In the laboratory assignments that make use of the wind tunnels in the basement lab in Krieger, we will perform flow visualization using glycerol-water fog. Here we’ll go over some of the fundamentals of flow visualization, and describe the operation of the fog generation apparatus.

**Flow visualization.** Flow visualization is used to reveal flow patterns and flow structures in what are essentially invisible flows. Familiar applications of flow visualization include the flow of smoke lines around models (like cars, say) in wind tunnels, and we are accustomed to referring to the resultant patterns as ‘streamlines’. Strictly speaking, we will distinguish three types of flow visualization patterns (the book discusses these in §2.2):

- **Streamlines** are lines that are everywhere parallel to the local fluid velocity vector.
- A **pathline** is the line that results from following a single fluid particle as it moves through the flow field.
- A **streakline** is the line formed from all the fluid particles that pass through a fixed point in space. As an example, if we place a source of smoke in the flow, then allow the smoke lines to move through the flow, we are looking at streaklines.

Streamline visualization is nice because it gives you direct information about the velocity field, while the other techniques give you integrated versions of the velocity field that are more difficult to interpret mathematically. Since we will, basically, be putting sources of smoke at fixed locations, our flow visualization apparatus generates streaklines. However, in the event that the flow is *steady*, streamlines, pathlines and streaklines are identical, and interpretation is easier.

**Fog generation apparatus.** The fog generation apparatus is shown in Fig. 1. The assembly is mounted on a wheeled rack so that it can be used with both of the wind tunnels in the Krieger lab. Sitting on the base of the rack is the fog machine (Rosco 1600). The fog machine uses a glycerol-water solution, which is drawn into the machine, heated to facilitate atomization, then...
forced through a nozzle in the form of a fog of fine drops. (The drops are under $5 \cdot 10^{-5}$ m in diameter.) The fog goes up a flexible aluminum duct into a plenum (basically a fancy word for supply tank), which is shown in Fig. 2. The output side of the plenum has four holes through which the fog flows. The wheeled rack is placed so that the output holes are close to (within a couple of inches of) the input screen of the wind tunnel, which can be seen in Fig. 1.

**Operation.** The power switch on the fog machine activates the heater. There is a remote control attached to the machine by a long cord that controls the volume of fog produced by the machine. The sequence for operating the fog machine is as follows:

1. Turn on the machine.
2. Wait for the machine to heat up. This will take a couple of minutes.
3. While waiting, prop open the door on the side of the room nearest the wind tunnel exit, and set up the floor-standing fan to blow air out the door. Set the fan to blow on the highest setting.
4. The ‘heater’ light on the remote will turn off when the machine is ready. Make sure the tunnel is running. Turn the toggle switch on the remote to ‘on’, and set the fog volume to about 1.5.
5. Wait for the duct and the plenum section to fill with fog. As the fog level in the plenum increases, fog will begin to issue from the holes on the output side, starting with the bottom hole and working up. Some fog will also leak out at various places: this is normal.
6. While running the experiment, adjust the fog level as appropriate. If there is a lot of extra fog leaking out of the apparatus that isn’t coming from the output holes, you may need to dial down the fog volume. You almost certainly will not need to increase the fog volume.
7. When you’re finished with the experiment, turn off the machine. Let the floor fan run for a few minutes to clear the room of fog, before shutting it off and closing the door.

Some things to keep in mind while running the fog apparatus:

- The flexible duct gets really hot - don’t touch it while the machine is on.
- Be patient while waiting for the fog to start coming out of the output holes. Similarly, if you do feel the need to increase the fog level during the experiment, increase the level on the remote control slowly, and wait for the changes to take effect. It is very easy to end up with way, way too much fog in the room.