Discussion Questions

Motion Planning and Configuration Space

1. Name five applications of motion planning
2. Name at least four types of motion planning algorithms/developments that have occurred in the field of motion planning over the years.
3. What motivated the introduction of randomized planning algorithms such as PRMs and RRTs?
4. Name 2 features of motion planning problems that do not have full heuristic or algorithmic solutions. In other words , what properties of an environment or robots greatly increase the "hardness" of a motion planning problem?
5. Define degree of freedom. Name/describe as many types of degrees of freedom and/or joints for robotic systems as you can.
6. Define configuration, C-Space, C-Free, C-Obst, and ∂C-Obst.
7. If a robot can move and turn in the xy plane and it has a mounted camera with a view radius of $\pi/3$ that can look in any direction in the plane (but not 'up' or 'down'), how many degrees of freedom does the robot have?
8. If a quadrotor is carrying a mobile arm attachment with 4 spherical joints, what is the dimension of this quadrotor's C-space?
9. We have an environment $E \subseteq \mathbb{R}^3$, and robot r composed of a mobile base with an attached manipulator arm composed of links ending with an endefector. Given a configuration $(x, y, z, \theta_1, ..., \theta_m)$ of r, how can we find the location of the endefector in E?

   Assume you have full knowledge of the robot - its base, links, joints and so on, meaning shape, type, size, and the way they relate to the values of the configuration.

10. Explain (in words) how you would check if a robot in a given configuration is in collision with an obstacle. Define other examples of "validity" for a robot.
11. Let $E \subseteq \mathbb{R}^3$ be an environment with obstacles, and let r be a robot. Given two configurations c_1 and c_2 of r, the c-space segment connecting c_1 and c_2 matches a continuous movement of r in E .

    Describe a procedure (use either pseudo-code or English) that decides if the motion corresponding to the line segment is valid, meaning that the robot can execute the movement without violating any constraints.

    (Hint: we can't collision check an entire line through C-space, but maybe we can approximate this line by a finite set of points)

12. What is a nonholonomic constraint? Kinematic constraint? How do these constraints affect C-space? C-free? How might adding a time component affect things?

13. Give an example of when computing the entire C-space for a motion planning problem is feasible (can be computed in a reasonable time). When is it infeasible? What algorithmic methods can alleviate this infeasibility? (Hint: think about PRMs)