**Undergraduate Programme in Mathematics**

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**MODULE HANDBOOK**

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| Module name | Dynamical System |
| Module level, if applicable | Bachelor |
| Code, if applicable | MMM-3306 |
| Subtitle, if applicable | - |
| Courses, if applicable | Dynamical System |
| Semester(s) in which the module is taught | 6$^{th}$ (Sixth Semester) |
| Person responsible for the module | Chair of the Lab. of Applied Mathematics |
| Lecture(s) | Dr. Fajar Adi Kusumo, M.Si., and Prof. Dr. Widodo, M.S. |
| Language | Bahasa Indonesia |
| Relation to curriculum | Compulsory course in the third year (6$^{th}$ semester ) Bachelor Degree |
| Type of teaching, contact hours | 150 minutes lectures and 180 minutes structured activities per week. |
| Workload | Total workload is 136 hours per semester, which consists of 150 minutes lectures per week for 14 weeks, 180 minutes structured activities per week, 180 minutes individual study per week, in total is 16 weeks per semester, including mid exam and final exam. |
| Credit points | 3 |
| Requirements according to the examination regulations | Students have taken Dynamical System course (MMM-3306) and have an examination card where the course is stated on. |
| Recommended prerequisites | Students have taken Elementary Linear Algebra course (MMM-1202), Elementary Differential Equations course (MMM-2301), and have participated in the final examination of the course.<br>Before taking this course, students must have a good understanding about the basic concepts of the Linear Algebra and Differential Equations. |
| Module objectives/intended learning outcomes | After completing the course, the students will be able to:<br>CO1. recognize the concept of the Discrete and Continuous Dynamical Systems.<br>CO2. recognize the concept of the Nonlinear Differential Equations<br>CO3. analyze the fixed point and periodic point of the Discrete Dynamical System.<br>CO4. analyze the invariant structures of the continuous dynamical system.<br>CO5. do simple analysis to the mathematical models which are use the nonlinear differential equations and difference equations. |
| Content | Topics :<br>**a.** Discrete Dynamical Systems : History and Definition of Discrete Dynamical Systems, Orbits, Graphical Analysis, Fixed Point, Fixed point and periodic points, Fixed point and periodic points, Bifurcations, Dynamics of quadratic maps' family $Q_c(x)=x^2 + c$.<br>b. Continuous Dynamical System : Linear and Nonlinear Differential Equations, Definition of the Dynamical System and examples, Invariant structures (equilibrium points, periodic solution, and invariant manifold), Linearization and Stability of the equilibrium point, First Integral and Lyapunov Function, Poincare Map (introduction). |
| Study and examination requirements and forms of examination | The final mark will be weighted as follows:<br><table><tr><td>No</td><td>Assessment methods (components, activities)</td><td>Weight (percentage)</td></tr><tr><td>1</td><td>Final Examination</td><td>40%</td></tr><tr><td>2</td><td>Mid-Term Examination</td><td>30%</td></tr></table> |

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| | 3        Class Activities: Quiz, Homework, etc                          30% | |
| | The initial cut-off points for grades A, B, C, and D should not be less than 80%, 70%, 50%, and 40%, respectively. | |
| Media employed | White/Black Board, LCD Projector, Laptop/Computer | |
| Reading List | 1. Robert L. Devaney, 2018, *A first course in chaotic dynamical systems*, CRC Press Taylor and Francis Group.<br>2. Stephen Wiggins, 2003, *Introduction to Applied Nonlinear Dynamical Systems and Chaos, 2nd Ed*, Springer-Verlag New York, Inc.<br>3. Lawrence Perko, 2001, *Differential Equations and Dynamical System*, 3rd Ed, Springer.<br>4. Verhulst, F., 1996, *Nonlinear Differential Equations and Dynamical Systems*, 2nd Ed., Springer-Verlag Berlin Heidelberg. | |

## PLO and CO Mapping

| | LO 1 | LO 2 | LO 3 | LO 4 | LO 5 | LO 6 | LO 7 | LO 8 | LO 9 |
|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | | | | | | v | | | v |
| **CO 2** | | | | | | v | | | v |
| **CO 3** | | | | | v | v | | | |
| **CO 4** | | | | | v | v | | | v |
| **CO 5** | | | | | v | | | | v |