Kingdom of Saudi Arabia

The National Commission for Academic Accreditation & Assessment

Course Specification

Institution: **University of Dammam**

College/Department: **College of Sciences / Department of Mathematics**

A. Course Identification and General Information

1. Course title and code: **Functional Analysis, Math 484**
2. Credit hours: **3**
3. Program(s) in which the course is offered: **Mathematics program**
4. Name of faculty member responsible for the course: **A specific team from the mathematics department**
5. Level/year at which this course is offered: **8th level/4th year**
6. Pre-requisites for this course (if any): **Math 342 – Math 362**
7. Co-requisites for this course (if any): **N/A**
8. Location if not on main campus: **College of Sciences – Girls Campus – Rayan City**

9. Mode of Instruction (mark all that apply)

a. traditional classroom	X	What percentage?	75%
b. blended (traditional and online)		What percentage?	
c. e-learning	X	What percentage?	25%
d. correspondence		What percentage?	
f. other		What percentage?	

Comments: **The e-learning concerns the use of blackboard, flip teaching, online assessment, ect.**

B Objectives

1. What is the main purpose for this course?

On successful completion of this course students will be able to:

identify metric and normed spaces and make mathematical connections between these two notions,

apply Bolzano Weiestrass and Ascoli theorems,

characterize compact sets in metric and normed spaces,

demonstrate proficiency with Banach spaces in mathematical construction of proofs and reasoning procedures in working with continuity and linearity concepts of operators defined on Banach spaces,

demonstrate proficiency with the concept of dual spaces and norms on dual spaces, know fundamental theorems in functional analysis (Baire theorem, Banach- Steinhauss theorem, open mapping theorem, closed graph theorem and Hahn- Banach theorem),

identify Hilbert spaces and Hilbert bases, and show familiarity with the basic notions defined on Hilbert spaces,

recognize adjoint operators and show familiarity with the basic notions of adjoint operators.

2. Briefly describe any plans for developing and improving the course that are being implemented. (e.g. increased use of IT or web based reference material, changes in content as a result of new research in the field)

- **Create, improve and complete (beamer or power point) presentations.**
- **Update the course by comparing to the contents at other universities.**

- **Follow up on the latest books to select the most appropriate to update the contents.**
- **Create a question bank.**
- **Find web sites related to the topic.**

C. Course Description (Note: General description in the form used in Bulletin or handbook) Course Description:

1. Topics to be Covered		
List of Topics	No. of Weeks	Contact hours
Introduction to the course (description of the course, discussion on the text books related to the course, teaching strategies and assessment methods) **A general review on some essential notions in analysis related to the course**	1	3
Metric spaces (Definitions, examples, properties of metric spaces, topology in metric spaces, continuity in metric spaces)	1	3
Metric spaces (compactness and completeness in metric spaces) **Introduction to normed spaces (definitions and examples)**	1	3
Normed spaces (linear applications, sub-vector spaces and Banach spaces)	1	3
Spaces of continuous functions (continuity, uniform continuity, ordinary convergence, uniform convergence, equicontinuity, uniform equicontinuity) **Application1: Ascoli theorem**	1	3
Review session on metric, normed and Banach spaces **Mid-term 1**	1	3
Spaces of continuous functions (some results about density) **Application2: Stone-Weierstrass theorem**	1	3
Fundamental theorems in functional analysis (Baire theorem and Banach **Steinhauss theorem)**	1	3
Fundamental theorems in functional analysis (open mapping theorem and closed graph theorem)	1	3
Fundamental theorems in functional analysis (Hahn Banach theorem and applications)	1	3
Review session on the application of fundamental theorems in functional analysis **Mid-term 2**	1	3
Hilbert spaces (scalar product, hermitian product, Cauchy Schwartz inequality, orthogonality, Projection on a convex closed set)	1	3

Orthogonal systems and Hilbert bases, Bessel inequality, Parseval equality, Fourier coefficients and Fourier series, convergence in the space Application 1: Riesz theorem	1	3
Application 2: Lax-Milgram theorem Compact operators on Hilbert spaces Adjoint operators on Hilbert spaces	1	3
Review session on Hilbert spaces and discussion of projects and exercises distributed during the semester to the students	1	3

2. Course components (total contact hours and credits per semester):

	Lecture	Tutorial	Laboratory or Studio	Practical	Other: Office hours	Total
Contact Hours	**2*15=30**	**0**	**0**	**2*15=30**	**4*15=60**	**120**
Credit	**2*15**	**0**	**0**	**1*15**	**0**	**45**

3. Additional private study/learning hours expected for students per week.
60

4. Course Learning Outcomes in NQF Domains of Learning and Alignment with Assessment Methods and

Teaching Strategy

On the table below are the five NQF Learning Domains, numbered in the left column.

First, insert the suitable and measurable course learning outcomes required in the appropriate learning domains (see suggestions below the table). **Second**, insert supporting teaching strategies that fit and align with the assessment methods and intended learning outcomes. **Third**, insert appropriate assessment methods that accurately measure and evaluate the learning outcome. Each course learning outcomes, assessment method, and teaching strategy ought to reasonably fit and flow together as an integrated learning and teaching process. (Courses are not required to include learning outcomes from each domain.)

Code #	NQF Learning Domains And Course Learning Outcomes	Course Teaching Strategies	Course Assessment Methods
1.0	**Knowledge**		

	Identify metric and normed spaces. Identify Banach spaces. Know fundamental theorems in functional analysis. Know Hilbert spaces and Hilbert bases. Recall adjoint operators and compact operators.	Interactive learning process through questions and answers in class. Worked examples through a sequential delivery of surveying lectures. Homework consisting in solving selected exercises.	Exams and homework are used to assess the acquired knowledge on the subject.
2.0	**Cognitive Skills**		
	To discuss relationships between metric and normed spaces and give some of their properties. To give examples of Hilbert and Banach spaces. To give and apply the basic theorems of functional analysis. To solve continuity, linearity and convergence problems in metric, normed, Banach and Hilbert spaces. To use concepts of compactness and completeness in mathematical construction of proofs and reasoning procedures. To solve questions related to dual spaces and adjoint operators.	Lectures are covered by different worked examples. Engage students in discussions with questions and answers. Homework consisting in solving selected exercises. Encourage and develop self education.	Homework include problems, solution of which requires scientific thinking, and applications of essential theorems and results of the course Oral and written tests. Explain and communicate the corrected answers of the exams and quizzes. Research projects.
3.0	**Interpersonal Skills & Responsibility**		
	Punctual attendance of classes is required. Students should demonstrate their sense of responsibility for learning by completing both reading and writing assignments in due time. Students learn to manage their time. Accustom students to take responsibility of self learning Students should act responsibly and ethically in carrying out individual as well as group projects.	Discussion. Explanation. Guidance and supervision of the group assignments for research projects. Assignments are given to the students at regular intervals for them to solve and submit on time.	Class attendance of students at the beginning of the lecture is recoded. Recording of submission of assignment Observations, interviews, and peer evaluations.

4.0	**Communication, Information Technology, Numerical**

	Ability to communicate in written and in oral. Ability to write reports in English Ability to explain each step in the problem solving process. Ability to apply course concepts to mathematical problem solving model. Ability to use information technology in communication and research projects. Interact with life problems using different methods of thinking and problem solving.	Research projects. Oral presentations.	Periodic written and oral tests. Discussion. Observation.
5.0	**Psychomotor**		
	N/A	N/A	N/A

5. Map course LOs with the program LOs. (Place course LO #s in the left column and program LO #s across the top.)

Course LOs #	**Program Learning Outcomes (Use Program LO Code #s provided in the Program Specifications)**						
	Metric spaces	**Normed spaces**	**Banach spaces**	**Spaces of continuous functions**	**Fundamental theorems in functional analysis**	**Hilbert spaces**	**Adjoint operators and compact operators**
Knowledge	**Recall**	**Recall**	**Recall**	**Remember**	**Remember**	**Recall**	**Recall**
Comprehension	**Discuss**	**Discuss**	**Discuss**	**Summarize**	**Summarize**	**Discuss**	**Explain**
Application	**Assess**	**Assess**	**Assess**	**Use**	**Use**	**Assess**	**Utilize**
Analysis	**Conclude**	**Conclude**	**Conclude**	**Conclude**	**Conclude**	**Conclude**	**Conclude**
Synthesis	**Categorize**	**Categorize**	**Categorize**	**Validate**	**Validate**	**Categorize**	**Categorize**
Evaluation	**Judge**	**Judge**	**Judge**	**Judge**	**Judge**	**Judge**	**Judge**

6. Schedule of Assessment Tasks for Students During the Semester

	Assessment task (e.g. essay, test, group project, examination, speech, oral presentation, etc.)	Week Due	Proportion of Total Assessment
1	**Quizz1**	**4**	**5%**
2	**Mid-term1**	**6**	**15%**
3	**Quizz2**	**8**	**5%**
4	**Mid-term2**	**11**	**15%**
5	**Homework**	**Every week**	**5%**
6	**Research project**	**15**	**5%**
7	**Final exam**	**As scheduled**	**50%**

D. Student Academic

Counseling and Support

1. Arrangements for availability of faculty and teaching staff for individual student consultations and academic advice. (include amount of time teaching staff are expected to be available each week)

4 hrs/week for students' consultation and academic advice.

E Learning Resources

1. List Required Textbooks

Kosaku Yosida, Functional Analysis, Springer-Verlag, 1980

Walter Rudin, Functional Analysis, McGraw Hill, 1991

Erwin Kreyszig, Introductory functional analysis with applications, John Wiley and sons, 1978

2. List Essential References Materials (Journals, Reports, etc.)

3. List Recommended Textbooks and Reference Material (Journals, Reports, etc)

4. List Electronic Materials, Web Sites, Facebook, Twitter, etc.

5. Other learning material such as computer-based programs/CD, professional standards or regulations and software.

F. Facilities Required

Indicate requirements for the course including size of classrooms and laboratories (i.e. number of seats in classrooms and laboratories, extent of computer access etc.)
1. Accommodation (Classrooms, laboratories, demonstration rooms/labs, etc.) **Lecture room with 20 seats. Smart class.**

2. Computing resources (AV, data show, Smart Board, software, etc.) **Computer room with at least 10 systems** **Computer room with 20 seats**
3. Other resources (specify, e.g. if specific laboratory equipment is required, list requirements or attach list)

G Course Evaluation and Improvement Processes

1 Strategies for Obtaining Student Feedback on Effectiveness of Teaching

Student course evaluation at the conclusion of the course. Sample of assignments and tests. Observations and discussions during the semester.

2 Other Strategies for Evaluation of Teaching by the Instructor or by the Department **Faculty assessment of the course and effectiveness of teaching delivery. Periodic self-assessment of the program.**
3 Processes for Improvement of Teaching **Participate to workshops on evaluation approaches and effective teaching methods to enable instructors to improve their teaching skill.** **Teaching method will focus on students' learning and on course learning outcomes.**
4. Processes for Verifying Standards of Student Achievement (e.g. check marking by an independent member teaching staff of a sample of student work, periodic exchange and remarking of tests or a sample of assignments with staff at another institution) **A committee reviews samples of student work in this course to check on the standard of grades and achievements.** **An external faculty member evaluates the course material and the students' work to compare the standard of grades and achievements with those at his university.**
5 Describe the planning arrangements for periodically reviewing course effectiveness and planning for improvement. **Carry out self- assessment at every two years and external assessment invited faculty members every four years. The feedback received from these assessments will be used to plan for further improvement in the course syllabus, teaching method, and delivery of course materials.**