0	65.0
4.5	430.0	0.0	65.0
5.0	477.8	0.0	65.0



The vehicle is going to hit the overturned truck in any event. For reaction times over approximately 3.75 s, the vehicle will hit the truck at full speed, 60 mi/h.

Problem 2-3

This problem involves only the braking distance, which is assumed to be the same as the length of the measured skid marks. The speed at the collision point is estimated to be 25 mi/h. Working backwards, we can estimate the speed at the beginning of the grass skid, and then the speed at the beginning of the pavement skid, as illustrated below:



The braking distance formula has two speeds. Thus, the computation starts with the grass skid, for which we have an estimate of the final speed, 25 mi/h. Then:

$$d_b = 250 = \frac{S_{f1}^2 - 25^2}{30(0.25 + 0.03)}$$

$$S_{f1}^2 = (250 * 30 * 0.28) + 25^2 = 2100 + 625 = 2725$$

$$S_{f1} = 52.2 \ mi/h$$

This is the speed at which the grass skid started; it is also the speed at which the pavement skid ended. Now, considering the pavement skid:

$$d_b = 120 = \frac{S_{f2}^2 - 52.2^2}{30(0.35 + 0.03)}$$

$$S_{f2}^2 = (120 * 30 * 0.38) + 52.2^2 = 1368 + 2725 = 4093$$

$$S_{f2} = 64.0 \ mi/h$$

Thus, when the skid began, the vehicle was traveling at 64 mi/h.

Problem 2-4

The total deceleration distance must be evaluated to answer this question. It is the sum of the reaction distance and the braking distance, such that:

$$d = d_r + d_b = 1.47\,t\,S + \frac{S^2}{30(F \pm 0.01G)}$$

In this case, the reaction time, t, is the AASHTO standard, or 2. 5 s. The friction factor, F, is based upon the standard AASHTO deceleration rate of 11.2 ft/s^2 (F = 11.2/32.2 = 0.348) and the deceleration is given as 60 mi'h to 40 mi/h. Then:

$$d = (1.47 * 2.5 * 40) + \frac{60^2 - 40^2}{30 * 0.348} = 220.5 + 191.6 = 412.1 \quad ft$$

Because the sign may be seen from 120 ft away, the sign should be placed *AT LEAST* 412.1-120 = 292.1 ft before the curve.

Problem 2-5

The "yellow" signal must be long enough to allow a vehicle that cannot safely stop before crossing the intersection line to proceed to enter the intersection at their ambient approach speed (40 mi/h). Thus, the last vehicle that should be allowed to enter the intersection during the "yellow" should have been one safe stopping distance away when the "yellow" was initiated. The safe stopping distance for this case is:

$$d = (1.47 * 40 * 1.0) + \frac{40^2}{30\,(0.348 - 0.02)} = 58.8 + 162.6 = 221.4 \quad ft$$

At 40 mi/h, it would take a vehicle:

$$\frac{221.4}{40 * 1.47} = 3.77 \quad s$$

to traverse the safe stopping distance. This should be the length of the subject "yellow" interval.

Problem 2-6

The safe stopping distance is:

$$d = (1.47 * 80 * 2.5) + \frac{80^2}{30(0.348 - 0.03)} = 294.0 + 670.8 = 964.9 \ \ ft$$

Note that the standard AASHTO values for reaction time (2.5 s) and friction factor (0.348) are used.

Problem 2-7

The minimum radius of curvature is found as:

$$R = \frac{S^2}{15(0.01e + f)} = \frac{70^2}{15(0.06 + 0.10)} = \frac{4900}{15 * 0.16} = 2{,}041.7 \ \ ft$$