UNIVERSITAS GADJAH MADA
Faculty of Mathematics and Natural Sciences
Mathematics Department
Sekip Utara Bulaksumur Yogyakarta 55281 Telp: +62 274 552243 Fax: +62 274 555131 Email: math@ugm.ac.id Website: matematika.fmipa.ugm.ac.id

Doctoral Program in Mathematics

Telp : +62 274 552243
Email : maths3@ugm.ac.id;
Website : http://math.fmipa.ugm.ac.id/dpmath

MODULE HANDBOOK
Doctoral in Mathematics

Module name:	Dynamical Systems
Module level, if applicable:	Doctoral
Code, if applicable:	MMM 7301
Semester(s) in which the module is taught:	1st (first) year
Person responsible for the module:	Chair of Applied Mathematics Research Group
Lecturer(s):	Prof. Dr.rer.nat Widodo, M.S.
Language:	Bahasa Indonesia
Relation to curriculum:	Doctoral Degree in Mathematics, Elective Course, 1nd semester
Credit points:	3 Semester Credit Unit
Type of teaching, contact hours:	3x50 minutes lectures, 3x50 minutes structured activities.
Workload:	• 3x50 minutes lectures, • 3x50 minutes structured activities, • 3x50 minutes individual study, • In 16 weeks per semester (including mid-term and final examinations). Total: 144x50 minutes per semester.
Recommended prerequisites:	Before taking courses, students must have a good understanding of the concepts of measure theory, metric space and topology space.
Module objectives/intended learning outcomes:	After completing this course the students should have ability to: • CO 1. Understand the problems in ergodic theory, absolute continuous measure, conditional expectation value, function space, Haar measure, Perron-Frobenius theory. • CO 2. Understand the Measure preserving Transformations: Ergodicity, Ergodic theorem, Mixing. Isomorphism, topological conjugation, measure preserving transformation conjugation, isomorphism problems. • CO 3. Understand and analyze the Measure on metric space, the invariant measure for continuous transformation, ergodicity interpretation and mixing, the relationship of invariant measure and non-wandering set. • CO 4. Understand and analyze the Measure entropy: partition entropy, conditional entropy, entropy of measure preserving transformation, metric entropy computation. • CO 5. Understand the Topological dynamics: Non-wandering sets, topological transitive, topological conjugations. • CO 6. Understand and analyze the Topology entropy: definition of topology entropy with open covers, Bowen's definition, topological entropy calculation. Relationship between topology entropy and metric entropy. Measure with maximum entropy, Affine transformation entropy).

Content:	1. Problems in ergodic theory, absolute continuous measure, conditional expectation value, function space, Haar measure, Perron-Frobenius theory. 2. Measure preserving Transformations: Ergodicity, Ergodic theorem, Mixing. Isomorphism, topological conjugation, measure preserving transformation conjugation, isomorphism problems. 3. Measure on metric space, the invariant measure for continuous transformation, ergodicity interpretation and mixing, the relationship of invariant measure and non-wandering set. 4. Measure entropy: partition entropy, conditional entropy, entropy of measure preserving transformation, metric entropy computation. 5. Topological dynamics: Non-wandering sets, topological transitive, topological conjugations. 6. Topology entropy: definition of topology entropy with open covers, Bowen's definition, topological entropy calculation. Relationship between topology entropy and metric entropy. Measure with maximum entropy, Affine transformation entropy).
Study and examination requirements and forms of examination:	The final mark will be weighted as follows: No Assessment methods (components, activities) Weight (percentage) 1 Final Examination 35% 2 Mid-Term Examination 30% 3 Projects/Presentation 25% 4 Peer Assessment/Quiz 10% Final grade will be determined as follows: Grade Criteria The initial cut-off points for grades A, B, C, and D should not be less than 80%, 65%, 50%, and 40%, respectively.
Media employed:	Board, LCD Projector, Laptop/Computer, MatLab or Worlframalpha
Reading List:	1. Ding, J., 1998. The Point Spectrum of Frobenius-Perron and Koopman Operators. Proceeding of the American Mathematical Society Vol. 126, No. 5, 1355-1361. http://www.ams.org./1998-126-05/S0002-9939-98-04188-4/home.html 2. Jablonski, M., 1984. On Convergence of Iterates of The Frobenius-Perron Operator. http://www.im.uj.edu.pl/actam/pdf/24-7-13.pdf 3. Lasota, A., and Mackey, M.C., 1994, Chaos, Fractals, and Noise, Stochastic Aspect of Dynamics, second edition, Springer-Verlag New York Inc. 4. Royden, H.L.,1989, Real Analysis, Third edition, Macmillan Publishing Company, New York. 5. Smyth, M.R.F., 2002. A Spectral Theoritic Proof of Perron-Frobenius. Mathematical Pro-ceedings of The Royal Irish Academy, 102 A. \ 6. Taylor, S.R., 2004, Probabilistic Properties of Delay Differential Equations, A Ph.D Thesis Presented to the University of Waterloo in Fulfillment of the Thesis Requirement for the Degree of Doctor of Philosophy in Applied Mathematics,Waterloo,Ontorio,Canada. http://www.math.uwaterloo.ca/~sr2taylo 7. Walters, P., 1982, An Introduction to Ergodic Theory, Graduate Text in Mathematics, Springer-Verlag New York Inc.

Mapping of The COs and PLOs

	PLO – 1 S3 Mat	PLO – 2 S3 Mat	PLO – 3 S3 Mat	PLO – 4 S3 Mat	PLO – 5 S3 Mat	PLO –6 S3 Mat
CO 1	v	v	v			
CO 2	v	v	v			
CO 3	v	v	v			v
CO 4	v	v	v	v	v	v
CO 5	v	v	v			
CO 6	v	v	v	v	v	v

Programme Learning Outcomes (PLO) Doctoral Programme in Mathematics

PLO-1	:	**Attitude:** Devote to God Almighty, uphold the humanity values, internalize academic values and ethics, responsible in working in the area of expertise independently.
PLO-2	:	**Knowledge:** Mastering philosophy of mathematics and one of the fields in mathematics (algebra, analysis, applied mathematics, statistics, computational mathematics, computational statistics).
PLO-3	:	**Knowledge:** Able to think logically, analytically, inductively, deductively, and structured; having the ability to manage, lead, and develop research programs independently, and able to communicate the thoughts as well as his work to the scientific community and the general public.
PLO-4	:	**Skill:** Creating new concepts and / or new methods (original) in the field of mathematics that are recognized nationally and internationally.
PLO-5	:	**Skill:** Able to apply mathematics according to their field of expertise to solve problems including those that require a multidisciplinary, cross-disciplinary, or trans-disciplinary approach.
PLO-6	:	***Life Long Learning:*** Having lifelong learning skills and adaptive to the development of science and technology, especially in fields related to Mathematics and its applications.