Module Description/Course Syllabi

Study Programme : Magister of Mathematics
Faculty of Mathematics and Natural Sciences.
Universitas Andalas

1. *Course number and name*

MAT82233 Stochastic Process

2. *Credits and contact hours/Number of ECTS credits allocated*

3 / 4,50 ECTS

3. *Instructors and course coordinator*

Dr. Dodi Devianto, M.Sc

4. *Text book, title, outhor, and year*

a. S. M. Ross. (1995). *Stochastic processes* (2nd edition). John Wiley & Sons, New York.
b. R. M. Bass. (2011). *Stochastic processes* (Cambridge Series in Statistical and Probabilistic Mathematics, Series Number 33). Cambridge University Press, New York.

5. *Recommended reading and other learning resources/tools*

a. R. G. Gallager. (2014). *Stochastic processes: theory for applications*. Cambridge University Press, New York.
b. S. I. Resnick. (2005). *Adventures in stochastic processes*. Birkhäuser, Boston
c. Z. Brzezniak and T. Zastawniak. (2000). *Basic stochastic processes*. Springer, New York.
d. S. M. Ross. (2003). *Introduction to probability models*. Academic Press, New York.
e. M. A. Pinsky and S. Karlin. (2011). *An introduction to stochastic modeling* (4th edition). Academic Press, London.
f. R. Durrett. (2018). *Essentials of stochastic processes*. Springer International Publishing, New York.
g. S. R. S. Varadhan. (2007). *Stochastic processes* (Courant Lecture Notes). American Mathematical Society, New York.
h. B. L. Nelson. (2010). *Stochastic modeling: analysis and simulation*. Dover publications, New York.
i. L. Rüschendorf. (2023). *Stochastic processes and financial mathematics* (Mathematics Study Resources, 1). Springer. New York.

6. *Specific course information*

A. Brief description of the content of the course (catalog description)

This course applies Case Based Method (CBM). CBM is a learning method that uses cases as a medium for learning development. Students explore, assess, interpret, synthesize, and information based on cases to produce an analysis and develop a

solution plan. Case-Solving Based Learning in this course provides knowledge about the concept of mathematical models based on probability which includes knowledge of probability spaces and probability models, Markov chains, Poisson processes, renewal processes, queue models, stochastic differential equations, and their applications.
B. Prerequisites or co-requisites
MAT81131 Probability Theory
C. Indicate whether a required or elective course in the program
Elective Course
D. Level of course unit (according to EQF: first cycle Bachelor, second cycle Master)
Second Cycle master
E. Year of study when the course unit is delivered (if applicable)
1st Year
F. Semester when the course unit is delivered
Second Semester
G. Mode of delivery (face-to-face, distance learning)
Mixture (Face to face and Distance learning)
7. *Intended Leening Outcomes*
ILO-2: Mastering mathematical concepts and applications (Real Analysis, Advanced Linear Algebra, and Statistics) in solving complex mathematical problems. PI-1. Able to explain basic mathematical concepts PI-2. Able to provide examples that are relevant to basic mathematical concepts PI-3. Able to determine solutions to simple problems using basic mathematical concepts. ILO-3: Able to master one or several mathematical problems in analysis, algebra, applied mathematics, statistics and combinatorics. PI-1: Able to identify theories used in related mathematical problems. PI-2: Able to apply theories for advancement in related fields (advanced theory). PI-3: Able to use advanced theory in solving related mathematical problems. ILO-4: Mastering scientific techniques and developing them in solving research problems through multidisciplinary or interdisciplinary approaches. PI-1: Able to apply mathematical techniques in research problem-solving. PI-2: Able to analyze research problems. PI-3: Able to formulate theorems/models and prove their validity. PI-4: Able to use various mathematical software to solve complex mathematical problems. ILO-5: Able to work and conduct research in mathematics and related fields of science by developing the latest issues independently or collaboratively and communicating them academically. PI-1. Capable of formally and correctly proving mathematical statements. PI-2. Able to employ relevant techniques for conducting research. PI-3. Capable of communicating research findings academically.

8. *Course Learning Outcomes* *ex. The student will be able to explain the significance of current research about a particular topic.*

1. Students are able to explain the concepts of measure theory and probability theory in stochastic processes (ILO-2: PI-1, PI-2, PI-3).
2. Students are able to explain the concept of random variables, distribution functions and probability models and their relation to the concept of Markov chains (ILO-3: PI-1, PI-2, PI-3).
3. Students are able to explain the concept of the Poisson process and the renewal process as well as the queuing model (ILO-3: PI-1, PI-2, PI-3).
4. Students are able to use the concepts of Brownian motion and Ito's stochastic calculus in stochastic differential equation models (ILO-4: PI-1, PI-2, PI-3, PI-4).
5. Students are able to reason intuitively and analytically and are able to express the results of their reasoning in writing, systematically and rigorously both individually and in groups (ILO-5: PI-1, PI-2, PI-3).

9. *Brief list of topics to be covered*

1. Introduction to measure theory and probability theory.
2. Random variable, special distributions and probability models.
3. Advanced model of Markov chains and transition probability matrix.
4. Advanced model of Poisson process, renewal process, and advanced queuing model.
5. Brownian motion and Ito stochastic calculus.
6. Stochastic differential equations and their applications.

10. Learning and teaching methods

Presentation, Small Group Discussion, Directed Learning.

11. Language of instruction

Bahasa Indonesia

12. Assessment methods and criteria

Summative Assessment :

1. Assignments: 50%
2. Participations: 10%
3. Midterm exam: 20%
4. Final exam : 20%

Formative Assessment:

1. Thumb up and thumb down
2. Minutes paper

SEMESTER STUDY PLAN

STOCHASTIC PROCESS

(ELECTIVE COURSES)

DEPARTMENT OF MATHEMATICS AND DATA SCIENCE

FACULTY OF MATHEMATICS AND NATURAL SCIENCES

UNIVERSITAS ANDALAS

2023

1 Semester Study Plan

<table>
<tr><td>  </td><td colspan="5">SEMESTER STUDY PLAN
STUDY PROGRAM OF S2 MATHEMATICS
FACULTY OF MATHEMATICS AND NATURAL SCIENCES
UNIVERSITAS ANDALAS</td></tr>
<tr><td colspan="6">SEMESTER STUDY PLAN</td></tr>
<tr><td>Course</td><td colspan="2">Code</td><td>i-learn URL</td><td>Credits</td><td>Semester</td><td>Compilation Date</td></tr>
<tr><td>Stochastic Process</td><td colspan="2">MAT 82233</td><td>http://sci.ilearn.unand.ac.id</td><td>3</td><td>2</td><td>November 01, 2023</td></tr>
<tr><td rowspan="2">Person in Charge</td><td colspan="3">Study Plan Creator</td><td>Head of Research Group</td><td colspan="2">Head of Study Program</td></tr>
<tr><td colspan="3">Dr. Dodi Devianto, M.Sc</td><td>Yudiantri Asdi, M.Sc</td><td colspan="2">Dr. Ferra Yanuar</td></tr>
<tr><td rowspan="2">Intended Learning Outcomes (ILO)</td><td colspan="5">ILO-Study Program</td></tr>
<tr><td>ILO-2</td><td colspan="5">Mastering mathematical concepts and applications (Real Analysis, Advanced Linear Algebra, and Statistics) in solving complex mathematical problems.
PI-1. Able to explain basic mathematical concepts
PI-2. Able to provide examples that are relevant to basic mathematical concepts
PI-3. Able to determine solutions to simple problems using basic mathematical concepts.</td></tr>
</table>

	ILO-3	Mastering one or several theories comprehensively for development in the fields of analysis, algebra, applied mathematics, statistics and combinatoric mathematics. PI-1. Able to identify theories used in related mathematical problems. PI-2. Able to apply theory for development in related fields (advanced theory). PI-3. Able to use advanced theory in solving related mathematical problems.
	ILO-4	Mastering scientific techniques and developing them in solving research problems through a multidisciplinary or interdisciplinary approach. PI-1. Able to use scientific techniques in solving research problems. PI-2. Able to analyze research problems. PI-3. Able to formulate theorems/models and prove their correctness. PI-4. Able to use several mathematical software to solve complex mathematical problems.
	ILO-5	Able to work and conduct research in the field of mathematics and related fields of science in accordance with developments in current issues independently or collaboratively and communicate it academically. PI-1. Able to prove mathematical statements formally and correctly. PI-2. Able to use related techniques to conduct research PI-3. Able to communicate research results academically.
	Course Learning Outcome (CLO)	
	CLO-1	Students are able to explain the concepts of measure theory and probability theory in stochastic processes (ILO-2: PI-1, PI-2, PI-3).

	CLO-2	Students are able to explain the concept of random variables, distribution functions and probability models and their relation to the concept of Markov chains (ILO-3: PI-1, PI-2, PI-3).
	CLO-3	Students are able to explain the concept of the Poisson process and the renewal process as well as the queuing model (ILO-3: PI-1, PI-2, PI-3).
	CLO-4	Students are able to use the concepts of Brownian motion and Ito's stochastic calculus in stochastic differential equation models (ILO-4: PI-1, PI-2, PI-3, PI-4).
	CLO-5	Students are able to reason intuitively and analytically and are able to express the results of their reasoning in writing, systematically and rigorously both individually and in groups (ILO-5: PI-1, PI-2, PI-3).
Brief description of Course	This course applies Case Based Method (CBM). CBM is a learning method that uses cases as a medium for learning development. Students explore, assess, interpret, synthesize, and information based on cases to produce an analysis and develop a solution plan. Case-Solving Based Learning in this course provides knowledge about the concept of mathematical models based on probability which includes knowledge of probability spaces and probability models, Markov chains, Poisson processes, renewal processes, queue models, stochastic differential equations, and their applications.	
Study Materials	1. Introduction to measure theory and and probability theory. 2. Random variable, special distributions and probability models. 3. Advanced model of Markov chains and transition probability matrix. 4. Advanced model of Poisson process, renewal process, and advanced queuing model. 5. Brownian motion and Ito stochastic calculus.	

	6. Stochastic differential equations and their applications.	
References	**Main:**	
	1. S. M. Ross. (1995). *Stochastic processes* (2nd edition). John Wiley & Sons, New York. 2. R. M. Bass. (2011). *Stochastic processes* (Cambridge Series in Statistical and Probabilistic Mathematics, Series Number 33). Cambridge University Press, New York.	
	Supporting:	
	1. R. G. Gallager. (2014). *Stochastic processes: theory for applications*. Cambridge University Press, New York. 2. S. I. Resnick. (2005). *Adventures in stochastic processes*. Birkhäuser, Boston 3. Z. Brzezniak and T. Zastawniak. (2000). *Basic stochastic processes*. Springer, New York. 4. S. M. Ross. (2003). *Introduction to probability models*. Academic Press, New York. 5. M. A. Pinsky and S. Karlin. (2011). *An introduction to stochastic modeling* (4th edition). Academic Press, London. 6. R. Durrett. (2018). *Essentials of stochastic processes*. Springer International Publishing, New York. 7. S. R. S. Varadhan. (2007). *Stochastic processes* (Courant Lecture Notes). American Mathematical Society, New York. 8. B. L. Nelson. (2010). *Stochastic modeling: analysis and simulation*. Dover publications, New York. 9. L. Rüschendorf. (2023). *Stochastic processes and financial mathematics* (Mathematics Study Resources, 1). Springer. New York.	
Instructional Media	**Software:**	**Hardware:**

	• LMS Unand (http://sci.ilearn.unand.ac.id/) • Zoom meeting • Whatsapp	• Computer/Laptop • Smartphones
Team Teaching	Dr. Dodi Devianto, M.Sc	
Required courses	MAT81131 PROBABILITY THEORY	
Academic Norms	Follow the Academic Regulations of Undergraduate Program, Universitas Andalas (https://akademPI.unand.ac.id/images/2022-03-30%20Peraturan%20Rektor%20Nomor%207%20Tahun%202022%20Penyelenggaraan%20PendidPIan-khusus%20Bab%20II.pdf)	

Week (1)	Course Outcome (2)	Indicators (3)	Form of Assessment (4)	Learning Activities [Estimated Time]					Learning Materials [Reference] (10)	Weight (11)
				Synchronous		Asynchronous		Media (9)		
				Face to Face Offline (5)	Face to Face Online (6)	Individual (7)	Collaboration (8)			
1-2	CLO 1: Students are able to explain the concepts of measure theory and probability theory in stochastic processes (ILO-2: PI-1, PI-2, PI-3).	• Discipline in implementing the college contract • Accuracy in understanding related material	Mid-term exam (10%) Independent assignment (5%)	Class: – introduction of semester learning plan – discussion about course material [2 x 3 x 50 minutes]		• Students find references and study material on the concepts of measure theory and probability (probability space and set of sigma-field in relation to stochastic processes.		LMS (ilearn UNAND)	• Introduction to Lectures (Assessment, Semester Learning Plan, Syllabus, Tuition Contract) • Basic concepts of measure theory.	**15%**

						• Independent work [2 x 3 x 120 minutes]			• Basic concepts of probability theory. • Basic concepts of stochastic processes	
3-7	CLO 2: Students are able to explain the concept of random variables, distribution functions, and probability models and their relation to the concept of Markov chains (ILO-3: PI-1, PI-2, PI-3).	• Accuracy in understanding related material • Accuracy in answering assignment questions • Neatness of assignment execution • Originality of assignment results	Mid-term exam (10%) Assignment (10%)	Class: - explanation of concepts - discussion about course materials [5 x 3 x 50 minutes]		• Students find the references and study of random variables, distribution functions with their properties, and Markov chains. • Independent work [5 x 3 x 60 minutes]	Students's discussion in groups [5x3x60] minutes	LMS (ilearn UNAND)	• Basic concepts of random variables and distribution functions and their properties. • Probability model • Advanced Markov chain model	**20%**
8	**Mid-term exam**									
9-11	CLO 3: Students are able to explain the concept of the Poisson process, the renewal process, and the queuing model	• Accuracy in understanding of related material • Accuracy in answering assignment questions	Final exam (5%) Participation (5%) Assignment (10%)	Class: - Explanation of the concepts, - Discussion about course materials		• Students find references and study material. • Independent work [3x 3 x 60 minutes]	Students discuss in groups [3x3x60]	• LMS	• The concept of the Poisson process and the renewal process (the process of birth and death).	**20%**

	(ILO-3: PI-1, PI-2, PI-3).	• Neatness in completing assignments • Originality of assignment results		[3 x 3 x 50 minutes]					• Advanced queue model concept with additional effects (bulking, jokeying, stucking).	
12-13	CLO 4: Students are able to use the concepts of Brownian motion and Ito's stochastic calculus in stochastic differential equation models (ILO-4: PI-1, PI-2, PI-3, PI-4).	• Accuracy in understanding of related material • Accuracy in answering assignment questions • Neatness in completing assignments • Originality of assignment results	Final exam (5%) Assignment (10%)	Class: - Explanation of the concepts, - Discussion about course materials [2 x 3 x 50 minutes]		• Students find references and study material • Independent work [2x 3 x 60 minutes]	Students discuss in groups [2x3x60]	• LMS	• Brownian concept of motion and its properties and Ito stochastic calculus. • The concept of stochastic differential equations and their applications.	**15%**
14-15	CLO 5: Students are able to reason intuitively and analytically and are able to express the results of their reasoning in writing, systematically and rigorously both	• Accuracy in understanding of related material • Accuracy in answering assignment questions	Assignment (15%) Final exam (10%) Participation (5%)	Practice: – Discussion about course materials. – Presentation group [2 x 3 x 50 minutes]		Students find out references and study material [2x 3 x 60 minutes]	Students discuss in groups [2x3x60 minutes]	• LMS	• Selected stochastic models with special cases. • Implementation of the stochastic model of choice and its application.	**30%**

	individually and in groups (ILO-5: PI-1, PI-2, PI-3).	• Neatness in completing assignments • Originality of assignment results								
16	**Final exam**									

II. Indicators, Criteria, and Proportions of Assessment

NO	FORM OF ASSESSMENT	PROPORTION (%)
1	Assignment	50%
2	Participation	10%
3	Mid-term exam	20 %
4	Final exam	20%
TOTAL		**100**

Assessment proportion for each Course Learning Outcome (CLO):

- CLO 1: 15 %
- CLO 2: 20%
- CLO 3: 20 %
- CLO 4: 15 %
- CLO 5: 30 %

III. Assessment Plan Table

Form of assessment Course Learning Outcomes (CLO)	Final exam	Mid-term exam	Assignments	Participation	Total of Proportion
1. Students are able to explain the concepts of measure theory and probability theory in stochastic processes (ILO-2: PI-1, PI-2, PI-3).		10%	5%		15%
2. Students are able to explain the concept of random variables, distribution functions, and probability models and their relation to the concept of Markov chains (ILO-3: PI-1, PI-2, PI-3).		10%	10%		20%
3. Students are able to explain the concept of the Poisson process, the renewal process, and the queuing model (ILO-3: PI-1, PI-2, PI-3).	5%		10%	5%	20%
4. Students are able to use the concepts of Brownian motion and Ito's stochastic calculus in stochastic differential equation models (ILO-4: PI-1, PI-2, PI-3, PI-4).	5%		10%		15%
5. Students are able to reason intuitively and analytically and are able to express the results of their reasoning in writing systematically and rigorously, both individually and in groups (ILO-5: PI-1, PI-2, PI-3).	10%		15%	5%	30%
Total of Proportion	20%	20%	50%	10%	100%

Matrix of CLO and ILO

CLO	ILO																	
	1		2			3			4				5			6		
	PI		PI			PI			PI				PI			PI		
	1	2	1	2	3	1	2	3	1	2	3	4	1	2	3	1	2	3
1			✓	✓	✓													
2						✓	✓	✓										
3						✓	✓	✓										
4									✓	✓	✓	✓						
5													✓	✓	✓			