# Subject Description Form

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|---|---|
| **Subject Code** | AMA615 |
| **Subject Title** | Nonlinear Optimization Methods |
| **Credit Value** | 3 |
| **Level** | 6 |
| **Expected background knowledge** | A course in Linear Algebra and a course in Advanced Calculus |
| **Objectives** | To enable students to learn to use more advanced mathematical and computational techniques applicable in solving real engineering and management problems. |
| **Intended Learning Outcomes** | Upon completion of the subject, students will be able to:<br>(a) Understand basic theory of nonlinear optimization.<br>(b) Solve unconstrained optimization problems.<br>(c) Solve constrained optimization problems. |
| **Subject Synopsis/ Indicative Syllabus** | **I. Unconstrained Optimization**<br><br>1.1 First, second order optimality conditions<br>Convex optimization<br>1.2 First order methods<br>Steepest descent methods, Conjugate gradient methods, Trust region methods<br>1.3 Second order methods<br>Newton methods, Quasi-Newton methods, Trust region Newton methods<br>1.4 Non-differentiable objective function<br>First order optimality condition, Proximal point methods, Smoothing methods<br><br>**II. Constrained Optimization**<br><br>2.1 First, second order optimality conditions, KKT conditions, Constraint Qualification<br>2.2 Penalty methods<br>2.3 Augmented Lagrangian methods (ALM)<br>2.4 Alternating direction method of multipliers (ADMM)<br><br>**III. Optimization methods in Data Science**<br><br>3.1 Least absolute shrinkage and selection operator (Lasso), Semi-smooth Newton methods<br>3.2 Folded concave penalized estimation, Difference-convex (DC) optimization methods<br>3.3 Non-Lipschitz regularization, Smoothing methods<br>3.4 Composite nonsmooth nonconvex optimization in deep learning |
| **Teaching/Learning** | The subject will be delivered mainly through lectures and tutorials. The |

<table>
<tr><td>Methodology</td><td>teaching and learning approach is mainly problem-solving oriented. The approach aims at the development of mathematical techniques and how the techniques can be applied to solving problems. Students are encouraged to adopt a deep study approach by employing high level cognitive strategies, such as critical and evaluative thinking, relating, integrating and applying theories to practice.</td></tr>
<tr><td>Assessment Methods in Alignment with Intended Learning Outcomes</td><td>
<table>
<tr><td rowspan="2">Specific assessment methods/tasks</td><td rowspan="2">% weighting</td><td colspan="3">Intended subject learning outcomes to be assessed (Please tick as appropriate)</td></tr>
<tr><td>a</td><td>b</td><td>c</td></tr>
<tr><td>1. Assignments</td><td>20%</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>2. Mid-term test</td><td>20%</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>3. Examination</td><td>60%</td><td>✓</td><td>✓</td><td>✓</td></tr>
<tr><td>Total</td><td>100 %</td><td colspan="3"></td></tr>
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<br>Continuous Assessment comprises of assignments and a mid-term test. A written examination is held at the end of the semester.</td></tr>
<tr><td>Student Study Effort Required</td><td>
<table>
<tr><td>Class contact:</td><td></td></tr>
<tr><td>▪ Lecture</td><td>26 Hrs.</td></tr>
<tr><td>▪ Tutorial</td><td>13 Hrs.</td></tr>
<tr><td>Other student study effort:</td><td></td></tr>
<tr><td>▪ Assignment</td><td>23 Hrs.</td></tr>
<tr><td>▪ Self-study</td><td>40 Hrs.</td></tr>
<tr><td>▪ Total student study effort</td><td>102 Hrs.</td></tr>
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<tr><td>Reading List and References</td><td>
<table>
<tr><td>Fletcher, R.</td><td>Practical Methods of Optimization, 2nd Edition</td><td>Wiley, 1987</td></tr>
<tr><td>Nocedal, J. and Wright, S.J.</td><td>Numerical Optimization, 2nd Edition</td><td>Springer, 2006</td></tr>
<tr><td>Dennis, J.E. and Schnabel, R.B.</td><td>Numerical Methods for Unconstrained Optimization and Nonlinear Equations</td><td>SIAM, 1996</td></tr>
<tr><td>Mangasarian, O.L.</td><td>Nonlinear Programming</td><td>SIAM, 1994</td></tr>
<tr><td>Rockafellar, R.T.</td><td>Convex Analysis</td><td>Princeton University Press, 1970</td></tr>
<tr><td>Facchinei, F. and Pang, J-S.</td><td>Finite-Dimensional Variational Inequalities and Complementarity Problems</td><td>Springer, 2003</td></tr>
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