Subject Description Form

<table>
<tr><td>Subject Code</td><td>COMP2014</td></tr>
<tr><td>Subject Title</td><td>Mathematics for Machine Learning</td></tr>
<tr><td>Credit Value</td><td>3</td></tr>
<tr><td>Level</td><td>2</td></tr>
<tr><td>Pre-requisite / Co-requisite / Exclusion</td><td>NIL</td></tr>
<tr><td>Objectives</td><td>The objectives of this subject are to:
• provide the basic concepts of mathematics for machine learning
• apply practical problem-solving skills by using appropriate numerical computing environments and mathematical software libraries</td></tr>
<tr><td>Intended Learning Outcomes</td><td>Upon completion of the subject, students will be able to:
<u>Professional/academic knowledge and skills</u>
(a) understand the basic concepts of mathematics for machine learning;
(b) apply proper mathematics concepts in solving problems;
(c) familiarize with numerical computing environments and mathematical software libraries;
<u>Attributes for all-roundedness</u>
(d) solve problems independently; and
(e) think critically for improvement in solutions.</td></tr>
<tr><td>Subject Synopsis/ Indicative Syllabus</td><td>
<table>
<tr><th>Topic</th><th>Duration of Lectures</th></tr>
<tr><td>1. Numerical computing software
Mathematical software libraries (e.g., Numpy, Pandas, Scikit-Learn; numerical computing environments (e.g., Pytorch, Keras, Matlab)</td><td>4</td></tr>
<tr><td>2. Linear algebra
Vector space; linear transformation and matrices; solving linear equations; matrix decomposition; eigenvalues and singular values; matrix norms and condition numbers; inverse matrices; column space and null space; non-square matrices as transformation between dimensions; pseudo-inverses</td><td>12</td></tr>
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	3. Optimization One-dimensional optimization; least squares; constrained optimization; convex optimization; gradient descent; stochastic gradient descent	4
	4. Probability and Statistics Recap of basic concepts in probability; maximum likelihood estimation; Bayes' rule; statistical inference	4
	5. Applications of mathematical skills in machine learning Linking mathematical skills with machine learning problems; examples of applications of mathematical skills in machine learning; the relevance to the machine learning subjects in COMP	2
	Total	**26**

Teaching/ Learning Methodology

Lectures provide students with the main concepts of the topic, together with comprehensive examples for easy understanding.

Tutorial and lab sessions offer an opportunity to students for practicing their skills.

Both written and programming assignments will be utilized in the course. Written assignments help students develop theoretical skills, whereas programming assignments emphasize on practical skills.

Assessment Methods in Alignment with Intended Learning Outcomes

Specific assessment methods/tasks	% weighting	Intended subject learning outcomes to be assessed (Please tick as appropriate)				
		a	b	c	d	e
Continuous Assessment						
1. Written assignments	20%	✓	✓		✓	✓
2. Programming assignments	15%	✓	✓	✓	✓	✓
3. Quizzes	25%	✓	✓		✓	✓
Examination	40%	✓	✓		✓	✓
Total	100%					

Both written assignments and quizzes are mainly used to assess the understanding of mathematics concepts and their applications to machine learning problems, i.e., the outcomes (a) and (b).

Quizzes are expected to be short and conducted in class. In contrast, written assignments may cover both short questions and long questions.

Programming assignments are mainly used to assess implementation skills, i.e., the outcome (c).

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<tr><td></td><td colspan="2">All assessment tasks are relevant to outcomes (d) and (e), i.e., independent problem-solving and critical thinking for improvements.</td></tr>
<tr><td rowspan="6">Student Study Effort Expected</td><td colspan="2">Class contact:</td></tr>
<tr><td>▪ Lecture</td><td>26 Hrs.</td></tr>
<tr><td>▪ Tutorial/Lab</td><td>13 Hrs.</td></tr>
<tr><td colspan="2">Other student study effort:</td></tr>
<tr><td>▪ Assignments, Quizzes, Self-study</td><td>66 Hrs.</td></tr>
<tr><td>Total student study effort</td><td>105 Hrs.</td></tr>
<tr><td>Reading List and References</td><td colspan="2">Reference Books:

1. Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong:
Mathematics for Machine Learning, Cambridge University Press, 2020.
PDF: https://mml-book.github.io/
2. Trevor Hastie, Jerome H. Friedman, Robert Tibshirani:
The Elements of Statistical Learning: Data Mining, Inference, and Prediction. Second Edition, Springer Series in Statistics, Springer 2001.
PDF: https://hastie.su.domains/Papers/ESLII.pdf
3. Ian Goodfellow and Yoshua Bengio and Aaron Courville:
Deep Learning, MIT Press, 2016.
4. Christopher Bishop:
Pattern Recognition and Machine Learning, 5th Edition. Information science and statistics, Springer 2007
5. A. Quateroni, F. Saleri, and P. Gervasio:
Scientific Computing with MATLAB (Texts in Computational Science and Engineering, 2), 4th Edition, Springer 2014.</td></tr>
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