

## Advanced Mechanics

## Problem set #2

1. A projectile is fired vertically; at initial speed  $v_0$ , in a uniform gravitational field. The drag is proportional to  $v^2$ , such that the terminal velocity is  $v_T$ .
  - a. How long would the projectile take to reach maximum height with no drag?
  - b. What is the actual time to reach maximum height?
  - c. What is the velocity of the projectile when it hits the ground?
2. Two superballs are dropped from a height,  $h$ , with the light ball (mass =  $m$ ) on top of the heavy ball (mass =  $M$ ). The balls are lined up perfectly so that all motion is in the vertical direction.
  - a. What percentage of the total energy is in the small ball after the collision?
  - b. How high does the light ball bounce?
3. A single stage rocket has an initial mass,  $m_0$ , and burns fuel at a constant rate,  $\alpha$ . The burned fuel is expelled at a relative velocity,  $u$ , to the rocket.
  - a. What is the height of burnout of the rocket in a uniform gravitational field?

For a specific rocket  $m_0 = 5 * 10^4$  kg,  $\alpha = 200$  kg/s, and  $u = 2000$  m/s. It carries  $10^4$  kg of fuel.

- b. How long does this rocket take to lift off?
- c. What is the height of the rocket at burnout?
- d. What is wrong with the design of this rocket?