Kinematics Problems

Recall

$$\vec{d} = \vec{v}_i t + \frac{1}{2}\vec{a}t^2 \qquad \vec{d} = \left(\frac{\vec{v}_f + \vec{v}_i}{2}\right) \cdot t \qquad \vec{v}_f = \vec{v}_i + \vec{a}t \qquad \vec{v}_f^{\,2} = \vec{v}_i^{\,2} + 2\vec{a}\vec{d}$$

Strategy

1. Read the problem carefully. Try to visualize the actual situation. Make a sketch if necessary.
2. Identify the quantities that are given in the problem.
3. Identify the quantity that is unknown, the one you have to find.
4. Select the equation or equations that will relate the given and unknown quantities.
5. Make sure the equations can be applied to the problem. In other words, is the acceleration constant?
6. Rewrite equations as needed to solve for the unknown quantity.
7. Substitute the given values including proper units into the equation and solve. Be sure your answer is in the correct units.
8. Make a rough estimate to see if your answer is reasonable.

Example 1
A ball rolls down a hill with a constant acceleration of $2.0\ m/s^2$. If the ball starts from rest, what is its velocity at the end of $4.0\ s$? How far did the ball move?

Example 2

An electron is accelerated uniformly from rest to a velocity of $2 \times 10^7 \, m/s$. If the electron traveled $0.1 \, m$ while it was being accelerated, what was its acceleration? How long did the electron take to attain its final velocity?

Example 3

During a $30 \, s$ interval, the velocity of a rocket increased from $200 \, m/s$ to $500 \, m/s$. What was the displacement of the rocket during this time interval?

Example 4

A bullet that is shot vertically into the air has an initial velocity of $500\ m/s$. The acceleration due to gravity is $9.8\ m/s^2\ [down]$. How long does it take before the bullet stops rising? How high does the bullet go?

Example 5

A balloon is ascending at a rate of $9.0\ m/s$ and has reached a height of $80\ m$ above the ground when it releases a package. How long does the package take to reach the ground?

Worksheet

1. For each of the following, choose an equation and solve for the missing variable.

   a) $v_i = 0$, $a = 2.5\ m/s^2$, $t = 3.5\ s$, $v_f = ?$

   b) $d = 5000\ m$, $v_i = 3.0\ m/s$, $v_f = 17\ m/s$, $a = ?$

   c) $d = 30\ m$, $t = 1.4\ s$, $a = 6.2\ m/s^2$, $v_i = ?$

   d) $d = 365.5\ m$, $v_f = 5.0\ m/s$, $v_i = 6.59\ m/s$, $t = ?$

   e) $v_f = 7.65\ m/s$, $v_i = 3.72\ m/s$, $t = 8.3\ s$, $d = ?$

   f) $v_f = 9.75\ m/s$, $v_i = 20.3\ m/s$, $a = -2.56\ m/s^2$, $d = ?$

2. A car accelerates from $25\ m/s$ to $35\ m/s$ at $1.7\ m/s^2$.

   a) How long does it take to complete this acceleration?

   b) How far does the car travel during its motion?

3. A shuttlecraft landing on a runway pops a parachute that causes it to decelerate to rest. If the shuttlecraft is initially traveling at $150\ m/s$, what acceleration must be provided by the parachute to stop the shuttle on a $2.5\ km$ long runway?

4. A train traveling with an initial speed of $150\ km/h$ accelerates at a rate of $2.0\ m/s^2$ over a distance of $2.0\ km$. How long does this motion take?

5. A boy with a slingshot launches a marble straight up in the air. If the marble is originally launched from a height of $2.5\ m$ above the ground with a velocity of $8.0\ m/s$,

   a) how long does it take the marble to reach the ground?

   b) what maximum height does it reach?

Answers

1.
   a) 8.75 m/s
   b) 0.028 m/s^2
   c) 17.1 m/s
   d) 63.1 s
   e) 47.2 m
   f) 61.9 m

2.
   a) 5.9 s
   b) 176.5 m

3. $-4.5\ m/s^2$

4. 28.5 s

5.
   a) 1.9 s
   b) 3.27 m above point of release