Question 1

Part a)

An aerodynamicist is testing a simulation he made that included viscous effects with a simulation he made excluding viscous effects. What kind of error is he testing here (multiple correct answers are possible)?

a) Model errors
b) Discretisation
c) Round-off
d) Iteration errors

Part b)

He can only test for this when he has established that the following errors are small (multiple correct answers are possible)?

a) Model errors
b) Discretisation errors
c) Round-off errors
d) Iteration errors

Question 2

Someone wants to solve the algebraic system of equations $A\mathbf{u} = \mathbf{f}$. When he plugs in the exact solution $\mathbf{u}$ into this equation, and computes the residual $\mathbf{r}$, i.e.

$$\mathbf{r} = A\mathbf{u} - \mathbf{f}$$

he finds that when he increases the mesh refinement, the magnitude of $\mathbf{r}$ goes down. What has he established?

a) Consistency
b) Stability
c) Convergence

Question 3

Consider the partial differential equation

$$\nabla^2 u = 0$$

on Ω. What kind of boundary conditions can be applied on the boundary $d\Omega$?

- Numerical
- Numerical and Dirichlet
- Numerical and Neumann
- Dirichlet and Neumann
- Dirichlet
- Neumann
- Numerical, Dirichlet and Neumann

Question 4

Consider the partial differential equation

$$\frac{\partial u}{\partial x} + \frac{\partial u}{\partial y} = 0$$

Part a)

How can this equation be qualified as?

- Hyperbolic
- Elliptic
- Parabolic
- Conic
- Biconic

Part b)

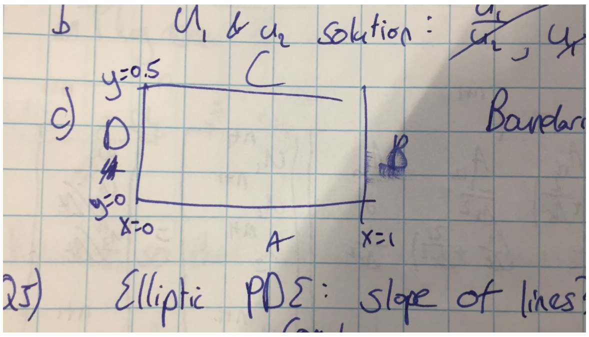
It is given that both u_1 and u_2 are solutions to the equation. What more is then a solution?

- $u_1 \cdot u_2$
- u_1/u_2
- $u_1 - u_2$
- $\log(u_1)$

Part c)

For the domain shown below, on what boundary can boundary conditions be applied (multiple answers can be correct)?

- A & D
- A & B
- B & C
- C & D
- Only A
- Only B
- Only C
- Only D
- A & C
- B & D

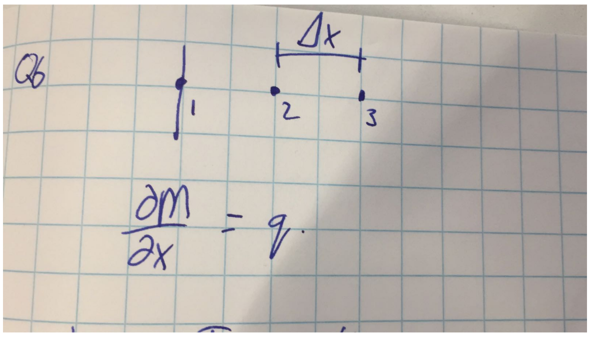


Question 5

If one is to find characteristics of elliptic PDEs, what numbers can be expected for the slope of the lines (multiple answers can be correct)?

- Rational numbers
- Irrational numbers
- Integers
- Integers only if a source term is present
- Complex numbers

Question 6



Consider the stencil shown above: one is researching a Neumann boundary condition, $dM/dx = q_0$ at the left boundary. To approximate this derivative, a one-sided three-point stencil is used with equal spacing Δx, as shown above. This leads to the following Taylor table.

	M_1	M_2	M_3	
1	a	b	c	R_1
$\Delta x \frac{\partial M}{\partial x}$	0	b	C_1	R_2
$\Delta x^2 \frac{\partial^2 M}{\partial x^2}$	0	$\frac{b}{2}$	C_2	R_3
$\Delta x^3 \frac{\partial^3 M}{\partial x^3}$	0	$\frac{b}{6}$	C_3	R_4

Part a)

Compute the entry R_2 and C_3.

Part b)

Solving this Taylor table leads to a matrix equation, shown below. Compute the entry A_{13} in terms of a, b and c, and compute j, the index next to q in the right-hand-side vector.

$$\frac{1}{\Delta x}\begin{bmatrix} A_{11} & A_{12} & A_{13} & \cdots \\ \vdots & \vdots & \vdots & \ddots \end{bmatrix}\begin{bmatrix} M_1 \\ \vdots \end{bmatrix} = \begin{bmatrix} q_j \\ \vdots \end{bmatrix}$$