

# How to prepare and present maths posters

**Joseph Webber**

Mathematics Institute, University of Warwick

# Why make a maths poster?

**Short answer:** to advertise what you've done and explain it clearly



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Normally presented in a poster session at a conference:

- break in the talks schedule and everyone is in one place
- you usually stay with your poster whilst people look at sometimes hundreds of examples
- poster serves as both an advert to attract and a visual aid if you're asked questions or need to go into more detail

**eye-catching ▪ meaningful ▪ clear ▪ detailed**

# Why make a maths poster?

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American Physical Society (APS) DFD-Interact session (2024)

Many conferences and meetings now feature **flash-talk** sessions (e.g. *DFD-Interact* at APS DFD)

- your poster is your **one slide** at the start of the session, used to introduce you to the room
- people then come to look at it for more **details and an in-depth discussion**

again, this needs to be...

**eye-catching ▪ meaningful ▪ clear ▪ detailed**

# Who's your audience?

**Conference posters:** can afford to be more technical and detail-heavy but have a think about how general the audience is.

**Policymakers:** need to sell the importance of your research but details aren't going to be all that important.

**Student conferences:** something of a mix between the two!

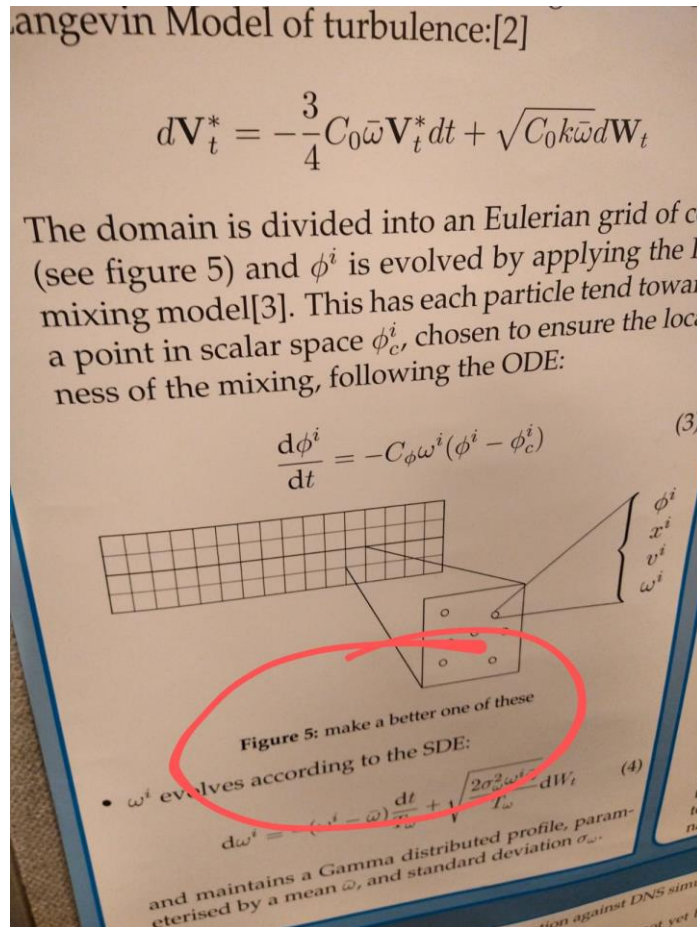
**Mixed audiences:** tell the story of *how* you got to where you did, not *what*

Who is the audience that needs to see your research?



# A myth

“being selected to give a poster at a conference is much worse than giving a talk”



play this stereotype to your advantage...

**people in a poster session are sometimes crying out to find something good!**

a good poster can go a really long way to **engaging new people, sharing your work, and really delving into the details**

# A myth

**“being selected to give a poster at a conference is much worse than giving a talk”**

- you see potentially hundreds of people instead of sometimes just a few  
*I've given talks to <5 people in a particularly boring session but the whole conference is there for a poster (and there's often a promise of free food and drink...)*
- you can afford to tailor what you say to the person you're talking to  
*this can be a great way to find people who you can build on your research with*
- you can go into more detail
- you get a two-way conversation and can easily pick up new ideas
- preparing a poster is **the best** way to prepare a paper

# What makes a good poster?

## The advert

- Needs to stand out from a field of potentially hundreds
- Important to communicate:
  - what you've done
  - how you've done it
  - that the results are good

## The project summary

- Give detail to a level short of that in the final paper, but some more specifics can be shown than in a talk
- Walks through the key points of *how* you've done your work
- Familiar structure: intro, methods, results, conclusions

## The slide deck

- Graphical pointers and equations that illustrate your prepared spiel
- More freedom to illustrate things with diagrams than in a paper
- Qualitative overview of results, but maybe not as technical

# What makes a bad poster?

## The advert

- Very easy to oversell the novelty or importance of work
- Can look a bit vapid and lacking substance
- Don't just want to point people to a paper; they'll never read it
- Need to be able to précis the key details

## The project summary

- Boring
- Can often result in really dense work
- Anyone who does want to build on your research will read the paper anyway

## The slide deck

- Useless if you're not there
- Needs some context to join the results together
- Easy to get thrown if your conversation ends up going in a different direction to plan



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Summarise your current research problem and what you've done this summer in 10 seconds (approx. 30 words)

- catchy **title that's specific** but **not too technical**
- easy to find **summary of your results**, laid out so that it's the focal point
- make it straightforward to **find more information** (QR code to paper?)

What's the title of your poster?

# The project summary

- Give detail to a level short of that in the final paper, but some more specifics can be shown than in a talk
- Walks through the key points of how you've done your work
- Familiar structure: intro, methods, results, conclusions

- Boring
- Can often result in really dense work
- Anyone who does want to build on your research will read the paper anyway

Break down what you've worked on this summer into at most 5 headings

- helpful to **compartmentalise** your research into subheadings
- don't be afraid of **some** equations and technical details
- a **clear narrative flow** is really important

Now summarise your work in < 5 bullet points

# The slide deck

- Graphical pointers and equations that illustrate your prepared spiel
- More freedom to illustrate things with diagrams than in a paper
- Qualitative overview of results, but maybe not as technical

- Useless if you're not there
- Needs some context to join the results together
- Easy to get thrown if your conversation ends up going in a different direction to plan

Sketch, or decide on, a graphical representation for each of the bullet points

- pictures are really important – what do you need to properly explain your work?
- write out briefly what you're going to say if someone comes up to you to ask about your poster
- oft-quoted rule of thumb: ~40% of a poster should be images (do we agree?)

**anyone prone to migraines should look away now...**

# Dynamics of super-absorbent hydrogels

JOSEPH WEBBER *Institute of Theoretical Geophysics, Department of Applied Mathematics and Theoretical Physics, University of Cambridge*  
Supervised by Prof Grae Worster, DAMTP

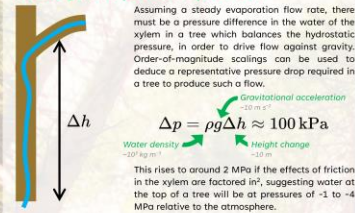
The current understanding of transport of water in plants relies on significant negative pressures<sup>1</sup> in the xylem to draw water up against gravity.

We expect such pressures to lead to cavitation, spontaneous boiling, and xylem collapse<sup>2</sup>, especially in plants subjected to water stress.

The pit membranes separating one xylem vessel from another both construct flow but also contain hydrogels formed from organic polymers and water<sup>3</sup>. These can be modelled using our new approach.

We propose a contribution from discontinuities in the liquid pressure arising at the interface between hydrogel and water in pits between xylem cells.

## The negative pressure problem



At pressures of around -0.1 MPa, water spontaneously boils and we expect cavitation, collapse of xylem vessels and damage to the tree. Though some authors claim to have measured such pressures<sup>4,5</sup>, they are difficult to reproduce even in laboratory environments without cavitation. This motivates seeking an additional driving mechanism in the transport of fluid, in addition to classical cohesion-tension theory.

## Pits and bordered pits

In between adjacent cells comprising the xylem of vascular plants lie pits, which permit the transport of sap laterally in addition to the vertical transport which occurs through the hollow lumen. These pits comprise a permeable membrane spanning a small gap of around 1-10 μm in diameter, with examples shown in cross-section in the first two images<sup>6</sup> on the right. In some conifer species the pit structure is more complicated, forming a so-called bordered pit. Here, as shown in the final four images of the figure, a solid torus structure (labelled T) is held in place by a flexible and permeable elastic margo (M) which surrounds it and deforms in response to pressure and flow.

These elastic pit structures comprise organic polymers surrounded by water, and some authors have suggested that the resulting hydrogel could play an important role in the transport of fluid in plants<sup>7</sup>. They are able to bend as a circular membrane, swell and dry<sup>8</sup>.

## Swelling and drying of hydrogels

The dynamics of gels can be understood as being driven by the flow of water throughout. The interstitial velocity of water is given by Darcy's law:

$$\mathbf{u} = \frac{k(\phi)}{\mu} \nabla p$$

When coupled with Cauchy's momentum equation, it becomes possible to derive a nonlinear diffusion equation governing the polymer fraction  $\phi$  as gel swells or dries.

Involving only a handful of material parameters of a gel:

- The osmotic pressure and how it relates to polymer fraction.
- The permeability.
- The shear modulus.
- The equilibrium polymer fraction  $\phi_0$ , which is the polymer fraction reached by a given hydrogel if placed in water and allowed to swell with no constraints<sup>9</sup>. This depends on temperature and can be as low as  $10^{-2}$  for some gels.

In addition, the shape of the hydrogel can be deduced from the forced biharmonic equation describing the displacement  $\zeta$  of any given point from its position at equilibrium:

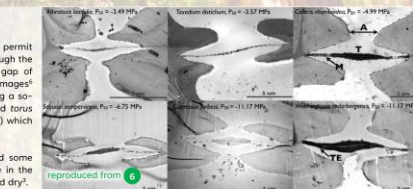
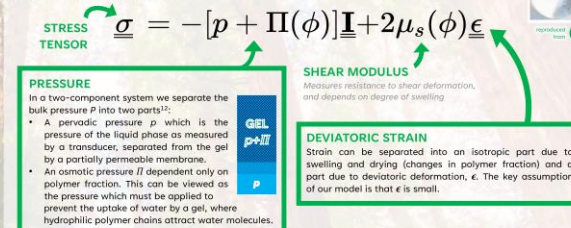
$$\nabla^4 \zeta = -3 \nabla^2 \zeta \left( \frac{\phi}{\phi_0} \right)^{1/3}$$

## Linear-elastic-nonlinear-swelling gels

Hydrogels comprise hydrophilic polymer chains (of volume fraction  $\phi$ ) surrounded by adsorbed water. In many cases, the polymer volume percentage may be as small as 1%. Modelling of hydrogels needs to couple an understanding of the gel as an elastic material with its porous nature, and therefore is a key problem in poroelasticity. Existing models can be grouped into two main approaches:

- **Fully-nonlinear models**<sup>7</sup> use a microscopic understanding<sup>10</sup> of polymer and water molecule interactions to describe the macroscopic behaviour of the gel.
  - + Accurately models gels under large strains due to swelling and drying.
  - Relies on a complicated chemical understanding of water-polymer interactions with parameters that are hard to measure macroscopically.
- **Fully-linear models**<sup>11</sup> use linear poroelasticity to relate the stresses and strains on a gel, with Darcy's law used to describe the flow of water.
  - + Describes any given gel using only macroscopic parameters which are easy to measure, and separates out fluid flow from elasticity.
  - Linear elasticity is invalid for large strains<sup>12</sup> - hydrogels may swell with isotropic swelling strains of much greater than 100%.

In our linear-elastic-nonlinear-swelling model, we allow for nonlinearities in the (potentially large) isotropic strains corresponding to the swelling and drying of gels whilst linearising around deviatoric strains corresponding to shearing deformation. In effect, a hydrogel swollen to any given degree is treated as an instantaneously incompressible linear-elastic material.



## Gel membranes & surface tension

To apply our model to understand the flow of water through pit membranes in a plant cell, we start by considering a single thin circular membrane. Under a load  $Q$  per unit area, the vertical deflection  $\zeta$  of a circular linear-elastic membrane satisfies

$$\nabla^4 \zeta = -Q/D$$

for  $D$  the bending moment<sup>13</sup>. Thus, if we assume that the membrane has a constant curvature  $\kappa$ , the curvature under a given load is set by

$$E\kappa^3 = Q$$

At curved interfaces between gel and water, there is a discontinuity in the pervasive pressure arising from an effect akin to surface tension<sup>14</sup>. This can be quantified by the relation

$$\Delta p = \gamma \kappa$$

Therefore, under a load which arises purely from hydrostatic pressures, there exists equilibrium solutions where

$$2\gamma\kappa = E\kappa^3 \Rightarrow \kappa = 0, \pm \sqrt{\frac{2\gamma}{E}}$$

## A simple experiment

Consider a U-shaped tube with a circular gel membrane placed in the left-hand arm, with equilibrium water heights  $h_1$  and  $h_2$  on the left and right sides, respectively. Then, the pressure difference across the membrane is given by

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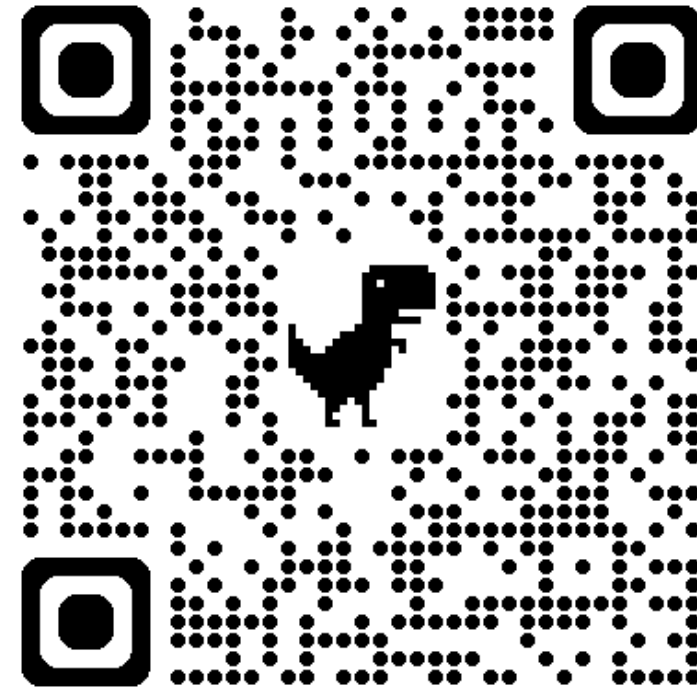
Which, for nonzero  $\gamma$ , admits an equilibrium solution where  $h_1 > h_2$  and thus a column of water is supported against gravity by the surface tension effect of the membrane.

$$h_1 - h_2 = \sqrt{\frac{2\gamma^3}{\rho^2 g^2 E}}$$



## Membranes in trees

As we have seen, a single hydrogel membrane can support a certain height of fluid against gravity due to discontinuities in the pervasive pressure across curved water-gel interfaces. If each bordered pit contains such a curved membrane, it is possible that water can be transported to great heights against gravity without the need for significant negative pressures (relative to atmospheric pressure) at the top. Each membrane need only contribute a small amount to the overall effect,  $2\gamma\sqrt{2\kappa}$ .



[https://jwebber.github.io/assets/files/cada\\_poster\\_posters\\_talk.pdf](https://jwebber.github.io/assets/files/cada_poster_posters_talk.pdf)



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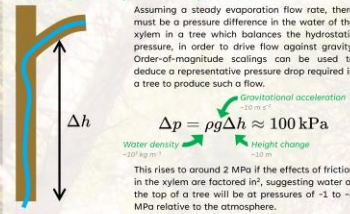
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$$\underline{\sigma} = -[p + \Pi(\phi)]\underline{\mathbf{I}} + 2\mu_s(\phi)\underline{\epsilon}$$

**STRESS TENSOR**

**PRESSURE**

In a two-component system we separate the bulk pressure  $P$  into two parts<sup>12</sup>:

- A periodic pressure  $p$  which is the pressure of the liquid phase as measured by a transducer, separated from the gel by a partially permeable membrane.
- An osmotic pressure  $\Pi$  dependent only on polymer fraction. This can be viewed as the pressure which must be applied to prevent the uptake of water by a gel, where hydrophilic polymer chains attract water molecules.

**GEL  $p+\Pi$**

**SHEAR MODULUS**

Measures resistance to shear deformation, and depends on degree of swelling

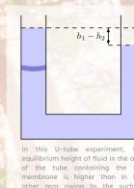
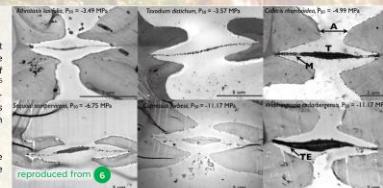
**DEVIATORIC STRAIN**

Strain can be separated into an isotropic part due to swelling and drying (changes in polymer fraction) and a part due to deviatoric deformation,  $\underline{\epsilon}$ . The key assumption of our model is that  $\underline{\epsilon}$  is small.

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**Permeability**

**Viscosity**

When coupled with Cauchy's momentum equation, it becomes possible to derive a nonlinear diffusion equation governing the polymer fraction  $\phi$  as a gel swells or dries,

$$\frac{\partial \phi}{\partial t} = \nabla \cdot \left[ \frac{k(\phi)}{\mu} \left( \frac{\partial \phi}{\partial \phi} \nabla \phi + 4\mu_s(\phi) \nabla \left( \frac{\phi}{\phi_0} \right)^{1/3} \right) \right]$$

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At curved interfaces between gel and water, there is a discontinuity in the periodic pressure arising from an effect akin to surface tension<sup>15</sup>. This can be quantified by the relation

$$\Delta p = \gamma \kappa$$

**Given by  $p^+ - p^-$ , akin to the Young-Laplace equation**

Therefore, under a load which arises purely from hydrostatic pressures, there exists equilibrium solutions where

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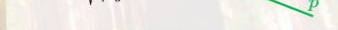
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- Clear colour, eye-catching(?) background
- List of further information/references

- Judicious use of equations
- Summary points on top left-hand corner
- Pictures used to illustrate points

- Generic, vague, title

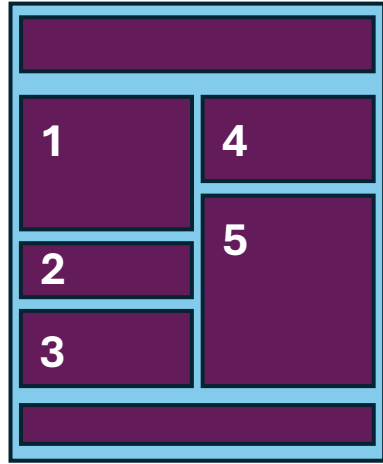
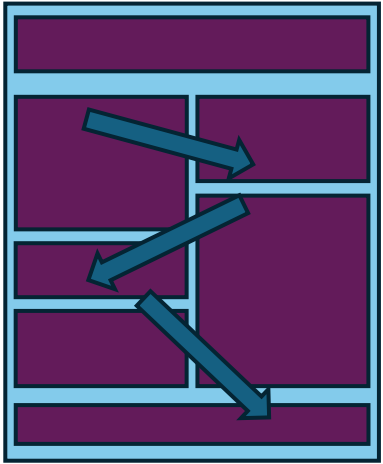
- No clear story
- Too much content
- Text style is too much like prose from a paper

- Where would you start talking about this?

- Contrast is low between elements
- Text is too small



# Some notes on layout



- it makes sense to break a poster up into chunks
- think about '**Z patterns**' or other, logical, routes
- take a few moments to think about how you're going to structure those chunks; you want a story to be told
- **landscape or portrait**? Often chosen by the session.

As a rule of thumb, the title and key subject matter should be readable from 3m away. Everything should be visible from 1.5m away.

**14pt : minimum size to be clear at 1.5m**

**25pt : minimum size to be clear at 3m**

**titles are usually >72pt**

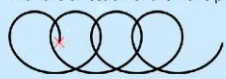
# Stokes drift through corals

JOSEPH WEBBER Trinity College, University of Cambridge

Project supervised by Prof Herbert Huppert FRS at the Institute of Theoretical Geophysics, Department of Applied Mathematics and Theoretical Physics. Funding from the Heilbronn Fund at Trinity College.

## Stokes drift

- Waves in the ocean result in a drift effect of water under the surface, in a phenomenon known as *Stokes drift*, named after Sir George Gabriel Stokes FRS (1819-1903, pictured).
- If we follow the path of an individual 'parcel' of water below the surface undergoing wave motion, we find that it spirals along, drifting with the direction of the wave propagation. In the adjacent diagram, a fluid parcel starts at the position of the red asterisk, and travels with the wave to the right.
- The drift is an entirely horizontal effect, and is well-documented, in, for example, Stokes' (1848) and Phillips' (1977). In a shallow sea, of depth 7m, and with waves travelling at  $\sim 7.5\text{ms}^{-1}$ , with  $\omega=2\text{s}^{-1}$ , a typical velocity is  $\sim 0.05\text{ms}^{-1}$ .

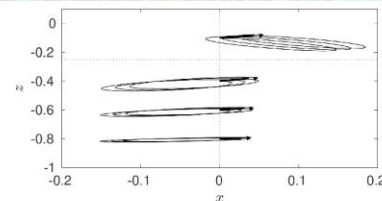


## Applications

Koehl *et al.*<sup>3</sup> and other papers emphasise the importance of flow of water through coral reefs to bring nutrients and oxygen to inhabitants – understanding the flow profile is vital for understanding these ecosystems. We plan to compare these results with those of fieldwork.

## Effect of a porous layer

- Placing a porous layer, like a coral reef, below the wave surface, as shown in the diagram below, damps the waves and means that the amplitude decreases as horizontal distance increases in the direction of wave propagation, denoted  $x$ .
- As the horizontal drift speed is dependent on the amplitude of the waves, the horizontal drift speed reduces with distance in the direction of wave propagation.
- Most notably, a vertical drift effect is introduced as a result of the damping.**
- This small drift effect can be seen by tracing out particle paths – in the below case,  $D=1$ ,  $d=0.25$ .



## Explanation

- We describe the fluid flow in two distinct regimes – the porous layer, dominated by viscous effects and described by Darcy's Law, and the upper layer, which is essentially inviscid.
- Matching the layers at their interface, we derive the wavenumber  $k$  as a function of frequency  $\omega$ , which is a complex number – the waves have both an oscillatory part and a decaying effect due to damping.

$$i\omega \tanh k(D-d) - i\nu \tanh \left[ \text{arctanh} \left( \frac{\omega^2}{gk} \right) - kd \right] = 0$$

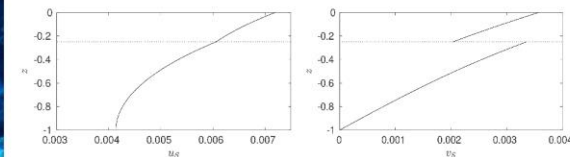
Frequency of waves   Viscosity of water   Depth of upper layer

Permeability of porous layer   Depth of porous layer   Gravity   Wavenumber

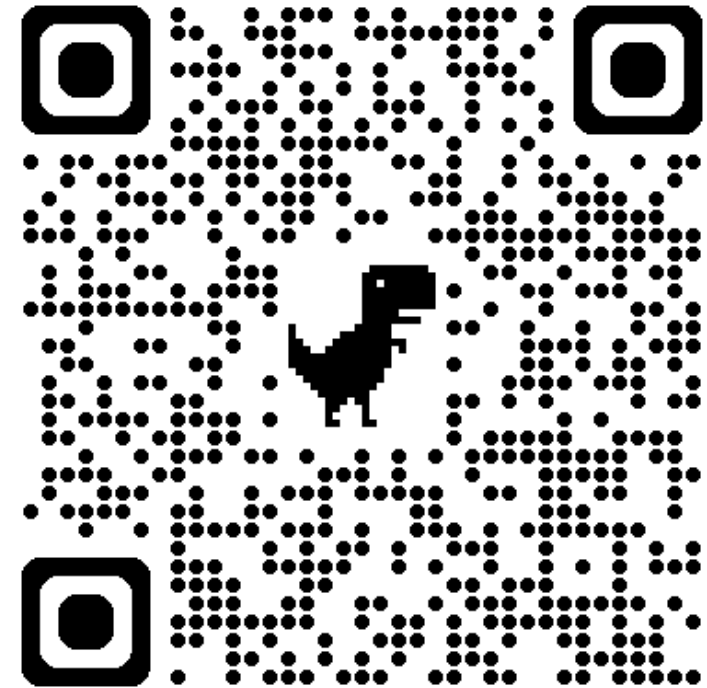
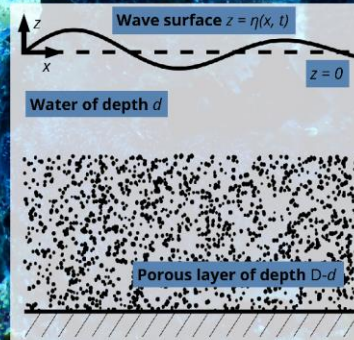
- The vertical drift can be understood by considering a small particle undergoing wave motion. The particle moves **forwards and down**, followed by **backwards**, and then **back up again**. But as the magnitude of vertical velocity reduces with distance due to damping, there is net motion perpendicular to the wave propagation.

## Velocity profiles

Fluid is naturally seen to drift faster in the upper layer, where there is no viscous resistance to its motion. The velocity profiles reduce to those for no reef in the limits as the reef becomes more porous, or thinner.



Stokes drift velocities in the horizontal (left) and vertical (right) directions at  $x = 0.00$  when  $D = 1.00$ ,  $d = 0.25$  and waves have a frequency  $\omega=2$



[https://jwebber.github.io/assets/files/stem\\_for\\_britain\\_poster\\_talk.pdf](https://jwebber.github.io/assets/files/stem_for_britain_poster_talk.pdf)

# Presenting your poster

- stand to the **side of the poster** so people can see it
- get the **balance** right between connecting with people browsing posters and not overwhelming your presence there is, often, a reason why someone actually *won't* look deeply
- make sure you **know what you're going to say** before the session starts
- always finish by making it clear where they can **get more information**
- number 1 rule: make sure you're enthusiastic when talking about the poster

# Getting started

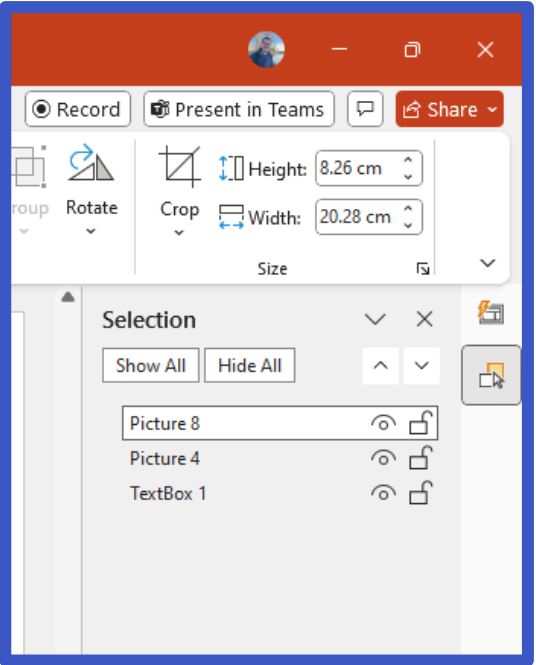
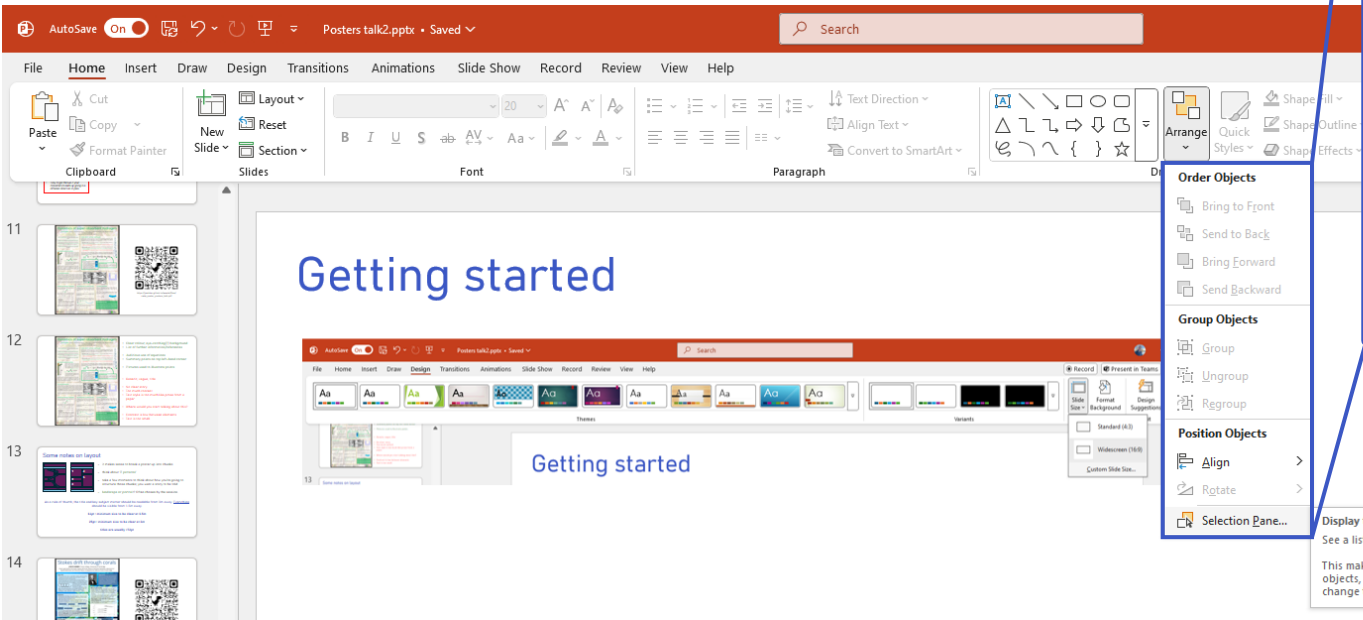
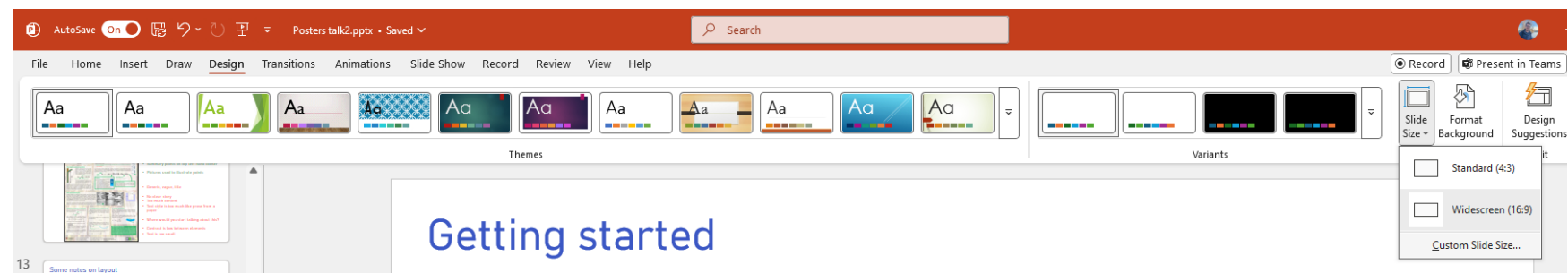
**Check the guidelines from the poster session: you might be completely constrained on size, layout, content, structure. They might even have a template!**

- if you're very confident using LaTeX, there exist some poster templates based on the beamer package that can look good
  - without a lot of work, they're hideous
  - I wouldn't bother
- using PowerPoint is nearly always a safe bet – you know how to use it already, it's flexible, and it has a lot of useful features



Allan Gaw / University of Edinburgh

# Getting started

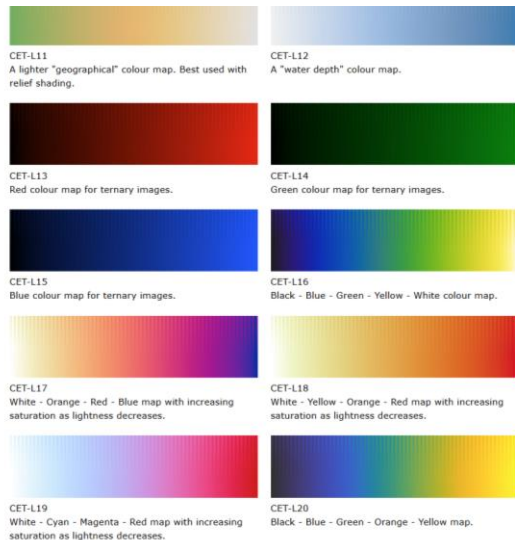


Display the Selection Pane  
See a list of all your objects.  
This makes it easier to select  
objects, change their order, or  
change their visibility.



# Fonts and colours

- body text **should be sans serif** for readability (a necessary but not sufficient criterion for the font to be acceptable on a poster)
- think about **colour contrast** with the background – it's really important, more than anything else, that text is clear: err on the side of caution
- fonts need to be **bigger than you think** – it'll look silly on screen and as it begins to print, but hold your nerve and trust yourself



perceptually-uniform  
colour maps available at  
[colorcet.com](http://colorcet.com) (in many  
formats)

[colourcontrast.cc](http://colourcontrast.cc)

**14pt : minimum size to be clear at 1.5m**

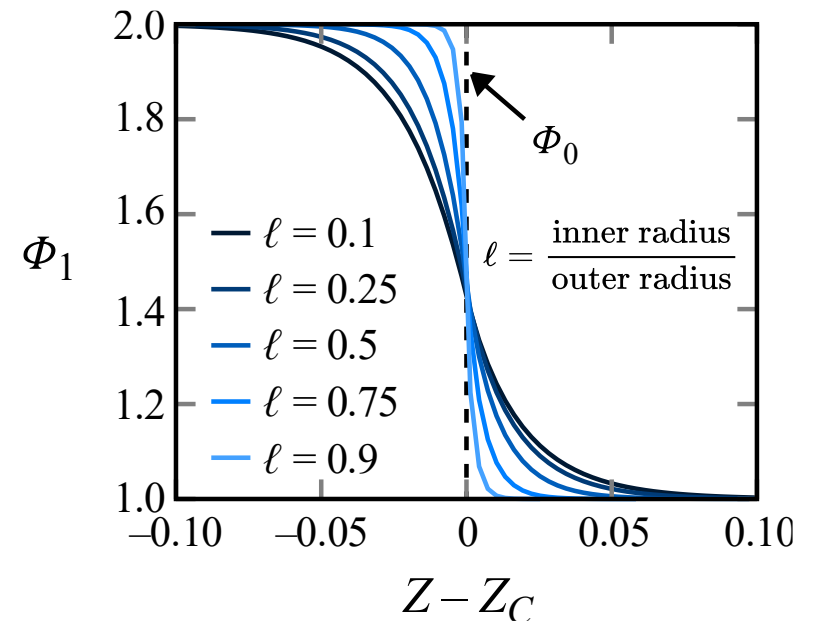
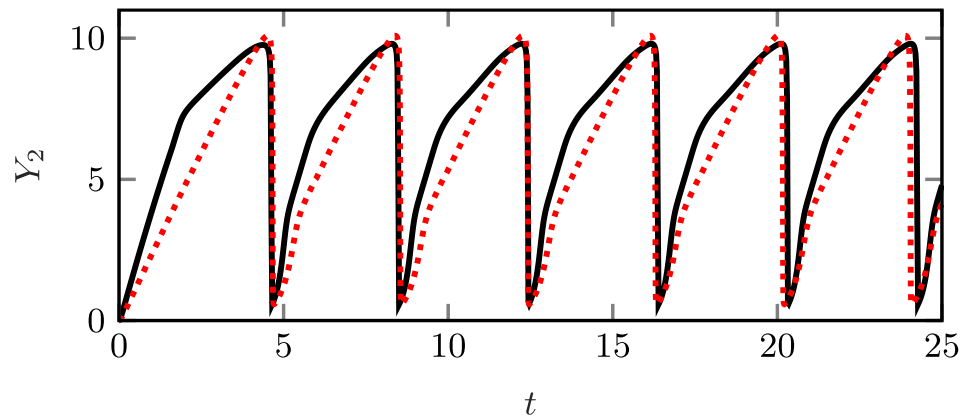
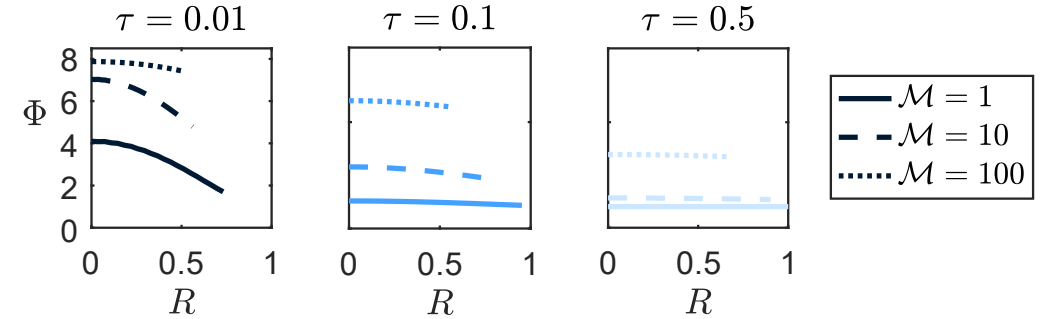
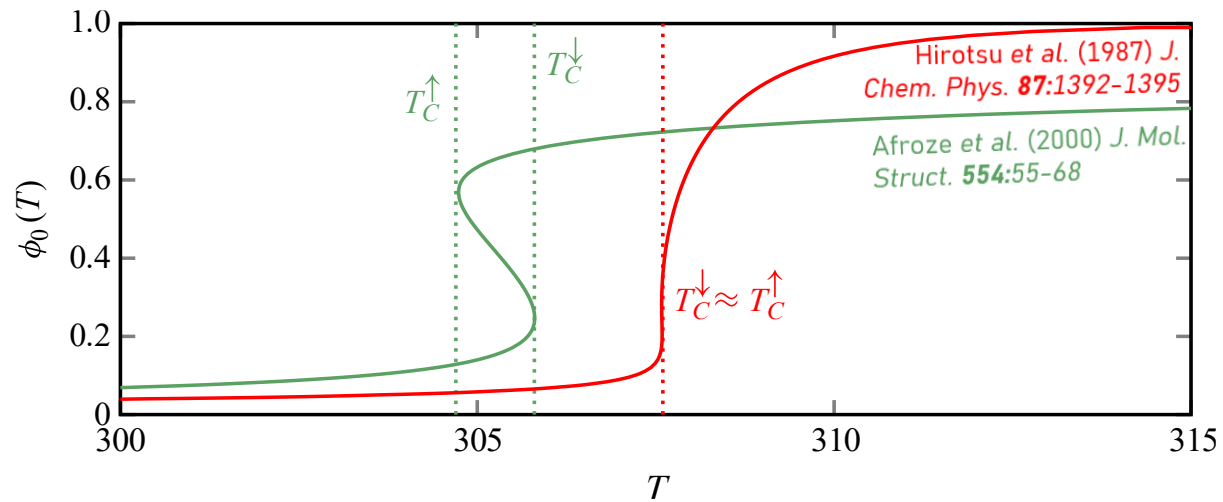
**25pt : minimum size to be clear at 3m**

**titles are usually >72pt**



# Figures

figures should be different from those that you'd use in a paper



# Equations

- don't shy away from equations **when they're needed to explain** the points
- define every term **near the equation**, and format things nicely ([viereck.ch/latex-to-svg](http://viereck.ch/latex-to-svg))

The diagram illustrates the equation  $\kappa\omega \tanh k(D-d) - i\nu \tanh \left[ \operatorname{arctanh} \left( \frac{\omega^2}{gk} \right) - kd \right] = 0$  with labels for its components:

- Frequency of waves** points to  $\omega$ .
- Permeability of porous layer** points to  $\kappa$ .
- Depth of porous layer** points to  $D$ .
- Viscosity of water** points to  $\nu$ .
- Gravity** points to  $g$ .
- Wavenumber** points to  $k$ .
- Depth of upper layer** points to  $d$ .

What poster pitfalls are you most likely to fall into?

**More helpful tips at**

[docs.hss.ed.ac.uk/iad/Researchers/Research\\_staff/Study\\_Guide\\_Designing\\_Effective\\_Conference\\_Posters\\_v2.0\\_.pdf](https://docs.hss.ed.ac.uk/iad/Researchers/Research_staff/Study_Guide_Designing_Effective_Conference_Posters_v2.0_.pdf)

a few final pointers:

- work with vector graphics (if nothing else, it lets you scale up) – **Inkscape is your friend**
- check the University's **branding guidelines** ([brand.warwick.ac.uk](https://brand.warwick.ac.uk)) for rules
- sketch out the story you want to tell before you start making the poster
- plan what you're going to say in advance

...and remember **why** you're making and presenting the poster (and **who** is seeing it)!