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 (10,10) in the (x,y) plane. The goal is at (10,10). There are obstacles at (3,2) and (7,6). 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.

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

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

with (x,y) the position, θ the heading angle, V 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 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 5 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.

   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).

4. 20% EXTRA CREDIT- Make a routine to plot the robots as points on the screen in real-time as the robots move. Then, you can see them move.

If you feel like it, make a movie too. Use MATLAB fns moviein, getframe, etc.