

## Worksheet 3: Trajectories

### Objectives

- Represent position, velocity and acceleration as vectors.
- Work with ballistic trajectories in the vertical and horizontal directions.

### Problems

1. Three identical steel balls are released at the same time from the same height above the ground. One is released with initial speed  $0$  m/s, one with initial speed  $v_0$  upward, and one with initial speed  $v_0$  downward. Once released, all are in free-fall until they hit the ground.
  - a. Draw a diagram of the initial situation. Show axis directions and the location of the origin.
  - b. Construct, for each ball, the kinematic equation giving height as a function of time.
  - c. Construct equations for the height differences as functions of time between:
    - The ball initially moving upward and the ball released from rest.
    - The ball released from rest and the ball initially moving downward.
  - d. Find the maximum height above the ground reached by the ball initially moving upward.
  - e. Substitute the height found in part d into the height equation for the ball released from rest and solve for  $t$  to find when this ball reaches that height. What do you find? What does it mean?

2. The distance-distance grid below shows two vectors:  $A$ , the change in position of a ball after 1 s in flight, and  $B$ , the vector that is added to the change every second by the acceleration due to gravity. Determine the subsequent positions of the ball at 1-s intervals using the following procedure:

- Starting at the ball's current position, copy the displacement vector from the previous second.
- Add to it the vector  $B$ .
- The sum is the displacement vector for the current second. The ball is now at the end of the sum vector.
- Repeat steps a–c until the ball hits the ground.

