1) At the instant shown, car A is traveling on straight road with a speed of 55 mi/h and car B is traveling on a curved "exit ramp" with a speed of 40 mi/h. Determine the velocity of car B with respect to car A. Express your answer in \( \hat{i}, \hat{j} \) notation and mi/h for the units (you do not need to do a units conversion).

\[
\vec{v}_{B/A} = 20.4 \hat{i} + 20.0 \hat{j} \text{ mi/h}
\]

\[
\vec{v}_A = 55 \text{ mi/h} \hat{i}
\]

\[
\vec{v}_B = -\left(40 \text{ mi/h}\right) \cos 30^\circ \hat{i} + \left(40 \text{ mi/h}\right) \sin 30^\circ \hat{j} = -34.41 \hat{i} + 20.00 \hat{j} \text{ mi/h}
\]

\[
\vec{v}_{B/A} = \vec{v}_B - \vec{v}_A = -34.41 \hat{i} + 20.00 \hat{j} \text{ mi/h}
\]

\[
\vec{v}_{B/A} = 20.4 \hat{i} + 20.0 \hat{j} \text{ mi/h}
\]

2) In problem 1, car B is slowing down at a rate of 1200 mi/h\(^2\) and the magnitude of the total acceleration of car B is 3400 mi/h\(^2\). Determine the radius of curvature of the exit ramp (in miles).

\[
\rho = 0.503 \text{ mi}
\]

\[
\alpha = \sqrt{\left(\frac{\dot{v}_B}{\rho}\right)^2 + \left(\frac{v_B^2}{\rho}\right)^2}
\]

\[
\sqrt{\alpha_B^2 - \left(\frac{\dot{v}_B}{\rho}\right)^2} = \frac{v_B^2}{\rho}
\]

\[
\rho = \frac{v_B^2}{\sqrt{\alpha_B^2 - \left(\frac{\dot{v}_B}{\rho}\right)^2}} = \frac{(40 \text{ mi/h})^2}{\sqrt{(3400 \text{ mi/h}^2)^2 - (1200 \text{ mi/h}^2)^2}} = 0.503 \text{ mi}
\]
3) The flight path of a jet aircraft as it takes off is given by the parametric equations \( x = 1.25t^2 \) and \( y = 0.03t^3 \), where \( t \) is the time after take-off measured in seconds and \( x \) and \( y \) are given in meters. Determine the magnitude of the total acceleration on the plane at \( t = 40 \text{ s} \).

\[
\mathbf{a} = 7.62 \frac{\text{m}}{\text{s}^2}
\]

\[
\mathbf{a} = \mathbf{\ddot{x}} \mathbf{i} + \mathbf{\ddot{y}} \mathbf{j}
\]

\[
\mathbf{\ddot{x}} = 2.50 \mathbf{i} + 0.18 \mathbf{j} \frac{\text{m}}{\text{s}^2}
\]

\[
\mathbf{\ddot{y}} = 2.50 \mathbf{i} + 0.18(40) \mathbf{j} \frac{\text{m}}{\text{s}^2} = 2.50 \mathbf{i} + 7.20 \mathbf{j} \frac{\text{m}}{\text{s}^2}
\]

\[
\mathbf{a} = \sqrt{(2.50)^2 + (7.20)^2} \frac{\text{m}}{\text{s}^2} = 7.62 \frac{\text{m}}{\text{s}^2}
\]

4) A test car starts from rest on a flat, straight course. It is subjected to the acceleration given in the diagram at right. Determine the time \( t \) when the car comes to rest again.

\[
\mathbf{a} (\text{ft/s}^2)
\]

\[
\begin{align*}
\text{when } v &= 0 \\
15 &= \frac{1}{2} t_1 \\
\Rightarrow \quad 10(15) &= \frac{1}{2} (t_1)(\frac{t_1}{2}) = \frac{1}{4} t_1^2 \\
150 &= \frac{1}{4} t_1^2 \\
\Rightarrow \quad t_1 &= 24.5 \text{ s} \\
\end{align*}
\]

\[
t = 10 \text{ s} + t_1 = 34.5 \text{ s}
\]
5) The winding drum $D$ is drawing in the cable at an accelerated rate of $5 \text{ m/s}^2$. Determine the acceleration of the crate $C$.

\[ \vec{a}_c = 2.5 \text{ m/s}^2 \uparrow \]

\[ L = S_D + 2S_c + \text{const} \]

\[ \Rightarrow 0 = v_D + 2v_C \]

\[ \Rightarrow 0 = a_D + 2a_C \]

\[ a_C = -\frac{a_D}{2} = -\frac{(+5 \text{ m/s}^2)}{2} = -2.5 \text{ m/s}^2 \]
6) The baseball player $A$ hits the baseball with a speed of $v_A = 40 \text{ ft/s}$ at an angle of $60^\circ$ from the horizontal. Player $B$ takes $\frac{1}{4}$ of a second to respond before he begins to run with a constant speed $v_B$. Player $B$ catches the ball at $C$ at an elevation that is 3 ft higher than the elevation at which Player $A$ hit the ball. Determine:
   a) the distance $d$,
   b) the speed at which Player $B$ must run (i.e., $v_B$),
   c) the velocity of the baseball relative to Player $B$ right before he catches the ball at $C$.

\[
\begin{align*}
\vec{d} &= 2 \hat{e}_x + 2 \hat{e}_y \\
\vec{v}_B &= 14.5 \hat{e}_x - 31.7 \hat{e}_y \\
\vec{v}_{ball/player} &= 5.5 \hat{e}_x - 31.7 \hat{e}_y \\
\end{align*}
\]