CITY UNIVERSITY
LONDON

IN3063: Mathematics and Programming for AI
2025-26
Coursework

V1.0

Submission deadlines:
Report and Code: Sunday 28th December 2025, 5pm
Group Presentation 19th January 2026, 5pm

Introduction

This coursework builds on the material covered in the lecture slides and the Jupyter notebooks used in the labs. On completing this coursework, you should be able to code your analysis in Python, as well as to implement neural network techniques from scratch. You will make use of the different concepts learned in the module:

- How to convert mathematical principles into algorithms
- How to implement those algorithms in Python
- How to organize your ideas in an appropriate code structure
- How to evaluate different algorithms

Python should be used for all implementations. Deliverables are:

- A written report of your work. Maximum 2000 words.
- Your practical implementation (code), with the appropriate comments.
- Presentation: A recorded group presentation (10 minutes) to be uploaded on Moodle

Module marking:

The coursework is divided into two components: 70% Coursework (Code and Report) and 30% Presentation.

Teamwork

This coursework should be completed in **groups of four (or possibly five)**.

- Groups will be assigned and will be available on Moodle.
- The code and the main report will be developed and written as a group.
- There will be a peer review process using Moodle tooling to evaluate each participant's contribution. All team members are expected to contribute to all parts of the work. Due to the peer-review and individual contributions, all group members might or might not achieve the same marks.

All team members are expected to contribute to **all** parts of the work: both the coding and the report. Teamwork does NOT mean division of labor. You can distribute the leading role for each assignment, but each of you must contribute to all the tasks. If you don't, you will not be evaluated for the tasks that you did not contribute to. Distributing the assignments is considered a form of academic misconduct.

The Coursework is divided into 2 different Tasks.

Submission

Submission is through Moodle (https://moodle4.city.ac.uk), and no other method of submission will be accepted.

Report:
You have to submit a written report of your work.

- The report is submitted as a pdf file.
- Maximum word count is 2000 (excluding tables/figures). Full report should not exceed 9 pages.
- The deadline to upload the report is 28th December, 2025

Code:

- The source code must be submitted as a zip file
- The deadline to submit the code is 28th December, 2025.

Format for reports: pdf format, single column, standard A4 margins, standard default line spacing of 1.15 including all figures.

Late submissions. This work is covered by the School's policies on the above. Note that as group work, this is not eligible for extensions. You can upload work to Moodle more than once, so there is no need for last minute submission. Don't leave submission to the last minute, make sure to submit something and then revise it. Late submissions will be graded **zero**.

Group Presentation

You will be evaluated in an oral presentation (10 minutes). During this presentation, you will present the task1 including results, discussions, any challenges faced, and learning from the coursework (reflection). The presentation will recorded and uploaded on moodle. The deadline to upload presentation is 19th January 2026.
You will lose points if you don't respect the time limit

Feedback

During the labs we can check your progress and give formative feedback. Evaluative feedback and marks on your coursework will be given out after the presentations. Drop-in hours are available at the Moodle site for additional feedback and questions.

The Tasks

In this coursework, you are expected to demonstrate what you have learned in the module in terms of Programming, Neural Networks, and Deep Learning.

The maximum number of marks which can be scored is 100.

In all tasks, you can use the built-in libraries of python (math, random, numpy, and matplotlib, etc). If you think that you might benefit from using another library, you can ask about it to the Lecturer on Moodle. You will use PyTorch in Task 2.

Note that you can use any library for the purpose of loading the datasets that you are using.

Task 1: 70 Marks

The aim of the task is to develop a multi-layer neural network for classification using numpy. You can use other API's/libraries for loading the dataset, but not for the neural network implementation.

For the task, you can choose any appropriate dataset (preferred imaging dataset).
The task requires following sub-tasks:

a. Dataset selection and description **(10%)**

Present and discuss the dataset along with the motivation of the choice. A relative complex dataset will have high weightage in this category (out of 10%). For instance, you can use MNIST, CIFAR-10, or other of your choice.

b. Implement sigmoid and ReLU layers **(10%)**

For this sub-task, you should implement forward and backward pass for sigmoid and ReLU. Present these activation functions in the report with any pros and cons if they have.

c. Implement softmax layer **(10%)**

Implement softmax with both forward and backward pass. Present the softmax in the report along with your implementation approach and any numerical issues when calculating the softmax function.

d. Implement dropout **(10%)**

Present dropout in the report. Implement inverted dropout. Forward and backward pass should be implemented. Present in the report.
Note: Since the test performance is critical, it is also preferable to leaving the forward pass unchanged at test time. Therefore, in most implementations *inverted dropout* is employed to overcome the undesirable property of the original dropout.

e. Implement a fully parametrizable neural network class **(10%)**

You should implement a fully-connected NN class where with number of hidden layers, units, activation functions can be changed. In addition, you can add dropout or regularizer (L1 or L2). Report the parameters used (update rule, learning rate, decay, epochs, batch size) and include the plots in your report.

f. Implement optimizer **(10%)**

Implement any two optimizers of your choice. Briefly present the optimizers in the report. The optimizers can be flavours of gradient descent. For instance: Stochastic gradient descent (SGD) and SGD with momentum. SGD and mini-batch gradient descent, etc.

g. <u>Evaluate different neural network architectures/parameters, present and discuss your results.</u> **(30%)**

Be creative in the analysis and discussion. Evaluate different hyperparameters. For instance: different network architectures, activation functions, comparison of optimizers, L1/L2 performance comparison with dropout, etc. It is highly recommended to support your results with plots/graph and brief discussion.

h. <u>Code quality and report presentation</u> **(10%)**

Follow good coding practice with appropriate comments.

<u>Task 2: 30 Marks</u>

The second task is about implementing deep learning networks using PyTorch. You can use any imaging or time-series dataset of your choice for this task. The dataset should be discussed and approved by Lecturer.

a. Present the dataset and the topic of your study. **(10%)**

b. Describe and implement a model. For instance, neural network or base convolutional neural network (in the case of images). Present in the report with a brief justification. **(10%)**

c. Implement at least two improvements. Describe your motivation in the report. For instance, the improvement can be the architecture changes, a different network, dropout etc. **(25%)**

d. Optimize hyperparameters, and present results. **(20%)**

e. Present, compare and discuss your results. You can include comparison of hyperparameters, different or improved models, etc. Please include plots/graphs where necessary. **(25%)**

f. Code quality and report presentation **(10%)**

Reports

Each report must have an additional first title page (not included in the page count), and as many references as needed (not counting in the page total). The title page should include your **group number, group members and github link**. Graphical illustration of your results is expected as well as numerical results and analysis.

You should present the results clearly and provide a discussion of the results, with conclusions related to the problems being addressed. The conclusions section might discuss as well some further work based on the results of this coursework.

Note

You are not only being marked on how good the results are. It matters that you try something sensible and clearly describe the problem, methods, what you did, and your interpretation of the results.

Coding & Referencing

You can use a jupyter notebook and/or python scripts for your coursework. Your code should be reproducible. Random number generators with fixed seeds should be included to ensure the reproducibility of the results as described in your report. However, note that your results should be robust to changes of the seeds. You need to add a README file with details on how to reproduce your code.

In addition**, your code must be tracked and made available on a git hosting platform (e.g. github),** with a full revision history indicating who submitted each commit. This repository should be available to the Lecturer of the module, Atif Riaz. **You should provide link of git repository in the first page of your report.**

Github username: atifR

Code quality, clarity, organization, and comments will be taken into account in the marking.

This is, in large part, a coding assignment. If you use code (or other materials) written by someone else, you must **cite** that code (or other material). **If you do not cite work appropriately you will have committed academic misconduct**. Making superficial changes to the code does not make it yours.

Use of LLMs, Generative AI tools

The University's policies on GenAI apply to the assignment. You can find a link to this on the module page on Moodle under School GenAI policy.

Plagiarism

If you copy the work of others (either that of another team or of a third party), with or without their permission, you will score no marks and further disciplinary action will be taken against you. The same applies if you allow others to copy your work.

See
https://studenthub.city.ac.uk/__data/assets/pdf_file/0006/372822/6.-Referencing-and-avoiding-plagiarism_FINAL.pdf