

## CE 3201

### Homework #2 Solution

1. (1)

$$d = \frac{V_2^2 - V_1^2}{2a} \Rightarrow V_1 = \sqrt{V_2^2 - 2ad}$$

Given: (a) collision speed  $V_2 = 40\text{mph} = 58.68\text{ft/s}$ , (b) deceleration  $a = -\mu g = -0.8g = -0.8(32.2) = -25.76\text{ft/s}^2$ , (c) skidding distance  $d = 150\text{ft}$ , the speed at the beginning of skidding is

$$V_1 = \sqrt{58.68^2 - 2(-25.76)150} = 105.69\text{ft/s} = 72.06\text{mph}.$$

(2)

$$d = d_s + d_r = d_s + V \cdot t_r$$

Given: (a) skidding distance  $d_s = 150\text{ft}$ , (b) speed during reaction time  $V = 105.69\text{ft/s}$  (from (1)), (c) reaction time  $t_r = 1\text{s}$ , the distance travelled between perception and collision is

$$d = 150 + 105.69(1) = 255.69\text{ft}$$

(3)

$$d = V_1 t + \frac{1}{2} a t^2$$

Given: (a) speed at the beginning of skidding  $V_1 = 105.69\text{ft/s}$  (from (1)), (b) skidding time  $t = 0.5\text{s}$ , (c) deceleration  $a = -25.76$ , the distance of skidding is

$$d = 105.69(0.5) - \frac{1}{2}(-25.76)0.5^2 = 49.63\text{ft}.$$

(4)

$$V_2 = V_1 + at$$

Given: (a) speed at the the beginning of skidding  $V_1 = 105.69\text{ft/s}$  (from (1)), (b) skidding time  $t = 1\text{s}$ , (c) deceleration  $a = -25.76$ , the speed after 1s skidding is

$$V_2 = 105.69 + (-25.76)1 = 79.93\text{ft/s} = 54.5\text{mph}.$$

(5)

$$d = \frac{V_2^2 - V_1^2}{2a} \Rightarrow a = \frac{V_2^2 - V_1^2}{2d}$$

Given: (a)  $V_2 = 0$  (complete stop), (b) speed at collision  $V_1 = 58.68ft/s$ , (c) distance travelled between collision and complete stop  $d = 20ft$ , the deceleration is

$$a = \frac{0^2 - 58.58^2}{2(20)} = -86.08ft/s^2.$$

(6)

$$V_2 = V_1 + at \Rightarrow t = \frac{V_2 - V_1}{a}$$

Given: (a)  $V_2 = 0$  (complete stop), (b) speed at collision  $V_1 = 58.68ft/s$ , (c) deceleration  $a = -86.08ft/s^2$  (from (4)), the time between collision and complete stop is

$$t = \frac{0 - 58.68}{2(-86.08)} = 0.68s.$$

2.

$$F = ma + R_a + R_{rl} + R_g$$

(1) Since the cyclist is coasting, meaning no power is added to the system,  $F = 0$ .

(2) When the bicycle has the maximum speed, acceleration  $a = 0$ , then  $ma = 0$ .

(3)

$$R_a = \frac{\rho}{2}C_D A_f V^2$$

Given: (a) air density  $\rho = 0.002378slugs/ft^3$ , (b) drag coefficient  $C_D = 1.2$ , (c) frontal area  $A_f = 5.4ft^2$ , the aerodynamic resistance is

$$R_a = \frac{0.002378}{2}(1.2)5.4V_{max}^2 = 0.0077V_{max}^2$$

(4)

$$R_{rl} = f_{rl}W$$

Given: (a) coefficient of rolling resistance  $f_{rl} = 0.008$ , (b) total weight  $W = 190lb$ , the rolling resistance is

$$R_{rl} = 0.008(190) = 1.52lb.$$

(5)

$$R_g = WG$$

Given: (a) total weight  $W = 190lb$ , (b) grade  $G = -0.06$ , the grade resistance is

$$R_g = 190(-0.06) = -11.4lb$$

From (1)-(5), we have

$$0 = 0 + 0.0077V_{max}^2 + 1.52 - 11.4 \Rightarrow V_{max} = 35.82ft/s = 24.41mph.$$

3.

Determine the rate of superelevation required for this curve.

design speed is 70 mi/h

$$R_v := 900 \quad V := 70 \quad g := 32.2 \quad \text{(given)}$$

calculate  $f_s + e$  (here represented by  $x$ )

$$x := \frac{(V \cdot 1.467)^2}{g \cdot R_v} \quad x = 0.364 \quad \text{which is equal to } f_s + e \quad \text{(Eq. 3.34)}$$

$$f_{s\max} := 0.10 \quad \text{(Table 3.5)}$$

$$e_{\text{required}} := x - f_{s\max} \quad e_{\text{required}} = 0.264 \quad \frac{\text{ft}}{\text{ft}}$$