Course Syllabus

<table>
<thead>
<tr>
<th>Course Title (in English)</th>
<th>Sensors and Embedded Systems for IoT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Course Title (in Russian)</td>
<td>Датчики и встраиваемые системы для Интернета вещей</td>
</tr>
<tr>
<td>Lead Instructor(s)</td>
<td>Somov, Andrey</td>
</tr>
</tbody>
</table>

Is this syllabus complete, or do you plan to edit it again before sending it to the Education Office?

- The syllabus is a final draft waiting for form approval

Contact Person

- Andrey Somov

Contact Person's E-mail

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1. Annotation

Course Description

This module will give a wide-ranging introduction to sensors and embedded systems in the scope of Internet of Things (IoT) paradigm. The module aims at providing full support to the non-engineering students with a series of carefully constructed concepts and exercises. It starts with setting the whole picture of IoT and its requirements for sensors and embedded systems. Then it introduces basic principles and simple projects, and moves towards more advanced IoT system design. Finally, the module will make overview of targeted applications including Smart-X, Oil & Gas industry, wearables and medical applications.

Course Prerequisites / Recommendations

- Programming in Python and attending of Introduction to ML is considered as a plus (not obligatory).

2. Structure and Content
<table>
<thead>
<tr>
<th>Topic</th>
<th>Summary of Topic</th>
<th>Lectures (# of hours)</th>
<th>Seminars (# of hours)</th>
<th>Labs (# of hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Introduction to Electronics</td>
<td>Electric current, voltage, resistivity and conductivity, grounds, electric circuits; Ohm’s law and resistors, voltage and current sources, Kirchhoff’s Law, capacitors, inductors.</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Digital electronics</td>
<td>Digital logic states, logic gates, combinational logic, sequential logic, analog/digital interfacing.</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Sensors</td>
<td>General principles, sensor types, ADC and DAC, communication interfaces.</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Voltage regulators and power supplies</td>
<td>Batteries and super capacitors, energy harvesting, power management, voltage regulator, DC/DC, rectifier.</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Electronic instrumentation and measurement techniques</td>
<td>Accuracy and precision, types of error, statistical analysis; general measurement system, systematic characteristics; measurement instrumentation.</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Microcontrollers</td>
<td>Structure of microcontroller (MCU), MCU families, I/O ports, interfaces, MCU programming.</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Programming embedded systems</td>
<td>Issues and concepts, application domains, languages in embedded and real-time systems, low-level programming, high-level languages, operating systems.</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Wireless sensor network</td>
<td>Sensor nodes, communication and protocols, operating systems, deployment.</td>
<td>2</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Internet of Things</td>
<td>Enabling technologies, sensors and actuators, virtualization techniques, low-power embedded systems.</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Applications of embedded systems</td>
<td>Smart-X applications, medicine, consumer applications, wearables, future outlook.</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Hands-on 1: Programming of a wireless sensor node.</td>
<td>Programming of a wireless sensor node</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Hands-on 2: Running ML on embedded systems.</td>
<td>Programming of embedded intelligence: Movidius + Raspberry Pi (self-driving car application)</td>
<td>2</td>
<td>0</td>
<td>9</td>
</tr>
<tr>
<td>From Engineering Idea to Market Focused Product (Lecture is delivered by Prof. Alexey Nikolaev, Skoltech)</td>
<td>IoT devices and markets - real-life examples; Product design process - user-centered, iterative, incremental; Projects development working sessions.</td>
<td>3</td>
<td>2</td>
<td>0</td>
</tr>
</tbody>
</table>

3. Assignments
### Assignment Summary

<table>
<thead>
<tr>
<th>Assignment Type</th>
<th>Assignment Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test/Quiz</td>
<td>There will be spontaneous Quiz during the lectures.</td>
</tr>
<tr>
<td>Homework</td>
<td>Modeling electronic circuits based on logic gates.</td>
</tr>
<tr>
<td>Team Project</td>
<td>Delivery of a team project.</td>
</tr>
</tbody>
</table>

### 4. Grading

**Type of Assessment**
- Graded

**Grade Structure**

<table>
<thead>
<tr>
<th>Activity Type</th>
<th>Activity weight, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test/Quiz</td>
<td>30</td>
</tr>
<tr>
<td>Projects</td>
<td>20</td>
</tr>
<tr>
<td>Final Project</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>20</td>
</tr>
</tbody>
</table>

**Grading Scale**

- A: 86
- B: 76
- C: 66
- D: 56
- E: 46
- F: 0

**Attendance Requirements**
- Optional

### 5. Basic Information

**Course Stream**
- Science, Technology and Engineering (STE)

**Course Term (in context of Academic Year)**
- Term 4

**Students of Which Programs do You Recommend to Consider this Course as an Elective?**
### 6. Textbooks and Internet Resources

#### Required Textbooks

<table>
<thead>
<tr>
<th>Required Textbooks</th>
<th>ISBN-13 (or ISBN-10)</th>
</tr>
</thead>
</table>

#### Web-resources (links)

<table>
<thead>
<tr>
<th>Web-resources (links)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><a href="https://www.embedded.com/">https://www.embedded.com/</a></td>
<td>Has a ton of useful information on embedded systems</td>
</tr>
</tbody>
</table>

### 7. Facilities

#### Equipment

- Measurement instrumentation, WaspMote sensor nodes, Movidius

#### Software

- Matlab, WaspMote IDE

#### Labs for Education

- Wireless Sensing Lab (TPOC4: 212)

### 8. Learning Outcomes
**Knowledge**

Understand sensors, sensing technologies and embedded systems in the context of Internet of Things.

**Skill**

Programming of embedded system.

Modelling electronic circuits.

Take measurements using sensors.

Running machine learning on embedded systems.

**Experience**

Ability to work with research literature on sensors and embedded systems.

Lots of hands-on experience.

Become familiar with software and hardware for sensors and embedded systems.

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**9. Assessment Criteria**

**Input or Upload Example(s) of Assignment 1:**

<table>
<thead>
<tr>
<th>Select Assignment 1 Type</th>
<th>Test/Quiz</th>
</tr>
</thead>
</table>

**Input Example(s) of Assignment 1 (preferable)**

The output of an AND gate with three inputs, A, B, and C, is HIGH when ________.

- A. \( A = 1, B = 1, C = 0 \)
- B. \( A = 0, B = 0, C = 0 \)
- C. \( A = 1, B = 0, C = 1 \)
- D. \( A = 1, B = 0, C = 1 \)

**Assessment Criteria for Assignment 1**

Correct answers on simple questions are expected.

**Input or Upload Example(s) of Assignment 2:**

<table>
<thead>
<tr>
<th>Select Assignment 2 Type</th>
<th>Report</th>
</tr>
</thead>
</table>

**Input Example(s) of Assignment 2 (preferable)**

After Week 1 the instructor will share the bunch of relevant IoT papers. Each student will choose a paper on the topic you are not familiar with and prepare the presentation on this paper. The slides will be presented during one of the seminars after Week 3.

**Assessment Criteria for Assignment 2**

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Requirements for the presentation:
1. Presentation time 20-25 minutes.
2. Number of slides 10-15. Use Power Point or LaTeX for making the slides.
3. Be prepared for Questions and Answers session (10 minutes).
4. Slides must clearly demonstrate:
   - context of the paper
   - goal of the paper
   - problem to be solved
   - approach, its pros and cons
   - novelty
   - conclusions
   - list of references (optional)

Input or Upload Example(s) of Assignment 3:

Select Assignment 3 Type: Project

Input Example(s) of Assignment 3 (preferable): Wireless Home Automation System with Multiple Sensors and Actuators.

Assessment Criteria for Assignment 3:
1. Modelling of the system.
2. Implementation: how many sensors/actuators are used (3/3 is OK), how the sensors are interfaced with actuators, is there an option for remote control, programming of microcontroller.
3. Report and system presentation.
Requirements for the presentation:
   - Presentation time 20-25 minutes.
   - Number of slides 10-15. Use Power Point or LaTeX for making the slides.
   - Be prepared for Questions and Answers session (10 minutes).
4. Slides must clearly demonstrate:
   - context of the Project
   - goal of the Project
   - problem to be solved
   - approach, its pros and cons
   - novelty
   - conclusions
   - list of references (optional)

Input or Upload Example(s) of Assignment 4:

Select Assignment 4 Type: Other

Input or Upload Example(s) of Assignment 5:

10. Additional Notes