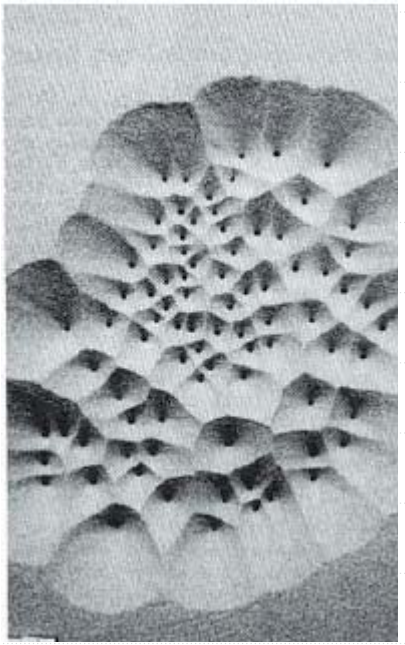
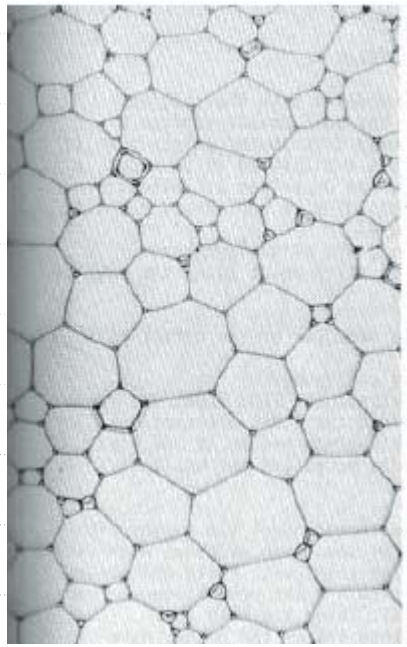
Physical Computing: *the building of machines that can through their embeddedness into a physical environment demonstrate complex behaviour.*

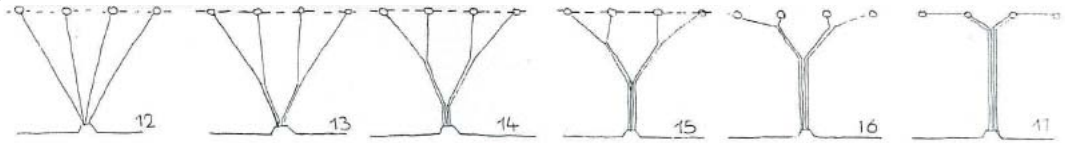
This workshop is devoted to exploring emergent form through physical models, in particular using soap films to generate least surface area shapes using a range of techniques.

Frei Otto, the german engineer, developed a range of techniques at the Institute of Lightweight Structures in Stuttgart (see "Finding Form" , Otto F & Rasch B; pub. Axel Menges 1995) and in this case the method is to use surface tension in supported soap films to generate the surfaces. This process occurs because the molecules in the film are all simultaneously computing their positions and trying to get as close together as possible. The images on the right show some emergent outcomes using different frames made of wire or string. This is an example of "natural computing", where the form of the result is the outcome of the parallel execution of simple algorithms by all the molecules. It is important to make the connection between what is going on here and what might be an appropriate algorithm in "virtual computing" (a computer program). Thinking about the controlled constraints of a 'closed 'digital computer experiment and the given natural/physical paramters of an 'open' environmental experiment. Can one said to be digital versus the other being analogue? Is there a distinction between analogue and digital processes?

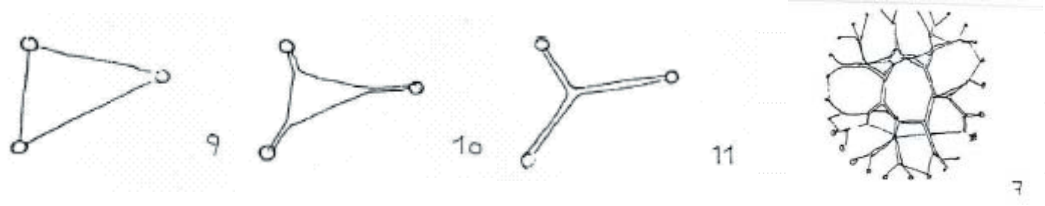
Today, we would like you to think and experiment with implicit material properties (like the tendencies of liquid molecules to move equal distance towards another, resulting in evenly distributed stresses and surface tension) and natural forces (gravity, mass, momentum) to drive the material. Through interaction



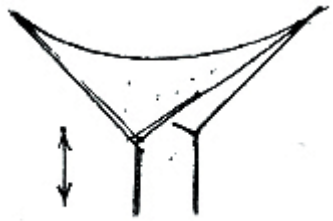




one-to-all system



all-to-all system



doubly curved surface

free-form edges transitions

they converge towards a structural result that can be observed as 'Form' (see again Frei Otto's soap film forms and shortest path systems, Antonio Gaudi's catenary arches).
You will work in groups and be given some materials (but are free to find yourselves appropriate materials) to set up either a soap film model to test and observe liquid molecules generate 'even curvature' models that describe minimal energy surfaces, or a minimal path system that demonstrates again the pull of liquid molecules tensioning threads and bundeling them into short segments between given fixed points. Minimal path groups should experiment with *all-points-to-one* and *all-to-all* systems (see pictures; although this is just visually meant since both are all-all), whereas minimal surface groups should concentrate on doubly curved surfaces under transitions. The ***transitions*** should be generating *free-form edges*, which means that they occur independently from rigid edges. Infact, adaptation is the strength of soap films, which makes them ideal for transitions.

Tasks

You should record your experiments since you can't keep them. Thus, find a way to take sequence photography or any way to capture the dynamic nature/ transition states of the models. With Janet you will make a page about your experiments.

Your page will have to be handed-in next week, since you will receive a a new task for physical computing. You will be asked to construct an adaptive machine analogous to 'backpropagation neural networks'.

for references see:
- Frei Otto, Finding Form
- IL book series
  (IL for Institute for Leightweight Construction)