EE 5322 Homework 4
Mobile Robot Control & Potential Fields

1. **Potential Field.** Use MATLAB to make a 3-D plot of the potential fields described below. You will need to use plot commands and maybe the mesh function. The work area is a square from (0,0) to (12,12) in the (x,y) plane. The goal is at (10,10). There are obstacles at (3,3) and (9,9). Use a repulsive potential of K_i / r_i for each obstacle, with r_i the vector to the i-th obstacle. For the target use an attractive potential of $K_T r_T$, with r_T the vector to the target. Adjust the gains to get a decent plot. Plot the sum of the three potential fields in 3-D on the x,y-plane square from (0,0) to (12,12).

2. **Potential Field Navigation.** For the same scenario as in Problem 1, a mobile robot starts at (0,0). The front wheel steered mobile robot has dynamics

$$\dot{x} = v_T \cos\phi \cos\theta$$
$$\dot{y} = v_T \cos\phi \sin\theta$$
$$\dot{\theta} = \frac{v_T}{L} \sin\phi$$

with *(x,y)* the position, θ the heading angle, v_T the wheel speed, L the wheel base, and ϕ the steering angle. Set L= 2.

   a. Compute forces due to each obstacle and goal. Compute total force on the vehicle at point *(x,y)*.
   b. Design a feedback control system for force-field control. Draw your control system.
   c. Use MATLAB to simulate the nonlinear dynamics assuming a constant velocity v_T and a steerable front wheel. The wheel should be steered so that the vehicle always goes downhill in the force field plot. Plot the resulting trajectory in the *(x,y)* plane. Use a square from (0,0) to (12,12).

3. **Platoon of Mobile Robots.**

There are 3 robots in a platoon. Robot 1 is the leader. For each robot *i* take the simplified Newton's law dynamics (with mass=1)

$$\ddot{x}_i = F_x^i$$
$$\ddot{y}_i = F_y^i$$

with *(x,y)* the position of the vehicle and F_x, F_y the forces in the x and y direction respectively. The obstacles and goal are the same as in problems 1 and 2.

   a. Program the forces for the leader node 1 to avoid the obstacles and go to the target. Same scenario as above (but with these simplified dynamics).
   b. Program the force on each follower to stay ½ unit from the leader and not to run into each other. Use repulsive POTENTIAL between followers as K_i / r_{ij}^2 with r_{ij}= distance between followers *i* and *j*. For the potential to the leader, use something like

$$V_{iL} = \tfrac{1}{2}(r_{iL} - r_D)^2$$

   with r_{iL} the distance from follower i to the leader, and r_D the desired separation. Play with the potentials to make it work properly. Compute forces properly using calculus.
   c. Simulate. Plots trajectories in (x,y) plane. Start all robots at (0,0).