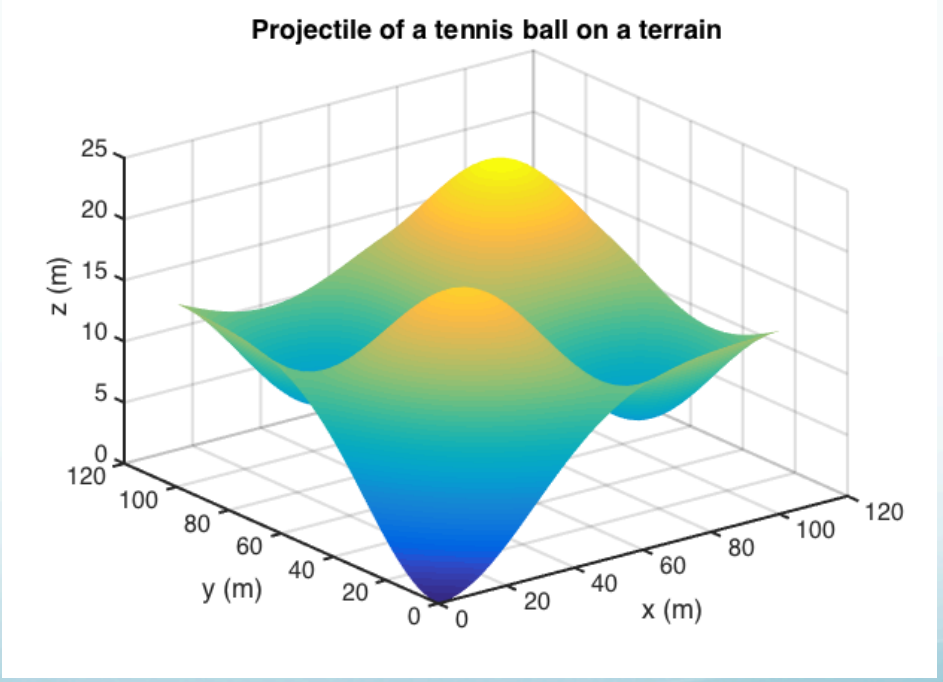
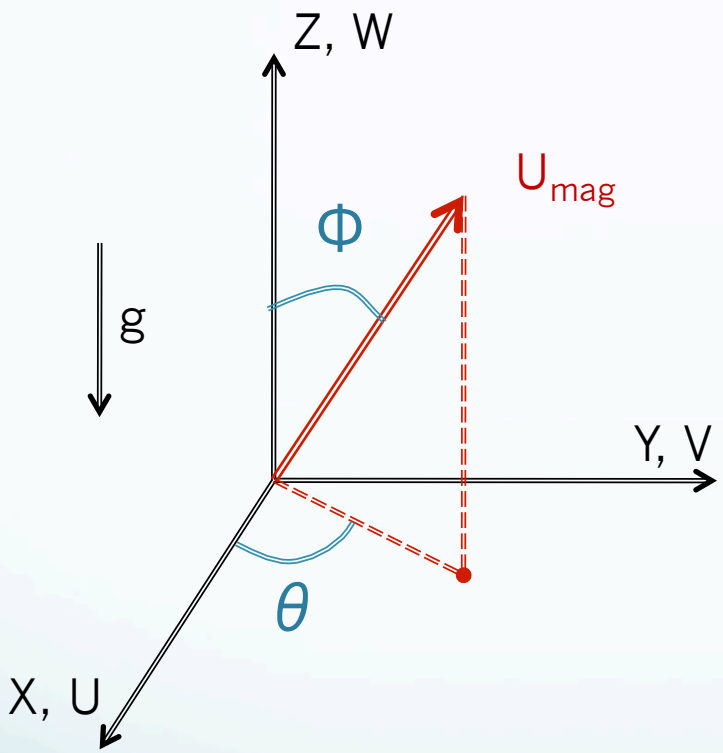
Project

- Projectile motion of a tennis ball on a 3-dimensional terrain.
- Objective: identify the location where the tennis ball hits the terrain.



Overview



- Given: initial position (X_o, Y_o, Z_o), initial velocity U_{mag} and launch direction (θ, Φ).
- Compute: time, 3 components of position (X, Y, Z) and 3 components of velocity (U, V, W) along trajectories.
- Physics includes gravity (g = 9.81 m/s^2) and air resistance.
- Use time step $\Delta t = 0.001$ s in all tasks.

Task 1A

- Write **projectile3d.m** to solve for positions and velocities along the trajectories of the ball (T, X, Y, Z, U, V, W).
- Ignore air resistance for task A.

$$\frac{dX}{dt} = U \qquad \frac{dU}{dt} = 0$$

$$\frac{dY}{dt} = V \qquad \frac{dV}{dt} = 0$$

$$\frac{dZ}{dt} = W \qquad \frac{dW}{dt} = -g$$

Task 1B

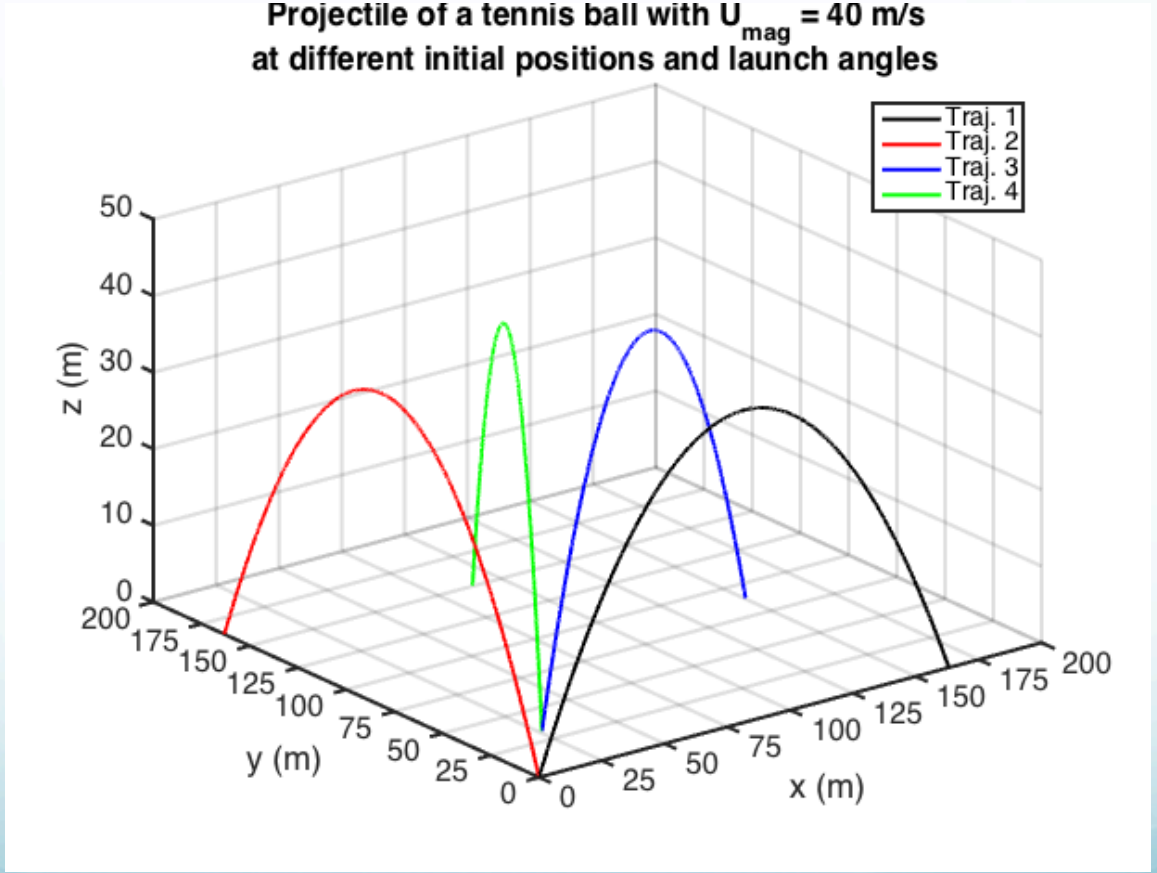
- For 4 different sets of initial position, velocity and direction, create table #1 to report the time, the position and velocities when the ball hits the maximum height and when it hits the ground.

Trajectory	X_o (m)	Y_o (m)	Z_o (m)	U_{mag} (m/s)	Θ (º)	Φ(º)
1	0	0	0	40	0	45
2	0	0	0	40	90	45
3	5	5	5	40	30	45
4	5	5	5	40	60	45

Trajectory	time (total)	max_height_position [X, Y, Z, U, V, W]	final_position [X, Y, Z, U, V, W]
1			
2			
3			
4			

Task 1C

- Create figure #1 to show the trajectories of 4 different launches.



Task 2A

- Modify **projectile3d.m** to solve for the trajectories of the ball taking into account the effect of air resistance.

$$\frac{dX}{dt} = U \qquad \frac{dU}{dt} = -C\frac{\rho_a A}{2m}U\sqrt{U^2+V^2+W^2}$$

$$\frac{dY}{dt} = V \qquad \frac{dV}{dt} = -C\frac{\rho_a A}{2m}V\sqrt{U^2+V^2+W^2}$$

$$\frac{dZ}{dt} = W \qquad \frac{dW}{dt} = -g - C\frac{\rho_a A}{2m}W\sqrt{U^2+V^2+W^2}$$

- C = coefficient of friction; A = πr^2 where r = 0.04 m
  m = 0.15 kg, ρ_a = 1.2 kg/m^3 (air).

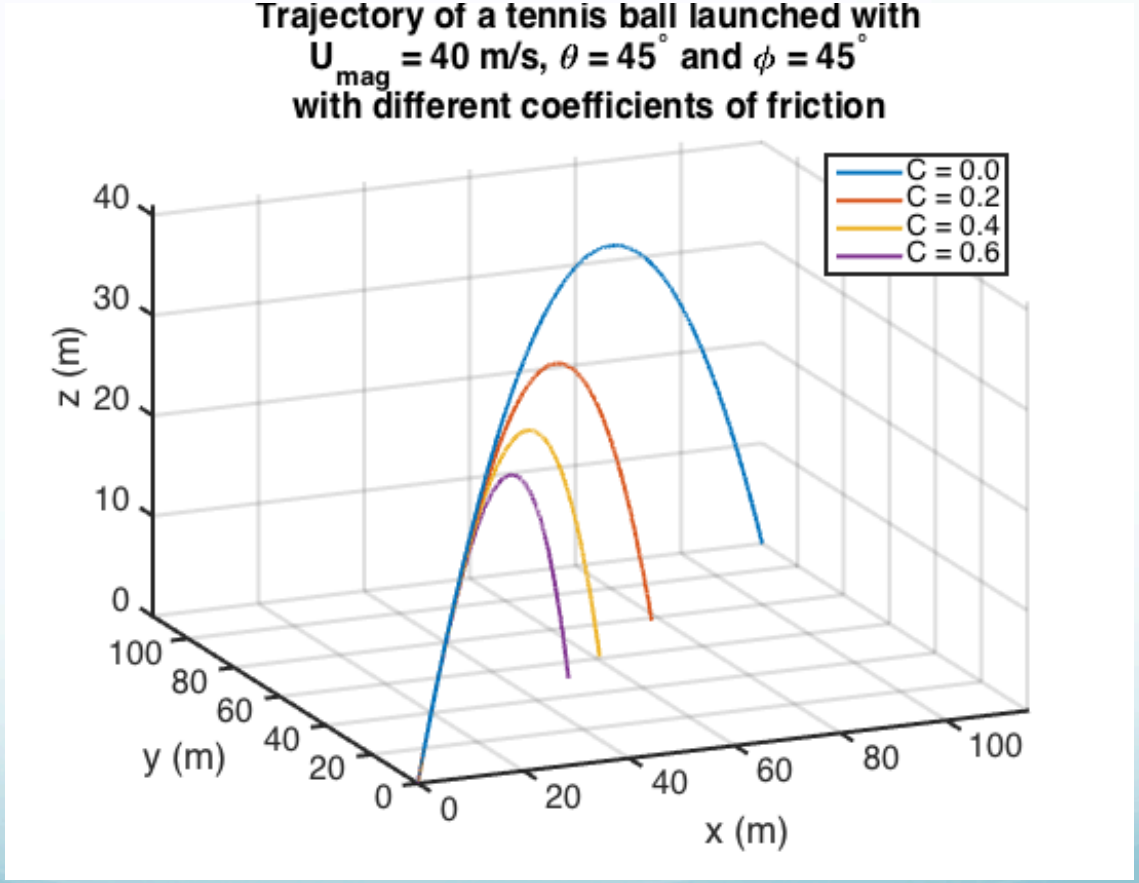
Task 2B

- For task #2, let $X_o = Y_o = Z_o = 0$, $U_{mag} = 40$ m/s, $\theta = \Phi = 45°$.
- Four trajectories with different coefficients of friction: C = 0, 0.2, 0.4 and 0.6.
- Create table #2 to report the positions and velocities when the ball hits the maximum height and when it hits the ground.

Trajectory	Time (total)	max_height_position [X, Y, Z, U, V, W]	final_position [X, Y, Z, U, V, W]
1			
2			
3			
4			

Task 2C

- Create figure # 2 to show the trajectories of the ball for four different coefficients of friction.



Task 3A

- Modify **projectile3d.m** into **trackprojectile.m** to incorporate the terrain and to locate the final positions of the ball on the terrain.
- Download terrrain.mat from TED.
- Three sets of initial conditions are given for Task 3:
  - All have U_{mag} = 40 m/s and C = 0.2

Trajectories	X_o (m)	Y_o (m)	Z_o (m)	Θ(°)	Φ(°)
1	0	0	0	45	45
2	1	2	3	10	60
3	2	3	4	60	55

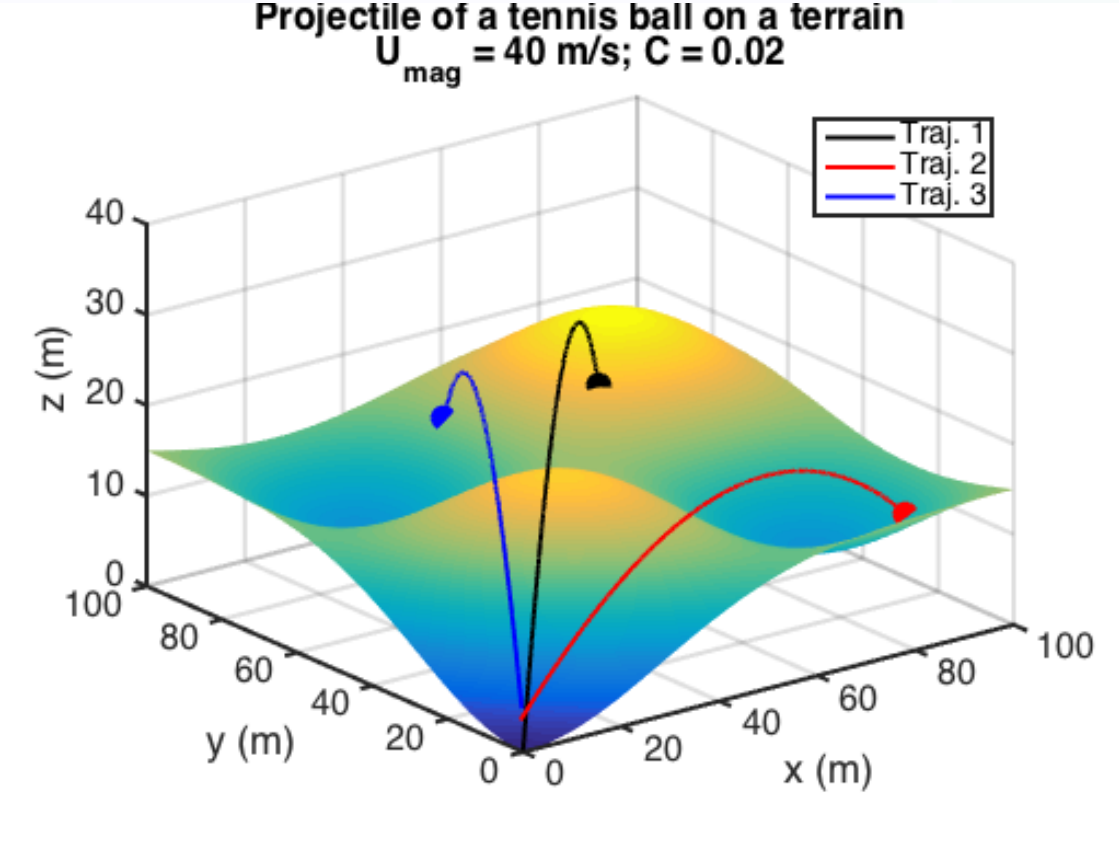
Task 3B

- Create table # 3 to report the time and final positions and velocities for each launch.

Trajectory	time (total)	final_position (X, Y, Z, U, V, W)
1		
2		
3		

Task 3C

- Create figure # 3 to include the terrain, the trajectories and the final positions.



Final Archive and Report

- A single archive of all files related to project is to be turned in via TED, named **project.zip**, before 9 PM on Friday March 13th 2015. The final archive must contain the following:

1. A **project.m** to include answers to all the tasks and all other .m files necessary to run your code. Your code has to run and give correct answers to get 70% of the grade.

2. A report (no more than 10 pages) is worth 30% of the grade. It should be named **report.pdf** and includes:
   - A description of the project and what you accomplish
   - Equations and methods you use to achieve the objectives
   - A flow chart of your program so that the reader can understand how your program works
   - An appendix which has description of all the .m files
   - Figures, tables and their descriptions from the tasks.

Schedule

- Task 1 should be completed by end of week 8.
- Task 2 should be completed by end of week 9.
- The whole project is due before 9 PM on Friday of week 10.
- Instruction and detail on how to format your answers in project.m will be given during week 9.
- Both the code and the report must be submitted via TED before deadline.
- Late submission will be deducted 20% of the total project grade per day (24 hours).