SE / CS 4TE3 (6TE3) Continuous Optimization Algorithms – Winter 2016

1 What the students should know and be able to do

1. Students should know and understand
   (a) convexity and the geometric and algebraic tools needed for continuous optimization
   (b) order of convergence of a sequence, and classification into constrained / unconstrained, convex / non-convex, linear, quadratic etc optimization
   (c) line search method and finding an – approximate – zero of a univariate function
   (d) search direction for convex minimization and convergence properties
   (e) Newton's method and its convergence properties
   (f) Quasi Newton methods and Conjugate Gradient methods
   (g) Trust-Region method and derivative-free optimization
   (h) Theoretical foundations of Interior Point Method – weak and strong duality, feasibility, Slater points etc – and challenges of non-convex optimization
2. Students should be able to
   (a) show basic algebraic and geometric properties of continuous optimization
   (b) determine the speed and order of convergence of a sequence
   (c) explain and implement direct search methods such as Nelder-Mead
   (d) explain and implement line search methods such as golden section
   (e) explain and implement steepest descent and Newton's methods
   (f) explain and implement Trust Region method
   (g) explain and implement Quasi Newton and Conjugate Gradient method
   (h) explain basic ideas behind the IPM method and identify which method/algorithm is suited

2 Mapping to Attributes with their Indicators

A01 Knowledge	
Competence in specialized engineering knowledge	1a–1h
A03 Investigation	
Uses appropriate techniques to collect data	2a, 2b
Assess the accuracy and precision of results and recognize limitations of the approach	2c–2h
A04 Design	
Recognizes and follows an engineering design process	2c–2h
Recognizes and follows engineering design principles	2c–2h
Obtains experience with open-ended problems	2h
Properly documents and communicates processes and outcomes	2b

Table 1: Rubric: **Competence in Specialized Engineering Knowledge**
Student work used: assignments, midterm, and final exams.

	Expectations			
Topic	**Below**	**Marginal**	**Meets**	**Exceeds**
Geometric and algebraic foundations for continuous optimization 1a–1d	cannot explain the geometric and algebraic properties	can explain the geometric and algebraic properties with a limited understanding	can explain the geometric and algebraic properties with a solid understanding	can explain the geometric and algebraic properties with a full understanding
Steepest Descent and Newton methods 1d,1e	does not show good grasp of the Steepest Descent and Newton methods	shows a limited understanding of the Steepest Descent and Newton methods	shows a solid understanding of the Steepest Descent and Newton methods	shows a full understanding of the Steepest Descent and Newton methods
Conjugate Gradients, Trust Region and Quasi Newton methods 1d,1f,1g	does not show good grasp of the Conjugate Gradients, Trust Region and Quasi Newton methods	shows a limited understanding of the Conjugate Gradients, Trust Region and Quasi Newton methods	shows a solid understanding of the Conjugate Gradients, Trust Region and Quasi Newton methods	shows a full understanding of the Conjugate Gradients, Trust Region and Quasi Newton methods
Strength, limitation, and suitability of continuous optimization methods 1a,1b,1h	does not show good grasp of the strength and limitation of continuous optimization	shows a limited understanding of the strength and limitation of continuous optimization	shows a solid understanding of the strength and limitation of continuous optimization	shows a full understanding of the strength and limitation of continuous optimization

Table 2: Rubric: **What students should be able to do**
Student work used: assignments, midterm, and final exams.

	Expectations			
Topic	**Below**	**Marginal**	**Meets**	**Exceeds**
Convexity, convergence, order of convergence 2a–2d	cannot properly explain and show key properties of an optimization instance	can properly properly explain, but not properly show key properties of an optimization instance	can properly explain and show key properties of an optimization instance	can properly explain and show key properties of an optimization instance, and add comments and interpretations
Solve an optimization instance via Steepest Descent and Newton methods 2d,2e	cannot properly formulate and solve an optimization instance via Steepest Descent and Newton methods	can properly formulate, but not properly solve an optimization instance via Steepest Descent and Newton methods	can properly formulate and solve an optimization instance via Steepest Descent and Newton methods	can properly formulate and solve an optimization instance via Steepest Descent and Newton methods, and add comments and interpretations
Solve an optimization instance via Conjugate Gradients, Trust Region and Quasi Newton methods 2d,2f,2g	cannot properly formulate and solve an optimization instance via Conjugate Gradients, Trust Region and Quasi Newton methods	can properly formulate, but not properly solve an optimization instance via Conjugate Gradients, Trust Region and Quasi Newton methods	can properly formulate and solve an optimization instance via Conjugate Gradients, Trust Region and Quasi Newton methods	can properly formulate and solve an optimization instance via Conjugate Gradients, Trust Region and Quasi Newton methods, and add comments and interpretations
Explain and show strength, limitation, and suitability of continuous optimization 2a,2b,2h	cannot properly explain and show strength, limitation, and suitability of optimization methods	can properly explain, but not show strength, limitation, and suitability of optimization methods	can properly explain and show strength, limitation, and suitability of optimization methods	can properly explain and show strength, limitation, and suitability of optimization methods, and add comments and interpretations