I. Bullet in a viscous fluid

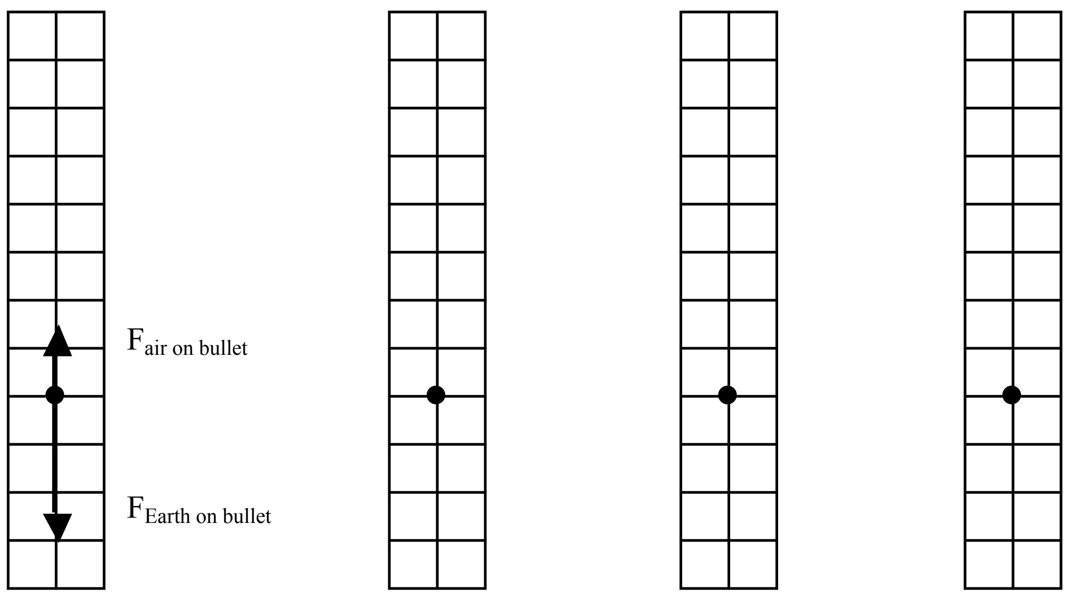
Consider a bullet of mass M shot vertically downward from a gun, into a thick, compressible fluid. The bullet is moving at speed $v_{initial}$ as it enters the fluid.

The fluid exerts a very odd force on the bullet. We model the force using both a constant buoyant force, F_B, and a velocity dependent viscous damping force proportional to $c_1 v$ (*i.e.*, $c_1 \neq 0$, $c_2 = 0$).

It is observed that the bullet slows down until it reaches terminal velocity.

A. In the grids below, sketch three free body diagrams for the bullet at the indicated times. Label all forces appropriately. Keep your scales consistent throughout your diagrams. The weight of the bullet is given in the free body diagram of the bullet just above the liquid:

GIVEN: Just before entering the liquid	t_0 (Just after entering the liquid)	t_1 (At half the net force of time t_0)	t_2 (Once it reaches v_{term})



B. Rank the forces in the free body diagram at time t_1. Explain how you arrived at your answer.

C. Write an equation of motion for the bullet (meaning, the differential equation describing its motion – *not the solution!*). Clearly state the positive direction of your chosen coordinate system.

D. Determine the speed of the bullet at time t_2 in terms of the given quantities. Show all work.

II. Throw down

A ball is thrown vertically downward at greater than terminal velocity from the top of a tall building. It experiences an air resistance force proportional to v. Find an equation that describes the velocity of the ball with respect to time. Let $+y$ be in the downward direction.

III. Toss up

A ball is tossed up in the air. How high does it go? (Which equation will you use to determine the answer? What are you assuming as you choose your equations? What do the terms in your equation mean?)