Problem 1.

\[ V = 15 \text{ mi/hr (22 ft/s)} \] - speed at collision.

\[ x = 20 \text{ ft} \] - skid marks on dry pavement; hence \( f = 0.6 \)

\[ \tan \theta = \frac{32}{100} = 0.03 \] - grade \( \tan \theta = G \)

\[ g = 32.2 \frac{ft}{s^2} \] - while not mentioned in the problem statement, \( g \) is known and is used in \( \frac{ft}{s^2} \) units.

By the same token, the speed at collision is converted to be used in \( \frac{ft}{s} \) (see above).

\[ V_0 \] is to be identified.

Value of \( V_0 \), the speed at the onset of skidding, can be derived from the following statement:

\[ D_b = \frac{V_0^2 - V^2}{2g(f + G)} \]
Keeping in mind that the car was going uphill, previous statement assumes the following form:

\[ D_b = \frac{V_0^2 - V^2}{2g(f+G)} \] \hspace{1cm} (1)

At this point, the length of the skid marks \( x \) should be converted to the breaking distance using the following statement:

\[ D_b = x \cos \alpha \] \hspace{1cm} (2)

In the case of this problem, you were allowed to assume \( D_b = x \) because the grade is relatively small. However, such conversion should be done on a general basis.

\[ \tan \alpha = 0.03 \Rightarrow \alpha = 1.72^\circ \]

\[ D_b = 20 \text{ ft} \cdot \cos 1.72^\circ = 19.99 \text{ ft} \] \hspace{1cm} (3)

Then, substitute \((3)\) and all known parameters into \((1)\):
\[ 19.99 \text{ ft} = \frac{V_0^2 - \left(22 \text{ ft} \right)^2}{2 \times 32.2 \frac{\text{ft}}{\sec^2} \times (0.6 + 0.03)} \]

Next step is to derive \( V_0 \):

\[ V_0^2 = 19.99 \text{ ft} \times 2 \times 32.2 \frac{\text{ft}}{\sec^2} \times (0.6 + 0.03) + \left(22 \frac{\text{ft}}{\sec} \right)^2 \]

\[ V_0 = \sqrt{811.03 + 484} \]

\[ V_0 \approx 36 \frac{\text{ft}}{\sec} \quad (24.54 \text{ mi/hr}) \]
Problem 2.

a) \( V_0 = 90 \text{ km/hr} \quad V = 0 \) - driver is sober

b) \( V_0 = 90 \text{ km/hr} \quad V = 55 \text{ km/hr} \) - driver is drunk

t = 0.3 - pavement is wet

Stopping distance equation \( SSD = \) 160 m

The surface is assumed to be flat; hence, \( G = \tan \theta = 0 \)
\( g = 32.2 \text{ ft/s}^2 \). For the sake of consistency, with metric units: \( g = 9.8 \text{ m/s}^2 \). It is also safe to use \( g = 10 \text{ m/s}^2 \)

Next, transform \([\text{km/hr}]\) into \([\text{m/s}]\):

\[ \frac{90 \text{ km}}{\text{hr}} \cdot \frac{1000 \text{ m}}{3600 \text{s}} = 25 \text{ m/s} \]

\[ \frac{55 \text{ km}}{\text{hr}} \cdot \frac{1000 \text{ m}}{3600 \text{s}} = 15.3 \text{ m/s} \]

Stopping distance equation will be used:

\[ SSD = V_0 t + D_b \quad (1) \]

\[ D_b = \frac{V_0^2 - V^2}{2g(t + \theta)} \quad (2) \]
For the case of a sober driver:

\[ D_b = \frac{V_0^2 - V^2}{2g + \frac{1}{4}} = \frac{(25 \text{ m/s})^2}{2 \times 9.8 \text{ m/s}^2 \times 0.3} \]

Note that since the surface is flat, \( G = 0 \)

\[ D_b = 106.3 \text{ m} \]

Knowing \( t_{1/2}, D_b \) and \( V_0 \), substitute all into (1) and derive \( t \) (driver's reaction time).

\[ V_0 t = t_{1/2} D - D_b \implies t = \frac{t_{1/2} D - D_b}{V_0} \quad (3) \]

\[ t_{1/2,bo} = \frac{160 \text{ m} - 106.3 \text{ m}}{25 \text{ m/s}} = 2.15 \text{ s} \]

For the case of a drunken driver:

\[ D_b = \frac{V_0^2 - V^2}{2g + \frac{1}{4}} = \frac{(25 \text{ m/s})^2}{2 \times 9.8 \text{ m/s}^2 \times 0.3} = 66.6 \text{ m} \]

Use (3) again to find driver's reaction time:

\[ t_{dr} = \frac{t_{1/2} D - D_b}{V_0} = \frac{160 \text{ m} - 66.6 \text{ m}}{25 \text{ m/s}} = 3.74 \text{ s} \]