MODULE HANDBOOK

STOCHASTIC PROCESS

BACHELOR DEGREE PROGRAM
DEPARTEMENT OF STATISTICS
FACULTY OF SCIENCE AND DATA ANALYTICS
INSTITUT TEKNOLOGI SEPULUH NOPEMBER

ENDORSEMENT PAGE

	MODULE HANDBOOK STOCHASTIC PROCESS **DEPARTMENT OF STATISTICS** **INSTITUT TEKNOLOGI SEPULUH NOPEMBER**

Proses ***Process***	**Penanggung Jawab** ***Person in Charge***			**Tanggal** ***Date***
	Nama ***Name***	**Jabatan** ***Position***	**Tandatangan** ***Signature***	
Perumus *Preparation*	Prof. Nur Iriawan	Dosen *Lecturer*		**March 28, 2019**
Pemeriksa dan Pengendalian *Review and Control*	Prof. Drs. Nur Iriawan, M.Ikom, Ph.D ; Dr. Bambang Widjanarko Otok, M.Si. ; Ahmad Choirudin, S.Si., M.Sc., Ph.D	Tim kurikulum *Curriculum team*		**April 15, 2019**
Persetujuan *Approval*	Prof. Nur Iriawan	Koordinator RMK *Course Cluster Coordinator*		**July 17, 2019**
Penetapan *Determination*	Dr. Kartika Fithriasari, M.Si	Kepala Departemen *Head of Department*		**July 30, 2019**

MODULE HANDBOOK

STOCHASTIC PROCESS

Module name	STOCHASTIC PROCESS	
Module level	Undergraduate	
Code	KS184901	
Course (if applicable)	STOCHASTIC PROCESS	
Semester	Fifth Semester (Ganjil)	
Person responsible for the module	Prof. Nur Iriawan	
Lecturer	Prof. Drs. Nur Iriawan, M.Ikom, Ph.D ; Dr. Bambang Widjanarko Otok, M.Si. ; Ahmad Choirudin, S.Si., M.Sc., Ph.D	
Language	Bahasa Indonesia and English	
Relation to curriculum	Undergradute degree program, **mandatory**, 5th semester.	
Type of teaching, contact hours	Lectures, <50 students	
Workload	1. Lectures : 3 x 50 = 150 minutes per week. 2. Exercises and Assignments : 3 x 60 = 180 minutes (3 hours) per week. 3. Private learning : 3 x 60 = 180 minutes (3 hours) per week.	
Credit points	3 credit points (sks)	
Requirements according to the examination regulations	A student must have attended at least 80% of the lectures to sit in the exams.	
Mandatory prerequisites	1. Probability Theory 2. Mathematics Statististics I	
Learning outcomes and their corresponding PLOs	*CLO. 1 Able to explain the meaning of stochastic processes by combining information on state variables and their parameters* *CLO. 2 Able to explain the Markov chain and compile a probability transition matrix of a problem that satisfies the Markov properties.* *CLO. 3 Able to calculate and understand the purpose of making n probability transition matrix steps.* *CLO. 4 Able to calculate the limit distribution of a stochastic matrix if the limit distribution is* *CLO. 5 Able to calculate the probability and time expectation that a process (system) will reach a certain state the first time (First Step Analysis)* .	PLO-01 PLO-03

	CLO. 7 Able to communicate effectively and cooperate in an interdisciplinary team and multidisciplinary teams. *CLO. 8 Have professional responsibility and ethics* *CLO. 9 Able to motivate oneself to think creatively and learn throughout life* *CPMK. 10 Able to explain concepts and be able to apply queuing models and understand that the queuing process is a special occurrence of a continuous Markov model, especially the process input-output (birth-death process).* *CPMK. 11 Able to calculate the performance of several queuing systems that are often found on a daily basis.* *CPMK. 12 Able to communicate effectively and collaborate in interdisciplinary and multidisciplinary teams.* *CPMK. 13 Have responsibility and professional ethics* *CPMK. 14 Able to motivate oneself to think creatively and learn lifelong*	PLO-04
Content	*Stochastic Processes is one of the courses part of the field of Statistical Modeling which is aimed at developing and analyzing probability models that capture the phenomenon of the effects of event randomness in the short and long term or in a narrow or wide area. The probability model studied will involve a variety of mathematical and computational models that are equipped with applications, both quantitative and qualitative in the real world in the fields of business, industry, environment, government, and society.*	
Study and examination requirements and forms of examination	• In-class exercises • Assignment 1, 2, 3 • Mid-term examination • Final examination	
Media employed	LCD, whiteboard, websites (myITS Classroom), zoom.	
Reading list	1. Beichelt, F. 2016. Applied Probability and Stochastic Processes. 2nd edition. LLC: Taylor dan Francis Group. 2. Cox, D.R. and Miller, H. D., 1996. The Theory of Stochastic Processes. London: Chapman dan Hall. 3. Karlin, S. and Taylor, H.M., 1998. An Introduction to Stochastic Modeling. 3rd edition. Academic Press. 4. Kulkarni, V.G., 2010. Modeling, Analysis, Design and Control of Stochastic System. New York: Springer. 5. Sheldon, M. 2009. Ross-Introduction to Probability Models. 10th edition. Amsterdam: Elsevier.	

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	Semester/SKS	V/3
	MK Prasyarat	Teori Peluang, Statistika Matematika I
RP-S1	Dosen Pengampu	Prof. Drs. Nur Iriawan, M.Ikom, Ph.D ; Dr. Bambang Widjanarko Otok, M.Si. ; Ahmad Choirudin, S.Si., M.Sc., Ph.D

Bahan Kajian *Study Materials*	Dasar Sains, Teori Statistika, dan Pemodelan *Basic of Science, Statistical Theory, and Modeling*
CPL yang dibebankan MK *PLO*	CPL-1 Mampu menerapkan pengetahuan teori statistika, matematika, dan komputasi CPL-3 Mampu menganalisis data dengan metode statistika yang tepat dan mengintepretasikannya CPL-4 Mampu mengindentifikasi,memformulasi, dan menyelesaikan masalah statistika di berbagai bidang terapan *CPL-1 Able to apply knowledge of statistical theory, mathematics, and computation* *CPL-3 Able to analyze data with appropriate statistical methods and interpret it.* *CPL-4 Able to identify, formulate, and solve statistical problems in various applied fields*
CP-MK *CLO*	CPMK.1 Mampu menjelaskan pengertian proses stokastik dengan memadukan informasi variabel state dan parameternya CPMK.2 Mampu menjelaskan Rantai Markov dan menyusun matriks transisi probailitas dari suatu masalah yang memenuhi sifat Markov CPMK.3 Mampu menghitung dan memahami tujuan membuat matriks transisi probailitas n langkah CPMK.4 Mampu menghitung distribusi limit suatu matriks stokastik bila distribusi limit itu ada CPMK..5 Mampu menghitung probabilitas dan ekspektasi waktu suatu proses (sistem) akan mencapai keadaan tertentu pertama kalinya (First Step Analysis) CPMK.6 Mampu menghitung probabilitas dan ekspektasi waktu kepunahan generasi suatu proses CPMK.7 Mampu menjelaskan sifat-sifat dan klasifikasi rantai Markov CPMK.8 Mampu menghitung biaya yang timbul bila proses (sistem) berada pada suatu state dalam jangka waktu tertentu dan dalam jangka waktu panjang CPMK.9 Mampu menjelaskan Sifat Stationary and independent increment dalam proses poisson serta menghitung peluang dari F(x) dan R(x) serta peluang dari proses poisson CPMK.10 Mampu menjelaskan konsep dan mampu menerapkan model antrian serta faham bahwa proses antrian merupakan kejadian khusus dari model markov kontinyu, khususnya proses input-output (birth-death process). CPMK.11 Mampu menghitung kinerja beberapa sistem antrian yang banyak dijumpai sehari-hari. CPMK.12 Mampu berkomunikasi secara efektif dan bekerjasama dalam tim yang interdisiplin dan multidisiplin CPMK.13 Memiliki tanggung jawab dan etika profesi CPMK.14 Mampu memotivasi diri untuk berpikir kreatif dan belajar sepanjang hayat *CPMK. 1 Able to explain the meaning of stochastic processes by combining information on state variables and their parameters* *CPMK. 2 Able to explain the Markov chain and compile a probability transition matrix of a problem that satisfies the Markov properties.*

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	CPMK. 3 Able to calculate and understand the purpose of making n probability transition matrix steps. *CPMK. 4 Able to calculate the limit distribution of a stochastic matrix if the limit distribution* *CPMK. 5 Able to calculate the probability and time expectation that a process (system) will reach a certain state the first time (First Step Analysis)* *CPMK. 6 Able to calculate probabilities and expectations time for The extinction of the generation of aprocess.* *CPMK. 7 Be able to explain the characteristics and classification of theMarkov chain.* *CPMK. 8 Able to calculate the costs that arise when the process (system) is in a state for a certain period of time and in the long term* *CPMK. 9 Able to explain Stationary Characteristics and independent increment in the Poisson process as well as calculating the odds of F (x) and R (x) as well as the probability from thePoisson* *CPMK. 10 Able to explain concepts and be able to apply queuing models and understand that the queuing process is a special occurrence of a continuous Markov model, especially the process input-output (birth-death process).* *CPMK. 11 Able to calculate the performance of several queuing systems that are often found on a daily basis.* *CPMK. 12 Able to communicate effectively and collaborate in interdisciplinary and multidisciplinary teams.* *CPMK. 13 Have responsibility and professional ethics* *CPMK. 14 Able to motivate oneself to think creatively and learn lifelong*

Perte-muan *Meeting*	**Kemampuan Akhir Sub CP-MK** *Final Ability*	**Keluasan (materi pembelajaran)** *Extent (learning material)*	**Metode Pembelajaran** *Learning methods*	**Estimasi Waktu** *Duration*	**Bentuk Evaluasi** *Evaluation Type*	**Kriteria dan Indikator Penilaian** *Assessment Criteria and Indicators*	**Bobot Penilaian** *Scoring*
1	Mampu menjelaskan pengertian proses stokastik dengan memadukan informasi variabel state dan parameternya	Pengertian Proses Stokastik dan Rantai Markov	1. CI 2.Diskusi 3.Latihan	150 menit	TT-0-P-L	1. Mampu menjelaskan perbedaan proses stokastik dengan parameter dan state spacenya 2. mampu mengindentifikasi ruang keadaan (state space) dan waktu keadaan	5%/5%

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1	*Being able to explain the notion of stochastic processes by integrating information state variables and parameters*	*understanding stochastic processes and Markov Chain*	*1. CI 2.Diskusi 3.Latihan*	*150 minutes*	*TT-0-PL*	(parameter space) dari suatu proses atau sistem stokastik *1. Able to explain differences in stochastic processes with their parameters and state space are* *3. able to identify state space and state space (parameter space) of a process or stochastic system*	*5% / 5%*
2	Mampu menjelaskan Rantai Markov dan menyusun matriks transisi probailitas dari suatu masalah yang memenuhi sifat Markov	- Probabilitas transisi 1 langkah - Matriks transisi dari kasus tertentu	1. CI 2.Diskusi 3.Latihan	150 menit	TT-P-O	Mampu mengindentifikasi transisi-transisi yang mungkin antar ruang keadaan seuai waktu proses, dan mampu menyusun matriks stokastiknya untuk 1 langkah	10%/15%
2	*Able to explain the Markov chain and compile a probability transition matrix of a problem that satisfies the properties Markov*	*- 1-step transition probability - The transition matrix from cashcertain us*	*1. CI 2.Diskusi 3.Latihan*	*150 minutes*	*TT-PO*	*able to identify the possible transitions between the state space of time regarding to the process, and able to prepare for the first step matrix stokastiknya*	*10% / 15%*
3	Mampu menghitung dan memahami tujuan membuat matriks transisi probailitas n langkah	Persamaan Chapman-Kolmogorov untuk menghitung probabilitas transisi n langkah	Presentasi Game Latihan soal & Diskusi (P-G-LS-D)	150 menit	TT-P-O	Mampu mengindentifikasi transisi-transisi yang mungkin antar ruang keadaan seuai waktu proses, dan mampu menyusun matriks stokastiknya untuk n langkah	5%/20%

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3	*Able to calculate and understand the purpose of making probability transition matrix n steps*	*Chapman-Kolmogorov equation to calculate transition probability n steps*	*Presentation Game Exercise Questions & Discussion (PG-LS-D)*	*150 minutes*	*TT-PO*	*Able to identify possible transitions between state spaces according to processing time, and able to arrange stochastic matrix for n steps*	*5% / 20%*
4-5	Mampu menghitung probabilitas dan ekspektasi waktu suatu proses (sistem) akan mencapai keadaan tertentu pertama kalinya (*First Step Analysis*)	*First Step Analysis* dengan absorbing dan non absorbing state	P-G-LS-D	150 menit	TT-0-P-L	Dapat menganalisis apakah matriks stokastik P mencapai kondisi *steady-state* dan mempunyai distribusi limit pada langkah ke-n bila $n \rightarrow \infty$.	15%/35%
4-5	*Able to calculate the probability and expectation that the time a process (system) will reach a certain state the first time (First Step Analysis)*	*First Step Analysis with absorbing and non absorbing state*	*PG-LS-D*	*150 minutes*	*TT-0-PL*	*Can analyze whether the stochastic matrix P reaches acondition steady-state and has a limit distribution in the nth step if* $n \rightarrow \infty$.	*15% / 35%*
6-7	Mampu menghitung distribusi limit suatu matriks stokastik bila distribusi limit itu ada	Distribusi Limit	P-G-LS-D	150 menit	Tugas, prsentasi, Diskusi, pengamatan aktifitas kelas	Dapat menentukan, Misal *T* adalah waktu pertama kali sistem masuk ke state	10%/45%
6-7	*Able to calculate the limit distribution of a stochastic matrix if the limit distribution exists*	*Limit Distribution*	*PG-LS-D*	*150 minutes*	*Assignments, presentation, discussion,*	*Can determine, For example T is the first time the system enters the system. state*	*10% / 45%*

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					observation of class activities		
8	**ETS/***Mid Term Examination*						
9 *9*	Mampu menghitung probabilitas dan ekspektasi waktu kepunahan generasi suatu proses *Able to calculate probability and expected time of extinction of the generation of a process*	Ekspektasi Biaya *Cost expectations*		150 menit *150 minutes*	Tugas, prsentasi, Diskusi, pengamatan aktifitas kelas *Assignments, presentation, discussion, class activity observations*	Dapat menghitung ekspektasi biaya total (EBT) dari suatu proses dalam jangka waktu tertentu *n*. Serta menghitung ekspektasi biaya persatuan waktu dalam jangka panjang. *Can calculate expected total cost (EBT) of a process within a certain time period n. As well as calculating the expected cost of the unit time in the long run.*	05%/50% *05% / 50%*
10 *10*	Mampu menjelaskan sifat-sifat dan klasifikasi rantai Markov *Able to explain the properties and classification of theMarkov chain*	Klas Transient, klas absorbing, klas recurrent dalam sebuah matrik transisi Markov *Transient Class, absorbing class, recurrent class in aMarkov transition matrix*	P-G-LS-D *PG-LS-D*	150 menit *150 minutes*	Tugas, prsentasi, Diskusi, pengamatan aktifitas kelas *Assignments, presentation, discussion, observations of class activities*	Mampu menjelaskan dan mengklasifikasikan kelas-kelas dalam matriks transisi Markov *Able to explain and classify classes class in the Markov transition matrix*	08%/58% *08% / 58%*
11	Mampu menghitung biaya yang timbul bila proses (sistem) berada pada suatu state dalam jangka		P-G-LS-D	150 menit	Tugas, prsentasi, Diskusi, pengamatan aktifitas kelas	Mampu menghitung performansi proses, antara lain occupancy times, firstpassage times, menghitung ekspetasi beaya total dan ekspetasi beaya persatuan	07%/65%

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11	waktu tertentu dan dalam jangka waktu panjang *Able to calculate the costs that arise when the process (system) is in a state for a certain period of time and in the long term*		*PG-LS-D*	*150 minutes*	*Assignments, presentation, discussion, observation of class activities*	waktu jika poses berada pada state tertentu dalam jangka panjang. *Able to calculate process performance, including occupancy times, first passage times, calculating total cost expectations and time unit cost expectations if possessions are in a certain state in the long run.*	*07% / 65%*
12	Mampu menjelaskan Sifat *Stationary and independent increment* dalam proses poisson serta menghitung peluang dari F(x) dan R(x) serta peluang dari proses poisson	4. Model Markov Kontinyu 5. Dekomposisi dan superposisi proses Poisson. 6. Matriks Rate dan diagram rate	P-G-LS-D	150 menit	Tugas, prsentasi, Diskusi, pengamatan aktifitas kelas	1. Memahami dan menguasai konsep Model Markov Kontinyu serta mampu membedakannya dengan Model Markov Diskrit. 2. Mampu menyusun matriks rate dan mampu mendapatkan matriks stokastik dari matriks rate untuk analisis transient. 3. Mampu menyusun sistem persamaan beda-diferensial untuk Proses Poisson dan mampu menyelesaikannya	10%/75%
12	*Be able to explain Stationary and independent increments in the Poisson process and calculate the odds of F (x) and R (x) as well as*	*1. Continuous Markov Model* *2. Decomposition and superposition of the Poisson process.*	*PG-LS-D*	*150 minutes*	*Assignments, presentation, discussion, observation of class activities*	*1. Understand and master the concept of the Continuous Markov Model and be able to distinguish it from the Discrete Markov Model.* *2. Able to compile rate matrix*	*10% / 75%*

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	the odds of the Poisson process	*3. Rate matrix andrate diagram*				*and able to get stochastic matrix from rate matrix for transient analysis.* *4. Able to compile a system of differential-differential equations for the Poisson Process and be able to solve it*	
13-14	Mampu menjelaskan konsep dan mampu menerapkan model antrian serta faham bahwa proses antrian merupakan kejadian khusus dari model markov kontinyu, khususnya proses input-output (birth-death process).	Model Antrian (proses input – output, sistem antrian kapasitas terbatas dan takterbatas)	P-G-LS-D	150 menit	Tugas, prsentasi, Diskusi, pengamatan aktifitas kelas	Mampu memahami proses birth-death dalam sebuah proses antrian	15%/90%
13-14	*Able to explain concepts and be able to apply queuing models and understand that the queuing process is a special occurrence of a continuous Markov*	*Queuing Model (input - output process, limited and unlimited capacity queuing system)*	*PG-LS-D*	*150 minutes*	*Assignments, presentation, discussion, observation of class activities*	*Able to understand the birth-death process in a queuing process*	*15% / 90%*

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	model, especially the input-output (birth-) process. death process).						
15 *15*	Mampu menghitung kinerja beberapa sistem antrian yang banyak dijumpai sehar-hari. *Able to calculate performance several queuing systems that are often found everyday.*	-	P-G-LS-D	150 menit	Tugas, prsentasi, Diskusi, laporan	1. Mampu mengidentifikasi sistem antri sesuai prosesnya **2.** Mampu menghitung kinerja performasi sistem antri jalur tunggal dan jalur ganda **3.** Mampu menghitung performansi sistem antri jaringan Jackson *1. Able to identify the queuing system according to the process* *2. Able to calculate the performance of the queuing system single line and dual line* *3. Able to calculate the performance of the Jackson network queuing system*	10%/100% *10% / 100%*
	-		*PG-LS-D*	*150 minutes*	*Task, presentation, discussion, report*		
16	**EAS/** *Final Examination*						

PUSTAKA/*REFERENCES* **:**

1. Beichelt, F. Applied Probability and Stochastic Processes, 2nd Ed., 2016, Taylor & Francis Group, LLC
2. Kulkarni, V.G., Modeling, Analysis, Design and Control of Stochastic System, Springer, New York, 2010.
3. Sheldon M. Ross-Introduction to Probability Models, Tenth Edition (2009), Elsevier, Amsterdam
4. Karlin, S. & Taylor, H.M., An Introduction to Stochastic Modeling 3rd Ed., Academic Press, 1998.

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5. Cox, D.R. dan Miller, H. D. (1996) The Theory of Stochastic Processes, Chapman & Hall, London