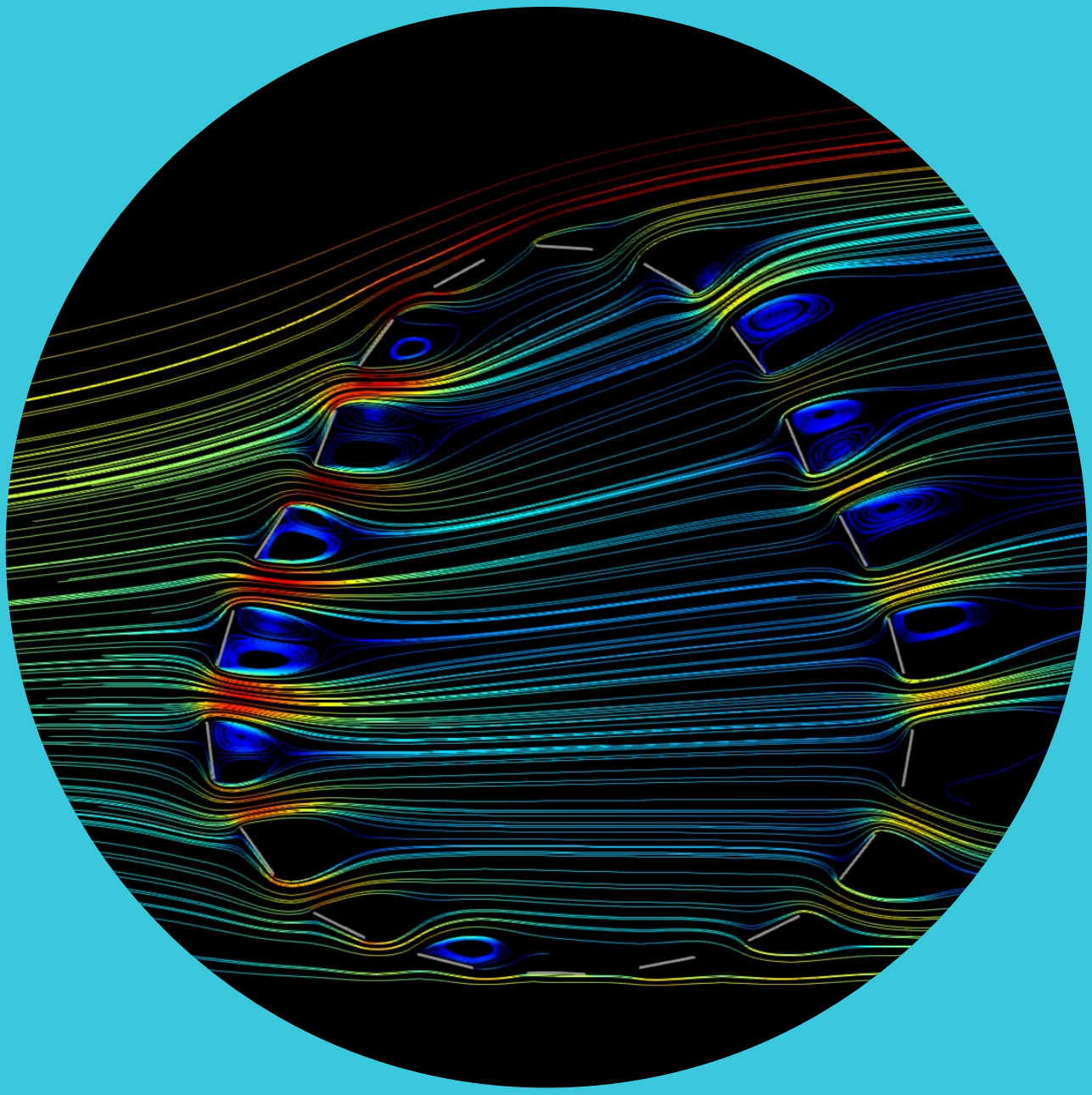
Researchers in Schools



Walking on Custard:
An Introduction to Complex Fluids
Key Stage 4 Programme

Pupil Name	
Coursebook Designed by	Dr Morgan Evans

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Timetable and Assignment Submission

Timetable – Tutorials

Tutorial	Date	Time	Location
1			
2			
3			
4			
5			
6 (Feedback)			
7 (Feedback)			

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1		
Tutorial 2		
Tutorial 3		
Tutorial 4		
Tutorial 5		

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after midnight on 9th August	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Course Rationale

Distinguishing between fluid and solid may seem quite trivial from a non-mathematical point of view, where suggesting that solid materials flow would be instantly frowned upon. Mathematically, however, classifying a material as either solid or fluid becomes a little more intricate.

This course is meant to be a very partial introduction to non-Newtonian fluids and their wonderful properties. These properties and the interesting phenomena arising because of them have kept mathematicians busy at work for centuries. There are a plethora of paths one can take when deciding what area of fluid dynamics they wish to experience; to name a few we have the aerodynamics of Formula 1 cars, the flow of blood around the body, how lava spills from a volcano... I could go on for a while.

During this course we will skim the surface of these areas and hopefully leave an ember of curiosity burning which, in time, may lead you down a path into the wonderful world of fluid dynamics.

In the first and second we look at the basic properties of all fluids, and how we might measure them. These are the fundamental skills needed before one can venture down any path of fluid dynamics research.

In the third tutorial we introduce non-Newtonian fluids and investigate some of their fantastic properties.

The fourth tutorial is spent invetigating a specific type of non-Newtonian fluid which, potentially, might just defy all that you currently know about fluids.

In the fifth tutorial we are going to run a simulation of a phenomenon linked to polymer melts on a computer! We will then analyse the results and produce some wonderful images that you can keep with you forever.

Uni Pathways Mark Scheme 2021

	Subject Knowledge	Critical Thinking	Written Communication
1st	The work shows a depth of knowledge and understanding of key concepts and mathematical methods, drawing on sources of evidence where appropriate. Knowledge is used to build and support highly effective mathematical arguments and explanations.	Analyses the available data/evidence and identifies all the relevant mathematical information. Identifies and critically evaluates available mathematical approaches and evidence, deciding on their credibility, strength and relative significance. Makes connections between different pieces of information and puts them together to form accurate solutions and verify answers and assumptions.	Mathematical arguments are complete, and the reasoning behind each step has been clearly communicated to the reader. The work has a coherent flow and is well structured. The writing style is appropriate; mathematic al language and key mathematical terms are used accurately and effectively to support the arguments and explanations made. There are no, or very few, errors in spelling or grammar. Consistent referencing, appropriate paragraphing and use of correctly labelled tables and figures; matching the style taught in the course.
2:1	The work shows an understanding of key concepts and mathematical methods, drawing on sources of evidence where appropriate. Knowledge is used to build and support effective mathematical arguments and explanations .	Analyses the available data/evidence and identifies all the relevant mathematical information. Engages with multiple approaches and critically evaluates their utility, forming judgements and using reasoning and evidence to inform problem solving strategy. Shows some understanding of the relative value of evidence and data.	Mathematical arguments are clearly made, with few gaps in logical reasoning. The work is well-structured. The writing style is appropriate; mathematic al language and key terms are used correctly. There are few errors in spelling or grammar. Mostly consistent referencing and use of tables and figures; matching the style taught in the course.

2:2	The work shows an understanding of key concepts and mathematical methods, with no major misconceptions. Beginning to apply this knowledge to build and support effective mathematical arguments and explanations.	Identifies and uses basic mathematical evidence and reasoning. Evaluates the quality of mathematical reasoning and evidence, forming judgements. Not yet showing understanding of the relative value of evidence and reasoning.	Mathematical arguments have been constructed, but there is little explanation from step to step. The work has some structure. The writing style can sometimes be informal; occasionally key terms are not used when it would be appropriate to do so. There are some errors in grammar and spelling, but these do not get in the way of communicating the content. Referencing has some consistency; matching the style taught in the course. Limited use of tables and figures.
3rd	Shows a developing understanding of key concepts and mathematical methods, with some misconceptions. Not yet applying this knowledge to build and support mathematical arguments and explanations.	Beginning to analysis mathematical evidence and reasoning. Describes or attempts to solve the problem without any/or little evaluation of whether the approach was reasonable or accurate.	Mathematical arguments to solve problems are poorly sequenced, with little or no explanation. The grammar, spelling, style, and structure of the work need improving in order to communicate ideas to the reader. Key terms are not always used correctly. Limited, or no use of referencing, tables and figures.

Baseline Assignment: Pupil Feedback Report

Name of Pupil	
Name of School	
Name of RIS teacher	
Title of Assignment	

How your assignment is graded:

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Marks

OVERALL MARK / 100		FINAL MARK / 100 (including any deductions)	
DEDUCTED MARKS		FINAL GRADE	

If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

Subject knowledge	
	mark
Critical thinking	
	mark

Written communication	
	mark

Problem Set	
Comment	*mark*

Final Assignment (problem-set): Pupil Feedback Report

Name of Pupil	
Name of School	
Name of RIS teacher	
Title of Assignment	

How your assignment is graded:

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-level
2:1	60-69	Performing to a good standard at A-level
2:2	50-59	Performing to an excellent standard at GCSE
3rd	40-49	Performing to a good standard at GCSE
Working towards a pass	0-39	Performing below a good standard at GCSE
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
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Marks

OVERALL MARK / 100		FINAL MARK / 100 (including any deductions)	
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If marks have been deducted (e.g. late submission, plagiarism) the teacher should give an explanation in this section:

Mark Breakdown and Feedback

Subject knowledge	
	mark
Critical thinking	
	mark

Written communication	
	mark
Problem Set	
Comment	*mark*

Subject Vocabulary

Word	Definition	In a sentence
Shear	An action resulting from an applied force which causes two parts of a body to slide across each other.	The water particles were subject to a shear force as they slid past each other.
Elongation / Extension	The action or process of lengthening something.	The elongation of the elastic band was due to Katie stretching it around her hand.
Fluid	A material that has no fixed shape which changes given an external pressure.	We all have body fluids.
Elastic	A material able to resume its normal shape after being stretched or deformed.	The tennis ball must have an elastic response because it returns to its original shape after being squeezed.
Flow	Move steadily and continuously.	From here the river flows North.
Deform	Alter/change the shape of an object.	The deformation of the steel girders was unbelievable under the enormous weight of the bridge.
Rate	The speed at which something happens or changes.	The growth rate of the economy isn't what was predicted.
Solid	A material that stays the same shape whether it is in a container or not.	A solid may turn to a liquid at certain temperatures
Rheology	The study of flow and deformation of any material under an applied force.	Rheology of jam is a very complicated topic.

Stress	A physical quantity showing the internal forces that particles of a material exert on each other.	The force exerted on the solid created a large internal stress.
Pressure	The perpendicular force per unit area.	The deeper in the water Rhodri went, the more pressure he felt.
Conservation	The act of conserving or preserving a quantity.	The conservation project is designed to keep the bee population from dropping.
Model	A mathematical description of an entity or a real life problem.	I used a simple mathematical model to describe my journey to work this morning.
Continuum	A continuous whole quantity.	My cup of tea must be in a continuum because it moves as a single body when I stir it.
Viscous	A material having a high resistance to flow.	Honey is a very viscous fluid.
Yield	Give way to pressure or force.	The elastic band gave way and snapped once the it was stretched past its critical yield.
Perpendicular	Two lines intersecting each other at 90 degrees or a right angle.	Perpendicular lines are always intersecting.
Linear	Represented by a straight line on a graph.	The path I took down the street was straight and therefore linear.
Non-linear	Represented by a curved line on a graph.	A quadratic graph is an example of a non-linear line.

Parallel	Two or more lines extending in the same direction as each other.	Two sprinters racing in the 100m run in parallel lanes.
Gradient	Change in value of a quantity with respect to change in another given variable. The slope of a line or curve.	The gradient of the hill was very big which made it hard to walk up.
Velocity	The speed of something in a given direction.	The velocity of the bird towards the sea was very large.
Sketch	A rough drawing or plot.	Here is a sketch of a graph I produced earlier.
Strain	A measure of the amount an object has changed shape as a result of a force.	The strain on the tent pole was large as it bent quite a lot in the wind.

Launch Event

The launch event is your opportunity to learn more about this course and Uni Pathways. You will watch some videos, listen to your teacher and have some discussion. Below is some room to make notes for some of the videos you will watch during the event.

Virtual Campus Tours

Notes…

The Scholars Programme Alumni

Notes…

Student Ambassadors

Notes…

Tutorial 1 – Viscosity & Basic Flows

What is the Purpose of Tutorial 1?

- State the definition of viscosity
- Label and explain the key features of simple shear flow
- Design and develop your own method to calculate the viscosity of a fluid in simple shear flow

Task 1: What can you tell me about the characteristics of these liquids?

Fill in the table below:

Liquid A	Liquid B	Liquid C	Liquid D

Definition: Viscosity

_____

_____

_____

Take another look at your liquids. Can you:

1) List the liquids in ascending order of viscosity?

2) Explain in one or two sentences how you came to this conclusion?

_____

_____

_____

Some factors that might affect viscosity are:

1)

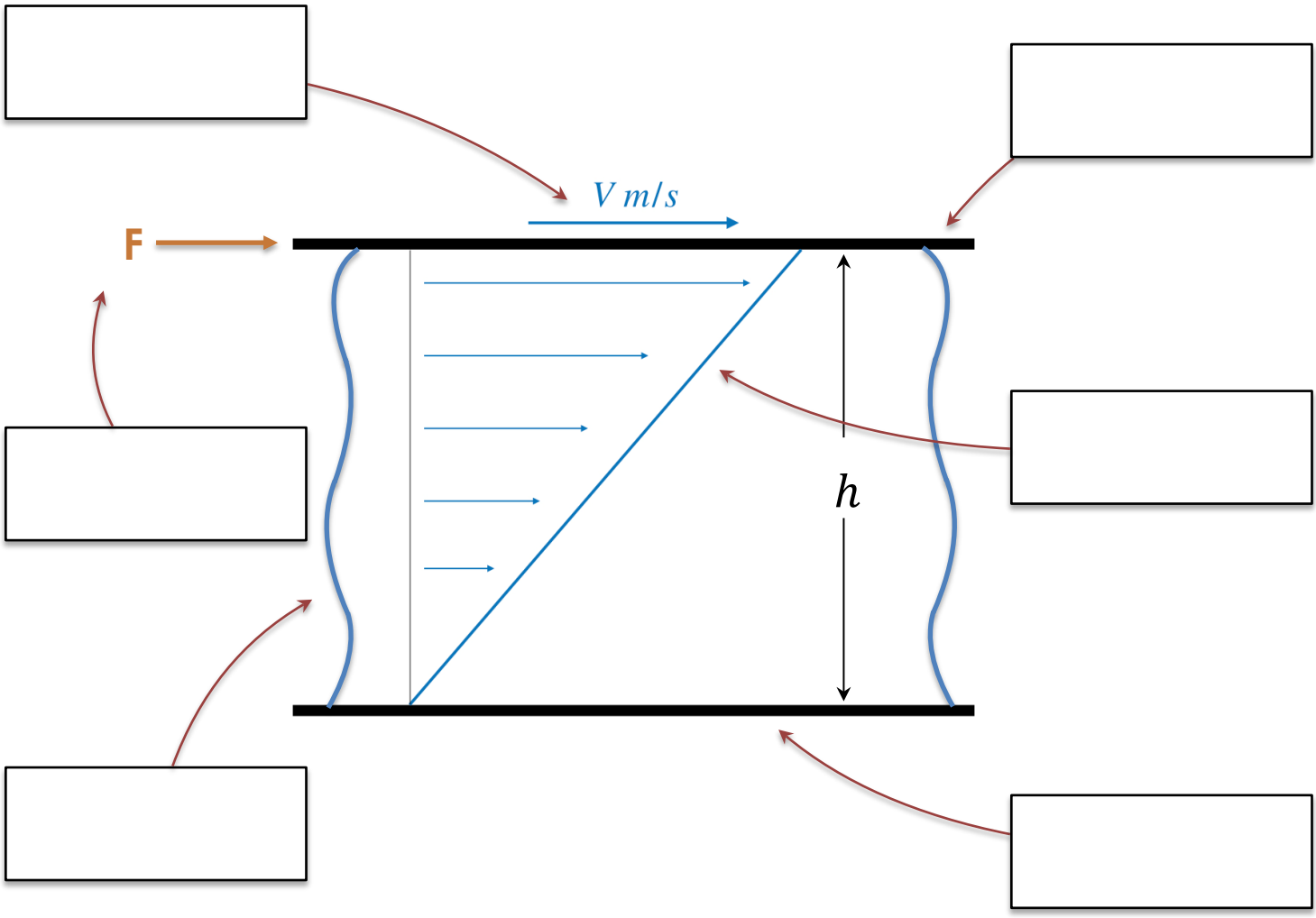
2)

3)

Task 2: Simple Shear Flow

SHEAR FORCE VELOCITY GRADIENT FIXED PLATE MOVING PLATE

MOVING PLATE VELOCITY FLUID



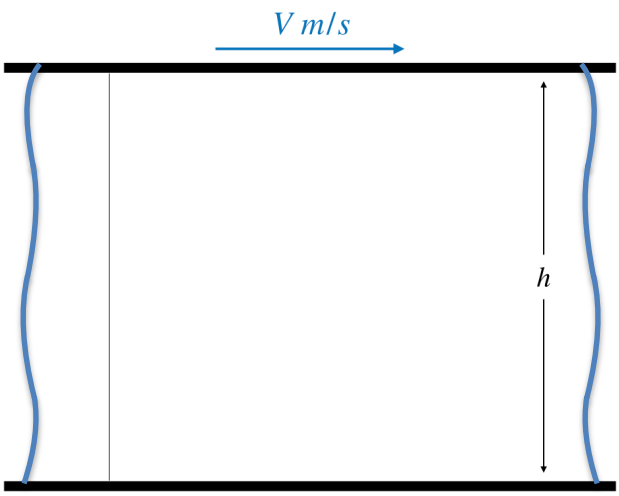
Definition:

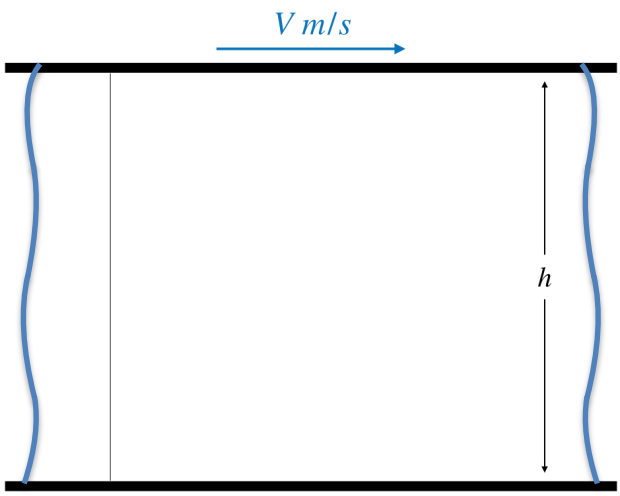
Shear Force:

Shear Stress:

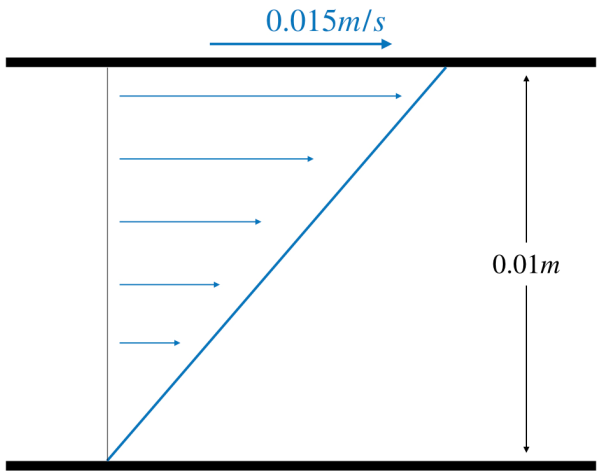
Shear Rate:

Key Concept: Not all fluids have a linear (straight) velocity gradient during simple shear flow.





Question:



Luca has been analysing a fluid in simple shear flow (see figure). After his first experiment, he decides to double the shear force on the top plate. As a result, the top plate now has a velocity of 0.02m/s.

What is the increase in the shear rate?

Task 3: How on earth can we measure a fluid's viscosity!?

In pairs, discuss how you might use the simple shear flow model to measure a fluid's viscosity.

Try and think about:

- How you can mathematically quantify the viscosity
- What happens when you test different liquids/fluids? How will it be able to identify differences in the viscosity?
- Any relationships that might arise between the shear force, shear rate and shear stress

Baseline Assignment

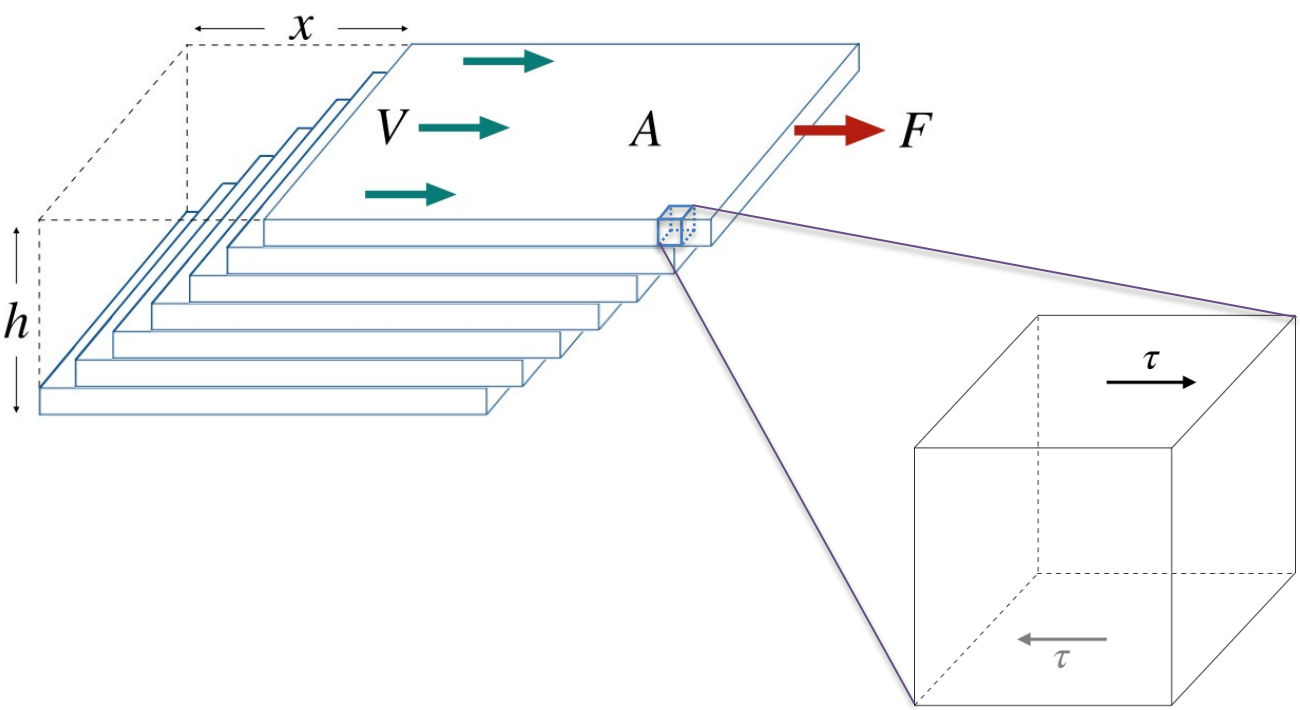
1) Using the shear flow scenario shown in the figure, describe each of the following terms in your own words:
    a. Shear force
    b. Shear rate
    c. Shear stress
2) Write a couple of paragraphs describing, in your own words, the viscosity of a fluid. Be sure to include any factors that may affect a fluid's viscosity and in what way might they change it.
3) Following on from Task 3 in the tutorial, write a couple of paragraphs explaining how your model will be used to measure Liquid A, B, C and D's shear viscosity. Be sure to explain in detail any problems you might encounter with your method. (Note: try to think of any relationships that might arise i.e. when I change one variable, how will another one be affected?)

Tutorial 2 – Shear Viscosity & The Newtonian Fluid

What is the Purpose of Tutorial 2?

- Explain the generic method of calculating a fluid's shear viscosity
- Recall and apply Newton's law of viscosity
- Classify a fluid as Newtonian or non-Newtonian using Newton's law

Task 1: So what is the "proper" way to calculate a fluid's shear viscosity?



Notes:

Key Concept: Newton's Law of Viscosity

1)

2)

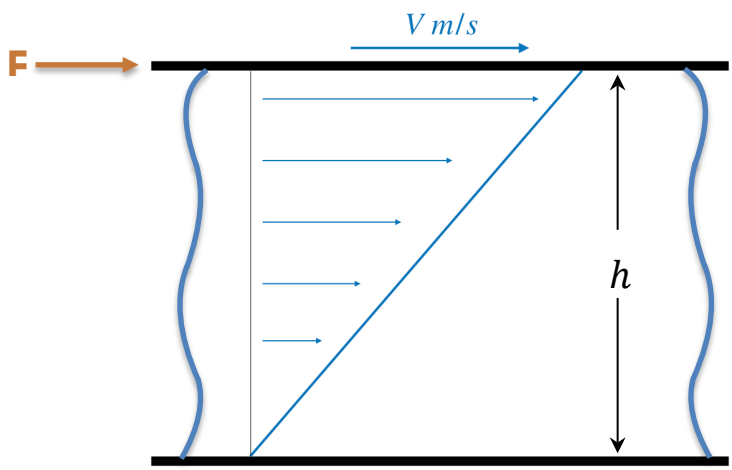
3)

4)

Definition: Shear Viscosity

Task 2: Let's check if you've been listening…

Using the definitions from tutorial 1, the definition of shear viscosity and/or Newton's Law of Viscosity, find the unknown values from the following fluids:

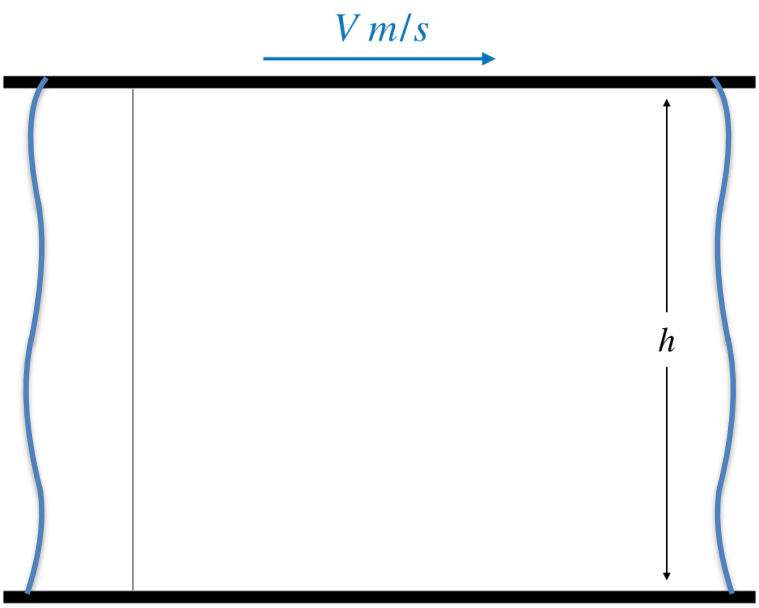


1) $\eta = 0.01$ Pa·s $\quad \dot{\gamma} = 2s^{-1} \quad \tau = ?$

2) $\eta = 0.01$ mPa·s $\quad \dot{\gamma} = 20s^{-1} \quad \tau = ?$

3) $F = 0.05N \quad A = 0.1m^2 \quad \dot{\gamma} = 100s^{-1} \quad \eta = ?$

Definition: Newtonian Fluid



Task 3: Classifying a fluid during simple shear flow…

Now we all know what a Newtonian fluid is, let's classify some fluids during simple shear experiments.

Newtonian?

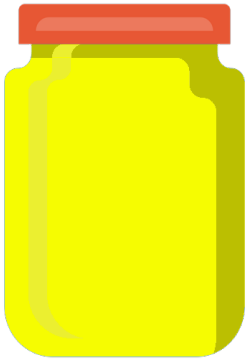
Fluid 1

Test 1: $\tau = 0.009275Pa$, $\dot{\gamma} = 3.71s^{-1}$

Test 2: $\tau = 0.0003575Pa$, $\dot{\gamma} = 0.143s^{-1}$

YES ☐

NO ☐



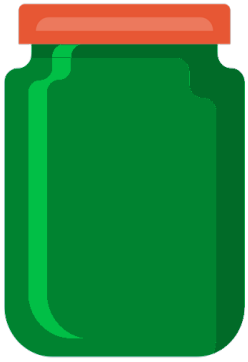
Fluid 2

Test 1: $\tau = 4.48 \times 10^{-4}Pa$, $\dot{\gamma} = 1.4s^{-1}$

Test 2: $\tau = 2.112 \times 10^{-4}Pa$, $\dot{\gamma} = 0.66s^{-1}$

YES ☐

NO ☐



Fluid 3

Test 1: $\tau = 0.0116$ m·Pa, $\dot{\gamma} = 0.93s^{-1}$

Test 2: $\tau = 0.564$ m·Pa, $\dot{\gamma} = 4.7s^{-1}$

YES ☐

NO ☐

Homework

1) For a Newtonian fluid in shear flow, the shear stress exerted by the fluid is equal to the

   a) Fluid viscosity divided by the velocity gradient parallel to the direction of shear

   b) Fluid viscosity divided by the velocity gradient perpendicular to the direction of shear

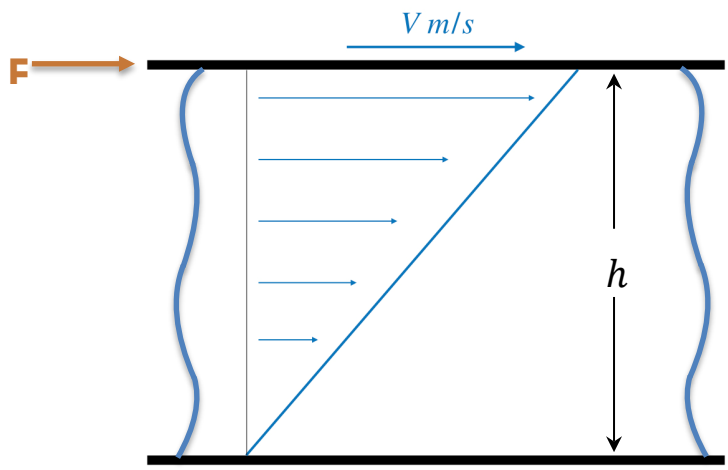
   c) Product of the fluid viscosity and the velocity gradient parallel to the direction of shear

   d) Product of the fluid viscosity and the velocity gradient perpendicular to the direction of shear

2) What are the two SI units used for the shear stress?

3) What is the one factor that affects a Newtonian fluid's viscosity? Explain your answer.

4) A fluid's velocity profile from one experiment is shown below. Does having this velocity gradient make it a Newtonian fluid? Explain your answer.



5) Find the missing values from these Newtonian fluids in steady shear:

   a) $\eta = 0.01$ Pa·s $\quad \dot{\gamma} = 3s^{-1} \quad \tau = ?$

   b) $\eta = 0.04$ mPa·s $\quad \dot{\gamma} = 18s^{-1} \quad \tau = ?$

   c) $F = 0.03N \quad A = 0.2m^2 \quad \dot{\gamma} = 80s^{-1} \quad \eta = ?$

Tutorial 3 – Non-Newtonian Fluids

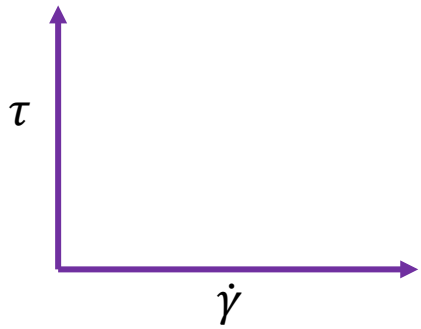
What is the Purpose of Tutorial 3?

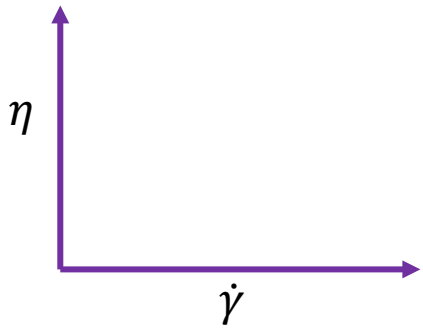
- Explain the difference between Newtonian and non-Newtonian fluids
- List and discuss different types of non-Newtonian behaviour
- Sketch graphs of the shear rate vs shear stress and shear rate vs shear viscosity for different types of non-Newtonian fluid
- Prepare a non-Newtonian fluid and investigate the Weissenberg effect

Task 1: What is the difference between a Newtonian and non-Newtonian fluid!?

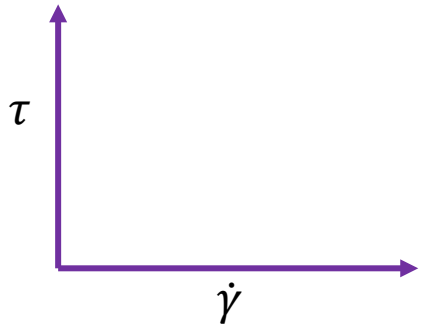
Task 2: Types of non-Newtonian behaviour

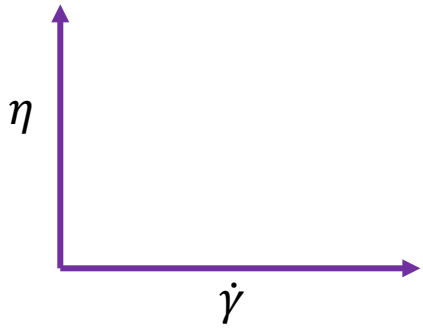
Newtonian:



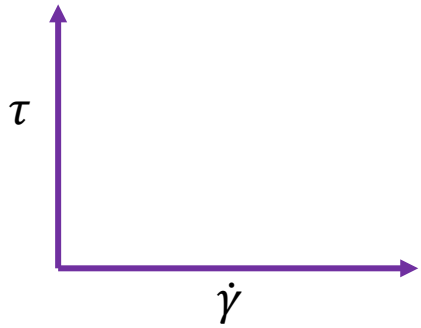


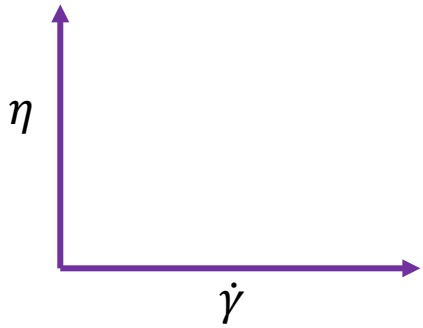
Shear Thinning:



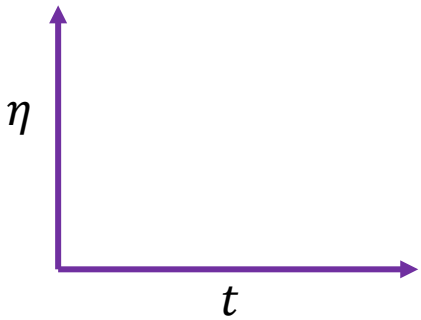


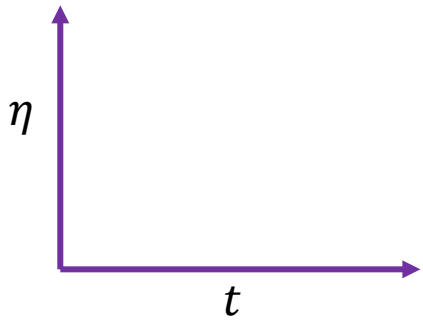
Shear Thickening:





Thixotropic & Rheopectic:





Task 3: The Weissenberg Effect

Let's make some slime…

- Add a **120ml** of PVA glue into a bowl
- Shake the bottle of magical liquid well
- Add your choice of colour
- Pour the magical liquid **a bit at a time** into the bowl and mix well until slime begins to form
- Once the slime has formed, take it out and work it with both hands until it reaches the desired consistency

The Weissenberg Effect…

- Place your rod in the fluid vertically
- Twist the rod in one direction slowly
- What happens to the fluid…

A video summarising the experiment:

For reference: https://www.youtube.com/watch?v=Z99bsizp4bY

Notes:

Homework

1) Write a short summary (1 - 3 paragraphs) highlighting the key difference between a Newtonian and a non-Newtonian fluid.

2) Write (in your own words) an explanation of each type of non-Newtonian behaviour listed in tutorial 3. Include examples of fluids that exhibit these behaviours and reference when necessary.

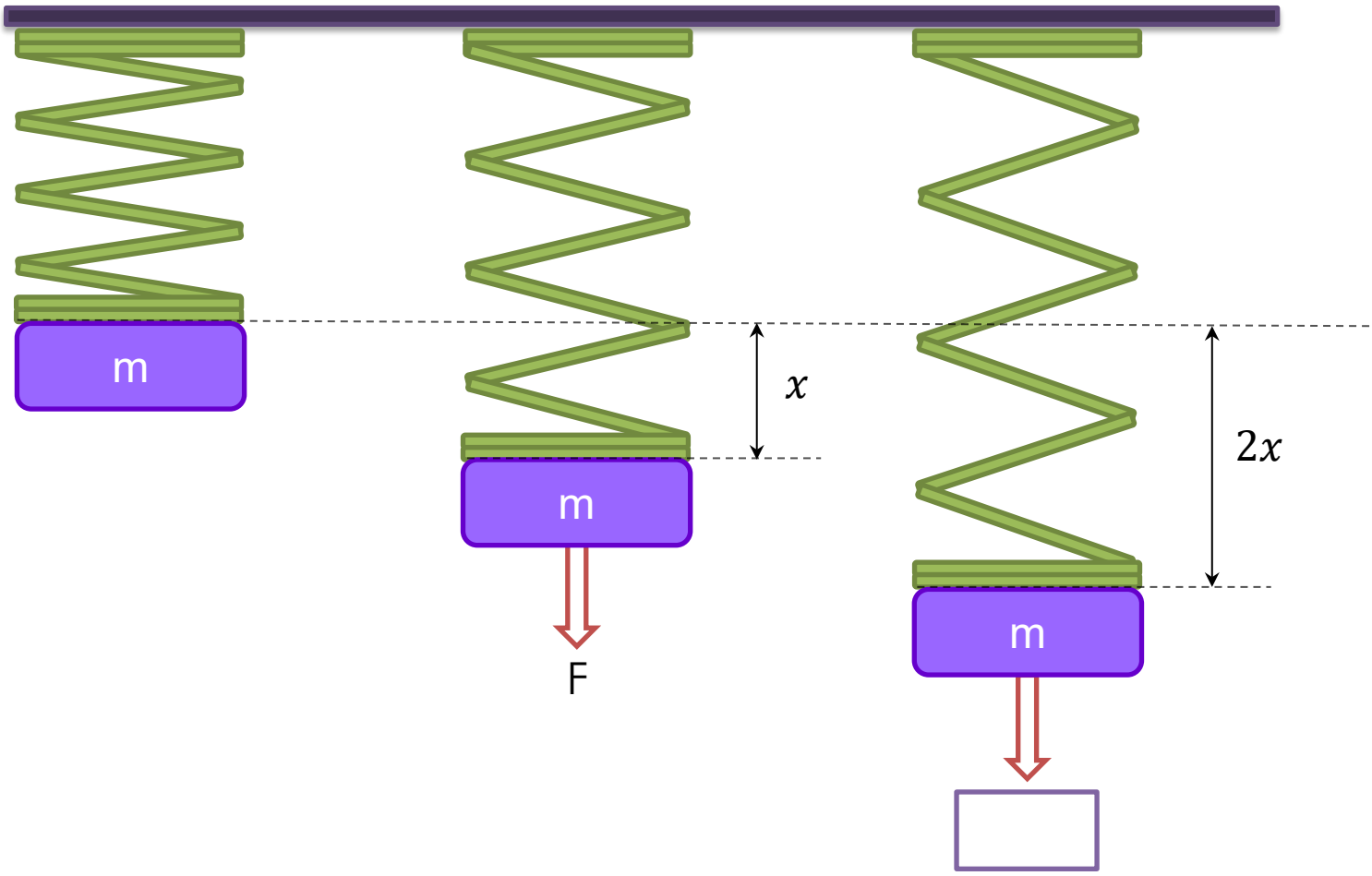
3) Find one interesting phenomenon, other than the Weissenberg rod climbing effect, related to non-Newtonian fluids and write a brief description of it.

Tutorial 4 – Solid or fluid? Viscoelastic fluids!

What is the Purpose of Tutorial 4?

- State and apply Hooke's Law
- Construct a "material spectrum" and justify the position of 5 key types of material / fluid
- Create your own viscoelastic fluid! Let's try not to make a mess…
- Investigate the types of non-Newtonian behaviour your fluid demonstrates
- Discuss different phenomena seen in viscoelastic fluids

Task 1: Hooke's Law and Elastic Solids



Hooke's Law:

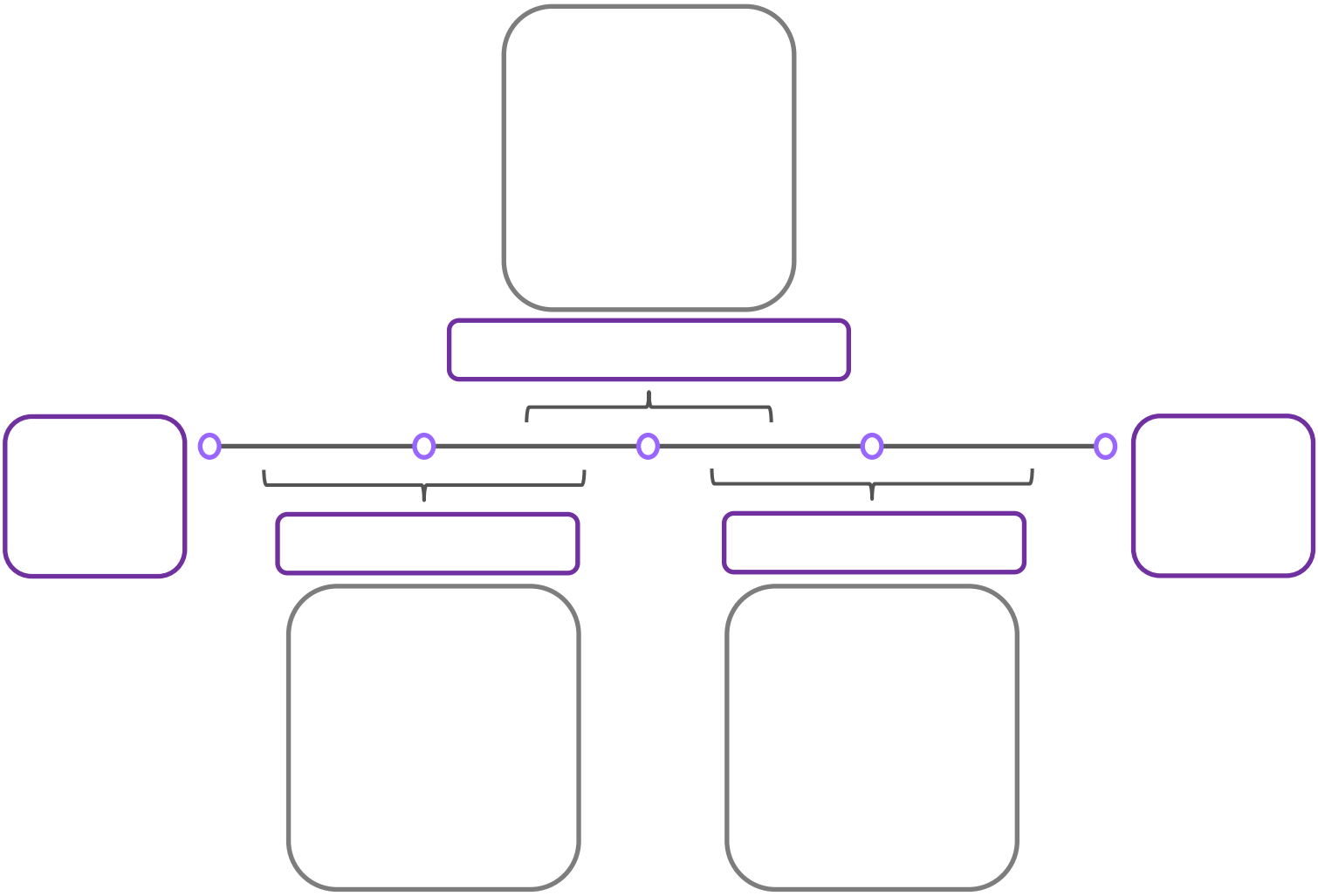
Notes:

Key Concept: All materials flow provided the experimental time-scale is long enough

Task 2: Can you complete the spectrum below using the key words listed?

RIGID SOLID VISCOUS FLUID ELASTIC SOLID INVISCID FLUID

VISCOELASTIC FLUID



Task 3: Let's Make a Viscoelastic Fluid!

Let's make a viscoelastic fluid…

- Fill your bowl half full with water
- Add your choice of colour
- Add cornflour **a bit at a time** into the bowl and mix well until material begins to form
- Once the material has formed, take it out and work it with both hands until it reaches the desired consistency

The Viscoelastic Effect…

- Work the material in your hands and make a note on what happens
- What type of non-Newtonian behaviour does this fluid exhibit?

Notes:

Homework

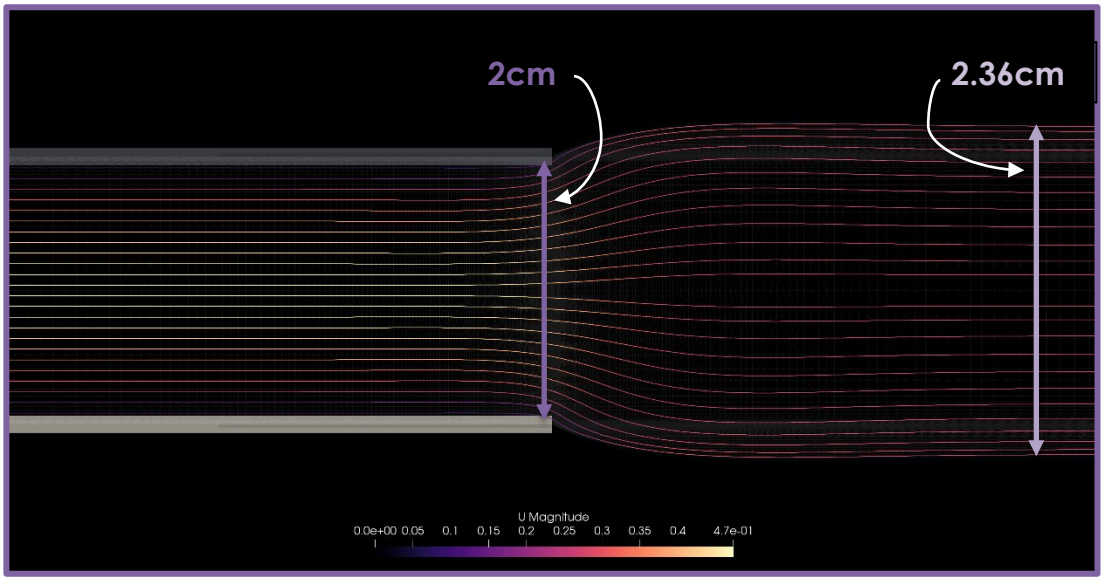
1) Investigate the extrudate swell phenomenon (also known as die-swell or the barus effect). Find 3 interesting points about it and write a short description of each.

   Note: think of polymer melts as melted plastics.

2) The swelling ratio (B) is defined as the ratio between the extrudate diameter D_{ex} (the diameter of the fluid after swelling) and the diameter of the die D_0 (pipe) at the exit.

$$B = \frac{D_{ex}}{D_0}$$

   Example: B = 2.36 / 2 = 1.18



   Sketch the extrudate swell for the following two fluids,

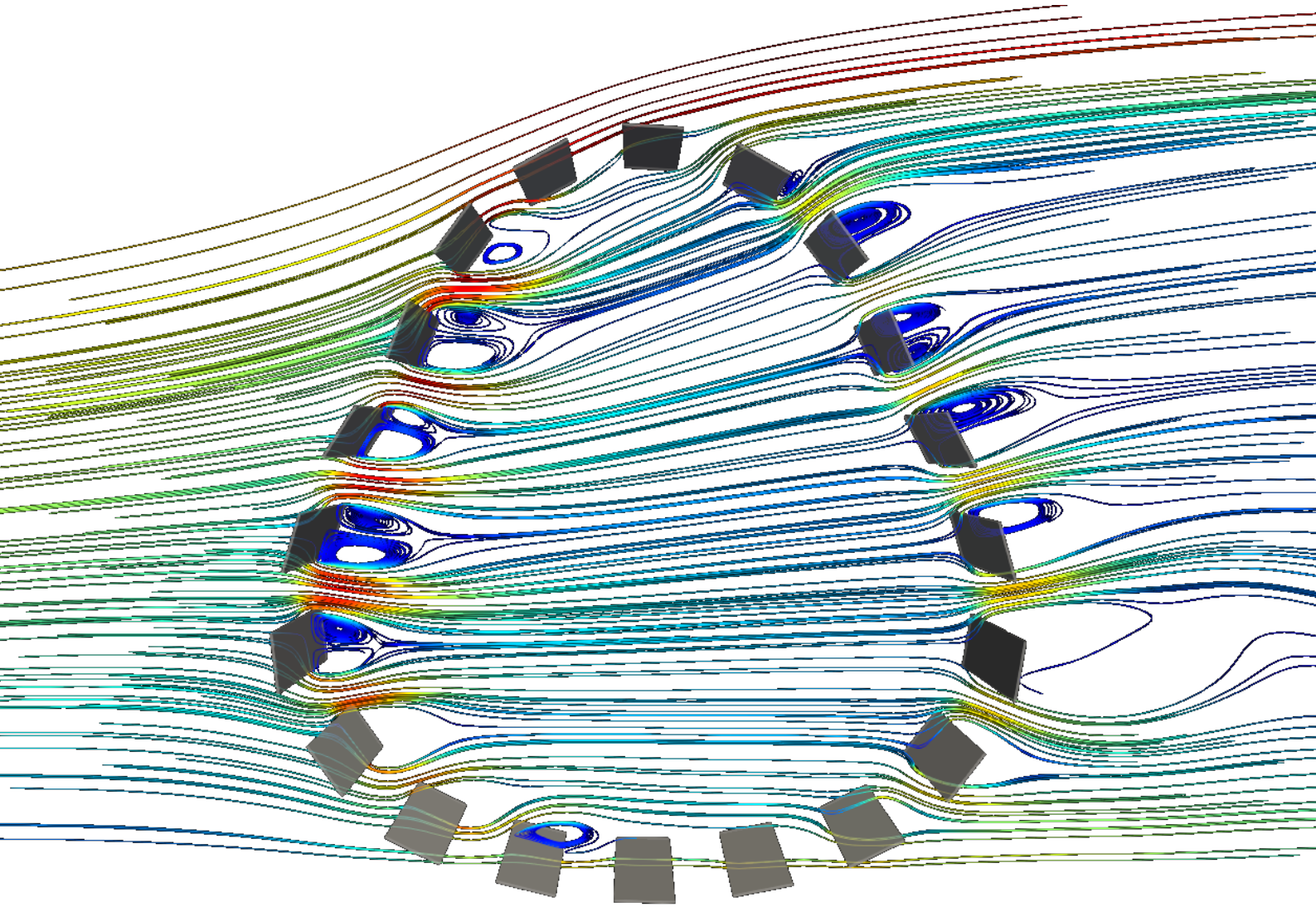
   a) $D_0 = 1.3cm$ $B = 1.4$

   b) $D_{ex} = 5.3cm$ $B = 2.7$

   c) $D_0 = 0.6cm$ $D_{ex} = 1.6cm$

3) Do Newtonian fluids experience extrudate swell, or is this phenomenon specific to non-Newtonian fluids?

Tutorial 5 – OpenFOAM!



What is the Purpose of Tutorial 5?

- Build/choose your own viscoelastic fluid for a computational simulation of extrudate swell
- Report on the properties your fluid shows compared to someone else's
- Create some cool images to visually show the non-Newtonian behaviour

Task 1: Fill in the blanks and choose your parameters

DENSITY SOLVENT VISCOSITY POLYMER VISCOSITY MODEL

RELAXATION TIME

DENSITY VISCOSITY MODEL

```
water
{
    parameters
    {
      type                    PTTLog;
      rho                     rho [1 -3 0 0 0 0 0 ]        0.01;
      etaS                    etaS [1 -1 -1 0 0 0 0]       0.5;
      etaP                    etaP [1 -1 -1 0 0 0 0]       0.5;

      lambda                  lambda [0 0 1 0 0 0 0]

      epsilon                 epsilon [0 0 0 0 0 0 0]      0.25;
      zeta                    zeta [0 0 0 0 0 0 0]         0.;
      delta                   delta [0 2 -2 0 0 0 0]       1e-60;

     destructionFunctionType        linear;

      stabilization                 coupling;
    }
}
```

```
air
{
    parameters
    {
      type                    Newtonian;
      rho                     rho [1 -3 0 0 0 0 0]         1.5e-4;
      eta                     eta [1 -1 -1 0 0 0 0]        1e-3;
    }
}
```

Notes:

Task 2: Let's look at our results!

Name	Lambda	Swelling Ratio

What do you notice about the swelling ratio as lambda changes? Why does this happen?

Print and glue a cool image from your simulation below

Final assignment

Essay: The Difference Between Newtonian and Non-Newtonian fluids

Write a short essay (between 500 and 1000 words) on the above title. Your work should include as much as possible of the following:

1) A detailed description of shear flow, the shear stress and the shear rate
2) The formal definition of shear viscosity
3) The factors that may affect a fluid's viscosity
4) Newton's law of viscosity
5) Types of non-Newtonian fluids and their different behaviours
6) A detailed outline of one interesting phenomenon found in viscoelastic fluids

Problem Set

Solve as many as you can of the following exercises. For each exercise, explain in detail how you found the solution.

1) Write Newton's law of viscosity linking the shear stress to the shear rate and label each term in the equation.

2) A Newtonian fluid flows between two plates 18cm apart, of which the lower one is stationary and the upper one is moving with velocity 4.5m/s and has a surface area of $20m^2$.

   A. what is the velocity of the fluid in contact with the lower plate?

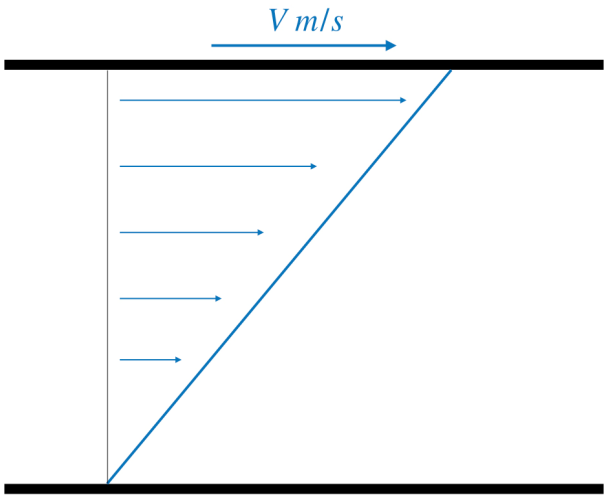
   B. what is the shear rate in the fluid?

   C. the tangential force on the upper plate is 0.5N, what is the viscosity of the fluid?

   D. given your viscosity value, what fluid might this be?

3) The image below depicts the velocity of a Newtonian fluid between two plates.

   Sketch what the velocity gradient of what a non-Newtonian fluid may look like



4) Katie decides to test whether her fluid is Newtonian or not; to do this she runs two parallel plate shear tests.

The fluid flows between two plates 20cm apart, of which the lower plate is stationary and the upper plate has a surface area of 25m2.

During the first test, a shear stress of 0.02Pa is applied to the top plate and the shear rate is measured at $4s^{-1}$.

For the second test, she applies a tangential force of 0.34375N on the upper plate and the velocity on the top plate is measured at 1.1m/s.

What type of fluid has Katie tested? Explain your answer.

5) Luca and Annie measure the extrudate swell ratio of **the same** polymer melt under different conditions. For each of the fluids;

a) calculate the swelling ratio:

Luca's fluid: $D_0 = 1.2cm$ $D_{ex} = 1.89cm$

Annie's fluid: $D_0 = 6.875 \times 10^{-1}cm$ $D_{ex} = 1.1cm$

b) list two reasons why the their swelling ratios may differ

Tutorial 6 – Feedback tutorial

What is the Purpose of Tutorial 6?

- To receive feedback on your final assignment
- To respond to the feedback from your Uni Pathways teacher
- To write targets for improvement on your final assignment

Final assignment feedback from your Uni Pathways Teacher

(Remember to look at the mark scheme to help you understand what you have done well so far, and how you can do even better in your final assignment)

Here are three things that my Uni Pathways Teacher thought I did well in my draft assignment
•   •   •

Here are three things that my Uni Pathways Teacher thinks that I could do to get a higher mark in my final assignment
•   •   •

Tasks from my Uni Pathways Teacher to do during the feedback tutorial to help me improve
•   •   •
My response:

Actions I will take to improve my final assignment after this tutorial…
•   •   •

Hand in date for my final assignment:	

Tutorial 7 – Final tutorial

What is the Purpose of Tutorial 7?

- To receive feedback and a grade on your final assignment.
- To reflect on the programme including what you enjoyed and what was challenging.
- To ask any questions you may have about university.

Final assignment feedback from my Uni Pathways Teacher

Final mark:	University style grade:
Feedback: Here are three things that my Uni Pathways teacher thought I did well in my final assignment • • •	

Here are three things that my Uni Pathways teacher thinks I should remember for when I am doing this kind of study in the future
• •

University

What questions do you still have about University after taking part in Uni Pathways?
•   •   •

Reflecting on Uni Pathways

What did you most enjoy about Uni Pathways?
•   •   •

What did you find challenging about the programme?	How did you overcome these challenges?
• • •	• • •

Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should you use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

1. **A marker in your assignment**: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].
2. **Bibliography**: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.

    a. **Websites** – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

    E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].

    b. **Books** – Author, date published, title of book (in italics), pages where the information came from.

    E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

    c. **Articles** – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.

    E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', Guardian, 10 July 2014.

Notes

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