Problems (Rectilinear Motion)

2/20 A particle moves along the positive x-axis with an acceleration \(a_x\) in meters per second squared which increases linearly with x expressed in millimeters, as shown on the graph for an interval of its motion. If the velocity of the particle at \(x = 40\) mm is 0.4 m/s, determine the velocity at \(x = 120\) mm.

\[
\begin{array}{|c|c|}
\hline
x, \text{ mm} & a_x, \text{ m/s}^2 \\
\hline
40 & 2 \\
\hline
120 & 4 \\
\hline
\end{array}
\]

2/21 A girl rolls a ball up an incline and allows it to return to her. For the angle \(\theta\) and ball involved, the acceleration of the ball along the incline is constant at 0.25g, directed down the incline. If the ball is released with a speed of 4 m/s, determine the distance \(s\) it moves up the incline before reversing its direction and the total time \(t\) required for the ball to return to the child’s hand.

2/29 A particle starts from rest at \(x = -2\) m and moves along the x-axis with the velocity history shown. Plot the corresponding acceleration and the displacement histories for the 2 seconds. Find the time \(t\) when the particle crosses the origin.

\[
\begin{array}{|c|c|}
\hline
t, \text{ s} & v, \text{ m/s} \\
\hline
0 & 0 \\
0.5 & 3 \\
1 & 3 \\
1.5 & 0 \\
2 & 2 \\
2.5 & 1 \\
3 & 0 \\
\hline
\end{array}
\]

2/33 If the velocity \(v\) of a particle moving along a straight line decreases linearly with its displacement \(s\) from 20 m/s to a value approaching zero at \(s = 30\) m, determine the acceleration \(a\) of the particle when \(s = 15\) m and show that the particle never reaches the 30-m displacement.

\[
\begin{array}{|c|c|}
\hline
s, \text{ m} & v, \text{ m/s} \\
\hline
0 & 20 \\
20 & 10 \\
30 & 0 \\
\hline
\end{array}
\]

2/41 The steel ball A of diameter \(D\) slides freely on the horizontal rod which leads to the pole face of the electromagnet. The force of attraction obeys an inverse-square law, and the resulting acceleration of the ball is \(a = K(L - x)^2\), where \(K\) is a measure of the strength of the magnetic field. If the ball is released from rest at \(x = 0\), determine the velocity \(v\) with which it strikes the pole face.

2/48 A subway train travels between two of its station stops with the acceleration schedule shown. Determine the time interval \(\Delta t\) during which the train brakes to a stop with a deceleration of 2 m/s\(^2\) and find the distance \(s\) between stations.

\[
\begin{array}{|c|}
\hline
\Delta t & a, \text{ m/s}^2 \\
\hline
0 & 2 \\
1 & 1 \\
2 & 0 \\
\hline
\end{array}
\]

\[
\begin{array}{|c|}
\hline
t, \text{ s} & x \\
\hline
8 & 0 \\
6 & 10 \\
\Delta t & \text{stop} \\
\hline
\end{array}
\]