**Launch 2.2 Crumpled Paper Toss**

Instructions (there is a place for your answers on the following pages):

For each scenario of projectile motion, use meters and seconds for units of measure, ignore the effects due to air resistance. By definition, gravity is the only force acting on a projectile once the projectile is in flight. Acceleration due to gravity is a constant 9.8 m/s2.

Observe two relationships and sketch a graph of each. Be sure to label the axes.

1. Graph the trajectory or the path that the ball follows as it falls. Trajectory is the projectile’s vertical distance (y) from the ground as a function of its horizontal distance (x) from the place the ball started. (label axes) . How far from where the person is standing does the ball hit the floor?\_\_\_\_\_\_\_
2. Graph the vertical motion that is the height (h) of the ball as the time passes since the ball is dropped (t). (label axes)
3. Initial position (height at time 0): h0 =\_\_\_\_\_.
4. Initial velocity in the vertical direction: vy0= \_\_\_\_\_\_\_\_\_\_\_
5. Initial velocity in the horizontal direction: vx0= \_\_\_\_\_\_\_\_\_\_\_.
6. Acceleration due to Gravity: g=\_\_\_\_

h(t) = g(t2) +vy0 (t) +h0

* + 1. where h is the height of the projectile above ground,
    2. t is the time elapsed since the projectile was released,
    3. g is the force of gravity, (use 9.8 m/s2, or 32 ft/s2)
    4. vy0 is the initial velocity in the vertical direction,
    5. h0 is the initial height of the object.

1. Write the formula for height as a function of time: \_\_ h(t) = ( ? ) (t2) + ( ? )(t) +h0\_
2. Sketch and label the horizontal lines on your “ height as a function of time” graph indicating
3. Write 4 equations to solve that would determine the time when the projectile will be 0, 1, 2 and 3 meters above the floor
4. Bonus: find an algebraic formula for the trajectory (path) of the projectile.

Scenarios:

1. Drop a balled up piece of paper from your hand held 2 meters above the floor.
2. Toss the projectile straight up in the air, releasing it 2 meters above the floor, and so its maximum height is 3 meters. The trajectory of the ball will be at a 90° angle with the ground. The initial velocity will be about 4.5 m/sec.
3. Toss a projectile from 2 meters above the ground with the same force as in #2, at an angle of 75° with the ground.
4. Toss the projectile from 2 meters above the ground with the same force as before at an angle of 0° with the ground (i.e. horizontal trajectory)

SCENARIO # 1. Drop a balled up piece of paper from your hand held 2 meters above the floor.

1. Distance from person that ball lands: \_\_\_\_\_\_\_\_ Graph of ball’s trajectory:
2. Graph of vertical motion of ball:
3. h0 =\_\_\_\_\_.
4. vy0= \_\_\_\_\_\_\_\_\_\_\_
5. vx0= \_\_\_\_\_\_\_\_\_\_\_

1. g=\_\_\_
2. formula:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
3. on the vertical motion graph in part b, sketch the horizontal lines for h=0,1,2, and 3 meters
4. Write 4 equations to solve that would determine the time when the projectile will be 0, 1, 2 and 3 meters above the floor:

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

1. Challenge: write the formula for the trajectory of the ball.

SCENARIO # 2. Toss the projectile straight up in the air, releasing it 2 meters above the floor, and so its maximum height is 3 meters. The trajectory of the ball will at a 90° angle with the ground. The initial velocity of the ball will be 4.5 m/sec

1. Distance from person that ball lands: \_\_\_\_\_\_\_\_ Graph of ball’s trajectory:
2. Graph of vertical motion of ball:
3. h0 =\_\_\_\_\_.
4. vy0= \_\_\_ \_\_\_\_
5. vx0= \_\_\_\_\_\_\_\_\_\_\_
6. g=\_\_\_
7. formula:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. on the vertical motion graph in part b, sketch the horizontal lines for h=0,1,2, and 3 meters
9. Write 4 equations to solve that would determine the time when the projectile will be 0, 1, 2 and 3 meters above the floor:
   1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
10. Challenge: write the formula for the trajectory of the ball.

SCENARIO # 3. Toss a projectile from 2 meters above the ground with the same force as in #2, this time at an angle of 75° with the ground.

1. Distance from person that ball lands: \_\_\_\_\_\_\_\_ Graph of ball’s trajectory:
2. Graph of vertical motion of ball:
3. h0 =\_\_\_\_\_.
4. vy0= \_\_\_\_\_\_\_\_\_\_\_(rough estimate)
5. vx0= \_\_\_\_\_\_\_\_\_\_\_(rough estimate)
6. g=\_\_\_
7. formula:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. on the vertical motion graph in part b, sketch the horizontal lines for h=0,1,2, and 3 meters
9. Write 4 equations to solve that would determine the time when the projectile will be 0, 1, 2 and 3 meters above the floor:
   1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
10. Challenge: write the formula for the trajectory of the ball.

SCENARIO # 4. Toss the projectile from 2 meters above the ground with the same force as before at an angle of 0° with the ground (i.e. horizontal trajectory)

1. Distance from person that ball lands: \_\_\_\_\_\_\_\_ Graph of ball’s trajectory:
2. Graph of vertical motion of ball:
3. h0 =\_\_\_\_\_.
4. vy0= \_\_\_\_\_\_\_\_\_\_\_
5. vx0= \_\_\_\_\_\_\_\_\_\_\_
6. g=\_\_\_
7. formula:\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
8. on the vertical motion graph in part b, sketch the horizontal lines for h=0,1,2, and 3 meters
9. Write 4 equations to solve that would determine the time when the projectile will be 0, 1, 2 and 3 meters above the floor:
   1. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
   2. \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_
10. Challenge: write the formula for the trajectory of the ball.