Course Specification

(Postgraduate Programs)

Course Title:	**Combinatorial Optimization**
Course Code:	**MAT 7253**
Program:	**Doctor of Philosophy in Mathematics**
Department:	**Mathematics and Statistics**
College:	**Science**
Institution:	**Imam Mohammad Ibn Saud Islamic University**
Version:	**2024 – V1**
Last Revision Date:	**None**

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A. General information about the course:

1. Course Identification

1. Credit hours:					
4 (4 Lectures, 0 Lab, 0 Tutorial)					
2. Course type					
A.	☐ University	☐ College	☒ Program	☐ Track	☐ Others
B.	☐ Required		☒ Elective		
3. Level/Year at which this course is offered: Level 3 / Year 2					
4. Course general Description:					
This course describes the most important ideas, theoretical results, and algorithms in combinatorial optimization. The course includes the essential fundamentals of graph theory, linear and integer programming, and complexity theory. It covers classical topics in combinatorial optimization as well as very recent ones. The emphasis is on theoretical results and algorithms with provably good performance. Applications and heuristics are mentioned only occasionally.					
5. Pre-requirements for this course (if any):					
None.					
6. Co-requisites for this course (if any):					
None.					
7. Course Main Objective(s):					
The objective of this course is to give a detailed knowledge within combinatorial optimization. Combinatorial (or discrete) optimization is one of the most active fields in the interface of operations research, computer science, and applied mathematics. This course covers classical optimization problems in graphs and networks, matchings, integral polyhedral, the traveling salesman problem, an introduction to matroids and to NP-completeness theory.					

2. Teaching mode (mark all that apply)

No	Mode of Instruction	Contact Hours	Percentage
1	Traditional classroom	60	100%
2	E-learning	0	0%
3	Hybrid • Traditional classroom • E-learning	0	0%
4	Distance learning	0	0%

3. Contact Hours (based on the academic semester)

No	Activity	Contact Hours
1.	**Lectures**	60
2.	**Laboratory/Studio**	0
3.	**Field**	0

4.	**Tutorial**	**0**
5.	**Others (specify)**	**0**
Total		**60**

B. Course Learning Outcomes (CLOs), Teaching Strategies and Assessment Methods

Code	Course Learning Outcomes	Code of CLOs aligned with program	Teaching Strategies	Assessment Methods
1.0	**Knowledge and understanding**			
1.1	**Identify various combinatorial optimization models using discrete optimization**	**K1, K2**	**4 lecture hours\week**	**Direct: Regular Exams**
1.2	**Describe different techniques of discrete optimization.**	**K1, K2**	• **4 lecture hours\week** • **Self-studys**	**Direct: Short Quizzes**
2.0	**Skills**			
2.1	**Use techniques of proof for polyhedral combinatorics and matroids.**	**S1, S2**	**Self-study**	**Direct:** • **Participations** • **Short Quizzes**
2.2	**Develop oral communication and technical writing skills for flows problems.**	**S4**	**Real-life problems**	**Direct: Homework and Mini projects**
2.3	**Analyze Internet searches for the Traveling Salesman Problem.**	**S3**	**Real-life problems**	**Direct: Short Quizzes**
2.4	**Choose out deep and not short proofs for optimal matchings.**	**S1, S2**	**Self-study**	**Direct: Participations**
3.0	**Values, autonomy, and responsibility**			
3.1	**Work with independence and responsibility.**	**V1, V2**	**Personal questions**	**Direct: Participation**
3.2	**Lead team works.**	**V1, V3**	**Teamwork and class discussions.**	**Direct: Homework and Mini projects**

C. Course Content

No	List of Topics	Contact Hours
1.	**Problems and Algorithms:** Optimal Trees and Paths, Measuring Running Times, Minimum Spanning Trees, Shortest Paths; Maximum Flow Problems, Network	**10**

	Flows Problems, Maximum Flow Problems, Minimum Cut Problem, Multicommodity Flows; Minimum Cost Flow Problems.	
2.	**Optimal Matchings:** Matchings and Alternating Paths, Maximum Matchings, Minimum Weight Perfect Matchings, T-joins and Postman Problem.	**10**
3.	**Integral Polyhedral:** Convex Hulls, Polytopes, Facets, Integral Polytopes, Total Unimodularity, Total Dual Integrality, Cutting Planes, Separation and Optimization.	**10**
4.	**The Traveling Salesman Problem:** Introduction, Heuristics for the TSP, Lower Bounds, Cutting Planes, Branch and Bound.	**10**
5.	**Matroids:** The Greedy Algorithm, Matroids Properties, Axioms and Constructions, Matroids Intersection, Applications.	**10**
6.	**NP and NP-completeness**: Introduction, Words, Problems, Algorithms and Running Time, The Class NP, The Class NP-complete.	**10**
Total		**60**

D. Students Assessment Activities

No	Assessment Activities *	Assessment timing (in week no)	Percentage of Total Assessment Score
1.	**HomeWorks, Quizzes, Mini projects**	**During the semester**	**30%**
2.	**Midterm**	**Week 9-10**	**30%**
3.	**Final Exam**	**Week 15-16**	**40%**

*Assessment Activities (i.e., Written test, oral test, oral presentation, group project, essay, etc.).

E. Learning Resources and Facilities

1. References and Learning Resources

Essential References	• **W. Cook, W. Cunningham, W. Pulleyblank, and A. Schrijver,** Combinatorial Optimization; Wiley-Blackwell, 1997. • **B. Korte, and J. Vygen,** Combinatorial Optimization; Springer, 2012. • **C. Papadimitriou, K. Steiglitz**, Combinatorial Optimization: Algorithms and Complexity; Dover Publications Inc., 2000.
Supportive References	1. **D. Avis, A. Hertz, and O. Marcotte (editors),** Graph Theory and Combinatorial Optimization, Springer, 2005. 2. **D.-Z. Du, P.M. Pardalos (editors),** Handbook of Combinatorial Optimization, Kluwer Academic Publishers, 1999.
Electronic Materials	**None**
Other Learning Materials	**None**

2. Educational and Research Facilities and Equipment Required:

Items	Resources
facilities (Classrooms, laboratories, exhibition rooms, simulation rooms, etc.)	▪ Each class room should be equipped with a whiteboard and a projector. ▪ Laboratories should be equipped with computers and an internet connection.
Technology equipment (projector, smart board, software)	The rooms should be equipped with data show and Smart Board.
Other equipment (depending on the nature of the specialty)	None

F. Assessment of Course Quality

Assessment Areas/Issues	Assessor	Assessment Methods
Effectiveness of teaching	Students	During the semester and at the end of the course each student will complete two evaluation forms.
Effectiveness of Students assessment	Instructor	At the end of each semester the course instructor should complete the course report, including a summary of student questionnaire responses appraising progress and identifying changes that need to be made if necessary.
Quality of learning resources	Students	During the semester and at the end of the course each student will complete two evaluation forms.
The extent to which CLOs have been achieved	Instructor	At the end of each semester the course instructor should complete the course report, including a summary of student questionnaire responses appraising progress and identifying changes that need to be made if necessary.
Other	None	

Assessors (Students, Faculty, Program Leaders, Peer Reviewer, Others (specify)

Assessment Methods (Direct, Indirect)

G. Specification Approval

COUNCIL /COMMITTEE	MATHEMATICS AND STATISTICS DEPARTMENT COUNCIL
REFERENCE NO.	8/1446
DATE	05/04/1446 (08/10/2024)