

| MM 552 Nonlinear Systems          |                                                                                                                                                                                                                                                                                                                                                                   |        |      | MECHANICAL ENGINEERING DEPARTMENT |                     |       |                |         |             |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|------|-----------------------------------|---------------------|-------|----------------|---------|-------------|
| Semester                          | Methods of Education                                                                                                                                                                                                                                                                                                                                              |        |      |                                   |                     |       |                | Credits |             |
|                                   | Lecture                                                                                                                                                                                                                                                                                                                                                           | Recit. | Lab. | Project/Field Study               | Homework            | Other | Total          | Credit  | ECTS credit |
| 1,2                               | 30                                                                                                                                                                                                                                                                                                                                                                | 12     |      |                                   |                     | 146   | 188            | 3       | 7.5         |
| Language                          | Turkish                                                                                                                                                                                                                                                                                                                                                           |        |      |                                   |                     |       |                |         |             |
| Compulsory / Elective             | Optional                                                                                                                                                                                                                                                                                                                                                          |        |      |                                   |                     |       |                |         |             |
| Prerequisites                     | -                                                                                                                                                                                                                                                                                                                                                                 |        |      |                                   |                     |       |                |         |             |
| Course Contents                   | Introduction to nonlinear systems. Phase plane analysis. Limit cycle analysis. Piecewise linearization. Series approximation methods. Poincare perturbation method. Krylow and Bogoliubov methods. Stability of non-linear systems. Liapunov theory. Nonlinear system synthesis. The use of nonlinear elements to improve system response, cost, and reliability. |        |      |                                   |                     |       |                |         |             |
| Course Objectives                 | To analyze behavior and stability of nonlinear systems and then to use the results in order to design engineering systems in a safely manner.                                                                                                                                                                                                                     |        |      |                                   |                     |       |                |         |             |
| Learning Outcomes and Competences | Understanding the nonlinear systems. Importance of stability and analyzing the nonlinear system in terms of stability. Nonlinear structures in engineering systems and effect of nonlinear components on the performance of engineering systems.                                                                                                                  |        |      |                                   |                     |       |                |         |             |
| Textbook and /or Reference        | 1. Khalil, Hassan, K., (1996). Nonlinear Systems. New Jersey: Prentice Hall.<br>2. Slotine, J.J.E., Li, W., (1993) Applied Nonlinear Control, New Jersey: Prentice Hall.                                                                                                                                                                                          |        |      |                                   |                     |       |                |         |             |
| Assessment Criteria               |                                                                                                                                                                                                                                                                                                                                                                   |        |      |                                   | If any, mark as (X) |       | Percentage (%) |         |             |
|                                   | Midterm Exams                                                                                                                                                                                                                                                                                                                                                     |        |      |                                   | X                   |       | 40             |         |             |
|                                   | Quizzes                                                                                                                                                                                                                                                                                                                                                           |        |      |                                   |                     |       |                |         |             |
|                                   | Homeworks                                                                                                                                                                                                                                                                                                                                                         |        |      |                                   |                     |       |                |         |             |
|                                   | Projects                                                                                                                                                                                                                                                                                                                                                          |        |      |                                   |                     |       |                |         |             |
|                                   | Term Paper                                                                                                                                                                                                                                                                                                                                                        |        |      |                                   |                     |       |                |         |             |
|                                   | Laboratory Work                                                                                                                                                                                                                                                                                                                                                   |        |      |                                   |                     |       |                |         |             |
|                                   | Other                                                                                                                                                                                                                                                                                                                                                             |        |      |                                   |                     |       |                |         |             |
|                                   | Final Exam                                                                                                                                                                                                                                                                                                                                                        |        |      |                                   | X                   |       | 60             |         |             |
| Instructors                       | Assoc. Prof. Metin U. SALAMCI                                                                                                                                                                                                                                                                                                                                     |        |      |                                   |                     |       |                |         |             |
| Week                              | Subject                                                                                                                                                                                                                                                                                                                                                           |        |      |                                   |                     |       |                |         |             |
| 1                                 | Introduction to nonlinear systems; Second Order Systems.                                                                                                                                                                                                                                                                                                          |        |      |                                   |                     |       |                |         |             |
| 2                                 | Linearisation. Linear vs. Nonlinear Systems.                                                                                                                                                                                                                                                                                                                      |        |      |                                   |                     |       |                |         |             |
| 3                                 | Phase plane analysis.                                                                                                                                                                                                                                                                                                                                             |        |      |                                   |                     |       |                |         |             |
| 4                                 | Phase plane analysis                                                                                                                                                                                                                                                                                                                                              |        |      |                                   |                     |       |                |         |             |
| 5                                 | Limit Cycle Teorems; Poincare-Bendixson Teorems.                                                                                                                                                                                                                                                                                                                  |        |      |                                   |                     |       |                |         |             |
| 6                                 | Limit cycle analysis.                                                                                                                                                                                                                                                                                                                                             |        |      |                                   |                     |       |                |         |             |
| 7                                 | Series approximation methods. Poincare perturbation method.                                                                                                                                                                                                                                                                                                       |        |      |                                   |                     |       |                |         |             |
| 8                                 | Krylow and Bogoliubov methods.                                                                                                                                                                                                                                                                                                                                    |        |      |                                   |                     |       |                |         |             |
| 9                                 | Stability of nonlinear systems.                                                                                                                                                                                                                                                                                                                                   |        |      |                                   |                     |       |                |         |             |
| 10                                | Lyapunov Method.                                                                                                                                                                                                                                                                                                                                                  |        |      |                                   |                     |       |                |         |             |
| 11                                | Lyapunov Method.                                                                                                                                                                                                                                                                                                                                                  |        |      |                                   |                     |       |                |         |             |
| 12                                | Lyapunov Method.                                                                                                                                                                                                                                                                                                                                                  |        |      |                                   |                     |       |                |         |             |
| 13                                | Frequency response of nonlinear systems.                                                                                                                                                                                                                                                                                                                          |        |      |                                   |                     |       |                |         |             |
| 14                                | Describing Function Analysis.                                                                                                                                                                                                                                                                                                                                     |        |      |                                   |                     |       |                |         |             |