1. A tiger leaps horizontally from a 7.5 meter high rock with a speed of 4.5 m/s. How far from the base of the rock will she land?  
\[ \Delta y = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2 \Delta y}{g}} = 1.24 \text{ s} \] 
\[ \Delta x = v_{ox} t = 5.57 \text{ m} \]

2. A diver running 1.6 m/s dives out horizontally from the edge of a vertical cliff and reaches the water below 3.0 seconds later.  
   a) How high is the cliff?  
   b) How far from the base of the cliff does the diver land?  
   
   \[ (a) \Delta y = \frac{1}{2} g t^2 = \frac{1}{2} (9.8)(3)^2 = 44.1 \text{ m} \]  
   \[ (b) \Delta x = v_{ox} t = (1.6)(3) = 4.8 \text{ m} \]

3. A ball is thrown horizontally from the roof of a building 56 meters tall and lands 45 meters from the base. What was the initial speed of the ball?  
\[ \Delta x = v_{ox} t \Rightarrow v_{ox} = \frac{\Delta x}{t} = \frac{45}{3.4} = 13.2 \text{ m/s} \]
\[ \Delta y = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(56)}{9.8}} = 3.4 \text{ s} \]

4. A ball thrown horizontally at 22.2 m/s from the roof of the building lands 36 meters from the base of the building. How high is the building?  
   \[ \Delta y = \frac{1}{2} g t^2, \text{ need to find time} \]  
   \[ \Delta x = v_{ox} t \Rightarrow t = \frac{\Delta x}{v_{ox}} = \frac{36}{22.2} = 1.62 \text{ s} \]  
   \[ \Delta y = \frac{1}{2} (9.8)(1.62)^2 = 12.9 \text{ m} \]

5. The pilot of an airplane traveling horizontally at 44 m/s wants to drop supplies to flood victims isolated on a patch of land 160 meters below. The supplies should be dropped how many seconds before the plane is directly overhead?  
\[ \Delta y = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(160)}{9.8}} = 5.715 \]

6. A bullet is fired horizontally from a gun. At the same time a similar bullet is dropped from the same height. The fired bullet will:  
   a) hit the ground first  
   b) hit at the same time as the dropped bullet  
   c) hit the ground second  
   d) never hit the ground
7. A marble with a speed of 0.20 m/s rolls off the edge of a table 0.80 m high.
   a) How long does it take to hit the floor?
   b) How far from the table will it hit the floor?

(a) Find time in the air

\[ \Delta y = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(0.80)}{9.8}} = 0.404 \text{ s} \]

(b) Find \( \Delta x \)

\[ \Delta x = v_{ox} t = (0.2)(0.404) = 0.081 \text{ m} \]

8. A steel ball rolls with constant velocity across a tabletop 0.950 m high. It rolls off and hits the ground 0.352 meters from the edge of the table. How fast was the ball rolling when it left the table?

\[ \Delta x = v_{ox} t \Rightarrow v_{ox} = \frac{\Delta x}{t} = \frac{0.352}{0.41} = 0.86 \text{ m/s} \]

Find time to drop .95 m

\[ \Delta y = \frac{1}{2} gt^2 \Rightarrow t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(0.95)}{9.8}} = 0.41 \text{ s} \]
Directions: Solve each and justify all answers.

A ball initially at rest rolls across a table with an acceleration rate of 0.55 m/s². The ball leaves the table with a speed of \( v_0 \) and lands 0.69 meters from the edge of the table.

(a) Find the time it takes the ball to reach position A in the picture above.

(b) Find the speed of the ball, \( v_0 \), as it leaves the table.

(c) Find the length of the table.

(d) Draw the horizontal velocity vs. time (v vs. t) graph for the entire trip of the ball using the graph below, and completely and accurately label the graph.

\[
\begin{align*}
\text{(a)} & \quad \text{Time to A = time to drop 1.2 m} \\
& \quad t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(1.2)}{9.8}} = 1.495 \text{ s} \\
\text{(b)} & \quad \Delta x = v_0 x t \quad \Rightarrow \quad v_0 x = \frac{\Delta x}{t} = \frac{0.69}{1.495} = 0.46 \text{ m/s} \\
\text{(c)} & \quad v^2 = v_0^2 + 2 a \Delta x, \text{ where } \Delta x = \text{ length of table} \\
& \quad \Delta x = \frac{v^2 - v_0^2}{2 a} = \frac{(1.39)^2 - (0.46)^2}{2(0.55)} = 1.76 \text{ m} \\
\end{align*}
\]
A 0.50 kg cart moves on a straight horizontal track. The graph of velocity $v_x$ versus time $t$ for the cart is given below.

(a) Indicate every time $t$ for which the cart is at rest. At rest $\Rightarrow v_x = 0 \Rightarrow t = 4.18 \text{ s}$

(b) From $t = 25 \text{ s}$ until the cart reaches the end of the track, the cart continues with constant horizontal velocity. The cart leaves the end of the track and hits the floor, which is 0.40 m below the track. Neglecting air resistance, determine each of the following.

i. The time from when the cart leaves the track until it first hits the floor

\[ \Delta y = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(0.4)}{9.8}} = 0.29 \text{ s} \]

ii. The horizontal distance from the end of the track to the point at which the cart first hits the floor

\[ \Delta x = v_{x0} t = (0.8)(0.29) = 0.23 \text{ m} \]

(c) Draw and label the acceleration vs. time graph for the time period of 0 to 25 seconds.
EXTRA PROBLEMS

1. A car drives off a wharf at 15 m/s. If the wharf is 25 m above water, calculate:
   a) the time of flight. Assume down is positive.
   b) the horizontal distance traveled
   c) the velocity at which the car hits the water.

   (a) Find time to bottom
   \[
   \Delta y = \frac{1}{2} g t^2 \Rightarrow t = \sqrt{\frac{2 \Delta y}{g}} = 2.26 \text{ s}
   \]

   (b) \( \Delta x = V_{ox} t = (15)(2.26) = 33.9 \text{ m} \)

   (c) \( V_x = V_{ox} = 15 \text{ m/s} \)
   \[
   V_y = V_{oy} + g t \Rightarrow V_y = g t = -22.1 \text{ m/s}
   \]
   \[
   V = \sqrt{V_x^2 + V_y^2} = 26.7 \text{ m/s}
   \]

2. A marble with a speed of 2.0 m/s rolls off the edge of a table 1.8 m high.
   a) How long does it take it to hit the floor?
   b) How far from the table will it hit the floor?

   (a) Find time to floor
   \[
   t = \sqrt{\frac{2 \Delta y}{g}} = 0.61 \text{ s}
   \]

   (b) \( \Delta x = V_{ox} t = (2)(0.61) = 1.22 \text{ m} \)

3. A ball rolls with a speed of 2.0 m/s across a level table that is 1.0 m above the floor. Upon reaching the edge of the table, it follows a parabolic path to the floor. How far along the floor is the landing spot from the table?

   \[ \Delta x = V_{ox} t = (2)(t) = (2)(0.45) = 0.9 \text{ m} \]

   Find time to floor
   \[
   t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(1)}{9.8}} = 0.45 \text{ s}
   \]

4. A rifle is fired horizontally and travels 200.0 m. The rifle barrel is 1.90 m from the ground. What speed must the bullet have been travelling at? Ignore friction.

   \[ \Delta x = V_{ox} t \Rightarrow V_{ox} = \frac{\Delta x}{t} = \frac{200}{0.62} = 200 \text{ m/s} \]

   Find time to ground
   \[
   t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(1.9)}{9.8}} = 0.62 \text{ s}
   \]
5. A skier leaves the horizontal end of a ramp with a velocity of 25.0 m/s and lands 70.0 m from the base of the ramp. How high is the end of the ramp from the ground?

\[ \Delta y = \frac{1}{2} g t^2 = \frac{1}{2} (9.8) (2.8)^2 = 38.4 \text{ m} \]

Find time to ground

\[ \Delta x = V_{ox} t \Rightarrow t = \frac{\Delta x}{V_{ox}} = \frac{70}{25} = 2.8 \text{ s} \]

6. A rescue pilot drops a survival kit while her plane is flying at an altitude of 2000.0 m with a forward velocity of 100.0 m/s. If air friction is disregarded, how far in advance of the starving explorer's drop zone should she release the package?

\[ \Delta x = V_{ox} t = (100)(21.2) = 2200 \text{ m in front} \]

Find time to ground

\[ t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(2000)}{9.8}} = 20.2 \text{ s} \]

7. A cat runs and jumps from one roof top to another which is 5 meters away and 3 meters below. Calculate the minimum horizontal speed with which the cat must jump off the first roof in order to make it to the other.

\[ \Delta x = V_{ox} t \Rightarrow V_{ox} = \frac{\Delta x}{t} = \frac{5}{1.78} = 2.8 \text{ m/s} \]

Find time to drop 3 m

\[ t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(3)}{9.8}} = .78 \text{ s} \]

8. An object is thrown off a cliff with a horizontal speed of 10 m/sec. After 3 seconds the object hits the ground. Find the height of the cliff and the total horizontal distance traveled by the object.

(a) Height of cliff

\[ \Delta y = \frac{1}{2} g t^2 = \frac{1}{2} (9.8) (9) = 44.1 \text{ m} \]

(b) Horizontal dist

\[ \Delta x = V_{ox} t = (10)(3) = 30 \text{ m} \]

9. A ski jumper competing for an Olympic gold medal wants to jump a horizontal distance of 135 meters. The takeoff point of the ski jump is at a height of 25 meters. With what horizontal speed must he leave the jump?

\[ \Delta x = V_{ox} t \Rightarrow V_{ox} = \frac{\Delta x}{t} = 135 \frac{135}{2.26} = 59.7 \text{ m/s} \]

Find time to ground

\[ t = \sqrt{\frac{2 \Delta y}{g}} = \sqrt{\frac{2(25)}{9.8}} = 2.26 \text{ s} \]

10. A motorcycle stunt driver zooms off the end of a cliff at a speed of 30 meters per second. If he lands after 0.75 seconds, what is the height of the cliff?

\[ \Delta y = \frac{1}{2} g t^2 = \frac{1}{2} (9.8)(.75)^2 = 2.76 \text{ m} \]
Use the diagram to the right to answer question 11 - 14. It represents a cart that is rolling along a tabletop at a constant velocity and a ball that will drop at the instant the cart rolls off the edge of the tabletop. The cart eventually lands at point Z.

11. Compare the time it takes for the cart to travel from X to Z, as compared to the time it takes the ball to fall from X to Y.
   A) The cart hits the ground before the ball.
   B) The ball hits the ground before the cart.
   C) They both hit the ground at the same time, the cart simply takes longer to get there.
   D) They time to fall for both is the same.

12. What happens to the velocity of the cart through its flight?
   A) The horizontal component of the velocity remains constant while the vertical component increases as gravity acts on the cart.
   B) The horizontal and vertical components of the cart’s velocity increase with the action of gravity on the cart.
   C) The vertical component of the cart’s velocity remains constant while the horizontal component increases as gravity acts on the cart.
   D) The velocity of the cart remains constant through out its flight.

13. If the cart’s velocity were doubled, what would happen to the time the cart falls as compared to the time the ball falls?
   A) The cart would land in half the time it takes the ball to fall.
   B) The cart would land in twice the amount of time it takes the ball to fall.
   C) The cart and ball will still land at the same time.
   D) The cart will not land now, it is moving too fast.

14. If the height of the table were tripled, what would happen to the flight of the ball?
   A) The time of flight would be $\sqrt{3}$ times longer and the cart would land further from the table.
   B) The time of flight would be three times longer but the cart would land the same distance from the table.
   C) The time of flight would be nine times longer and the cart would land three times the original distance from the table.
   D) The time of flight would be unchanged, but the cart would land three times the original distance from the table.