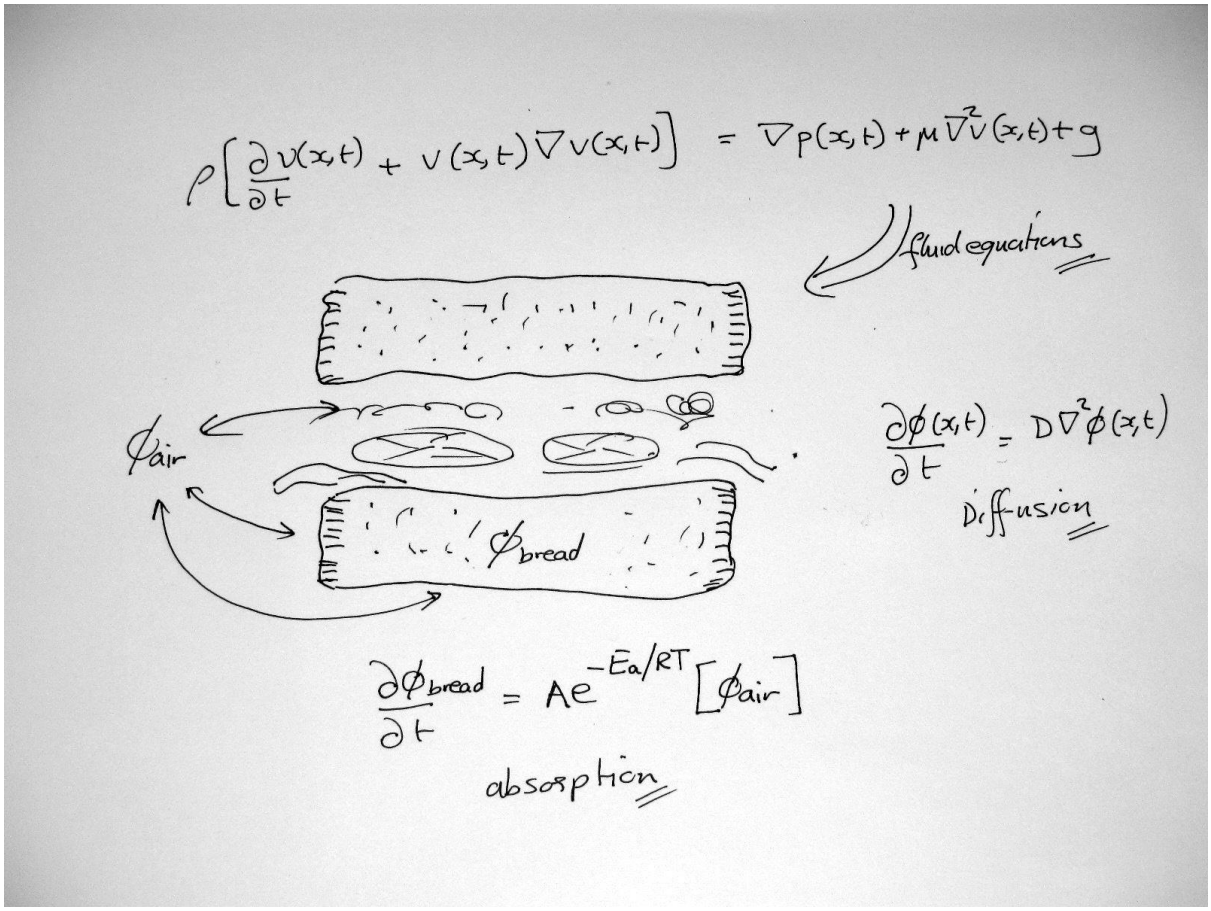
Sandwich equations

These are just some of the equations of physics for your sandwich describing the flow of liquid water through the sandwich, the moisture exchange between the filling, the bread, and the air; including the adsorption by the bread.



Feeling daunted by the equations? You should be! These are as complicated as modelling the weather - and very similar too. Water, tomato juice etc. flow through the filling like rivers over the earth. Water gets absorbed into the bread or flows over the top like rain on the soil. Moisture enters the air and is exchanged between the filling and bread – not quite rain, but similar. The

absorption of moisture by the bread is a chemical and physical process dependent on vapour concentrations and temperature at the interface. You would need a supercomputer to solve these equations in detail – it would be easier to send a loaf of bread to the moon.

But the equations show up a few tips and tricks to avoid a soggy sandwich, which you have probably already worked out.

- Don't apply unnecessary pressure (the $p(x,t)$ term) it squeezes out the water.
- The equations describe the deterioration with time due to slow diffusion of the moisture. So eat your sandwich while it is fresh.
- Use a thick layer of butter, it is hydrophobic and keeps moisture away from the bread.
- Control the loss, or uptake, of moisture from the air into the bread. Butter protects the top. Crusts are good; they stop the edges drying out ($\varphi_{air} < \varphi_{bread}$) or going soggy ($\varphi_{bread} < \varphi_{air}$). Wrap the sandwich tightly to keep air away from the underneath – but don't squeeze it of course.
- Most equations are temperature dependent particularly viscosity and absorption rates. Keep it cool to reduce the reaction rates.
- Use the right bread. Under a microscope soft white bread has an enormous surface area and rapidly soaks up water. The fine structures and lack of fibre cause its structure to collapse as it takes up water. A coarser structure and more fibre has greater resistance to the dampness – and can't dry out so quickly either.