1. A bead of liquid rests on a solid substrate, spreading out on the substrate over an area $A$. If a surfactant is introduced into the liquid, will the area of contact increase, decrease, or stay the same? Draw a diagram and explain your reasoning.

A) Increase  
B) Decrease  
C) Stay the same

2. A sufficiently thin piece of steel ($\rho_{\text{steel}} = 8000 \, \text{kg/m}^3$) can float at the surface of water, even though steel is heavier than water, due to surface tension. Consider a long steel cylinder of length $L$ and radius $r$, where $r \ll L$. The diagram at left is a cross-sectional view of the cylinder when it is partially submerged in water. The point where the cylinder is tangent to the water surface is characterized by the angle $\theta$. Assume that at this point the water surface is tangent to the cylinder (i.e. perpendicular to the radius $r$ shown in the figure).

a) On the diagram, draw the location and direction of the forces exerted on the cylinder by surface tension. What are the magnitudes of these forces?

b) If the cylinder is in static equilibrium, what is the angle $\theta$, in terms of $\rho_{\text{steel}}, r, g,$ and $\gamma$? You may neglect buoyancy (it wouldn’t significantly affect the answer anyway). Does your answer make sense (e.g. how does $\theta$ change if you vary $\rho_{\text{steel}}$ or $\gamma$?)
3. The capillary tube shown at right has a conical shape that narrows towards the right end. It contains a small volume of water, which forms a meniscus at either end, as shown. The water wets the inside surface of the capillary tube. If both ends of the tube are open to the air, which way will the water flow? (You may neglect the effects of gravity.) Explain.

A) To the right (towards the narrow end)
B) To the left (towards the wide end)
C) The water will remain where it is

4. You have probably noticed that when a steady stream of water flows from a faucet, the stream gets thinner as it descends (as seen in the photo at left). The shape of this stream of water is described by an interesting mathematical function, which you can derive by using the equations of kinematics and the continuity equation for fluid flow.

If the faucet has a radius \( r_0 \) and the water exits the faucet with a speed \( v_0 \), find an expression for \( r(h) \), the radius of the stream of water in terms of the height \( h \) that the water has fallen from the faucet. This expression is graphed at right (it is graphed “twice” so you can see the total cross-section of the stream.)