# Module Description/Course Syllabi

Study Programme: Master of Mathematics
Faculty of Mathematics and Natural Sciences
Universitas Andalas

**1. *Course number and name***

MAT81241 Dynamic Optimization

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

3 sks / 4,53 ECTS

**3. *Instructors and course coordinator***

1. Prof. Dr. Muhafzan

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

1. Friesz, T. L., 2010, Dynamic Optimization and Differential Games, Springer, New York.
2. Lewis, F. L., Vrabie, D. L., Syrmos, V. L., 2012, Optimal Control, third edition, Wiley, New Jersey

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

S. P. Sethi, Optimal Control Theory: Applications to Management Science and Economics, 4th Edition, Springer, Switzerland, 2021.

**6. *Specific course information***

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

This course introduces the dynamic optimization problem for both continuous time system and discrete time system. Lecture begins by introducing the concept of variational calculus for both continuous time system and discrete time system. The existence solution of the dynamic optimization problem is analyzed. Then the

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|---|
| lecture on discrete linear quadratic regulator problem and the tracking problem is considered as well.<br><br>This course is equipped with self-study activities through practice problems, discussion/review of material, and other forms of learning. Furthermore, to meet the demands of global developments in the mastery of technology for a master of mathematics, participants of this course are also equipped with the skills to use Matlab software related to the dynamic optimization. |
| |
| ***B. Prerequisites or co-requisites*** |
| - |
| |
| ***C. Indicate whether a required or elective course in the program*** |
| Elective |
| |
| ***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)*** |
| 2nd year |
| |
| ***F. Semester when the course unit is delivered*** |
| Odd Semester |
| |
| ***G. Mode of delivery (face-to-face, distance learning)*** |
| Face to face |
| |

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| **7. *Intended Learning Outcomes*** |

ILO-1: Possesses a good ethics and integrity
PI-1: Possess academic ethics
PI-2: Demonstrate academic integrity
ILO-3: Comprehensive mastery of one or several theories for development in the fields of analysis, algebra, applied mathematics, statistics and combinatorial mathematics
PI-2: Able to identify complex mathematical problems
PI-3: Able to solve complex 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 analyse research problems.
PI-4: Able to use various 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 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 in an academic manner

**8. *Course Learning Outcomes***

1. Students are familiar with dynamic optimization system problems (both continuous and discrete) on various real phenomena
2. Students master the theoretical aspects related to dynamic optimization (both continuous and discrete)
3. Students are able to solve the dynamic optimization problems using various appropriate methods
4. Students are able to analyze and interpret the optimal solution of dynamic optimization problems
5. Students are able to use Matlab software to solve several dynamic optimization problems

| **9. *Brief list of topics to be covered*** |
| --- |
| Variational calculus for continuous time system, dynamic optimization for continuous time system, variational calculus for discrete time system, dynamic optimization for discrete time system, discrete linear quadratic regulator problem, the tracking problem. |
| |
| ***10. Learning and teaching methods*** |
| Directed Learning, Teacher Centered Learning |
| |
| ***11. Language of instruction*** |
| Indonesia and English |
| |

| ***12. Assessment methods and criteria*** |
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| **Summative Assessment** :<br>1. Mid-term exam: 40%<br>2. Final exam: 40%<br>3. Assignment (home work): 20% |

# SEMESTER STUDY PLAN

# DYNAMIC OPTIMIZATION / MAT81241

# (ELECTIVE COURSE)


**DEPARTMENT OF MATHEMATICS AND DATA SCIENCE**

**FACULTY OF MATHEMATICS AND NATURAL SCIENCES**

**UNIVERSITAS ANDALAS**


**2024**

**SEMESTER STUDY PLAN (SSP)**
**BACHELOR PROGRAM OF MATHEMATICS**
**FACULTY OF MATHEMATICS AND NATURAL SCIENCES**
**UNIVERSITAS ANDALAS**

| Course Name | Course Code | URL *I-Learn* | Credits | Semester | Compilation Date |
|---|---|---|---|---|---|
| Dynamic Optimization | MAT81241 | https://sci.ilearn.unand.ac.id | 3 | 3 | 5 May 2024 |

| Person In Charge | Study Plan Creator | Head of Research Group | Head of Study Program |
|---|---|---|---|
| | Prof. Dr. Muhafzan | Dr. Ahmad Iqbal Baqi | Prof. Dr. Ferra Yanuar |

**Intended Learning Outcomes (ILO) and Performance Indicator (PI)**

| Intended Learning Outcomes | |
|---|---|
| **ILO-1** | Possesses a good ethics and integrity<br>PI-1: Possess academic ethics<br>PI-2: Demonstrate academic integrity. |
| **ILO-3** | Comprehensive mastery of one or several theories for development in the fields of analysis, algebra, applied mathematics, statistics and combinatorial mathematics<br>PI-2: Able to identify complex mathematical problems<br>PI-3: Able to solve complex mathematical problems |
| **ILO-4** | Mastering scientific techniques and developing them in solving research problems through multidisciplinary or interdisciplinary approaches<br>PI-1: Able to apply mathematical techniques in research problem-solving.<br>PI-2: Able to analyse research problems.<br>PI-4: Able to use various 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 by developing the latest issues independently or collaboratively and communicating them academically.<br>PI-1: Capable of formally and correctly proving mathematical statements.<br>PI-2: Able to employ relevant techniques for conducting research.<br>PI-3: Capable of communicating research findings in an academic manner |
| **Course Learning Outcomes** | |
| 1 | Students are familiar with dynamic optimization system problems (both continuous and discrete) on various real phenomena (**ILO-1**: **ILO-3**: **ILO-4**) |
| 2 | Students master the theoretical aspects related to dynamic optimization (both continuous and discrete) (**ILO-3**: **ILO-4; ILO-5**) |
| 3 | Students are able to solve the dynamic optimization problems using various appropriate methods: (**ILO-3**: **ILO-4; ILO-5**) |

<table>
<tr><td></td><td>4</td><td>Students are able to analyze and interpret the optimal solution of dynamic optimization problems. ( ILO-3: ILO-4; ILO-5)</td></tr>
<tr><td></td><td>5</td><td>Students are able to use Matlab software to solve several dynamic optimization problems (ILO-3: ILO-4; ILO-5)</td></tr>
<tr><td>Brief Description</td><td colspan="2">This course introduces the dynamic optimization problem for both continuous time system and discrete time system. Lecture begins by introducing the concept of variational calculus for both continuous time system and discrete time system. The existence solution of the dynamic optimization problem is analyzed. Then the lecture on discrete linear quadratic regulator problem and the tracking problem is considered as well.<br><br>This course is equipped with self-study activities through practice problems, discussion/review of material, and other forms of learning. Furthermore, to meet the demands of global developments in the mastery of technology for a master of mathematics, participants of this course are also equipped with the skills to use Matlab software related to the dynamic optimization.</td></tr>
<tr><td>Course Materials</td><td colspan="2">1. Variational calculus for continuous time system<br>2. Dynamic optimization for continuous time system<br>3. Variational calculus for discrete time system<br>4. Dynamic optimization for discrete time system<br>5. Discrete linear quadratic regulator problem<br>6. The tracking problem</td></tr>
<tr><td>References</td><td colspan="2">Main:<br>[1]. Friesz, T. L., 2010, Dynamic Optimization and Differential Games, Springer, New York<br>Additional:<br>[2]. Lewis, F. L., Vrabie, D. L., Syrmos, V. L., 2012, Optimal Control, third edition, Wiley, New Jersey</td></tr>
<tr><td>Learning Media</td><td>Software:<br>• LMS Unand (http://fmipa.ilearn.unand.ac.id/)<br>• Zoom meeting<br>• Whatsapp</td><td>Hardware:<br>• Computer/Laptop<br>• Smartphone</td></tr>
<tr><td>Team Teaching</td><td colspan="2">1. Prof. Dr. Muhafzan</td></tr>
<tr><td>Assessment</td><td colspan="2">Homework(assignment), Mid-Term exam, Final exam</td></tr>
<tr><td>Required courses</td><td colspan="2">-</td></tr>
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**Weekly Study Plan**

| Week / Meet (1) | Course Outcomes (2) | Indicator (3) | Assessment (4) | Activities/Forms of Learning [Time estimated] | | | | | Subject, references (10) | Weight (11) |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Synchronus* | | Asynchronus** | | Media (9) | | |
| | | | | Face to face Offline (5) | Face to face Online (6) | Individual (7) | Collaboration (8) | | | |
| 1-2 | **CLO-1**<br>Students are familiar with dynamic optimization system problems (both continuous and discrete) on various real phenomena | • Discipline in implementing the lecture contract<br>• Accuracy in understanding related material<br>• Accuracy in answering assignment questions<br>• Neatness of assignment work<br>• Originality of assignment results | Assignment : 3%<br>Mid term: 7% | Teaching and discussion:<br>- Explanation of Semester Learning Plan<br>- explanation of learning material<br>- explanation of the task<br>- explanation of the assessment<br>[2 × 3 × 50 minutes] | Teaching and discussion:<br>- Explanation of Semester Learning Plan<br>- explanation of learning material<br>- explanation of the task<br>- explanation of the assessment<br>2 × 3 × 50 minutes] | • Students read and study learning materials<br>• Students do assignments independently [2× 3 × 60 minutes] | | • PPT<br>• I learn (LMS Unand)<br>(Specific condition: Zoom meeting, WA group, learning video) | • Assessment Rules, SSP, Course Contract<br>• Variational calculus for continuous time system<br>[1] | 10% |
| 3-4 | **CLO-2**<br>Students master the theoretical aspects related to dynamic optimization (both continuous and discrete)<br><br>**CLO-3**<br>Students are able to solve the dynamic | • Accuracy in understanding related material<br>• Accuracy in answering assignment questions<br>• Neatness of assignment work<br>• Originality of assignment results | Assignment : 5%<br>Mid term: 15% | • Lecture:<br>- explanation of concepts<br>- discussion, question and answer of lecture material<br>[2 × 3 × 50 minutes] | • Lecture:<br>- explanation of concepts<br>- discussion, question and answer of lecture material<br>[2 × 3 × 50 minutes] | • Students read and study learning materials<br>• Students do assignments independently [2× 3 × 60 minutes] | | • PPT<br>• I learn (LMS Unand)<br>• (Specific condition: Zoom meeting, WA group, learning video) | Dynamic optimization for continuous time system<br>[1] | 20% |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | optimization problems using various appropriate methods | | | | | | | | | |
| 5-7 | **CLO-3**<br>Students are able to solve the dynamic optimization problems using various appropriate methods<br><br>**CLO-5**<br>Students are able to use Matlab software to solve several dynamic optimization problems | • Accuracy in understanding related material<br>• Accuracy in answering assignment questions<br>• Neatness of assignment work<br>• Originality of assignment results | Assignment : 5%<br>Mid term: 15% | • Lecture:<br>- explanation of concepts<br>- discussion, question and answer of lecture material<br>[3 × 3 × 50 minutes] | • Lecture:<br>- explanation of concepts<br>- discussion, question and answer of lecture material<br>[3 × 3 × 50 minutes] | • Students read and study learning materials<br>• Students do assignments independently [3× 3 × 60 minutes] | | • PPT<br>• I learn (LMS Unand)<br><br>• (Specific condition: Zoom meeting, WA group, learning video) | • Dynamic optimization for continuous time system<br>• Variational calculus for discrete time system<br><br>[1, 2] | 20% |
| **8-9** | **MID-TERM EXAM** | | | | | | | | | |
| 10-11 | **CLO-3**<br>Students are able to solve the dynamic optimization problems using various appropriate methods<br><br>**CLO-5**<br>Students are able to use Matlab software to solve several dynamic optimization problems | • Accuracy in understanding related material<br>• Accuracy in answering assignment questions<br>• Neatness of assignment work<br>• Originality of assignment results | Assignment : 3%<br>Final term: 7% | • Lecture:<br>- explanation of concepts<br>- discussion, question and answer of lecture material<br>[2 × 3 × 50 minutes] | • Lecture:<br>- explanation of concepts<br>- discussion, question and answer of lecture material<br>[2 × 3 × 60 minutes] | • Students read and study learning materials<br>• Students do assignments independently [2× 3 × 60 minutes] | | • PPT<br>• I learn (LMS Unand)<br><br>• (Specific condition: Zoom meeting, WA group, learning video) | Dynamic optimization for discrete time system<br><br>[1, 2] | 10% |

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|---|---|---|---|---|---|---|---|---|---|---|
| 12-13 | **CLO-3**<br>Students are able to solve the dynamic optimization problems using various appropriate methods<br><br>**CLO -4**<br>Students are able to analyze and interpret the optimal solution of dynamic optimization problems | • Accuracy in understanding related material<br>• Accuracy in answering assignment questions<br>• Neatness of assignment work<br>• Originality of assignment results | Assignment : 5%<br>Final term: 15% | • Lecture:<br>- explanation of concepts<br>- discussion, question and answer of lecture material<br>[2 × 3 × 50 minutes] | • Lecture:<br>- explanation of concepts<br>- discussion, question and answer of lecture material<br>[2 × 3 × 50 minutes] | • Students read and study learning materials<br>• Students do assignments independently [2× 3 × 60 minutes]<br>- | | • PPT<br>• I learn (LMS Unand)<br><br>• (Specific condition: Zoom meeting, WA group, learning video) | Discrete linear quadratic regulator problem<br>[1, 2] | 20% |
| 14-16 | **CLO-3**<br>Students are able to solve the dynamic optimization problems using various appropriate methods<br><br>**CLO -4**<br>Students are able to analyze and interpret the optimal solution of dynamic optimization problems | • Accuracy in understanding related material<br>• Accuracy in answering assignment questions<br>• Neatness of assignment work<br>• Originality of assignment results | Assignment : 5%<br>Final term: 15% | - Presentation project by students<br><br>[3 × 3 × 50 minutes] | • Lecture:<br>- explanation of concepts<br>- discussion, question and answer of lecture material<br>[3 × 3 × 50 minutes] | • Students read and study learning materials<br>• Students do assignments independently [3× 3 × 60 minutes] | Students present the project outcomes<br><br>[3 × 3 × 60 minutes] | • PPT<br>• I learn (LMS Unand)<br><br>Specific condition: Zoom meeting, WA group, learning video) | The tracking problem<br>[1, 3] | 20% |
| | | | | | | | | | **Total Weight** | 100% |
| **17-18** | **FINAL EXAM** | | | | | | | | | |

1 credit = 50 minutes face-to-face meeting, 60 minutes structured study, 60 minutes independent study

Each meeting duration is 2 credits = 2×50 minutes

**Indicators, Criteria, and Assessment Weights**

1. Assessment weight for each Assessment

| NO | Assessment | Weight (%) |
|---|---|---|
| 1 | Mid-Term Exam | 40 |
| 2 | Final Exam | 40 |
| 3 | Assignment (Homework) | 20 |
| **TOTAL** | | **100** |

2. Assessment weight for Intended Learning Outcome
   - CLO-1: 10 %
   - CLO-2: 25 %
   - CLO-3: 25 %
   - CLO- 4: 20 %
   - CLO-5: 20 %

**Assessment Plan Table:**

| No. | CLO | Assessment | | | Weigth (%) |
|---|---|---|---|---|---|
| | | Homework (%) | Mid-Term Exam (%) | Final Exam (%) | |
| 1 | Students are familiar with dynamic optimization system problems (both continuous and discrete) on various real phenomena (**ILO-1**: **ILO-3**: **ILO-4**) | 2 | 4 | 4 | 10 |
| 2 | Students master the theoretical aspects related to dynamic optimization (both continuous and discrete) (**ILO-3**: **ILO-4; ILO-5**) | 5 | 10 | 10 | 25 |
| 3 | Students are able to solve the dynamic optimization problems using various appropriate methods: (**ILO-3**: **ILO-4; ILO-5**) | 5 | 10 | 10 | 25 |
| 4 | Students are able to analyze and interpret the optimal solution of dynamic optimization problems. ( **ILO-3**: **ILO-4; ILO-5**) | 4 | 8 | 8 | 20 |
| 5 | Students are able to use Matlab software to solve several dynamic optimization problems (**ILO-3**: **ILO-4; ILO-5**) | 4 | 8 | 8 | 20 |
| **Total** | | **20** | **40** | **40** | **100** |