**Assignment 4: Projectile Motion with Air Resistance**

1. **Dependency on Time Step**

Begin with the ROOT macro that has been uploaded to Scholar called graph\_projectile.C (Projectile Motion Example).

Use the program to investigate the dependency on the time step used. Consider a projectile launched from y=0 with an initial speed of 40 m/s at an angle of 45 degrees.

2. **Dependency on Derivative Method**

The program in part 1 uses the Euler method to calculate the next iteration in position and velocity.

Modify the program to use first the Euler-Cromer method, and second the Midpoint method, and compare the results using these three methods (Again, consider a projectile launched from y=0 with an initial speed of 40 m/s at and angle of 45 degrees.

3. **Effects of Air Resistance on Time-of-Flight**

Use the code above, with appropriate modifications, to calculate the time that it takes for a pitcher in baseball to throw a 95 mph fastball from the pitcher’s mound to home plate (a distance of 60 feet, 6 inches). Assume the ball is released from a height of 2.0m above the ground. How does this time compare to the zero air resistance case?

4. **Effects of Air Resistance on Maximum Range**

Use the code above, with appropriate modifications, to calculate the optimal angle at which a baseball should be launched, assuming an initial speed of 95mph, to achieve maximum distance.

At what angle should the baseball be launched to achieve ½ this distance?

Compare the times-of-flight for these two cases.

**5. Human Projectile Motion from Stratosphere to Near-Earth**

Begin with the ROOT macro that has been uploaded to Scholar called graph\_human\_projectile.C (Human Projectile Motion Example).

Modify this program to take into account the variation of density with altitude – use the fit that you completed in the final part of assignment 4 to parametrize the density as a function of altitude.

Calculate the time-of-flight and maximum velocity for a projectile of m=80kg, starting from rest, beginning at an altitude of 39045m, and reaching a final altitude of 2400m. Assume the cross-sectional area of the projectile is 1.4m2.