

***Science and Technology***

*Computer Science*

***Computational Neural Modelling***

*CST 4157*

Module Leader: *Chris Huyck*

*Term AY 2023 (January)*

[Duration of the module 12 weeks]

Document Version *1*

**Online location of handbook**

This handbook can also be accessed via My Learning at: [Course: 2022-23 CST4157 Computational Neural Modelling (mrooms.net)](https://mdx.mrooms.net/course/view.php?id=35534).

**Other formats available**

This handbook is available in a large print format. If you would like a large print copy or have other requirements for the handbook, please contact the Disability Support Service disability@mdx.ac.uk

**Disclaimer**

The material in this handbook is as accurate as possible at the date of production. You will be notified of any minor changes promptly. If there are any major changes to the module you will be consulted prior to the changes being confirmed. Please check the version number on the front page of this handbook to ensure that you are using the most accurate information.

**Other documents**

Your module handbook should be read and used alongside your programme handbook and the information available to all students on My Learning and UniHub, including the Academic Regulations. Your programme handbook can be found on the My Learning programme page for your programme.

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# Welcome

Modelling neurons on a computer is a complex and poorly understood art. In this module, we will work on modelling neurons, evaluating our models, and using these models for actual computation. Alignment with cognitive behaviour and development of neuro-cognitive models will be explored.

Students are expected to come to the labs and lectures, develop code, and openly discuss issues in neuron simulation. Discussion of current literature is encouraged.

# The module teaching team

|  |
| --- |
| *Module Leader: Chris Huyck* |
|  | Room number: | T127  |
| Email: | *c.huyck@mdx.ac.uk* |
| Telephone number: | *208-411-5412* |
| Office hours: | *Fridays 2-4* |

# Communication with the teaching team

*Students may contact staff via e-mail, phone, by dropping into staff office hours, and by making an appointment to see them outside office hours.*

*Staff will contact students by e-mail, phone, the My Learning module page and via lectures and seminars.*

*The team may send urgent group and/or individual messages about the module to you by email, so it is important that you read your University email regularly.*

*All staff have office hours, it is not necessary to book an appointment during these hours, you just need to drop-in.*

*In the first instance problems should be dealt with by talking to a member of the module team. You can give feedback on this module to the module leader, your Student Voice Leader, to your personal tutor, and through the end of module evaluation survey.*

Our most important consideration is your health, wellbeing and safety as well as our staff and people related to the University. Remember that you – as part of #TeamMDX – can stay up-to-date with the guidance on Coronavirus at

<https://unihub.mdx.ac.uk/coronavirus-covid19>

# Module overview

|  |  |  |
| --- | --- | --- |
| 1. | Module code: | CST 4157 |
| 2. | **Title:** | Computational Neural Modelling |
| 3. | **Credit points:** | 15 |
| 4. | **FHEQ level:** |  |
| 5. | **Start term:** |  |
| 6. | **Module leader:** | Chris Huyck |
| 7. | **Accredited by:** |  |
| 8. | **Module restrictions:** |  |
| 1. Pre-requisite
 |  |
| 1. Programme restrictions
 |  |
| 1. Level restrictions
 |  |
| 1. Other restrictions or requirements
 |  |
| 9. | **Aims:**To gain an understanding of modelling neurons, synapses, and neural topologies in a computer. This includes the strengths and weaknesses of models, how to use these models to perform useful computations, and ideas about how to move from these models to functioning model brains. |
| 10. | **Learning outcomes:****Knowledge**On successful completion of this module, the student will be able to:1. Critically evaluate common computational models of neurons.2. Critically evaluate common computational models of synaptic plasticity.3. Modify common mechanisms for building and growing computational neural topologies to solve novel problems.**Skills**On successful completion of this module, the student will be able to:4. Implement a range of spiking neural models in a computer simulation.5. Use computational spiking neurons to implement simple algorithms. |
| 11. | **Syllabus:**1. Point models of neurons (including integrate and fire, LIF, models with adaptation, Izhikevich models, and Boltzmann machines)
2. Compartmental models of neurons
3. Modelling plasticity (including STDP, short term plasticity, long term plasticity, and structural plasticity)
4. Topology
5. Cell Assemblies
6. Programming with Cell Assemblies
7. Stochasticity, Nengo, and Taylor Series
 |
| 12. | **Learning and teaching strategy:**Weekly lectures and labs. For example, a typical run might have one lecture of one hour, and one practical computational model development labs of two hours per week. Labs will be based around the standard PyNN Nest model used in the Human Brain Project.  |
| 13. | **Assessment scheme:** |
| 1. **Formative assessment scheme**

Weekly laboratory sessions will enable direct formative assessment of computational models and modelling.  |
|  | 1. **Summative assessment scheme**

Assessment will be based solely on course work. Typically, this will consist of two course works, both involving computational models developed by the student. An example course work pair is course work 1, spike time model, due in week 5, worth 35%, and course work 2, an HBP agent brain model, due in week 12, worth 65%.Coursework 1 will consist of running code, alignment with spike data, and a 1000 word report. This will match learning outcome 1 and 4.Coursework 2 will consist of running code linked to a running agent, and a 1500 word report. This will match learning outcome 1,3, 4 and 5, and the exceptional student will implement plasticity to match outcome 2. If no plasticity is implemented, this outcome will be met by the report alone. |
| Seen examination | ..…0…% |
| Unseen examination | …..0…% |
| Coursework (no examination) | ….100.…% |
| 14. | **Timetabled examination required** | No |
| 15. | **Length of exam** | ……..hours |
| 16. | **Learning materials*** Essential
* Recommended
 | Trappenberg, T. (2009). *Fundamentals of computational neuroscience*. OUP Oxford.Davison, A. P., Brüderle, D., Eppler, J. M., Kremkow, J., Muller, E., Pecevski, D., ... & Yger, P. (2009). PyNN: a common interface for neuronal network simulators. *Frontiers in neuroinformatics*, *2*, 11.Gewaltig, M. O., & Diesmann, M. (2007). Nest (neural simulation tool). *Scholarpedia*, *2*(4), 1430.Eliasmith, C. (2013). *How to build a brain: A neural architecture for biological cognition*. Oxford University Press. |

#

***Research Ethics –*The teaching, learning, assessment and research activities undertaken in this module have been considered and are not likely to require ethical approval**.

* However, please seek advice if undertaking the module entails carrying out any research activities involving **human participants, human data, animals/animal products, precious artefacts, materials or data systems.** If you submit work that includes data gathered from or about people, this may be treated as academic misconduct and could lead to fail grade being awarded.
* Research ethics approval seeks to ensure all research is designed and undertaken according to certain principles of ethical research. These include:

1. Primary concern must be given to the **safety, welfare and dignity** of participants, researchers, colleagues, the environment and the wider community

2. Consideration of **risks** should be undertaken before research commences with the aim of minimising risks to those involved – i.e. human participants or animal subjects, colleagues, the environment and the wider community, as well as actual or potential risks to those directly or indirectly affected by the research.

3. **Informed consent** should be freely given by participants, and by a trained person when collecting or analysing human tissue (details on accessing and completing online training for gaining informed consent for HTA purposes can be found below in Section 8).

4. Respect for the **privacy, confidentiality and anonymity** of participants

5. Consideration of the rights of **people who may be vulnerable** (by virtue of perceived or actual differences in their social status, ethnic origin, gender, mental capacities, or other such characteristics) who may be less competent or able to refuse to give consent to participate

6. Researchers have a responsibility to the general public and to their profession; as such they should balance the anticipated benefits of their research against **potential harm, misuse or abuse** which must be avoided

7. Researchers must demonstrate the highest standards of **ethical conduct and research integrity**. They must work within the limits of their skills, training and experience, and refrain from exploitation, dishonesty, plagiarism, infringement of intellectual property rights and the fabrication of research results. They should declare any actual or potential conflicts of interest, and where necessary take steps to resolve them.

8. When using human tissues for research, Human Tissue Act and Human Tissue Authority (HTA) requirements must be met. Please contact the relevant designated person (DP) in your department or the HTA Designated Individual (DI) (Dr Lucy Ghali - L.Ghali@mdx.ac.uk). Further information is provided below in the section: "Human Tissue Authority Information", see 'Governance Structure" document and SOPs etc.

9. Research should **not involve any illegal activity**, and researchers must comply with all relevant laws.

* For more information about ethics go to the Middlesex Online Research Ethics (MORE) system which has information and guidance to help you meet the highest standards of ethical research using this link: https://MOREform.mdx.ac.uk
* Information and further guidance on how to complete a research ethics application form (e.g., video guides and templates) can be found on the MORE MyLearning site\*: http://mdx.mrooms.net/enrol/index.php?id=12277 (Log in required)

\*Middlesex University Definition of Research document can be located on this site.

# Learning resources

The core reading for this course is from Fundamentals of Computational Neuroscience by Thomas Trappenberg 2010. References and links to papers will also be provided. Students are encouraged to suggest papers themselves.

# Expectations of studying this module

**Attendance and Engagement**

The module team are here to help and support you achieve your goals. One of the key elements to successfully completing this module is engaging with all of the learning opportunities we offer as well and working with your peers to support one another.

This module is designed as a combination of contact sessions, directed study and independent study. This means you must participate in all the allocated sessions and you must complete all set prework and activities outside them. Students are expected to take an active part in all learning sessions whether these are online or on campus; lectures, and lab sessions.

To make the most of this module please complete the following every week

* Complete all prework in preparation for learning sessions. This may be watching videos, reading through set material or chapters and completing activities. Please make notes of points you need to clarify and discuss these in learning sessions with module tutors.
* Read through the notes making a note of any points you need to discuss with your tutor.
* Complete the set activities before the next session, making a note of any points you need to discuss with your tutor.
* Complete further reading from the core text online.

The module team is committed to support you and your fellow students whilst you undertake this module. In order for you to get the most out of sessions you need to come prepared and ready to contribute. Please ensure that any work set by the team has been completed before workshops. After each class please review what has been covered and make a note of anything you would like clarification on.

Engaging with online and on-campus in-person learning and activities is integral to your success.  Middlesex University supports you to achieve your full potential through a number of strategies, all of which provide a supportive learning environment online, remotely, face-to-face, or blended.

Further information on attendance and engaging with your programme will be available at your Induction and updates online at UniHub at the weblink below. <https://unihub.mdx.ac.uk/study/assessment/attendance>

## Professional behaviour and online conduct

The programme of study you are undertaking is underpinned by developing professional behaviour and attitude. It is important that you are respectful and supportive to your fellow students and tutors. Adopting this approach will create a positive atmosphere within sessions and is something you can use in your professional life. You must come to sessions prepared and ready to contribute where appropriate. To access some of the rooms and specialist space used for this module you will need your University ID card. Please remember that your University ID should be carried with you always whilst on campus and you must be able to identify yourself if asked to do so. Please conduct your email communication with fellow students, tutors and all relevant staff in a formal and courteous manner. It is helpful to provide your student number and if you have a query relating to a module include the module number as well.

In the same way that we help you understand how to effectively participate in learning on campus, we also want to make sure that you can make the most of online learning. Our principles of online learning class conduct are available at: <https://unihub.mdx.ac.uk/covid-19-updates-faq/online-classroom-conduct>

## Academic Integrity and Misconduct

You should be aware of the University’s academic integrity and misconduct policies and procedures. Taking unfair advantage over other students in assessment is considered a serious offence by the University. Action will be taken against any student who contravenes the regulations through negligence, foolishness or deliberate intent. Academic misconduct takes several forms, in particular:

* **Plagiarism** – using extensive unacknowledged quotations from, or direct copying of, another person’s work and presenting it for assessment as if it were your own effort. This includes the use of third party essay writing services.
* **Collusion** – working together with other students (without the tutor’s permission), and presenting similar or identical work for assessment.
* **Infringement of Exam Room Rules** – Communication with another candidate, taking notes to your table in the exam room and/or referring to notes during the examination.
* **Self-Plagiarism** – including any material which is identical or substantially similar to material that has already been submitted by you for another assessment in the University or elsewhere.

Students who attempt to gain unfair advantage over others through academic misconduct will be penalised by sanctions, according to the severity of the offence, which can include exclusion from the University. Links to the relevant University regulations and additional support resources can be found here:

**Student Success Essentials** Course which includes Academic Integrity

[**Access to course**](https://mdx.mrooms.net/mod/lesson/view.php?id=877307). -You will have to log into to MyUniHub and then MyLearning to access the course.

Full details on academic integrity and misconduct and the support available can be found at  [Academic Integrity | UniHub (mdx.ac.uk)](https://unihub.mdx.ac.uk/study/academic-integrity)

The Academic Integrity and Misconduct policy is available in our Public Policy Statements (under Academic Quality) at: [Our policies | Middlesex University London (mdx.ac.uk)](https://www.mdx.ac.uk/about-us/policies)

Referencing & Plagiarism: Suspected of plagiarism?:

<http://libguides.mdx.ac.uk/c.php?g=322119&p=2155601>

Referencing and avoiding plagiarism:

 <https://unihub.mdx.ac.uk/study/writing-numeracy/awl-resources/writing>

The Middlesex University Students’ Union (MDXSU) Advice Service offers free and independent support in making an appeal, complaint or responding to any allegations of academic or non-academic misconduct.

<https://www.mdxsu.com/advice>

## Extenuating circumstances:

There may be difficult circumstances in your life that affect your ability to meet an assessment deadline or affect your performance in an assessment. These are known as extenuating circumstances or ‘ECs’. Extenuating circumstances are exceptional, seriously adverse and outside of your control. Please see link for further information and guidelines:

<https://unihub.mdx.ac.uk/your-study/assessment-and-regulations/extenuating-circumstances>

# Assessment

Formative assessment**:** Formative assessment is completed during your year of study and provides the opportunity to evaluate your progress with your learning. Formative assessments help show you and us that you are learning and understanding the material covered in this course and allow us to monitor your progress towards achieving the learning outcomes for module. Although formative assessments do not directly contribute to the overall module mark they do provide an important opportunity to receive feedback on your learning.

|  |  |
| --- | --- |
| Formative assessment | Deadline |
| *Fitting a Neural Model to Data* | *February 3rd , 2023 5 pm* |
| *Build a Chatbot in Neurons* | *March 31st , 2023 5 pm* |

Summative assessment**:** Summative assessment is used to check the level of learning at the end of the course. It is summative because it is based on accumulated learning during the course. The point is to ensure that students have met the learning outcomes for the course and are at the appropriate level. It is the summative assessment that determines the grade that you are awarded for the module.

The are two assessment components in this module:

# Course Work 1: Fitting a Neural Model to Data

## Due end week 6 (February 3rd, 2023)

## This course work is worth 40% of the overall module mark.

The course work is to develop a neural model in PyNN and Nest that approximates the behaviour of known neural data. In this case, a rat neuron has a time varying input. The model should take the input, and spike when the actual biological neural spikes. A 1000 word report should discuss the models used and their performance.

The data comes from Jolivet, R., Kobayashi, R., Rauch, A., Naud, R., Shinomoto, S., & Gerstner, W. (2008). A benchmark test for a quantitative assessment of simple neuron models. Journal of neuroscience methods, 169(2), 417-424. It describes rat neurons that have an electrode embedded. The electrode is provided with a time varying input, and the voltage of the neuron is measured. I've used that data to infer spikes (when a neuron goes above 0 voltage, and then returns below 0).

Aligning spikes is not a simple process. Describe how you align actual spikes with the simulated spikes from your model.

Here is the [data](https://cwa.mdx.ac.uk/cst4157/coursework/clampSpikeData.csv), the [spikes](https://cwa.mdx.ac.uk/cst4157/coursework/spikes.txt), a sample [program in txt](https://cwa.mdx.ac.uk/cst4157/coursework/simpleSolutionpy.txt), and a sample [program in py](https://cwa.mdx.ac.uk/cst4157/coursework/simpleSolution.py).

**Marking scheme**:

|  |  |
| --- | --- |
| **Points** | **Area** |
| 10 | Running Code |
| 40 | Quality of Results |
| 20 | Discussion of Model |
| 20 | Discussion of Results |
| 10 | References |

Please submit the code and the report to the moodle page.

# Course Work 2: Build a Chatbot in Neurons

## Due end week 12 (March 31st, 2023 (5 pm))

## This course work is worth 60% of the overall module mark.

The course work is to build a chatbot in neurons in PyNN and Nest. You can use the NEAL stuff. In particular the generator stuff should be enough to give you a reasonable system. It comes with an example system. You should expand that system.

If you'd like, you can extend the system to include the parser. So, user input words actually turn on words in the parser, which then turns on queries to the generator, which then turns on the output words.

A 1500 word report should be written.

This coursework can be done in groups of up to three. An additional 500 words should be included for each additional team member. An additional paragraph should be included (beyond the word count) stating what each member did.

Here is the [tar ball for code](https://cwa.mdx.ac.uk/cst4157/coursework/cw2.tar.gz), the

**Marking scheme**:

|  |  |
| --- | --- |
| **Points** | **Area** |
| 10 | Running Code |
| 40 | Quality of Results |
| 25 | Discussion of Model |
| 20 | Discussion of Results |
| 5 | References |

Please submit the code and the report to the moodle page.

The table below specifies the associated deadlines:

|  |  |  |  |
| --- | --- | --- | --- |
| Summative assessment | Weighting | Deadline | Feedback |
| Fitting a Neural Model to Data | *40%* | February 3rd, 2023 (5 pm) | *February 24th* |
|  Build a Chatbot in Neurons | *60%* | March 31st, 2023 (5 pm) | *April 28th* |

In order to pass this module, you need to have a 40% average on the two course works.

Before you submit your work for final grading, please ensure that you have accurately referenced the work. It is your responsibility to check the spelling and grammar, as all written assessments will assess technical proficiency in the English. This means accurate and effective spelling, punctuation and grammar. Details of how it will be assessed will be provided in the marking criteria for each assessment and the University overall approach can be found within the Grade Criteria Guide in the University Regulations <https://www.mdx.ac.uk/about-us/policies> (scroll to university regulations)

Reasonable adjustments will be made for those students who have a declared disability/specific learning condition which would affect performance in this area.

If you have submitted a formative or draft assessment, you will receive feedback but no grade. The comments should inform you about how well you have done or tell you about the areas for improvement. All assignments should be submitted online unless specified in assessment briefs.

Reassessment for this module normally takes place in the following way:

The failed component or components can be resubmitted for the summer course work deadline. The mark is typically capped at 40/100.

Further information is available at

https://unihub.mdx.ac.uk/study/assessment

Middlesex University is committed to being fair in its approach to assessing student learning following the [UK Quality Code for Higher Education (Quality Code) (2018](https://www.qaa.ac.uk/quality-code)) and the [UK Quality Code - Advice and Guidance: Assessment (2018)](https://www.qaa.ac.uk/quality-code/advice-and-guidance/assessment) and [External Expertise (2018).](https://www.qaa.ac.uk/quality-code/advice-and-guidance/external-expertise)

The Assessment Fairness guidance, policies and procedures put in place by Middlesex University is our commitment to ensure fairness in assessment and are available at <https://www.mdx.ac.uk/about-us/policies>

If you have any queries or would like to know more on how this approach has been applied to modules you are studying please contact your Programme Leader.

## 7.2 Feedback on your assignments

You will be provided with feedback on all coursework that is helpful and informative, consistent with aiding the learning and development process. The nature of the feedback shall be determined at programme level but may take a variety of forms including: written comments; individual and group tutorial feedback; peer feedback; or other forms of effective and efficient feedback.

Feedback will normally be provided within 15 WORKING DAYS of the published coursework component submission date.

## 7.3 How is your assignment mark agreed?

The following diagram provides an overview of the marking process for your module assessment. Further information on the role of external examiners can be found at. <https://www.mdx.ac.uk/about-us/policies/academic-quality/handbook> (section 4)

## 7.4 Anonymous Marking Assessment Policy

We have worked with the Middlesex University Students’ Union (MDXSU) to create an anonymous marking policy, in response to student feedback.  Anonymous marking ensures that your identity (your name, student number and other personal/identifiable information) is not made available to academics when they are marking your work.  This means that you can have confidence that your assessments will be marked fairly and consistently.  However, there are some forms of assessment for which anonymity cannot be guaranteed and these are recognised in the policy.  We believe that it is important to provide you with the support and guidance needed to help you develop and prepare for your final assessments (those which count towards your final grades i.e. summative assessments).  Therefore, anonymous marking will not apply to learning activities and assessments that do not contribute to your final grades (i.e. formative assessments).  If you require further information and support to understand how anonymous marking works in your programme modules please contact the Module Leader for more information.

The Anonymous Marking Assessment Policy is available at: <https://www.mdx.ac.uk/__data/assets/pdf_file/0037/563599/anonymous-marking-assessment-policy.pdf>

# Learning Planner

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Week beginning** | **Week (s)** | **Lecture** | **Lab** | **Staff** | **Student Activity** | **Assessment and feedback** |
| Jan 9th | 1 | Simple Point Neural Models |  | CH | Lecture and Lab |  |
| Jan 16th | 2 | Other Point Neuron Models |  | CH | Lecture and Lab |  |
| Jan 23rd | 3 | Hodgkin Huxley Models |  | CH | Lecture and Lab |  |
| Jan 30th | 4 | Other Complex Neural Models and Features | Course work support | CH | Lecture and Lab | Course work 1 due |
| Feb 6th | 5 | Long Term Plasticity |  | CH | Lecture and Lab |  |
| Feb 13th | 6 | Short Term and Structural Plasticity |  | CH | Lecture and Lab |  |
| Feb 20th | 7 | Topology |  | CH | Lecture and Lab |  |
| Feb 27th | 8 | Cell Assemblies | Course work support | CH | Lecture and Lab |  |
| Mar 6th | 9 | Binary CAs and FSAs | Course work support | CH | Lecture and Lab |  |
| Mar 13th | 10 | Stochasticity |  | CH | Lecture and Lab |  |
| Mar 20th | 11 | Nengo and Taylor Series | Course work support | CH | Lecture and Lab |  |
| Mar 27th | 12 | Conclusion | Course work support | CH | Lecture and Lab | Course work 2 due |

# University 20-point Scale

*Both course works are marked out of 100. The mark given below (on the 20 point scale) is a direct conversion of the weighted sum of the marks for the course works.*

|  |  |  |  |
| --- | --- | --- | --- |
| **20-point scale** | **General scale** | **General scale (full ranges)** | **Percentage used for aggregation purposes only** (for areas marking directly to the 20 point scale on modules with multiple assessment components) |
| **1** | 80% - 100% | 79.50% - 100% | 90% |
| **2** | 76% - 79% | 75.50% - 79.49% | 77.5% |
| **3** | 73% - 75%  | 72.50% - 75.49% | 74% |
| **4** | 70% - 72%  | 69.50% - 72.49% | 71% |
| **5** | 67% - 69%  | 66.50% - 69.49% | 68% |
| **6** | 65% - 66%  | 64.50% - 66.49% | 65.5% |
| **7** | 62% - 64%  | 61.50% - 64.49% | 63% |
| **8** | 60% - 61%  | 59.50% - 61.49% | 60.5% |
| **9** | 57% - 59% | 56.50% - 59.49% | 58% |
| **10** | 55% - 56%  | 54.50% - 56.49% | 55.5% |
| **11** | 52% - 54%  | 51.50% - 54.49% | 53% |
| **12** | 50% - 51%  | 49.50% - 51.49% | 50.5% |
| **13** | 47% - 49%  | 46.50% - 49.49% | 48% |
| **14** | 45% - 46% | 44.50% - 46.49% | 45.5% |
| **15** | 42% - 44%  | 41.50% - 44.49% | 43% |
| **16** | 40% - 41%  | 39.50% - 41.49% | 40.5% |
| **17** | 35% - 39%  | 34.50% - 39.49% | 37% |
| **18** | 30% - 34% | 29.50% - 34.49% | 32% |
| **19** | 0% - 29%  | 0.01% - 29.49% | 15% |
| **20** | Non-participation | 0% | 0% (non-submission of a component) |