# Subject Description Form

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| **Subject Code** | AMA4801 |
| **Subject Title** | Compressed Sensing |
| **Credit Value** | 3 |
| **Level** | 4 |
| **Pre-requisite** | Operations Research Methods (AMA3820) or<br>Optimization Methods (AMA4850) |
| **Objectives** | To provide students with a basic introduction to compressed sensing, including the theoretical background, practical algorithms, and applications from which instances of compressed sensing problems arise.<br>To introduce some software for compressed sensing. |
| **Intended Learning Outcomes** | Upon completion of the subject, students will be able to:<br>(a) describe some applications that lead to compressed sensing problems;<br>(b) understand some basic theory behind compressed sensing;<br>(c) understand the basic idea behind some popular compressed sensing algorithms;<br>(d) master some software related to compressed sensing. |
| **Subject Synopsis/ Indicative Syllabus** | Background:<br>Applications that lead to compressed sensing problems. NP-hardness of compressed sensing problems.<br><br>Basic theory:<br>Basis pursuit. Sparse recovery under nullspace property and restricted isometry property. Concentration inequality. Sparse recovery with some random matrices. Sparse recovery under measurement noise.<br>Review of convex optimization. Fenchel duality and dual problem of Basis Pursuit (with and without noise). Relationship with LASSO.<br><br>Algorithms:<br>Iteratively Soft-Thresholding Algorithm (ISTA) and Fast Iteratively Soft-Thresholding Algorithm (FISTA). Iteration complexity and convergence.<br>Solving compressed sensing problems using TFOCS and SPGL1.<br>Nonconvex sparsity inducing regularizers and nonconvex models for compressed sensing. Iteratively Hard-Thresholding Algorithm (IHTA) and its convergence. Iteratively Reweighted L1 algorithms and their convergence. |
| **Teaching/Learning Methodology** | The subject will mainly be delivered through lectures and tutorials. The lectures will be conducted to introduce the theoretical background, and practical problems / scenarios will be discussed in the tutorial sessions to illustrate how the theory developed can be applied in practice. |

**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 |
| 1. Assignments/Project | 40% | ✓ | ✓ | ✓ | ✓ |
| 2. Midterm Test | 20% | ✓ | ✓ | ✓ | ✓ |
| 3. Examination | 40% | ✓ | ✓ | ✓ | ✓ |
| Total | 100% | | | | |

Explanation of the appropriateness of the assessment methods in assessing the intended learning outcomes:
This subject focuses on the mathematical foundation of compressed sensing and related algorithms. Many of these topics are based on theory in compressed sensing and optimization. **Exam-based assessment** is an appropriate assessment method, including a 20% midterm test and a 40% examination.
Since this subject also emphasizes on understanding the implementation of various numerical methods in compressed sensing, a mini-project that takes a weight of 30% is appropriate for assessing the intended learning outcomes (c) and (d), in which students will be encouraged to analyze large datasets using numerical methods and communicate their findings. A 10% worth of assignments are also included as a component of continuous assessment in order to keep students in progress.
Continuous Assessment comprises assignments, mini-project and test. A written examination is held at the end of the semester.

**Student Study Effort Required**

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| Class contact: | |
| ▪ Lecture | 26 Hrs. |
| ▪ Tutorial | 13 Hrs. |
| Other student study effort: | |
| ▪ Assignments/Projects | 15 Hrs. |
| ▪ Self-study | 55 Hrs. |
| Total student study effort | 109 Hrs. |

**Reading List and References**

References:


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|---|---|---|
| Amir Beck | First-order methods in optimization | SIAM 2017 |
| Simon Foucart, Holger Rauhut | A Mathematical Introduction to Compressive Sensing | Birkhauser 2013 |