Module 3

Introduction to Computational Methods for the Brain Sciences

Module Overview

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Imperial College London
THE MICHAEL J. FOX FOUNDATION FOR PARKINSON'S RESEARCH
Founding funders:
UKRI Medical Research Council
EDMOND J. SAFRA PHILANTHROPIC FOUNDATION

Welcome to Module 3 — Introduction to Computational Methods for the Brain Sciences

Course Overview

- Hands-on introduction to Python/R for brain and health data
- Foundations of **data handling, visualisation, and reproducible workflows**

Objectives

- **Understand computational techniques** used in brain sciences
  - Demystify tools and avoid “black box” thinking
  - Focus on *doing*, not just listening
- **Build core programming skills**
  - Programming fundamentals
  - Data manipulation and analysis
  - Basic pipeline development
- **Develop scientific reasoning**
  - Hypothesis formulation and testing
  - Basic inference and interpretation
- **Learn in context: Parkinson’s disease**
  - Work with clinical and omics-related datasets relevant to brain sciences

Workshops Overview

- 4 workshops led by **Cynthia Sandor** (Python, stats, time-series, ML)
- 2 workshops led by **Nathan Skene** (R + single-cell)
- 1 workshop lead by **Martina Simplicio** (psychiatry) / Guest Session

Nir Grossman / Dr Nurun Fancy/ Dr Anna Mallach/ Dr Eugene Duff

Final **Hackathon** for assessment and integration of all skills

Lecturers

Dr Cynthia Sandor

Dr Nathan Skene

Dr Martina Simplicio

Dr Nir Grossman

Dr Nurun Francy

Dr Anna Mallach

Dr Eugene Duff

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Workshops Details

Thursday 6 November – Introduction to Python and Clinical Data in Parkinson's Disease
Friday 7 November – Introduction to Statistical Analysis and EHR Data

Monday 10 November – Introduction to Time-Series Data (Wearable Devices)
Tuesday 11 November – Introduction to Machine Learning

Wednesday 12 November – Introduction to Single-Cell Datasets

Monday 17 November – Identifying Cell-Type Specific Effects in Genetic Disorders

Tuesday 18 November
Morning: Dr *Martina Simplicio — Psychiatry Applications: Cognitive Differences in Self-Harm*
Afternoon: Department of Brain Sciences — Cutting-Edge Computational Neuroscience Showcase
•Dr *Anna Mallach — Using Spatial Transcriptomics to Resolve Cellular Changes in Alzheimer's Disease*
•Dr *Nurun Fancy — Single-cell transcriptomics: Uncovering the cellular story of neurodegeneration*
•Dr *Eugene Duff — Plasma Proteomic Evidence for Increased β-Amyloid Pathology Following SARS-CoV-2 Infection* (*Nature Medicine*, 2025)
•Dr *Nir Grossman — Sleep Onset as a Predictable Critical-State Transition* (*Nature Neuroscience*, 2025)

Friday 21 November – Hackathon & Assessment

Psychiatry applications Workshops

Tuesday 18 November

This workshop aims to give an opportunity to all students to learn about some psychiatry research and how computational approaches can be applied to psychiatry. Further it aims to exemplify the relationship between experimental data and subjective experience in understanding psychopathology.

9.30-10.45: *Dr Martina Simplicio & Ioanna Vamvakopoulou —*
Understanding Cognitive Mechanisms of Self-Harm

11-12: Lived Experience session
We will be joined via Teams by 2-3 young people from our Young People Advisory Group who will share their experiences of self-harm behaviour. Students will have the opportunity to ask questions.

Note* The workshop will cover **sensitive topics** (self-harm behaviour, addiction, depression). In particular, the lived experience session may resonate or not with personal / friends / family difficulties. Students are encouraged to be mindful of this, to make sure they look after themselves as needed and to feel free to skip the Lived Experienced Session if they prefer, without any justification needed.

Dr Martina Simplicio

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Workshops Details

Module 3 - Introduction to Computational Methods for Brain Science					
Module Lead: Nir Grossman					
Date	Time	Content	Activity/format	Room / Teams Link	Lecturer
WEEK 5					
Thursday 6th Nov	9:30 - 10:00	Module overview and outline of the assessments	Lecture	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	Cynthia Sandor
	10:30 - 11h00	Introduction to Python & Parkinson's Disease Clinical Data	Lecture	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	Cynthia Sandor
	11:00 - 12:30	Programming tutorial + Challenge (https://github.com/Sandoretal/Module_3/tree/main/tutorial_1)	Tutorial + Practical	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	
	13:30-16:00	Programming tutorial + Challenge (https://github.com/Sandoretal/Module_3/tree/main/tutorial_1)	Tutorial + Practical	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	
	16:00-17:00	Private study			
Friday 7th Nov	9:30-10:30	Introduction to Statistics and Electronic Healthcare Records	Lecture	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	Cynthia Sandor
	10:30-12:30	Programming tutorial + Challenge (https://github.com/Sandoretal/Module_3/tree/main/tutorial_2)	Tutorial+Pratical	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	
	13:30:16:00	Programming tutorial + Challenge (https://github.com/Sandoretal/Module_3/tree/main/tutorial_2)	Tutorial + Practical	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	
	16:00-17:00	Private Study			
WEEK 6					
Monday 10th Nov	9:30-10:30	Introduction to Time Series Data	Lecture	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	Cynthia Sandor
	10:30-13:00	Programming tutorial + Challenge (https://github.com/Sandoretal/Module_3/tree/main/tutorial_3)	Tutorial+Pratical	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	
	14:00-16:00	Programming tutorial + Challenge (https://github.com/Sandoretal/Module_3/tree/main/tutorial_3)	Tutorial+ Practical	RCS1 311B - Versatile Teaching Laboratory (VTL) 3B SOUTH KEN	
	16:00-17:00	Private study			
Tuesday 11th Nov	9:30-11:00	Introduction to Machine Learning	Lecture	CXGH 1.14 - Glenister Lecture Theatre	Cynthia Sandor
	11:00-13:00	Programming tutorial + Challenge (https://github.com/Sandoretal/Module_3/tree/main/tutorial_4)	Tutorial	CXGH 1.14 - Glenister Lecture Theatre	
	14:00-16:00	Programming tutorial + Challenge (https://github.com/Sandoretal/Module_3/tree/main/tutorial_4)	Practical	CXGH 1.14 - Glenister Lecture Theatre	
	16:00-17:00	Private study			
Wednesday 12th Nov	9:30-11:00	Single-cell RNA sequencing	Lecture	RCS1 212A - Versatile Teaching Laboratory (VTL) 2A SOUTH KEN	Nathan Skene
	11:00-13:00		Tutorial	RCS1 212A - Versatile Teaching Laboratory (VTL) 2A SOUTH KEN	
	14:00-16:00		Practical	RCS1 212A - Versatile Teaching Laboratory (VTL) 2A SOUTH KEN	
Thursday 13th Nov		Consolidation and learning	Private study		
Friday 14th Nov		Consolidation and learning	Private study		
WEEK 7					
Monday 17th Nov	9:30-11:00	Enriching Genes in Cell Types	Lecture	CXRB 116A - Collaborative Learning Suite A	Nathan Skene
	11:00-13:00		Tutorial	CXRB 116A - Collaborative Learning Suite A	
	14:00-16:00		Practical	CXRB 116A - Collaborative Learning Suite A	
	16:00-17:00	Private Study			
Tuesday 18th Nov	9:30-11:00	Psychiatry applications - Cognitive differences in self harm	Lecture	CXRB 116A - Collaborative Learning Suite A	Martina Di Simplicio
	11:15-12:30	Lived experience interview	Interview	CXRB 116A - Collaborative Learning Suite A	Martina Di Simplicio
	14:30-15:30	Cutting-edge Computation Research in DoB	Lecture	CXRB 116A - Collaborative Learning Suite A	Nir Grossman /Anna Mallach/Nurun Fancy/ Eugene Duff
	15:00-17:00	Private Study	Tutorial	CXRB 116A - Collaborative Learning Suite A	Nir Grossman
Wednesday 19th Nov		Consolidation and learning	Private Study		
Thursday 20th Nov		Consolidation and learning	Private Study		
Friday 21st Nov	10:00-17:00	ICA (Hackathon)		CXRB 116A - Collaborative Learning Suite A all day and CXLB 976 - 9th Floor Teaching Room 3-4pm	Nir Grossman

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Module Structure lead by me: W1 to W4

Dr Cynthia Sandor

Learning Philosophy

- Learn by doing: hands-on coding, real data, real problems
- Each day functions as a stand-alone workshop

Daily Schedule

- 09:30 – 10:30 | Morning lecture — workshop introduction
- 11:00 – 12:30 | Programming tutorial — guided coding
- 13:30 – 16:00 | Challenge session — apply skills to a new dataset/problem
- 16:00 – 17:00 | Private study — consolidate learning

Format

- Programming tutorial: learn coding tools for different data types
- Challenge: apply what you learned to real data

Support

- Work in groups of ~8 to encourage discussion and idea-sharing
- Code independently during challenge blocks
- TAs in person to answer questions — please make use of them
- Use Microsoft Teams to ask questions between sessions

Solutions

- Notebook solutions shared the following day on Teams (MT)

My Team

My research group developed the tutorials and the hackathon.

Dr Katarzyna Zoltowska

Marirena Bafaloukou

Anastasia Illina

Cecilia Rodriguez

Rishideep Chatterjee

Teaching assistants: answer questions and assess the hackathon

Antigoni Fogel

Ionna Biggart

Sahar Rahbar

Rocio Mexia Diaz

Aleksandra Kulbaka

Lucas Iijima

Matthew Bennett

Chenyu Zhao

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Your Group

Group 1	Group 2	Group 3	Group 4	Group 5	Group 6	Group 7	Group 8
Phillip Press	Viola Cerlani	Duru Okay	Yossra Serroukh	Harsimran Kaur	Jenna Lin	Muireann Hogan	Lucia Jing
Margarida Neves	Anya Kaur Haddon	Chloe Kam	Rebekah Bourne	Luca Pastorello	Mustafa Gunaydin	Edona Bajrami	Zishan Lin
Olivia Pownall	Anais Chia	Wenbo Liao	Hattie Oliver	Luoyuan Zhang	Laura Raklec	Francesca Murley-Holme	Stephanie Sun
Charlotte Yu	Shobana Chandrashekar	Yunyi Gao	Thishany Kuganeswaran	Ellie Carre	Hanna Altessaid	Ruben Thiagarajah-Fernar	Neera Gahir
Chun Hei Leung	Katie Hay	Anas Saleem	Hanyue Pang	Veronika Shevchenko	Alisija Dabasinskaite	Felix Varenne	Chuyi Zhang
Andrea Fan	Nina Jeffrey	Chi U Chau	Zeinab Ben Halim	Amina Bououdine	Ema Ferra	Ruofan CAO	Lili Yassin
Adelina Shahata	Asma Abdullahi	YINUO Wang	Isabella Coloru	Krystal Tan	Temi Lana	Xinrui Fan	Keya Tanwani
Tanaka Udugama Jal	Vea Bley	Mari Hronska	Lucas Yebra Garcia	Sarah Kurbanov			

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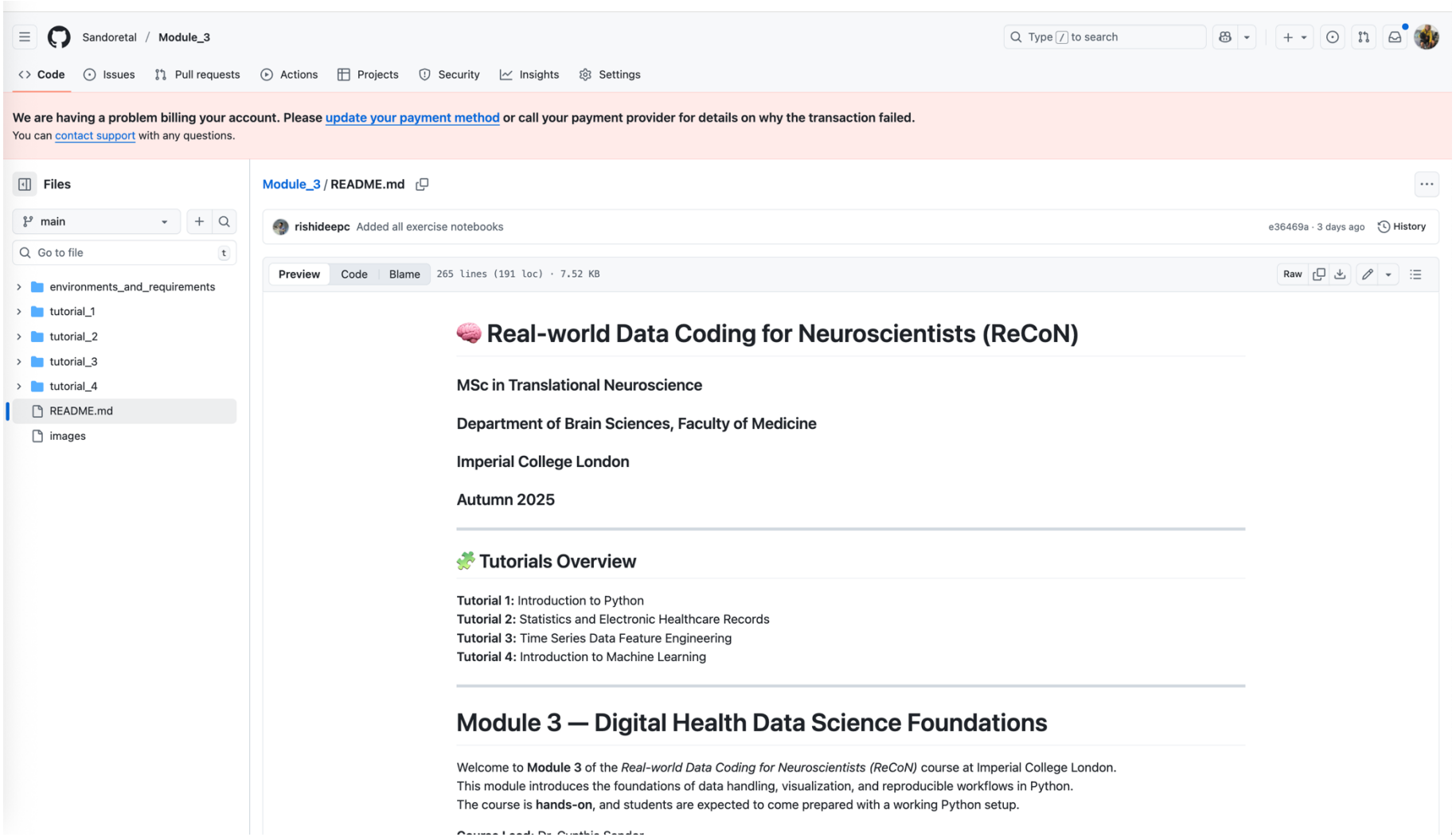
Where to find Tutorial & Challenge?

https://github.com/Sandoretal/Module_3



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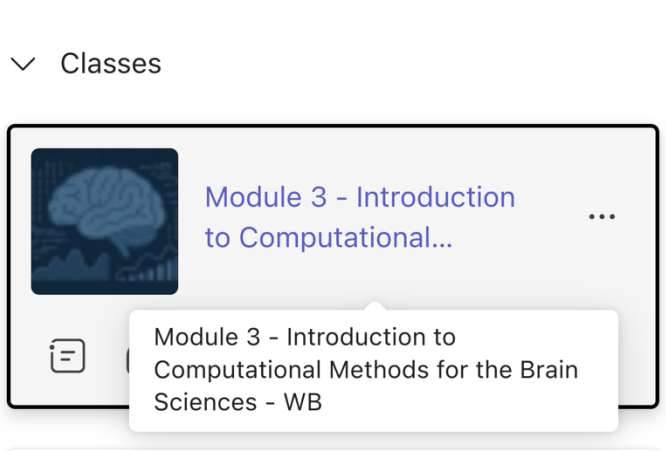
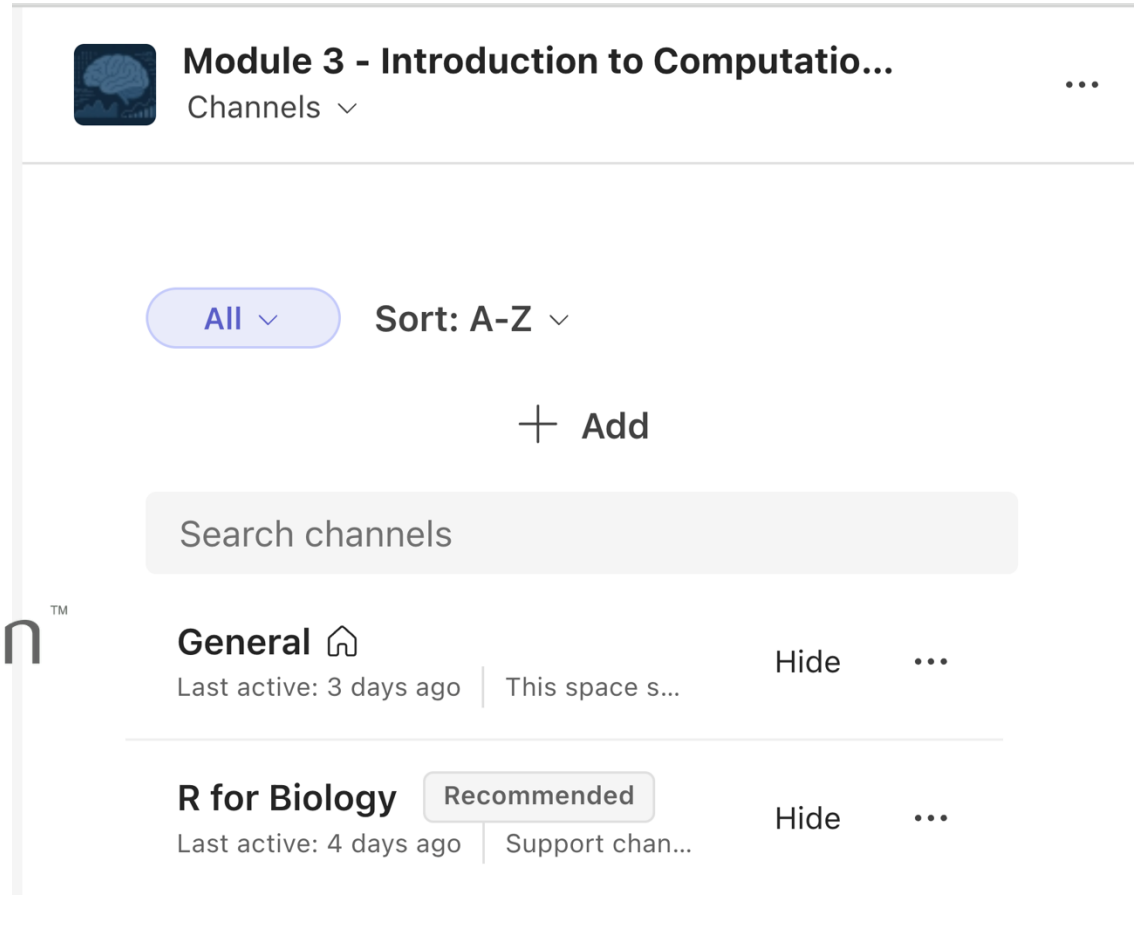
Microsoft Teams Class





Dr Cynthia Sandor

Dr Nathan Skene

- Questions between sessions
- Solutions – Next Day

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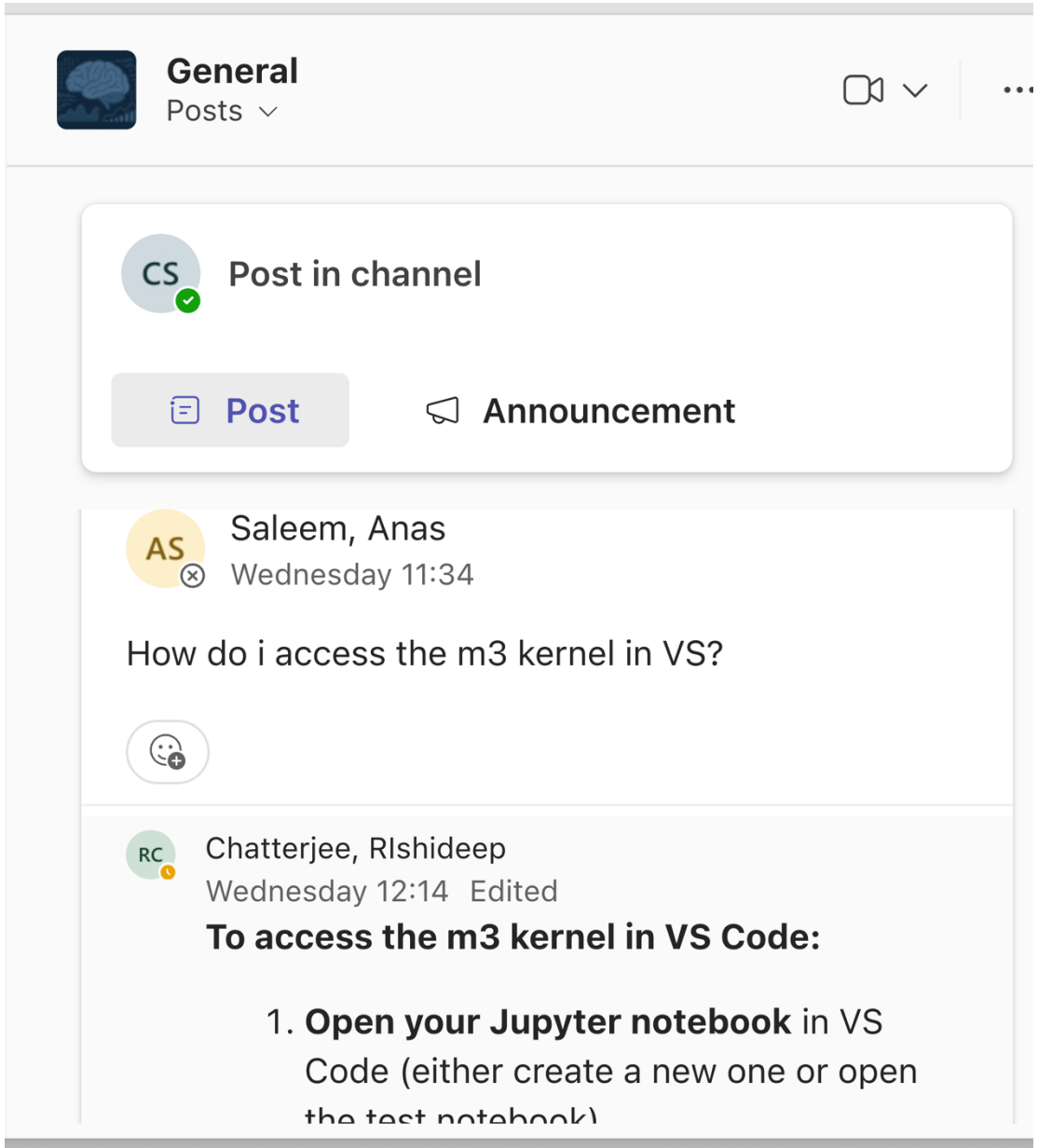
Microsoft Teams Class: Example



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Assessment- Hackathon

Performance in solving a computational research problem under time pressure.

.Assessment includes both individual and group components.

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Hackathon- Mission Example

Longitudinal questionnaire data have been collected from >20,000 people at two timepoints. Half the participants were surveyed early in 2020 and then in Christmas 2020–21. The other half were surveyed in May 2020, mid lockdown, and then again in Christmas 2021, mid resurgence. A subset of the measures taken have been curated for you to analyse.

Work in groups to address scientific questions from the data

- Select a combination of questions to address
- Marks will relate to the number and difficulty of questions answered
- You have full access to the Internet and your notes during this assessment **but should not work across groups**
- Recommendations include (**but are not limited to**):

Easy | What demographic has been sampled in this study?
Intermediate | How does mental health relate to age & other variables at baseline or during the pandemic?
Intermediate | Has mental health changed during the pandemic?
Difficult | Which sub-populations have been most affected?
Advanced | To what degree can mental health be predicted from demographic and lifestyle variable

You can grab food/drinks/coffee at any point, and we'll also take a lunch break

Hackathon- Schedule

Stage 1 — 09:30–09:50
Individual Planning
•Task: Prepare and submit 2 individual slides 50%
•Submission: via MT to TA

Stage 2 — 09:50–14:00
Group Analysis
•Task: Collaborative coding and data analysis
We will **provide a semi-empty iPython notebook via Github**
(includes structure, headings, and cells — but students must fill in analysis)
•Output: Submit group analysis code MT to TA 20%
•Note: Coding stops at deadline

Break 14h 14h30

Stage 3 — 14:30–15:00
Group Slide Preparation
•Task: Create **final presentation slides 8**

Stage 4 — 15:00–16:00
Group Presentations
•Format: 8 min presentation + 2 min Q&A 30%