Course Name: Non Linear and Dynamic Programming
COURSE CODE: DS312

I. Basic Course Information

Major or minor element of program: Both Major Minor
Department offering the course: Operations Research and Decision Support Department

Academic level: 300 Level
Semester in which course is offered: Second (Spring) Semester
Course pre-requisite(s): DS311 [Linear and Integer Programming]

Credit Hours: 3
Contact Hours Through:

Lecture	Tutorial*	Practical*	Total
2.5	0.0	1.5	4.0

* 1.5 hours for **either** Tutorial or Practical

Approval date of course specification: January 2015

II. Overall Aims of Course

- Introduce the topological properties of convex sets, separation and support of convex sets, polyhedral sets, extreme points and extreme directions, properties of convex functions and minima "maxima" over a convex set.
- Presents algorithms for solving both unconstrained and constrained nonlinear programming problems and the issue of convergence is discussed.
- Discuss penalty and barrier function method for solving nonlinear programming in which the problem is solved as a sequence of unconstrained problems.
- The method of feasible directions and the methods proposed by Zoutendijk are introduced.
- An introduction to multi-stage optimization through Dynamic Programming.
- Treating some mathematical programming problems via Dynamic technique (Linear, Non-Linear, Transportation…).

III. Program ILOs covered by course

Program Intended Learning Outcomes (By Code)			
Knowledge & Understanding	Intellectual Skills	Professional Skills	General Skills
K16,K17,K20	I12,I13,I14	P12,P14,P15	G1,G2,G4,G6

IV. Intended Learning Outcomes of Course (ILOs)

a. Knowledge and Understanding

On completing the course, students should be able to:

K.1 Explain the methods and theories needed to solve Non-Linear Programming problems.

K.2 Learn the difference between methodologies used to solve Non-Linear programming problems.

K.3 Study the usage of Dynamic programming to solve Non-Linear programming problems

b. Intellectual/Cognitive Skills

On completing the course, students should be able to:

I.1 Relate between different theories studied to solve Non-Linear programming problems.

I.2 Analyze the theories presented and recognizing its relation with the methods used.

I.3 Comprehend and communicate data presented graphically and/or mathematically.

c. Practical/Professional Skills

On completing the course, students should be able to:

P.1 Apply the techniques and theorems in real applications.

P.2 Analyze specific data and information to build the mathematical model.

P.3 Apply the tools studied concerning Non-linear and Dynamic to solve a real problem (case study).

d. General and Transferable Skills

On completing the course, students should be able to:

G.1 Gather data from various sources, including the electronic media, such as internet.

G.2 Choose a case study from the real world and apply the techniques studied.

G.3 Be fully responsible for the preparation of the case study and manage the presentation schedule of his/her work.

G.4 Exercise research skills, such as data collection, tabulation, analysis, report presentation and class discussions.

V. Course Matrix Contents

	Main Topics / Chapters	Duration (Weeks)	Course ILOs Covered by Topic (By ILO Code)			
			K & U	I.S.	P.S.	G.S.
1-	Convex sets and functions	1	K1,K2,K3	All	All	All
2-	Kuhn-Tucker optimality conditions	1	K1,K2	All	P1,P2	G1,G3, G4
3-	Lagrangian duality and saddle point optimality conditions	1	All	All	All	All
4-	The concept of an algorithm	1	K1,K2,K4	I2,I3	All	G1,G2,G3
5-	Unconstrained optimization	3	All	All	All	G1,G2,G3
6-	Penalty and Barrier functions	1	All	I2,I3	P1,P2	All

7-	Method of Zoutendijk and its convergence analysis	1	K1,K2	I2,I3	P1,P2	G1,G4
8-	Dynamic programming: Principle of Optimality, Concepts of state and stage	1	All	All	All	All
9-	Solution of Discrete Problems through forward and backward Dynamic Programming	2	All	All	All	All
10-	Continuous and Multi-stage Dynamic programming problems.	1	All	All	All	All
	Net Teaching Weeks	**13**				

VI. Course Weekly Detailed Topics / hours / ILOs

Week No.	Sub-Topics	Total Hours	Contact Hours	
			Theoretical Hours	Practical Hours*
1	Convex sets and functions	2.5	2.5	
2	Kuhn-Tucker optimality conditions	4	2.5	1.5
3	Lagrangian duality and saddle point optimality conditions	4	2.5	1.5
4	The concept of an algorithm	4	2.5	1.5
5	Unconstrained optimization:The three-point interval search method-The Golden section search method-	4	2.5	1.5
6	The Lagrangean method-The Newton-Raphson method- The modified Newton-Raphson- method-The method of steepest descent (ascent)	4	2.5	1.5
7	**Midterm Exam**			
8	The Fletcher-Reeves method - The Marquardt method-The modified Marquardt method-The BFGS method	4	2.5	1.5
9	Penalty and Barrier functions	4	2.5	1.5
10	Method of Zoutendijk and its convergence analysis	4	2.5	1.5
11	Dynamic programming: Principle of Optimality, Concepts of state and stage	4	2.5	1.5
12	Solution of Discrete Problems through forward Dynamic Programming	4	2.5	1.5
13	Solution of Discrete Problems through Backward Dynamic Programming	4	2.5	1.5
14	Continuous and Multi-stage Dynamic programming problems.	4	2.5	1.5
15	**Final Exam**			
Total Teaching Hours		**51**	**33**	**18**

* **No Practical/Tutorial during the first week of the semester**

VII. Teaching and Learning Methods

Teaching/Learning Method	Selected Method	Course ILOs Covered by Method (By ILO Code)			
		K & U	Intellectual Skills	Professional Skills	General Skills
Lectures & Seminars	√	All	All		G4
Tutorials	√	K2	All	All	
Computer lab Sessions					
Practical lab Work	√	All	All		All
Reading Materials	√	All	All		All
Web-site Searches	√	All	All	All	G1,G3
Research & Reporting					
Problem Solving / Problem-based Learning					
Projects					
Independent Work					
Group Work	√	All	All	All	All
Case Studies					
Presentations					
Simulation Analysis					
Others (Specify):					

VIII. Assessment Methods, Schedule and Grade Distribution

Assessment Method	Selected Method	Course ILOs Covered by Method (By ILO Code)				Assessment Weight / Percentage	Week No.
		K & U	I.S.	P.S.	G.S.		
Midterm Exam	√	All	All	All	G4	20%	7
Final Exam	√	All	All		G4	60%	15
Quizzes							
Course Work	√	All	All	All	G4	10%	5, 10
Report Writing							
Case Study Analysis							
Oral Presentations							
Practical	√	All	All		All	5%	6, 11
Group Project	√	All		All	All	5%	12
Individual Project							
Others (Specify):							

IX. List of References

Essential Text Books	• D. Bertsekas, Dynamic Programming and Optimal Control, Vols. 1 & 2, 2nd ed. Athena Scientific. 2000. • D. Bertsekas , Nonlinear Programming: 2nd Edition. Athena Scientific. 1999 • David M.Himelblan, Applied Non-Linear Programming, Mc GrawHill, 1972 • Mokhtar S. Bazaraa, Non-Linear Programming Theory and Algorithms , JohnWiley &Sons Inc., 1993
Course notes	• None
Recommended books	• Adda, Jerome, and Cooper, Russell, Dynamic Economics. MIT Press, 2003. • Richard Bellman, Dynamic Programming, Princeton University Press. Dover • 2003 • Thomas H. Cormen, Charles E. Leiserson, Ronald L. Rivest, and Clifford Stein, Introduction to Algorithms, 2nd ed. McGraw-Hill. 2001. • Nancy Stokey, and Robert E. Lucas, with Edward Prescott, Recursive Methods in Economic Dynamics. Harvard Univ. Press.1989. • Avriel, Mordecai , Nonlinear Programming: Analysis and Methods. Dover Publishing. 2003 • Nocedal, Jorge and Wright, Stephen J., Numerical Optimization. Springer, 1999 • Hiller & Lieberman, Introduction to operations research, McGraw-Hill, 2001
Periodicals, Web sites, etc …	• http://www.stanford.edu/~boyd/cvxbook.html • http://en.wikipedia.org/wiki/Dynamic_programming • http://mat.gsia.cmu.edu/classes/dynamic/dynamic.html • http://plus.maths.org/issue3/dynamic/ • http://en.wikipedia.org/wiki/Nonlinear_programming • http://www-unix.mcs.anl.gov/otc/Guide/faq/nonlinear-programming-faq.html

X. Facilities required for teaching and learning

- Appropriate teaching accommodation
- Computer lab
- Computer aided data show
- Laptop computer

Course coordinator: Ass. Prof. Tarek H. M. Abou-El Enien

Head of Department: Prof. Mohamed Mostafa Saleh

Date: January 2015