1. A driver takes 3.5 s to react to a complex situation while traveling at a speed of 60 mi/h. How far does the vehicle travel before the driver initiates a physical response to the situation (i.e., putting his or her foot on the brake)?

   Solution:

$$d_r = 1.47 * S * t = 1.47 * 60 * 3.5 \text{ (ft)} = 308.7 \text{ (ft)}$$

2. A driver traveling at 65 mi/h rounds a curve on a level grade to see a truck overturned across the roadway at a distance of 350 ft. If the driver is able to decelerate at a rate of 10 ft/s^2, at what speed will the vehicle hit the truck? Plot the result for reaction time ranging from 0.50 to 5.00 s in increments of 0.5 s. Comment on the results.

   Solution:

   $d_r = 1.47 * S * t$

   $d_b = 1.075 * S^2 / a$

   $d = d_r + d_b$

t/s	S/(mi/h)	d_r/ft	a/(ft/s^2)	d_b/ft	d/ft
0.50	65	47.775	10	454.1875	501.9625
1.00	65	95.55	10	454.1875	549.7375
1.50	65	143.325	10	454.1875	597.5125
2.00	65	191.1	10	454.1875	645.2875
2.50	65	238.875	10	454.1875	693.0625
3.00	65	286.65	10	454.1875	740.8375
3.50	65	334.425	10	454.1875	788.6125
4.00	65	382.2	10	454.1875	836.3875
4.50	65	429.975	10	454.1875	884.1625
5.00	65	477.75	10	454.1875	931.9375

Comment: No matter what the reaction time is, the driver traveling at 65 mi/h will hit the truck. Moreover, the brake distance (d_b=454.1875ft) is more than 350 ft.

t/s	S/(mi/h)	d_r/ft	a/(ft/s^2)	d_b/ft	d/ft
0.50	53.74349	39.50146	10	310.499	350.0004
1.00	50.63071	74.42714	10	275.5729	350
1.50	47.71828	105.2188	10	244.7812	350
2.00	45.00099	132.3029	10	217.6971	350
2.50	42.47196	156.0844	10	193.9157	350.0001
3.00	40.12286	176.9418	10	173.0582	350
3.50	37.9444	195.2239	10	154.7761	350
4.00	35.92654	211.248	10	138.752	350
4.50	34.05886	225.2994	10	124.7006	350
5.00	32.33087	237.6319	10	112.3681	350

Comment: The larger the reaction time is, the smaller the initial speed is and the smaller the brake distance is. It is important to travel under the limited speed. Drugs or alcohol will enlarge the reaction time to cause more accidents.

3. A car hits a tree at an estimated speed of 25 mi/h on a 3% upgrade. If skid marks of 120 ft are observed on dry pavement (F=0.35) followed by 250 ft (F=0.25) on a grass-stabilized shoulder, estimate the initial speed of the vehicle just before the pavement skid began.

Solution:

$$d_b(shoulder) = \frac{S^2(\text{shoulder}) - S^2(\text{hit})}{30(\text{F(shoulder)} + 0.01\text{G})}$$

$$S^2(shouler) = 250 * 30 * (0.25 + 0.03) + 25 * 25(\text{mi/h})^2 = 2725\ (\text{mi/h})^2$$

$$d_b(pavement) = \frac{S^2(\text{pavement}) - S^2(\text{shoulder})}{30(\text{F(pavement)} + 0.01\text{G})}$$

$$\text{S(pavement)} = \sqrt{120 * 30 * (0.35 + 0.03) + 2725} = 63.98\ (mi/h)$$

4. How long should the "yellow" signal be for vehicles approaching a traffic signal on a 2% downgrade at a speed of 40 mi/h? Use a standard reaction time of 1.0 s and the standard AASHTO deceleration rate.

Solution:

$$\text{t(yellow)} = \text{t} + \frac{S}{15(0.348-0.01\text{G})*1.47} = 1.0 + \frac{40}{15*(0.348-0.01*2)*1.47}\ \text{s} = 6.53\ \text{(s)}$$

5. What minimum radius of curvature may be designed for safe operation of vehicles at 70 mi/h if the maximum rate of superelevation (e) is 6% and the maximum coefficient of side friction (f) is 0.10?

Solution:

$$R = \frac{S^2}{15(0.01\text{e}+\text{f})} = \frac{70^2}{15(0.01*6+0.10)}\ \text{ft} = 2041.67\ \text{(ft)}$$

6. Plot the relationship between the approach speed v_0 and the length of dilemma zone for the following data: a_1=0.5g, d=1sec, w=65ft, L=15ft, and t=4.5sec.

Solution:

$X_C - X_0$: ft

v_0: mi/h

$$X_C - X_0 = \left[v_0 \mathrm{d} + \frac{{v_0}^2}{2a_1}\right] - [v_0 t - (w + L)]$$

$$X_C - X_0 = \left[1.47 * v_0 + \frac{1.47 * 1.47 * {v_0}^2}{2 * 0.5 * \frac{1}{0.3048}}\right] - [4.5 * 1.47 * v_0 - (65 + 15)]$$

$$X_C - X_0 = 0.65864232{v_0}^2 - 5.145v_0 + 80$$