**Course Title**: Introduction to Energy Management

<table>
<thead>
<tr>
<th>Semester*</th>
<th>Code</th>
<th>Program**</th>
<th>No of hours per week: lectures + exercises</th>
<th>Total</th>
<th>ECTS credits</th>
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<tr>
<td>5</td>
<td>18669</td>
<td>ME</td>
<td>2 + 1</td>
<td>3</td>
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</tbody>
</table>

**Lecturer**: Neven, Dučić

**Course objective:**
Familiarising with the energy resources situation in the World, Europe and Croatia; enabling rational thinking and decision making on energy planning and energy policy; application of basic economic methods for financial evaluation of energy projects.

**Prerequisite:**

**Learning outcomes:**
Understanding energy and environment interaction, primary energy production, reserves and consumption, energy transformations including renewable energy technologies. Ability to apply economic and financial evaluation of energy projects. Understanding the concept of sustainable development. Understanding how to improved energy efficiency in industry, building sector, transport. Basics of energy system planning, energy policy, energy markets, energy sector restructuring.

**Course contents**

<table>
<thead>
<tr>
<th>Lecture/Topic:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Energy after Kyoto: intro discussion, lecture: Energy after Kyoto</td>
</tr>
<tr>
<td>2. Energy transformations: intro discussion, lecture: Energy transformations</td>
</tr>
<tr>
<td>3. Economy and financial evaluation of energy projects: intro discussion, lecture: Economy and financial evaluation of energy projects</td>
</tr>
<tr>
<td>4. Primary energy overview: intro discussion, lecture: Production, reserves and consumption of the primary energy-generating products</td>
</tr>
<tr>
<td>5. Sustainable development of energy: lecture: Sustainable development of energy, discussion</td>
</tr>
<tr>
<td>6. Energy efficiency: intro discussion, lecture: Overview of rationalisation mechanisms of energy use in industry</td>
</tr>
<tr>
<td>8. Energy system planning: lecture: Energy system planning</td>
</tr>
<tr>
<td>9. Context of Energy politics: lecture: Croatia as transition country, from non-aligned to euroatlantic integrations</td>
</tr>
<tr>
<td>11. Renewable energy sources: intro discussion - renewable energy sources status - independent work (grouping into two groups), lecture: renewable energy sources - economic aspects</td>
</tr>
</tbody>
</table>

**Recommended literature:**

**Type of exercises:**
- x auditory; | laboratory; | x practicum; | design; | other

**Examination:**
- x final exam; | x continuous testing; | x other

**Language**
- Croatian / English

**Tutorials in English for incoming students**
- YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
### Course Title: Energy Markets

<table>
<thead>
<tr>
<th>Semester*</th>
<th>Code</th>
<th>Program**</th>
<th>No of hours per week: lectures + exercises</th>
<th>Total</th>
<th>ECTS credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>18602</td>
<td>ME</td>
<td>2 + 1</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

**Lecturer:** Neven, Dušić; Željko, Bogdan; Ante, Ćurković; Dražen, Lončar

### Course objective:

### Prerequisite:

### Learning outcomes:
Understanding energy and emissions markets and their influence on energy system. Knowledge of market playing.

### Course contents

#### Lecture/Topic:


9. Regional integration. SEE REM.

10. District heating market. Cogeneration plants operation in deregulated energy market.


12. Emission (SOx, NOx, CO2) markets and its influence on energy markets.

13. 

14. 

15. 

### Recommended literature:
2. L. L. Lai (Editor) Power System Restructuring and Deregulation, John Wiley & Sons, 2001

### Type of exercises:
- [x] auditory; [ ] laboratory; [x] practicum; [ ] design; [ ] other

### Examination:
- [x] final exam; [ ] continuous testing; [x] other

### Language
- Croatian

** Tutorials in English for incoming students **YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
# Energy Management

<table>
<thead>
<tr>
<th>Course Title</th>
<th>Energy Management</th>
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</thead>
<tbody>
<tr>
<td><strong>Semester</strong></td>
<td><strong>Code</strong></td>
</tr>
<tr>
<td>10</td>
<td>39941</td>
</tr>
</tbody>
</table>

**Lecturer:** Neven, Dujić

**Course objective:**
Familiarizing with management, especially with management in energy sector engineering. Fundamentals of product strategy management. Studying methods of energy accounting and energy auditing in energy sector, industry and final consumption. Finding opportunities to increase the rational use of energy.

**Prerequisite:** Introduction to Energy Management, Thermal Power Plants, Thermal engineering (HVAC)

**Learning outcomes:**
Understanding basics of demand side management and mechanisms (technical, legal or financial) that influence energy consumption. Recognizing opportunities for increasing rational use of energy. Learning the basics of energy auditing with application on different sectors.

## Course contents

### Lecture/Topic:

1. Introduction in management. Organization, human resources, production, energy engineering.
2. Drivers, planning, organising and monitoring. Strategy management.
4. Identification, evaluation and implementation of energy conservation measures.
5. Monitoring, evaluation of implemented conservation measures.
6. Energy conservation in power plants.
7. Energy conservation in industry.
8. Energy conservation in final consumption I.
9. Energy conservation in final consumption II.
12. 
13. 
14. 
15. 

### Recommended literature:


### Type of exercises:

- x auditory; 
- laboratory; 
- x practicum; 
- design; 
- x other

### Examination:

- final exam; 
- x continuous testing; 
- x other

### Language:

Croatian

### Tutorials in English for incoming students

YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
Course Title: Energy Economics

<table>
<thead>
<tr>
<th>Semester*</th>
<th>Code</th>
<th>Program**</th>
<th>No of hours per week: lectures + exercises</th>
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<td>ME</td>
<td>2 + 1</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Lecturer: Neven, Duić

Course objective:
Studying methods of investment evaluation in energy sector, methods for energy production cost calculation and energy pricing methodology.

Prerequisite: Introduction to Energy Management, Steam Generators, Thermal Power Plants

Learning outcomes:
Understanding of economic and ability to apply economic and financial evaluation of energy projects. Learning the basics of cost calculation for electricity and heat production from CHP and power plants

Course contents

<table>
<thead>
<tr>
<th>Lecture/Topic:</th>
</tr>
</thead>
<tbody>
<tr>
<td>7. Tariff systems. Electricity production costs in different conversion systems. Internal and external costs. Energy costs. Fixed and variable costs.</td>
</tr>
<tr>
<td>8. Colloquium II</td>
</tr>
<tr>
<td>9. Electricity and heat production cost calculation methodology I.</td>
</tr>
<tr>
<td>10. Electricity and heat production cost calculation methodology II.</td>
</tr>
<tr>
<td>11. Electricity and heat production cost calculation methodology III.</td>
</tr>
<tr>
<td>12. Energy production cost calculation methodology IV.</td>
</tr>
<tr>
<td>13.</td>
</tr>
<tr>
<td>14.</td>
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<td>15.</td>
</tr>
</tbody>
</table>

Recommended literature:

Type of exercises: x auditory; laboratory; x practicum; design; other

Examination: x final exam; x continuous testing; other

Language: Croatian

Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
Course Title: Energy Planning

<table>
<thead>
<tr>
<th>Semester*</th>
<th>Code</th>
<th>Program**</th>
<th>No of hours per week: lectures + exercises</th>
<th>Total</th>
<th>ECTS credits</th>
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<tbody>
<tr>
<td>8, 10</td>
<td>18600</td>
<td>E ME</td>
<td>2 + 1</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Lecturer: Neven, Duić

Course objective:
The aim is to qualify students for energy systems planning based on modelling of energy demand and supply while taking into account all available resources and technologies and all economic, environmental and social aspects of their use. The course will prepare students for energy strategic thinking and planning.

Prerequisite: Introduction to Energy Management, Thermal Power Plants, Energy Economics, Thermal engineering, Environmental Protection, Process Dynamics

Learning outcomes:
Understanding of energy planning process. Introduction to energy planning methodologies, tools and software and ability to use them. Development of skills for analysis of all important aspects of energy system.

Course contents

<table>
<thead>
<tr>
<th>Lecture/Topic:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Introduction. The need for energy planning.</td>
</tr>
<tr>
<td>3. Characterisation of present situation II. Bottom up approach.</td>
</tr>
<tr>
<td>4. Demographic scenario.</td>
</tr>
<tr>
<td>8. Energy planning tools</td>
</tr>
</tbody>
</table>

Recommended literature:
4. Duić, Neven; Carvalho, Maria Graça. Increasing renewable energy sources in island energy supply: case study Porto Santo. Renewable Energy Reviews, (8), 2004
5. Henrik Lund; Renewable Energy Systems-The Choice and Modeling of 100% Renewable Solutions, Academic Press

Type of exercises: x auditory; laboratory; x practicum; design; other

Examination: x final exam; continuous testing; other

Language: Croatian

Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
Course Title: Combustion and radiation modelling

Semester*: Code  Program**  No of hours per week: lectures + exercises  Total  ECTS credits
8, 10  18762  ME  2 + 2  4  5

Lecturer: Željko Bogdan; Neven Duić; Daniel Rolph Schneider;

Course objective:
Introduction to processes of combustion and heat radiation, and methods for their calculations inside furnaces, boilers and combustion chambers. The objective is to provide the required foundation for students involved in research on any aspect of reacting flow, combustion and radiation, to be familiar with mathematical modelling and numerical simulations, which then can serve as guidance toward greater understanding of combustion and radiation processes that is required for producing combustion devices with ever higher efficiency and with lower pollutant emissions.

Prerequisite: Thermodynamics; Fluid Dynamics

Learning outcomes:
A complete understanding of the concepts underlying combustion and heat radiation processes in practical application such as furnace, boilers, and other combustion chambers. Basics of the combustion and heat radiation mathematical modelling and numerical simulation. Knowledge of the physical processes (fluid dynamics, heat and mass transfer) and chemical processes (thermodynamics and chemical kinetics) involved in combustion.

Course contents

<table>
<thead>
<tr>
<th>Lecture/Topic:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Combustion statics</td>
</tr>
<tr>
<td>2. Combustion dynamics</td>
</tr>
<tr>
<td>3. Fuel gas combustion</td>
</tr>
<tr>
<td>4. Fuel liquid combustion</td>
</tr>
<tr>
<td>5. Pulverized coal combustion</td>
</tr>
<tr>
<td>6. Production of pollutants: CO2, SOx, NOx, soot and particles</td>
</tr>
<tr>
<td>7. Radiation intensity distribution</td>
</tr>
<tr>
<td>8. Diffusion and flux models of radiation</td>
</tr>
<tr>
<td>10. Discrete radiation model, optical characteristics of media</td>
</tr>
<tr>
<td>11. Temperature calculations: mean gas temperature, gas temperature fluctuations, mean particle temperature</td>
</tr>
<tr>
<td>13. Numerical methods</td>
</tr>
</tbody>
</table>

Recommended literature:
2. Kuo, K.K., Principles of Combustion, John Wiley & Sons, New York, 1986,

Type of exercises: x auditory; laboratory; x practicum; design; other
Examination: x final exam; x continuous testing; x other
Language: Croatian/English

Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
Course Title: Numerical Methods in Aerospace Engineering II

<table>
<thead>
<tr>
<th>Semester*</th>
<th>Code</th>
<th>Program**</th>
<th>No of hours per week: lectures + exercises</th>
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<tr>
<td>8, 10</td>
<td>18629</td>
<td>AE</td>
<td>2 + 1</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

Lecturer: Neven, Ducić

Course objective:
The aim of the course is to provide a fundamental understanding of the physical modelling, numerical discretization and solver technology in Computational Fluid Dynamics (CFD), applied to the analysis and design of modern engineering devices and systems. The course covers problem setup and simulation stages, analysis and interpretation of numerical results and their limitations.

Prerequisite:
Continuum Mechanics

Learning outcomes:
Understanding of Computational Fluid Dynamics (CFD) from physical modelling of the flow processes for aeronautical applications to numerical techniques and the simulation process for the solution of governing equations. Understanding of all stages that are required to produce the results of the numerical simulation, including analysis of physical problem, geometry modelling, mesh generation, flow specification, numerical parameter specification, calculation of the numerical solution, and results analysis and their limitations.

Course contents

Lecture/Topic:
1. Introduction - overview of numerical methods
2. Flow fields; classification of flows
3. Conservation laws of fluid motions
4. Discretization of the flow domain - mesh types and mesh generation techniques
5. Workshop mesh generation
6. The Finite Volume Method
7. Differencing schemes and their properties
8. Implicit and explicit solution methods, segregated and coupled approach.
9. Linear equation solver technology. Direct and iterative solver characteristics and matrix requirements.
11. Introduction to turbulence and turbulence modelling
12. Workshop – simple numerical simulation of fluid flow
13. Advanced topics: Large Eddy Simulation (LES), fluid-solid interaction
14. Workshop - numerical simulation on a geometry of aeronautical interest
15. 

Recommended literature:

Type of exercises:
- [ ] auditory;
- [ ] laboratory;
- [X] practicum;
- [ ] design;
- [ ] other

Examination:
- [X] final exam;
- [ ] continuous testing;
- [ ] other

Language:
- Croatian/English

Tutorials in English for incoming students:
- YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
Course Title: Numerical Methods in Continuum Mechanics

Semester* | Code | Program** | No of hours per week: lectures + exercises | Total | ECTS credits
--- | --- | --- | --- | --- | ---
8, 10 | 18628 | ME | 2 + 1 | 3 | 4

Lecturer: Neven, Dušić, Hrvoje, Jasak

Course objective:
The aim of the course is to provide a fundamental understanding of the physical modelling, numerical discretization and solver technology in Computational Fluid Dynamics (CFD), applied to the analysis and design of modern engineering devices and systems. The course covers problem setup and simulation stages, analysis and interpretation of numerical results and their limitations.

Prerequisite: Continuum Mechanics

Learning outcomes:
Understanding of Computational Fluid Dynamics (CFD) from physical modelling of the flow processes in modern engineering devices to numerical techniques and the simulation process for the solution of governing equations. Understanding of all stages that are required to produce the results of the numerical simulation, including analysis of physical problem, geometry modelling, mesh generation, flow specification, numerical parameter specification, calculation of the numerical solution, and results analysis and their limitations.

Course contents

Lecture/Topic:
1. Introduction - overview of numerical methods
2. Flow fields; classification of flows
3. Conservation laws of fluid motions
4. Discretization of the flow domain - mesh types and mesh generation techniques
5. Workshop - mesh generation
6. The Finite Volume Method
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11. Introduction to turbulence and turbulence modelling
12. Workshop – simple numerical simulation of fluid flow
13. Advanced topics: Large Eddy Simulation (LES), fluid-solid interaction
14. Workshop - numerical simulation on a geometry of modern engineering devices

Recommended literature:

Type of exercises: X auditory; laboratory; X practicum; design; other
Examination: X final exam; X continuous testing; X other
Language: Croatian/English

Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
Course Title: New technologies in Energy Generation

Semester* | Code | Program** | No of hours per week: lectures + exercises | Total | ECTS credits
---|---|---|---|---|---
18459 | ME | 3 + 2 | | 5 | 5

Lecturer: Željko, Bogdan

Course objective: Introduction to new technologies for power and heat generation based on renewable energy sources

Prerequisite: Termodinamika 1

Learning outcomes:

---

Course contents

Lecture/Topic:

1. Introduction: Renewable energy sources
2. Solar energy.
3. PV cells and systems
4. Economy of solar heat and PV systems
5. Small hydro power plants
6. Wind energy
7. Environmental and Economy characteristics of wind energy utilization
8. 
9. 
10. 
11. 
12. 
13. 
14. 
15. 

Recommended literature:

Type of exercises: [ ] auditory; [ ] laboratory; [ ] practicum; [ ] design; [ ] other
Examination: [ ] final exam; [ ] continuous testing; [ ] other
Language: Croatian
Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
Course Title: Hydrogen and fuel cells

Semester*: Bachelor program: Semester 1-7, Master program: Semester 8-10
Code: 18805
Program**: ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
No of hours per week: lectures + exercises: 2 + 1
Total: 3
ECTS credits: 4

Lecturer: Željko Bogdan; Mihajlo Firak

Course objective:
Course of lectures has a goal to make students competent for application of hydrogen and fuel cells in power and transport engineering. Hydrogen production, storage and transport, fuel cell working principles and design as well as fuel cell based energy systems are considered.

Prerequisite: Termodinamika 1

Learning outcomes:

Course contents

3. Hydrogen use. PEM FC components and materials. FC stack design. Auxiliary equipment
4. Hydrogen use. PEM FC chemical thermodynamic. Gibbs’ energy and Nernst equation
5. Hydrogen use. PEM FC electrochemical kinetics. Butler-Volmer equation
7. Application. Actual examples of the stationary systems. Stationary powerstations 250 kW-2MW, UFC, SIEMENS, small home FC 2-10 kW, Plugpower, Sulzer, Vaillant. Inverters and grid connection
9. Safety aspects. Component testing, regulations and standards
12. Hydrogen use. PEM FC components and materials. FC stack design. Auxiliary equipment
13. Hydrogen use. PEM FC chemical thermodynamic. Gibbs’ energy and Nernst equation

Recommended literature:

Type of exercises:  □ auditory;  □ laboratory;  □ practicum;  □ design;  □ other
Examination:  □ final exam;  □ continuous testing;  □ other
Language: Croatian

Tutorials in English for incoming students: YES
Course Title: Process Dynamics

<table>
<thead>
<tr>
<th>Semester*</th>
<th>Code</th>
<th>Program**</th>
<th>No of hours per week: lectures + exercises</th>
<th>Total</th>
<th>ECTS credits</th>
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<tr>
<td>6</td>
<td>33982</td>
<td>ME</td>
<td>1 + 2</td>
<td>3</td>
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</tr>
</tbody>
</table>

Lecturer: Dražen, Lončar

Course objective: To make students capable of mathematical modelling and simulation of simple technical systems within the lumped parameters assumption. The course is a prerequisite for process control oriented courses.

Prerequisite: Thermodynamic I, Fluid mechanic I


Course contents

Lecture/Topic:


2. "System" as a methodological tool. Notion of dynamic system.


6. 

7. 

8. 

9. 

10. 

11. 

12. 

13. 

14. 

15. 

Recommended literature:

Šerman, N.: Uvod u regulaciju procesa, nastavni tekst dostupan na web-u
Šerman, N.: Osnove matematičkog modeliranja i simulacije dinamičkih sustava, nastavni tekst dostupan na web-u

Type of exercises: [ ] auditory; [ ] laboratory; [x] practicum; [ ] design; [ ] other

Examination: [x] final exam; [ ] continuous testing; [ ] other

Language: Croatian

Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
<table>
<thead>
<tr>
<th>Course Title</th>
<th>Process control</th>
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<td><strong>Course Title</strong></td>
<td><strong>Process control</strong></td>
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<tr>
<td><strong>Semester</strong></td>
<td><strong>Code</strong></td>
</tr>
<tr>
<td>7</td>
<td>18948</td>
</tr>
</tbody>
</table>

**Lecturer:** Dražen Lončar

**Course objective:**
The objective is to familiarize students with control engineering essentials, including basic concepts of the signals and system theory. The course is a prerequisite for the Power Systems Control course, offered to students majoring in Power Engineering.

**Prerequisite:** Process Dynamics

**Learning outcomes:**
Understanding the structures, basic components and terminology of control systems. The difference between open-loop and closed-loop control. Setting up simulation experiments of simple control systems. Defining controller structure with respect to controlled process and perform parameters tuning in order to assure required performance of the system.

**Course contents**

<table>
<thead>
<tr>
<th>Lecture/Topic</th>
<th>Lecture/Topic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Mathematical model of a linear system: state space and SISO annotation. Roots of the characteristic equation, influence to the system's transients, stability.</td>
</tr>
<tr>
<td>4.</td>
<td>Unit pulse (Dirac) and its transform. L-transform in solving linear diff. equations â€“ Heaviside expansion formulae.</td>
</tr>
<tr>
<td>5.</td>
<td>Transfer function and its graphical presentation (s-plane to H(s) plane mapping). Block algebra. Open and closed loop systems.</td>
</tr>
<tr>
<td>6.</td>
<td>Frequency response (physical meaning, transfer function approach), graphic presentation. Block algebra in frequency domain. Hall's diagram.</td>
</tr>
<tr>
<td>7.</td>
<td>Elementary linear components (equation, transfer function, frequency response and technical example for each of them): Static gain, integrator.</td>
</tr>
<tr>
<td>8.</td>
<td>Elementary linear components (cont.): 1st order lag and 2nd order oscillator.</td>
</tr>
<tr>
<td>9.</td>
<td>Elementary linear components (cont.): pure derivative, 1st order lead, time delay. Summary overview of elementary components.</td>
</tr>
<tr>
<td>10.</td>
<td>Stability, Hurwitz and Nyquist criteria. Interpretation of the Nyquist criterion in Bode coordinates, stability margins.</td>
</tr>
<tr>
<td>13.</td>
<td>Controllers: continuous (linear PID and its derivatives), discrete (2 and 3 point). Examples of physical (continuous) and algorithmic (discrete) realisation.</td>
</tr>
<tr>
<td>14.</td>
<td>Extended heuristic control concepts: feed-back + feed-forward combination, cascade control, decoupling of control loops operating on MIMO controlled plant.</td>
</tr>
<tr>
<td>15.</td>
<td>Parallel operation of (two) controllers controlling the same controlled variable.</td>
</tr>
</tbody>
</table>

**Recommended literature:**

**Type of exercises:**
- [ ] auditory; [ ] laboratory; [ ] practicum; [ ] design; [ ] other

**Examination:**
- [ ] final exam; [ ] continuous testing; [ ] other

**Language:**
Croatian

**Tutorials in English for incoming students:**
YES

** Bachelor program:** Semester 1-7, **Master program:** Semester 8-10

**ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering**
Course Title: Process control basics

Semester: 8
Code: 18910
Program: ME
No of hours per week: lectures + exercises: 2 + 2
Total: 4
ECTS credits: 5

Lecturer: Dražen Lončar

Course objective:
The aim is to provide students majoring in HVAC with basic knowledge and understanding of the process control and control engineering.

Prerequisite:

Learning outcomes:
Fundamental understanding of dynamical behaviour of thermo-hydraulic processes. Understanding the structures, basic components and terminology of control systems. The difference between open-loop and closed-loop control. Setting up simulation experiments of simple control systems.

Course contents

1. Introduction: Basic notions - plant, control, supervision, protection. An engineering approach to automation and automatic control.
2. Dynamic system, mathematical modelling, the idea of digital simulation.
3. Linearity, linearization of nonlinear mathematical model.
5. Laplace transform and its application in solving the linear differential equation.
6. Transfer function, block algebra.
7. Frequency response: physical meaning, graphic presentation, relation to the transfer function.
8. Elementary linear components
11. Controllers: continuous (linear PID and its derivatives), discrete (2 and 3 point).
13. Examples of physical (pneumatic PI) and algorithmic (software) controller.
14. Requirements to the measuring and actuating units.
15. Some typical examples of automation equipment.

Recommended literature:

Type of exercises: x auditory; laboratory; x practicum; design; other
Examination: x final exam; x continuous testing; other
Language: Croatian

Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
Course Title: Ship automation and control systems

Semester: 8  Code: 18876  Program: ME

No of hours per week: lectures + exercises: 3 + 2  Total: 5  ECTS credits: 8

Lecturer: Dražen Lončar

Course objective:
The objectives are to acquaint the students with basics of theory underlying the automation of ship systems and to enable the students for use of mathematical modelling and simulation in coping with system operation in unsteady conditions.

Prerequisite:

Learning outcomes:
Fundamental understanding of dynamical behaviour of processes and systems. Understanding the structures, basic components and terminology of control systems. The difference between open-loop and closed-loop control. Setting up simulation experiments of simple control systems in order to study relevant aspects of marine automation (positioning, motion control, power generation and distribution).

Course contents

Lecture/Topic:
1. Introduction: Basic notions - plant, control, supervision, protection. An engineering approach to automation and automatic control.
5. Laplace transform, transfer function, block algebra. Frequency response: physical meaning, relation to the transfer function.
8. Interpretation of the Nyquist criterion in Bode coordinates, stability margins.
10. Controllers: continuous (linear PID and its derivatives), discrete (2 and 3 point). Control loop extensions (feed-back + feed-forward combination, cascade control, etc.).
11. Parallel operation of (two) controllers controlling the same controlled variable.
12. The role of the prime mover speed controller in characteristic operational conditions.
14. Realisation of Logic gates and memories: physical (pneumatic), algorithmic (software)
15. Overview of typical automation equipment.

Recommended literature:

Type of exercises:  x auditory;  laboratory;  x practicum;  design;  other

Examination:  x final exam;  x continuous testing;  other

Language: Croatian

Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7,  Master program: Semester 8-10
** ME – Mechanical Engineering,  NA – Naval Architecture,  AE – Aeronautical Engineering
Course Title: Power plant control

<table>
<thead>
<tr>
<th>Semester</th>
<th>Code</th>
<th>Program**</th>
<th>No of hours per week: lectures + exercises</th>
<th>Total</th>
<th>ECTS credits</th>
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<tr>
<td>9</td>
<td>18936</td>
<td>ME</td>
<td>2 + 1</td>
<td>3</td>
<td>5</td>
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</table>

Lecturer: Dražen Lončar

Course objective:
The objectives are to elucidate requirements imposed by the power system to individual power plants as well as the reflex of these requirements to the power plant operational regimes and process control strategies. The goal is to prepare students majoring in Power Engineering to cope with the increasing demands on power plant operational flexibility imposed by free electricity market.

Prerequisite: Process control

Learning outcomes:
Understanding of role of power plant in power system with respect to frequency and power control. Understanding of implication of primary, secondary and tertiary control on power plant operation and operational efficiency. Differentiation of control strategies and evaluation of impact of control system performance on plant life cycle. Setting up simulation experiments focused on optimal plant scheduling in changing power market conditions.

Course contents

<table>
<thead>
<tr>
<th>Lecture/Topic:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Public power system - interrelation between the power system requirements and the process control in individual power plant.</td>
</tr>
<tr>
<td>2.</td>
<td>Electricity production: prime mover - AC generator set (with synchronous and asynchronous generator), island operation, operation to the grid. Frequency control in island operation.</td>
</tr>
<tr>
<td>3.</td>
<td>Frequency control in a public grid. Primary, secondary and tertiary control. Requirements to the plant operational flexibility and major limitations of various kinds of power sources (hydro, thermal, wind, solar etc.).</td>
</tr>
<tr>
<td>4.</td>
<td>The role of the prime mover speed controller in characteristic operational conditions.</td>
</tr>
<tr>
<td>5.</td>
<td>Requirements to the prime mover speed controller's statics, speed controller in combination with active power controller.</td>
</tr>
<tr>
<td>6.</td>
<td>Operation of conventional thermal power block with water-steam Rankine cycle: constant pressure and sliding pressure regimes.</td>
</tr>
<tr>
<td>7.</td>
<td>Typical modes of the block control (&quot;turbine leads&quot;, &quot;turbine follows&quot;, coordinated mode) and their influence to dynamic performance of the block.</td>
</tr>
<tr>
<td>8.</td>
<td>Thermal power block with once-through boiler with steam reheat: interrelation between control modes and thermal stress in main components. Example of grid requirements (UCTE) to the operational flexibility.</td>
</tr>
<tr>
<td>9.</td>
<td>Process control in hydro power plants: Particularities with respect to the turbine type and the plant configuration.</td>
</tr>
<tr>
<td>10.</td>
<td>Summary overview of the subject and suggestion for the exam preparation.</td>
</tr>
<tr>
<td>11.</td>
<td></td>
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<tr>
<td>12.</td>
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<tr>
<td>13.</td>
<td></td>
</tr>
</tbody>
</table>

Recommended literature:
Šerman, N.: Uloga regulatora brzine vrtnje agregata "pogonski stroj - sinkroni generator", nastavni tekst dostupan na web-u  
Šerman, N.: Utjecaj tehnološke opreme i strategije vođenja na dinamičke performance termoenergetskog bloka, nastavni tekst dostupan na web-u

Type of exercises: x auditory; laboratory; practicum; design; other

Examination: x final exam; x continuous testing; other

Language: Croatian

Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
Course Title: Advanced thermal power plant control

Course objective:
The goal is to introduce students majoring power engineering into basic aspects of implementation of the advanced control algorithms in thermal power plant control.

Prerequisite: Process control

Learning outcomes:

Course contents

<table>
<thead>
<tr>
<th>Lecture/Topic:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Hierarchy of the thermal power plant control systems. Control system performance requirements. Steady state optimisation. Constrained and unconstrained minimum (maximum) of the function.</td>
</tr>
<tr>
<td>3.</td>
<td>Inclusion of the additional process variables and process models in the control loop. Internal Model Control (IMC).</td>
</tr>
<tr>
<td>5.</td>
<td>Static and dynamic decoupling of the multivariable control loops. Examples of steam turbine with controlled extraction (static decoupling) and steam pressure and plant power control (dynamic decoupling).</td>
</tr>
<tr>
<td>8.</td>
<td>Advanced control concepts implementation in thermal power plant control Basic functions and principal structure of the system</td>
</tr>
<tr>
<td>9.</td>
<td>Typical function blocks used in control system software.</td>
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<tr>
<td>10.</td>
<td>Summary of described concepts and its application in thermal power plants control. Development trends with respect to potential application.</td>
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<td>11.</td>
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<td>12.</td>
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<td>14.</td>
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<td>15.</td>
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</table>

Recommended literature:

Type of exercises: x auditory; laboratory; x practicum; design; other

Examination: x final exam; x continuous testing; other

Language: Croatian

Tutorials in English for incoming students: YES
Course objective:
Introduction to steam generators constructional and operational characteristics and calculation methods

Prerequisite: Termodinamika 1, Mehanika fluida 1

Learning outcomes:
Differentiating types of steam generators and understanding principles of their functioning. Knowing basic elements of steam generator. Ability to conduct the calculation of combustion in the steam generator furnace; to define heat and mass balance of the steam generator; to calculate the efficiency of steam generator. Student will be able to do the heat calculation of steam generator by using MS Visual Basic and MS Excel software. Understanding principles of two-phase flow and ability to conduct hydraulic calculation of forced and natural circulation in one- and two-phase flows. Introduction to instabilities of two-phase flow in evaporator. Learning primary and secondary measures of SO\(_x\) and NO\(_x\) emissions reduction. Introduction to legislation prescribing pollutants emission limit values to the atmosphere.

Course contents

<table>
<thead>
<tr>
<th>Lecture/Topic</th>
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<tbody>
<tr>
<td>1.</td>
<td>Introduction: Position of SG in power plants, T-s diagram of the process, SG parameters</td>
</tr>
<tr>
<td>2.</td>
<td>Classification of steam generators.</td>
</tr>
<tr>
<td>4.</td>
<td>Basic constitutional elements of SG.</td>
</tr>
<tr>
<td>5.</td>
<td>Heat balance of SG</td>
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<tr>
<td>6.</td>
<td>Coal Combustion</td>
</tr>
<tr>
<td>7.</td>
<td>Gaseous and liquid fuel combustion</td>
</tr>
<tr>
<td>8.</td>
<td>Heat balance and heat transfer calculations</td>
</tr>
<tr>
<td>9.</td>
<td>Pressure drop and hydraulics calculations</td>
</tr>
<tr>
<td>10.</td>
<td>Aerodynamics calculation.</td>
</tr>
<tr>
<td>11.</td>
<td>Performance and test measurements of SG</td>
</tr>
<tr>
<td>12.</td>
<td>Nuclear SG</td>
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<tr>
<td>13.</td>
<td>Environmental protection</td>
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<td>14.</td>
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<td>15.</td>
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</table>

Recommended literature:

Type of exercises:
- auditory; laboratory; practicum; design; other

Examination:
- final exam; continuous testing; other

Language: Croatian

Tutorials in English for incoming students: YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
<table>
<thead>
<tr>
<th>Course Title</th>
<th>Thermal Power Plants</th>
</tr>
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<tbody>
<tr>
<td><strong>Semester</strong></td>
<td><strong>Code</strong></td>
</tr>
<tr>
<td>18803 ME 3 + 1</td>
<td>4</td>
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</table>

**Lecturer:** Željko Bogdan, Daniel Rolph Schneider

**Course objective:**
Introduction to modern thermal power plants, introduction to technical characteristics of thermal power plants and methods for evaluation of their operational behaviour

**Prerequisite:** Generatori pare, Turbostrojevi

**Learning outcomes:**
Understanding modern steam turbine and gas turbine plants. Ability to understand design characteristics which enable higher efficiency of these plants. Introduction to combined and cogeneration power plants. Basics of nuclear power plants. Understanding problems of materials on high temperatures. Basics of hydro and wind power plants. Student will learn how to use the mathematical model for designing and simulation of operation of power plant. Introduction to the calculation of costs of electricity production. Knowing basics of “clean coal” concepts.

**Course contents**

<table>
<thead>
<tr>
<th>Lecture/Topic</th>
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<tbody>
<tr>
<td>1. Classification of thermal power plants.</td>
</tr>
<tr>
<td>2. Steam-turbine power plants â€“ process improvement</td>
</tr>
<tr>
<td>3. Gas-turbine power plants â€“ process improvement</td>
</tr>
<tr>
<td>4. Cogeneration power plants</td>
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<tr>
<td>5. Combined power plants</td>
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<tr>
<td>6. Nuclear power plants</td>
</tr>
<tr>
<td>7. Condensers and cooling towers</td>
</tr>
<tr>
<td>8. High temperature resisting materials</td>
</tr>
<tr>
<td>9. Equipment lifetime calculations</td>
</tr>
<tr>
<td>10. Modelling and optimisation of thermal power plants</td>
</tr>
<tr>
<td>11. Advanced coal combustion technologies</td>
</tr>
<tr>
<td>12. Calculation of power generation costs</td>
</tr>
<tr>
<td>13. Assessment methods for splitting production costs on heat and power</td>
</tr>
</tbody>
</table>

**Recommended literature:**

**Type of exercises:**
- x auditory;
- x laboratory;
- practicum;
- design;
- other

**Examination:**
- x final exam;
- continuous testing;
- other

**Language:**
Croatian

**Tutorials in English for incoming students:**
YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10
** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering
# Course Title

**Thermal power plants planning**

<table>
<thead>
<tr>
<th>Semester*</th>
<th>Code</th>
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<th>No of hours per week: lectures + exercises</th>
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<td>4</td>
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</tbody>
</table>

**Lecturer:** Željko, Bogdan

**Course objective:**
Introduction to planning principles, site selection, design and erecting of new power plants

**Prerequisite:** Termodinamika I, Termoenergetska postrojenja

**Learning outcomes:**

<table>
<thead>
<tr>
<th>Lecture/Topic:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. New capacity planning</td>
</tr>
<tr>
<td>2. Site selection criteria</td>
</tr>
<tr>
<td>3. Space requirements</td>
</tr>
<tr>
<td>4. Role of accumulative and reversible hydro power plants in power system</td>
</tr>
<tr>
<td>5. Role of gas turbine plants in power system</td>
</tr>
<tr>
<td>6. Power plant types in Croatian electric system.</td>
</tr>
<tr>
<td>7. Options for future development.</td>
</tr>
<tr>
<td>8. Colloquy</td>
</tr>
<tr>
<td>9. Layout of thermal power plant</td>
</tr>
<tr>
<td>10. Coal handling and ash removal equipment</td>
</tr>
<tr>
<td>11. Storage requirements for liquid and gaseous fuel</td>
</tr>
<tr>
<td>12. Cooling water systems</td>
</tr>
<tr>
<td>13. Auxiliary equipment</td>
</tr>
<tr>
<td>14. Electrical equipment</td>
</tr>
</tbody>
</table>

**Recommended literature:**

**Type of exercises:**
- auditory
- laboratory
- practicum
- design
- other

**Examination:**
- final exam
- continuous testing
- other

**Language:**
- Croatian

**Tutorials in English for incoming students:**
- YES

* Bachelor program: Semester 1-7, Master program: Semester 8-10

** ME – Mechanical Engineering, NA – Naval Architecture, AE – Aeronautical Engineering