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1 Executive summary

This deliverable presents the report on the integration of AIISM in the curricula of Master Programs at the Faculty of Mathematics that is responsible for MEDIS Project in Petrozavodsk State University.

Integration of AIISM will be done on the following departments:

- Department of probability theory and data analysis
- Department of computer science
- Department of mathematical analysis
- Department of applied mathematics and cybernetics
- Department of geometry and topology
- Department of theory and practice of teaching of mathematics

2 Possibilities for the Integration of AIISM Courses

According to the analysis of both the proposed AIISM courses (fulfilled on the basis of available Deliverables of WP1) and the curricula of the master programme “Applied Mathematics and Informatics” fulfilled in WP3.1 the following possibilities and obstacles for the Integration of AIISM Courses have been discovered:

1. The duration of the proposed courses is 15 weeks and the duration of each semester in the master programme “Applied Mathematics and Informatics” is also 15 weeks. Thus, the proposed master program of Petrozavodsk State University is suitable for AIISM courses implementation.
2. The proposed AIISM courses can be integrated into curricula as elective courses of a variable part of a Master Program. According to current regulations elective courses equal to 28 credits of ECTS. Thus, the proposed courses can be considered as elective courses to be chosen by students.
3. The Bachelor Programme “Applied Mathematics and Informatics” provides prospective Master students with good knowledge in computer architecture that will meet requirements of AIISM courses.
4. The Bachelor Programme “Applied Mathematics and Informatics” provides prospective Master students with good knowledge in programming that will fully satisfy requirements of AIISM courses.
5. The Bachelor Programme “Applied Mathematics and Informatics” doesn’t provide prospective Master students with sufficient knowledge in electronics (in particular in analog electronics, microcontrollers, soldering ect) necessary for some AIISM courses. But prospective Master students also arrive to the program “Applied Mathematics and Informatics” from the Faculty of Physics and Technics. Such students have good proficiency in electronics but could have not enough experiences in programming. We propose to combine students with different background knowledge in united teams for the AIISM course projects realisation.

3 Program Proposal of EU Partners

3.1 Industrial Computers module

The Industrial Computers is an AISSM module structured with different activities. These activities are developed during 3 hours/day (during 15 weeks) through a PBL methodology, using as a case study the example of the control of the liquids tank. To develop the course, students have to apply the knowledge acquired from the lectures and the laboratory practices. The proposed learning activities are the following:

- Lecture and problems: lecturer presents main ideas of lecture contents and proposes some application problems which student solves individually (1 h).
- Laboratory session: To implement (1 h 15'') a practical problem previously presented during lecture. Students work by teams of two students.
- Seminars: a panel discussion with student teams (4 students) lasting 45 minutes is proposed, consisting generally of solving a problem by means of PBL.
- Mini-project: dedicated to planning, design and development of the control system of the educational liquids tank. The mini-project is performed by teams of 4 students during 2 hours. Weekly, the mini-project is advanced progressively.

Based in the previous proposals, the set of chapters to group different topics is the following:

1. Introduction to industrial informatics
2. Computer architecture
3. Project management
4. Software development
5. Process interface
6. Graphical user interface
7. Task scheduling
8. Regulation strategies
9. Integration and validation

Chapters 1 and 2 introduce basics about computer architecture and the applicability of computers to industry.

Another basic of an engineer is the correct management of a project. This is the objective of the chapter 3 that is spread along the course. This is also a horizontal content of the module, so it is spread along the course and in a position where student understands its implications.

Chapter 4 develops skills on C programming to be applied on the application creation. This is a horizontal requirement of the module.

Chapter 5 deals with the connection of the computer to the real world, the so called "process interface". This is set tends to motivate the student because he/she sees the interaction with physical reality.

Taking into consideration that the actual student's generation is accustomed to stunning visual

user interfaces. Chapter 6 is in place for introducing another motivating set of activities related to this aspect.

At this point, it is necessary to start coordinating actions inside the application. So chapter 7 introduces the very basics around task coordination/scheduling.

And, finally, the student needs to see that your development works. From the point of view of the teacher, it is adequate to introduce here the regulation problem according to chapter 8.

A serious project of industrial informatics needs an investing on testing of each piece and integration. This important task is in chapter 9.

The scheduling distribution in weeks for this module is shown in Figure 1.

Week	Chapter	Type	Topic
1 INTRODUCTION			
1	1	Lecture	Introduction to industrial informatics
1	1	Lab	Development environment - Programming the "Hello World"
1	1	Seminar	C programming (1) - Basic resources
1	1	Miniproject	Presentation of the problem to solve
2	1	Lecture	Structure and design of industrial informatics systems
2	1	Lab	Event oriented programming
2	1	Seminar	C programming (2) - Programming tools
2	1	Miniproject	Analysis of the project requirements
2 COMPUTER			
3	2	Lecture	Computer architecture
3	2	Lab	Using libraries in C
3	2	Seminar	C programming (3) - Libraries
3	2	Miniproject	Project formal specification
3 PROJECT PLANNING			
4	3	Lecture	Project management (1)
4	3	Lab	Tools for project management
4	3	Seminar	Discussing cases of project management systems
4	3	Miniproject	Project planning
4 PROGRAMMING + DATA			
5	4	Lecture	Modular programming
5	4	Lab	Modular programming in C
5	4	Seminar	Modular programming resources
5	4	Miniproject	Modular decomposition of the program
6	4	Lecture	Data representation and sharing
6	4	Lab	Data sharing between C modules
6	4	Seminar	Choosing the appropriate data representation
6	4	Miniproject	Implementation of the shared data module
5 PROCESS INTERFACE			
7	5	Lecture	Process interface (1) - Introduction and digital input
7	5	Lab	Digital input
7	5	Seminar	DAQ card (1) - Introduction and digital input
7	5	Miniproject	Implementation of the process interface module (1) - DI
8	5	Lecture	Process interface (2) - Digital output
8	5	Lab	Digital output
8	5	Seminar	DAQ card (2) - Digital output
8	5	Miniproject	Implementation of the process interface module (2) - DO
9	5	Lecture	Process interface (3) - Analog input and output
9	5	Lab	Analog input and output
9	5	Seminar	DAQ card (3) - Analog input and output
9	5	Miniproject	Implementation of the process interface module (3) - AIO
6 USER INTERFACE			
10	6	Lecture	Graphical user interface (1) - Introduction
10	6	Lab	Programming GUI controls
10	6	Seminar	Graphical user interface for the industry (1) - Basic
10	6	Miniproject	Implementation of the user interface module (1) - Basic
11	6	Lecture	Graphical user interface (2) - Advanced resources
11	6	Lab	Programming a GUI for an industrial application
11	6	Seminar	Graphical user interface for the industry (2) - Advanced
11	6	Miniproject	Implementation of the user interface module (2) - Advanced
7 TASKS			
12	7	Lecture	Task scheduling
12	7	Lab	Basic scheduler
12	7	Seminar	Scheduling strategies
12	7	Miniproject	Implementation of the task scheduler module
8 REGULATION			
13	8	Lecture	Foundations and continuous control
13	8	Lab	Programming regulation strategies (1) cc
13	8	Seminar	Control strategies (1) cc
13	8	Miniproject	Implementation of the regulator module (1) cc
14	8	Lecture	Event-driven control
14	8	Lab	Programming regulation strategies (2) edc
14	8	Seminar	Control strategies (2) edc
14	8	Miniproject	Implementation of the regulator module (2) edc
10 PROJECT (2) ENDING			
15	10	Lecture	Project documentation and presentation
15	10	Lab	Tools for project documentation
15	10	Seminar	Project documentation strategies
15	10	Miniproject	Documentation and presentation of the project

Figure 1 Scheduling of the Industrial Computers AIISM module

About the module assessment [WP1.4 UPV], we will collect all grades earned along the continuous assessment developed along the course and proceed to obtain the final grade for the module.

To do this we establish the following proportion between the different sections to ensure a fair rating for differentiating their individual acquisition of knowledge and skills against the student group work:

- The evaluation of the student attitude (A) a 10% of the final score.
- The evaluation of the miniproject represents (MP) a 40% of the final score.
- The evaluation of the Laboratory (L): 20% of the final score.
- The evaluation of the Problems (P): 15% of the final score.
- The evaluation of the Seminars (S): 15% of the final score.

With all the information of ratings and percentages described will get a single grade for each student.

According to the results of the analysis presented in [WP3.1 PetrSU] the “Applied Mathematics and Informatics” master’s program of the Faculty of Mathematics fits perfect for integration of the AIISM courses.

In this manner, after the analysis of the curricula of this master program and the Industrial Computers AISSM module, the following possibilities and obstacles for the Integration of AIISM Courses have been encountered:

- The module can be integrated into curricula as elective courses of a variable part of this Master Program, thus the students that study the AISSM will obtain the Applied Mathematics and Informatics Master Degree. According to current regulations elective courses equal to 28 credits of ECTS.
- The duration of the proposed courses is 15 weeks and the duration of each semester in the master programme “Applied Mathematics and Informatics” is also 15 weeks. Thus, the proposed master program of Petrozavodsk State University is suitable for the Industrial Computer module implementation.
- The Bachelor Programme “Applied Mathematics and Informatics” provides prospective Master students with good knowledge in computer architecture that will meet requirements of Industrial Computer module.
- The Bachelor Programme “Applied Mathematics and Informatics” provides prospective Master students with good knowledge in programming that will fully satisfy requirements of Industrial Computer module.
- The Bachelor Programme “Applied Mathematics and Informatics” doesn’t provide prospective Master students with sufficient knowledge in electronics (in particular in analog electronics) necessary for the Industrial Computer module. But prospective Master students also arrive to the program “Applied Mathematics and Informatics” from the Faculty of Physics and Technics. Such students have good background in electronics but could have not enough experiences in programming. The solution could be to combine students with different background knowledge in united teams for the module activities and projects realisation.

In this manner, the Industrial Computer module can be integrated into curricula in the 1st year (autumn or spring semesters) or the 2nd year (autumn semester) covering a elective course slot.

The selected program has 10 elective courses in autumn semester and 6 elective courses in spring semester. Each course has assigned 4 ECTS (144 working academic hours for each student including exams defined by PSU). The students of AIISM intensification will need to study 5 academic hours in week, or 75 academic hours in a course, so the addition of preparatory works, textbooks reading, exams etc. will give us about 3-4 ECTS credits. Hence the Industrial Computer module could change an equivalent elective course (See Table 1).

	Autumn	ECTS	Spring	ECTS
1st year	English Language	2	English Language (3)	3
	History & Methodology of Applied Math & Informatics	3	Contemporary Problems of Applied Math & Informatics	4
	Continuous Math. Models	3	Discrete & Probabilistic Models	4
	Contemporary Computer Technologies	3	Research Seminar	4
	Research Seminar	2	Elective Courses	8
	Elective Courses	4	Practice and Scientific Work	7
	Practice and Scientific Work	13		
	Sum	30	Sum	30
2nd year	Research Seminar	3	Master Thesis Preparation	30
	Elective Coerces	16		
	Practice and Scientific Work	9		
	Sum	30		30
Total sum for 2 years				120

Table 1. The curricula of master program “Applied Mathematics and Informatics”

3.2 Microcontroller module

The above mentioned module is an AIISM module containing different learning activities. These activities are taught during 5 hours/day, one day of the week (during 15 weeks) through a PBL methodology, using as a case study the example of the control of a liquids tank. The total supervised contact time is 75 hours during the semester. The total workload for the students is approximately 150 hours, resulting in 5 credit points (ECTS).

To successfully run through the course, students have to apply the knowledge acquired from the lectures and the laboratory practices. The proposed learning activities are the following:

- Lecture: lecturer presents main ideas of lecture contents and proposes some application problems which student solves individually (1 h contact time).
- Laboratory session: To implement (1 h 45’’) a practical problem previously presented during lecture. Students work by teams of two students. Contact time is given by a technician and the lecturer.

- Seminars: a panel discussion with student teams (4 students) lasting 45 minutes is proposed, consisting generally of presenting the solution for a problem, which previously was analysed by the student team. The lecturer leads the discussion and summarizes the main results.
- Mini-project: dedicated to planning, design and development of the control system of an industrial production and transportation process. Teams of 4 students work on the mini-project during 2 hours/week (supervised by a technician and partly by a lecturer). Independent work of about another 2-3 hours/week advance the mini-project progressively.

Based on the previous proposals, the set of chapters to group different topics is the following:

1. Introduction to microcontrollers and process control
2. Project management and project planning
3. Input-/Output system of microcontrollers
4. Timer and interrupt functions on microcontroller systems
5. Graphic systems for microcontrollers
6. Communication systems on microcontrollers
7. Implementation of Control methods on microcontrollers
8. Integration and validation

Chapter 1 focuses on an introduction to microcontrollers, sample Applications, definition of Basic concepts and important terms.

Chapter 2 deals with project-management. There is no lecture for this topic, as it is not the main focus of this course. The contents of this chapter are worked out by seminars about project management methods and project documentation strategies.

Chapter 3 focuses on the I/O-system of microcontrollers. The interfaces of the microcontroller interact with the process directly. The chapter introduces the different kinds of input- and output-signals and their programming in the microcontroller.

Chapter 4 introduces timer and interrupts. In addition this chapter deals with the concepts of programming timer and interrupts using the microcontroller Arduino Due.

Chapter 5 deals with graphical user interfaces for microcontrollers. The main part of this chapter focuses on a graphical TFT-display wired to the microcontroller Arduino Due. In detail the necessary libraries and functions are explained.

Chapter 6 gives a short introduction to concepts of communication between microcontrollers.

This lecture focuses on special communication mechanisms used with microcontrollers.

Chapter 7 introduces algorithms of closed loop control. Key feature of closed loop control is the recirculation of a current value and comparison with a desired value. There are different types of controllers – their mathematical models will be explained.

Chapter 8 deals with the integration and validation of the mini-project. There is no lecture for this topic. The contents of this chapter are worked out by a seminar about test and validation strategies. In addition the students learn directly by developing the mini-project and integrating and documenting their own mini-project.

Figure 2 shows the scheduling of this module spread to 15 weeks:

Type	Topic	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
INTRODUCTION																
Lecture	Introduction to microcontrollers; architecture of microcontrollers	x														
Lab	Development environment; connection of microcontroller to PC	x														
Lecture	Introduction to Process Control and mini project		x													
Seminar	C programming basics		x													
PROJECTMANAGEMENT																
Project	Formal specification of the mini-project		x													
Project	Analysis of project specification			x												
Seminar	Project management			x												
Project	Project planning, management and timetable of mini-project				x											
Project	Design of mini-project					x										
Seminar	Discussing mini-project status										x					
Lab	Tools for project documentation															x
Seminar	Project documentation strategies															x
I/O-SYSTEM of microcontrollers																
Lecture	Digital I/Os of microcontrollers			x												
Lab	Digital I/O			x												
Lecture	Analog I/Os of microcontrollers				x											
Lab	Analog I/O				x											
Lecture	Amplifier circuits for actuators and sensors					x										
Lab	Build up a basic amplifier circuit					x										
Seminar	Libraries					x										
Lecture	State machines, scheduling						x									
Seminar	Software tools for modeling of state machines						x									
Project	Using libraries in the mini-project						x									
TIMER AND INTERRUPT HANDLING																
Lecture	Timer Handling							x								
Lab	Basic timer functions							x								
Project	Implementing digital I/O							x								
Lecture	Interrupt handling								x							
Lab	Basis interrupt functions								x							
Project	Implementing analog I/O								x							
GRAPHIC SYSTEM																
Lecture	Displays and graphic routines									x	x					
Lab	Basic Display functions									x						
Project	Implementing state machine and controller									x						
Lab	Advanced display functions										x					
Project	Implementing display										x					
Project	Implementing user interface											x				
COMMUNICATION between microcontrollers																
Lecture	Communication between different microcontrollers												x	x		
Lab	Basic communication methods (Serial)												x			
Project	Communication to other liquid tanks												x	x		
Lab	Advanced Communication Methods													x		
Lecture	Communication between different microcontrollers															x
CONTROL METHODS																
Lecture	Closed Loop Controller: modeling and algorithms												x			
Lab	Programming closed loop controllers												x			
INTEGRATION AND VALIDATION																
Project	Module integration and documentation of the mini-project.															x
Lecture	Testing microcontroller projects															x
Seminar	Test and validation strategies															x
Project	Test and validation of the project; documentation of the mini-project															x

Figure 2 Scheduling of the Microcontroller module

Deliverable [WP1.4 USTUTT] describes the details of grading the students in the module.

The overall grade is calculated by different grades, earned along the continuous assessment of the students during the whole module.

For the microcontroller module the following proportion of grading between the different learning activities ensures a fair rating for differentiating the individual acquisition of knowledge and skills of the students:

- The evaluation of the student attitude (A): 10% of the final score.
- The evaluation of the miniproject (MP) represents 40% of the final score.
- The evaluation of the Lecture (L): 15% of the final score.
- The evaluation of the Laboratory (P): 20% of the final score.
- The evaluation of the Seminars (S): 15% of the final score.

According to the results of the analysis presented in [WP3.1 PetrSU] the “Applied Mathematics and Informatics” master’s program of the Faculty of Mathematics fits perfect for integration of the AIISM courses.

In this manner, after the analysis of the curricula of this master program and the Microcontroller AISSM module, the following possibilities and obstacles for the Integration of AIISM Courses have been encountered:

- The module can be integrated into curricula as elective courses of a variable part of this Master Program, thus the students that study the AISSM will obtain the Applied Mathematics and Informatics Master Degree. According to current regulations elective courses equal to 28 credits of ECTS.
- The duration of the proposed courses is 15 weeks and the duration of each semester in the master programme “Applied Mathematics and Informatics” is also 15 weeks. Thus, the proposed master program of Petrozavodsk State University is suitable for the Microcontroller module implementation.
- The Bachelor Programme “Applied Mathematics and Informatics” provides prospective Master students with good knowledge in computer architecture that will meet requirements of the Microcontroller module.
- The Bachelor Programme “Applied Mathematics and Informatics” provides prospective Master students with good knowledge in programming that will fully satisfy requirements of the Microcontroller module.
- The Bachelor Programme “Applied Mathematics and Informatics” doesn’t provide prospective Master students with sufficient knowledge in electronics (in particular in analog electronics) and production technology necessary for the Microcontroller module. But prospective Master students also arrive to the program “Applied Mathematics and Informatics” from the Faculty of Physics and Technics. Such students have good background in electronics but could have not enough experiences in programming. The solution could be to combine students with different background

knowledge in united teams for the module activities and projects realisation. To give the necessary background knowledge in production systems, chapter 1 of the Microcontroller module should be emphasised and additional background literature should be given.

In this manner, the Microcontroller module can be integrated into curricula in the 1st year (autumn or spring semesters) or the 2nd year (autumn semester) covering an elective course slot.

The selected program has 10 elective courses in autumn semester and 6 elective courses in spring semester. Each course has assigned 4 ECTS (144 working academic hours for each student including exams defined by PSU). The students of AIISM intensification will need to study 5 academic hours in week, or 75 academic hours in a course, so the addition of preparatory works, textbooks reading, miniproject-homework, exams etc. will give a total workload of approximately 150 hours. Hence the Industrial Computer module could change an equivalent elective course (See Table 2, marked in yellow).

	Autumn	ECTS	Spring	ECTS
1st year	English Language	2	English Language (3)	3
	History & Methodology of Applied Math & Informatics	3	Contemporary Problems of Applied Math & Informatics	4
	Continuous Math. Models	3	Discrete & Probabilistic Models	4
	Contemporary Computer Technologies	3	Research Seminar	4
	Research Seminar	2	Elective Courses	8
	Elective Courses	4	Practice and Scientific Work	7
	Practice and Scientific Work	13		
	Sum	30	Sum	30
2nd year	Research Seminar	3	Master Thesis Preparation	30
	Elective Courses	16		
	Practice and Scientific Work	9		
	Sum	30		30
Total sum for 2 years				120

Table 2. The curricula of master program “Applied Mathematics and Informatics”

3.3 Mobile and Cloud Computing module

This module is an AIISM module structured with different activities. Similar to the other modules, the activities are developed during 3 hours/day (during 15 weeks) through a PBL methodology, using as a case study the example of the remote control of the liquids tank. To develop the course, students have to apply the knowledge acquired from the lectures and the laboratory practices. The proposed learning activities are the following:

- Lecture and problems: lecturer presents main ideas of lecture contents and proposes some application problems which student solves individually (1 h).
- Laboratory session: To implement (1 h 15'') a practical problem previously presented during lecture. Students work by teams of two students.
- Seminars: a panel discussion with student teams (4 students) lasting 45 minutes is proposed, consisting generally of solving a problem by means of PBL.
- Mini-project: dedicated to planning, design and development of the control system of the educational liquids tank. The mini-project is performed by teams of 4 students during 2 hours. Weekly, the mini-project is advanced progressively.

Based in the previous proposals, the set of chapters to group different topics is the following:

1. Fundamentals of Remote Monitoring and Control
2. Integrated Development Environment
3. Basic App Development
4. Graphical user interface (GUI)
5. Security
6. Reliability

The first 2 lectures will give an introduction to the fundamentals of remote monitoring and control of embedded systems as well as the liquid tank system which will be used throughout the course. Lectures 3 and 4 will give an overview of a number of integrated development environments (IDEs) for developing apps that will be deployed on the most common operating systems, i.e. IOS and Android. Lectures 5 and 6 lecture will cover practical aspects of developing a basic app in one of the platforms using an example. The main feature of the app will be inter-device communication using Bluetooth and WiFi. The basics for designing a functional and intuitive graphical user interface will be covered in lectures 7 and 8. It will provide knowledge on the programming of GUI controls as well as addressing the limited bandwidth issues that can occur while dealing with media streaming. Security and Reliability will be addressed in lectures 9-12 that will cover the security related issues that a system connected to the internet might experience, suggest solutions and discuss the role based access control approach as well as reliability of embedded systems and usage of fault tolerance and testing for dependable systems design. It will also cover the synchronization issues that can occur with multiple accesses during remote monitoring and control of these systems. The last lecture will be a seminar for discussions of the research finding in the selected topics.

Additionally, the labs are the practical exercises that follow the corresponding lectures that help the students to acquire basic set of skills related to the topic of the lecture. Each lecture will be followed by a seminar where the student teams present the outcomes of their course work, as well as submit a written report, as well as miniprojects dedicated to planning, design and development of the control system of the educational liquids tank. The mini-project is performed by teams of 4 students during 2 hours.

The schedule distribution in weeks for this module is shown in Table 3.

Week	Type	Topic
1 – Introduction		
1	Lecture	Fundamentals of Remote Monitoring and Control
1	Seminar	Research of Remote Monitoring and Control
1	Laboratory	Lab introduction - Liquid tank system I
1	Miniproject	Presentation of project goals
2	Lecture	Lab introduction - Liquid tank system
2	Seminar	Research of mobile communication
2	Laboratory	Lab introduction - Liquid tank system II
2	Miniproject	Control systems and mobile devices
2 – IDE		
3	Lecture	Dedicated IDE's for IOS and Android (Anita)
3	Seminar	IDE for mobile devices
3	Laboratory	IDE introduction - installation and usability
3	Miniproject	Design and structuring of control application
4	Lecture	Cross-platform development tools (Titanium, PhoneGap, etc)
4	Seminar	State of the Art on development tools
4	Lab	Basic app development !
4	Miniproject	Testing of mobile apps and I/O address mapping
3 – Basic App Development		
5	Lecture	Inter-device communication 1 (Anita)
5	Seminar	Research inter-device communication
5	Lab	Basic app development II
5	Miniproject	Implement basic control logic
6	Lecture	Inter-device communication 2 (Anita)
6	Seminar	Research synchronisation in distributed systems.
6	Lab	GUI development and implementation
6	Miniproject	Implement complex control logic
4 – Graphical User Interface (GUI)		
7	Lecture	Graphical User Interface (GUI) 1 (Anita)
7	Seminar	Structure of code for GUII
7	Lab	GUI development and implementation II
7	Miniproject	Add control logic to GUI
8	Lecture	Graphical User Interface (GUI) 2 (Anita)
8	Seminar	Propose structure of code implementing wireless communication on micro-controller
8	Lab	Implement wireless communication with the PC
8	Miniproject	Mapping of physical I/O to mobile devices
5 – Security		
9	Lecture	Security in mobile communication
9	Seminar	Research application areas of secure wireless communication

9	Lab	Access control and synchronization mechanisms I
9	Miniproject	Build a library of functions to secure access
10	Lecture	Security and control
10	Seminar	Research on secure control systems
10	Lab	Access control and synchronization mechanisms II
10	Miniproject	Secure sending and receiving of messages.
6 – Reliability		
11	Lecture	Reliability in mobile communication
11	Seminar	Research methods of reliability
11	Lab	Implement reliable communication
11	Miniproject	Simple distributed reliable control application
12	Lecture	Fault tolerance
12	Seminar	Research one fault tolerance for mobile devices
12	Lab	Implement fault tolerant communication
12	Miniproject	Add synchronous data transfer to distributed application.
13	Lecture	Testing of reliable mobile applications
13	Seminar	Research on testing of mobile communication
13	Laboratory	Testing approaches for mobile communication
13	Miniproject	Determine latency of traffic in miniproject.
7 – Research findings		
14	Lecture	Research on dependable mobile communication 1 (All)
14	Seminar	Research on app controlled ES
14	Laboratory	App control framework
14	Miniproject	Add hierarchical supervisory control of distributed control application.
15	Lecture	Research on dependable mobile communication 2 (All)
15	Seminar	Research on reliable communication for embedded control systems
15	Laboratory	Final project demonstration
15	Miniproject	Presentation of the project(s)

Table 3 Schedule of the Remote Monitoring and Control Module

About the module assessment [WP1.4 MDH], we will collect all grades earned along the continuous assessment developed along the course and proceed to obtain the final grade for the module.

To do this we establish the following proportion between the different sections to ensure a fair rating for differentiating their individual acquisition of knowledge and skills against the student group work:

- The evaluation of the student attitude (A) a 10% of the final score.
- The evaluation of the miniproject represents (MP) a 40% of the final score.
- The evaluation of the Laboratory (L): 20% of the final score.
- The evaluation of the Problems (P): 15% of the final score.
- The evaluation of the Seminars (S): 15% of the final score.

With all the information of ratings and percentages described will get a single grade for each student.

3.4 Industrial Networks and Fieldbuses module

The Industrial Networks and Fieldbuses module has been prepared as a 15 week long 3 ECTS course, corresponding to a total workload of 81 hours. This workload is distributed between classes 3 hour long (totalling 45 hours), and individual study (comprising 36 hours total). Class hours include lectures, seminars and assisted laboratory, and individual study includes independent laboratory work (mini-project). The division of effort between these 4 activity types will differ from week to week depending on the subject matter and the expected output for the mini-project work for that week.

- 3 Lecture and problems: lecturer presents main ideas of lecture contents and proposes some application problems which students solve individually (0h45 to 1h30).
- 4 Seminars: a panel discussion by teams of 4 students, 0h45 long, consisting research related to communication protocols, or to the problem to be solved later during laboratory and/or mini-project session.
- 5 Laboratory session: Lasting from 0h45 to 1h30, the students (in teams of 2) implement a practical problem previously presented during the lecture, following the guidance provided by the lecturer.
- 6 Mini-project: dedicated to planning, designing, development and configuration of several industrial communication protocols, and using these protocols in a distributed automated control system. The mini-project is performed by teams of 4 students over an average of 2h00 each week.

As mentioned in previous documents, this module is organized in the following chapters:

1. Introduction
2. Modbus/TCP
3. Discrete Event Control
4. Modbus/RTU
5. CAN
6. CAN Open
7. Hierarchical Control

Chapter 1 (Introduction to Industrial Filedbuses and Networks) is taught over the first 2 weeks (weeks 1 and 2), and introduces the field of industrial communication networks, providing an overview of how these are organized.

Chapter 2 focuses on the Modbus protocol in general, and its implementation over the TCP/IP stack in particular. During these 2 weeks the students are expected to implement a very simple control algorithm for 3 conveyors that only use *binary* sensors and actuators.

Chapter 3 also takes 2 weeks (weeks 5 and 6), and during this period the students become

acquainted with methodologies for modeling complex discrete event control algorithms, and how to implement these in software.

In chapter 4 the serial version of the Modbus protocol is introduced over weeks 7 and 8. This serial Modbus protocol is used for the communication between an Arduino and the computer running both the simulated plant floor and the discrete event control program. This involves implementing the Modbus serial protocol on both the PC as well as the Arduino in the laboratory sessions. The buttons and the lights on the Arduino are then used during the mini-project sessions as a physical interface with an operator, and the control algorithm is extended to take into account a RUN and STOP state.

In chapter 5, corresponding to weeks 9 and 10, the students come into contact with the CAN fieldbus and use it to establish a network of Arduino devices. This network is used to simulate remote discrete Input/Outputs, and the students are expected to integrate these remote I/Os as an extra physical interface to the operator (RUN, STOP and PAUSE buttons, and GREEN and RED lights).

In chapter 6 the students are asked to implement the CAN-Open protocol over the CAN network, and to use it in the mini-project. This is done during weeks 11, 12 and 13.

In chapter 7 the industrial networks module focuses on hierarchical control architectures, and the communication protocols used in this capacity. In the first of two weeks (week 14) the students are asked to build a small SCADA based (Supervisory Control And Data Acquisition) graphical user interface (GUI) for a plant floor supervisor and/or operator. The mini-project session of week 15 (the last week of the module) is used for the presentations of the mini-project work.

The scheduling of the classes for this module are summarised Figure 3.

Week	Type	Topic
1 – Introduction		
1	Lecture	Introduction to computer communications. OSI reference Model.
1	Seminar	Research of protocols, and location within the OSI reference model.
1	Laboratory	Analysis of protocols using protocol analyser (wireshark)
1	Miniproject	Presentation of project goals
2	Lecture	Foundations of industrial networks – an historical perspective.
2	Seminar	Research of field-buses (WorldFIP, MAP, Profibus, IPnet, ...)
2	Laboratory	Analysis of timing properties of control loops.
2	Miniproject	Requirements analysis, including timing requirements.
2 – Modbus/TCP		
3	Lecture	Modbus - Data model and Protocol Architecture.
3	Seminar	Structure of code implementing Modbus protocol
3	Laboratory	Implement a basic Modbus Client and Server Application
3	Miniproject	Design and structuring of control application
4	Lecture	Modbus TCP protocol
4	Seminar	TCP/IP and the Sockets API
4	Lab	Implement a basic Modbus/TCP Client and Server
4	Miniproject	Testing of modbus client and I/O address mapping
3 – Discrete Event Control		
5	Lecture	Discrete control logic
5	Seminar	Research discrete event systems modelling (grafcet, SFC, Petri Nets, ...)
5	Lab	Implementation of state machine based control logic
5	Miniproject	Implement basic control logic
6	Lecture	Synchronisation of control in discrete event systems
6	Seminar	Research synchronisation in distributed systems.
6	Lab	Implementation algorithms of state machine synchronisation
6	Miniproject	Implement complex control logic
4 – Modbus/RTU		
7	Lecture	Serial communication protocols - Modbus RTU and Modbus ASCII
7	Seminar	Structure of code implementing Modbus serial protocol
7	Lab	Implement a basic Modbus/RTU Master (on computer)
7	Miniproject	Add control logic that uses input obtained from Modbus/RTU master
8	Lecture	Overview of micro-controller programming
8	Seminar	Propose structure of code implementing Modbus serial protocol on micro-controller
8	Lab	Implement Modbus/RTU slave on micro-controller
8	Miniproject	Mapping of physical I/O to Modbus points and registers
5 – CAN		
9	Lecture	Introduction to the CAN protocol
9	Seminar	Research application areas of CAN networks (vehicular, avionics, industry,...)
9	Lab	Configuring the mcp2515 controller over SPI (on micro-controller)
9	Miniproject	Build a library of functions to access CAN controller
10	Lecture	Simple messaging using the CAN protocol
10	Seminar	Industrial communication solutions based on CAN
10	Lab	Configuring a CAN Network
10	Miniproject	Sending and receiving CAN messages.
6 – CAN Open		
11	Lecture	CAN-Open: The Object Dictionary (OD), and PDO transfers
11	Seminar	Research methods of implementing an OD
11	Lab	Implement a basic CAN-Open OD
11	Miniproject	Simple distributed control application based on sending and receiving asynchronous PDOs
12	Lecture	CAN-Open: Synchronous PDO transfers
12	Seminar	Research configuration of Synchronous PDOs in the OD
12	Lab	Implement periodic Synch message, and PDO response
12	Miniproject	Add synchronous data transfer to distributed application.
13	Lecture	Response time analysis of Event and Time triggered networks
13	Seminar	Research pros and cons of time triggered vs event triggered approaches
13	Laboratory	Calculate response times in specific sample scenarios.
13	Miniproject	Determine maximum response times of traffic in miniproject.
7 – Hierarchical Control		
14	Lecture	Industrial Communication Architectures (CIM, ISA88/95)
14	Seminar	Research on OPC, MAP, MMS, CIP, Profinet
14	Laboratory	Hierarchical control architectures
14	Miniproject	Add hierarchical supervisory control of distributed control application.
15	Lecture	Data transfer with OPC
15	Seminar	Research commercial OPC offerings
15	Laboratory	Access process data using an OPC/Modbus gateway
15	Miniproject	Presentation of the project(s)

Figure 3 Scheduling of the Industrial Networks and Fieldbuses AIISM module

Grading and assessing the individual work of each student is done on a continuous bases,

throughout the 15 weeks of the module.

The final grade of each student is obtained from a weighted average of the following evaluation criteria: :

- evaluation of the student attitude (A), 10% of the final grade.
- evaluation of the miniproject (MP), 45% of the final grade.
- evaluation of the Laboratory work (L): 30% of the final grade.
- evaluation of the Seminars (S): 15% of the final score.

3.5 Process Controllers and Simulators module

The Process Controllers and Simulators module in AISSM course is structured with different activities. These activities are developed during 4 hours/day (during 15 weeks) through a PBL methodology, using as a case study the example of the control of the liquids tank. The learning sessions are organized in these activities: lectures, seminars, laboratories, mini-project and tutorship.

The proposed learning activities are the following:

- **Lectures** - the first step in the learning process for each of the topics in a module. The lecturer presents the main topics, basic knowledge and the structure of the contents. This includes some application examples. Some lectures include elements of general theory not directly included in the exercises and mini-projects but very important for the applications.

- **Laboratory sessions (labs)** - the first practical exercise that students take to acquire a basic set of skills related to the topic presented in the lecture. The exercises in the lab solve specific and well-defined problems; they are guided, fully documented, and of progressively increasing complexity. The lab provides students with a set of tools and skills that can be used to solve more open problems during the seminars.

- **Seminars** - During the seminars the students must solve problems on the topic of the lecture. They have already collected experiences on related topics and procedures in the previous laboratories.

- **Mini-projects** - During the mini-project students use the knowledge and skills that they have acquired in the lectures, labs and seminars to develop the couple controller-simulator for a physical process in an integral way. The problem of the mini-project is the highest complexity problem in the course. The working teams in the mini-project are the same as in the seminars. The designs developed by the teams during the seminars are used as components of the mini-project's problem's solution. The teams can combine seminar designs of different other teams to solve their mini-project.

Based in the previous proposals, the set of chapters to group different topics is the following:

1. Introduction

Classification and characteristics of the Computer Control Systems (CCS): embedded (specialized) systems; control systems for industrial applications with standardized functions.

2. Architecture of Computer Control Systems

Functional organization of the modern hierarchical industrial control systems.

Types of computer control and data acquisition systems: data collection systems, supervisor control, direct numerical control, logical controllers, etc. Modern, decentralized and distributed control systems.

3. Organization and structure of computers for control purposes

- Organization and structure of computers for the industrial controller and for embedded system. Analog and discrete I / O subsystems; analog and discrete control peripherals.
- Organization of computational processes in CCS for continuous control. Concept of static and dynamic process scheduling.
- Organization of computational processes in CCS interacting with discrete objects: implementation of synchronous, asynchronous and synchronous-asynchronous state machines.

4. Basic control algorithms

Controllers for analog objects - standard functions and algorithms; concept of configuration vs coding - specialized languages for continuous control system. Controllers for discrete objects - logical and sequential controllers.

5. Real-Time software environment

Real-Time operating systems - functions and subsystems; management processes (tasks). Scheduling in hard real-time constraints.

6. SCADA

Basic structure. Functions. Standards. Connection to the controllers. Interfaces.

7. Simulators – general theory

Software-in-the-Loop simulators. Hardware-in-the-Loop simulators. Agent-based simulators.

8. Simulators – practical aspects

Computer simulators including process periphery. Connecting the controller to the simulator. Setting-up the simulator. Induction of errors and special situations. Keeping the history of the process. Analysis encountered in real operation problems. Training of the personnel.

9. Simulation of distributed objects and control systems

Virtual monomachine approach. Component approach. Communication network influences – simulation.

10. Simulators validation

Validation using the "Configure/Reconfigure" approach.

11. Real-Time system improvement using simulation environment

Model improvements. Software improvements. Performance optimization.

The course has been scheduled assuming duration of 15 weeks, with 4 hours of direct teacher student interaction per week.

Another basic of an engineer is the correct management and documentation of a project. This is the objective of the following activities that are spread along the course. This is also a horizontal content of the module, so it is spread along the course and in a position where student understands its implications.

The scheduling distribution in weeks for this module is shown in the Table 4.

Table 4

Chapter	Type	Topic	Week														
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Introduction																
1	Lecture		x														
1	Seminar		x														
1	Lab		x														
1	Mini-project		x														
2	Architecture of Computer Control Systems																
2	Lecture			x													
2	Seminar			x													
2	Lab			x													
2	Mini-project			x													
3	Organization and structure of computers for control purposes																
3	Lecture				x												
3	Seminar				x												
3	Lab				x												
3	Mini-project				x												
4	Basic control algorithms																
4	Lecture					x											
4	Seminar					x											
4	Lab					x											
4	Mini-project					x											
5	Real-Time software environment																
5	Lecture						x										
5	Seminar						x										
5	Lab						x										
5	Mini-project						x										
5	Real-Time software environment																
5	Lecture							x									
5	Seminar							x									
5	Lab							x									
5	Mini-project							x									
6	SCADA																
6	Lecture								x								
6	Seminar								x								
6	Lab								x								
6	Mini-project								x								
6	SCADA																
6	Lecture									x							
6	Seminar									x							
6	Lab									x							
6	Mini-project									x							

7	Simulators – general theory													
7	Lecture													X
7	Seminar													X
7	Lab													X
7	Mini-project													X
7	Simulators – general theory													
7	Lecture													X
7	Seminar													X
7	Lab													X
7	Mini-project													X
8	Simulators – practical aspects													
8	Lecture													X
8	Seminar													X
8	Lab													X
8	Mini-project													X
8	Simulators – practical aspects													
8	Lecture												X	
8	Seminar												X	
8	Lab												X	
8	Mini-project												X	
9	Simulation of distributed objects and control systems													
9	Lecture													X
9	Seminar													X
9	Lab													X
9	Mini-project													X
10	Simulators validation													
10	Lecture													X
10	Seminar													X
10	Lab													X
10	Mini-project													X
11	Real-Time system improvement using simulation environment													
11	Lecture													X
11	Seminar													X
11	Lab													X
11	Mini-project													X

About the module assessment [WP1.4 TUS], at this level we will collect all grades earned along the continuous assessment developed along the course and proceed to obtain the final grade for the course.

To do this we establish a just proportion between the different sections to ensure a fair rating for differentiating their individual acquisition of knowledge and skills against the student group work.

The proposal will apply as follows:

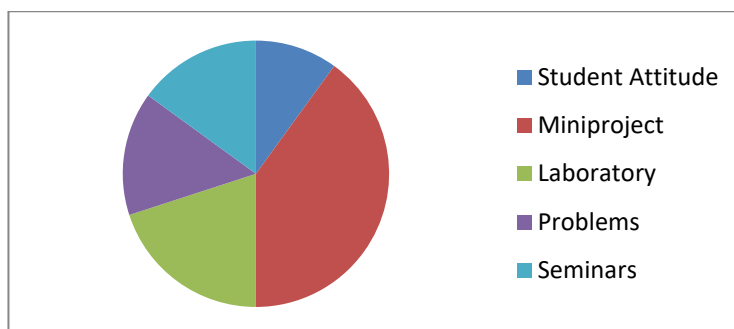
- The evaluation of the student attitude (A) a 10% of the final score.
- The evaluation of the miniproject represents (MP) a 40% of the final score.
- The evaluation of the Laboratory (L): 20% of the final score.
- The evaluation of the Problems (P): 15% of the final score.

- The evaluation of the Seminars (S): 15% of the final score.

With all the information of ratings and percentages described will get a single grade for each student.

For the calculation of the final grade (FG) can be followed as the following equation:

$$FG= A*0.1+MP*0.4+L*0.2+P*0.15+S*0.15$$



Distribution of percentages for final grade

4 Integration of AIISM Courses into Curricula at PetrSU.

AIISM Courses can be integrated into Curricula as elective courses in the 1st year (autumn or spring semesters) or the 2nd year (autumn semester) (see Table 5).

Table 5

The curricula of master program “Applied Mathematics and Informatics”

	Autumn	ECTS	Spring	ECTS
1st year	English Language	2	English Language (3)	3
	History & Methodology of Applied Math & Informatics	3	Contemporary Problems of Applied Math & Informatics	4
	Continuous Math. Models	3	Discrete & Probabilistic Models	4
	Contemporary Computer Technologies	3	Research Seminar	4
	Research Seminar	2	Elective Courses	8
	Elective Courses	4	Practice and Scientific Work	7
	Practice and Scientific Work	13		
	Sum	30	Sum	30
2nd year	Research Seminar	3	Master Thesis Preparation	30
	Elective Coerces	16		
	Practice and Scientific Work	9		
	Sum	30		30
Total sum for 2 years				120

Now we have **10 elective courses** in autumn semester and **6 elective courses** in spring semester. Each of that courses costs 4 ECTS credits (that is 144 working academic hours for each student including exams). The students of AIISM courses will need to study 5 academic hours in week, or 75 academic hours in a course, so the addition of preparatory works, textbooks reading, exams etc. will give us about 3-4 ECTS credits. Hence each AIISM course could change our elective courses in accordance with the table 6.

Table 6

The elective courses of master program “Applied Mathematics and Informatics”

Autumn	Spring
Modelling of socio-economic dynamics	Applied optimization problems
Pattern Recognition	Smart spaces
Basics of Financial Mathematics	Software development project
Digital Signals and Images Processing	Data and Text Mining

Mobile devices architecture and programming Methods and algorithms for parallel computation Web services development Distributed and peer-to-peer systems Software verification Software development project	Web security Programming in Metso DNA
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We can propose several slightly different options to include all AIISM courses in the master program “Applied Mathematics and Informatics”.

As Option 1

AIISM courses can be integrated into Curricula as a chain:

1st year, autumn semester – one introductory course (4 credits)

1st year, spring semester – 2 courses (8 credits in the sum)

2nd year, autumn semester – 2 residuary courses (8 credits in the sum).

As Option 2

AIISM courses (except one of them) could be taught in one semester (autumn of 2nd year). Introductory course should be given earlier (e.g. in the spring of the 1st year).

As additional option we could try to integrate several of that courses in another master programs of Petrozavodsk State University, e.g. the new master program “Intelligent robots design and programming” which is elaborated now.

5 Adaptation of EU Proposal to PetrSU Curricula

The analysis of the options presented above enabled to develop the Curricula based on the Option 1. Thus, the proposed AIISM disciplines are grouped as the Module 2 by student’s choice and included into existing Curricula with the distribution of academic hours shown at the Table 7.

Table 7

Subject	Semester	ECTS Credits	Academic Hours per Semester					Academic Hours per Week	
			Total	Contact Hours	Lectures	Laboratory Lessons	Self Work	1 Semester	2 Semester
Programming of Industrial Computers	1	3	108	75	54	21	33	5	
Programming of Controllers and Simulators	1	3	108	75	36	21	33	5	
Programming of Microcomputers	1	3	108	75	36	21	33	5	
Mobile and Cloud Computing	2	3	108	75	36	21	33		5
Industrial Networks and Fieldbuses	1	3	108	75	36	21	33	5	

As it is presented in the Table 7, every subject has equal number of ECTS credits, namely 3 ECTS credits that is an equivalent of 108 academic hours. This total number of academic hours is divided to 75 contact hours and 33 academic hours of self student’s work. Contact hours include 54 academic hours of lectures and 21 academic hours of laboratory lessons.

Contact hours of 54 academic hours per a semester correspond to 5 academic hours per a week that include 3 academic hours per a week for lectures and 2 academic hour per a week for laboratory lessons. Usual practice for lessons scheduling in PetrSU is that laboratory lessons are scheduled as 2 academic hours per 2 weeks, what gives the same total number of laboratory lessons.

The distribution of AIISM disciplines within the developed curricula is that the majority of subjects are scheduled for the 1st semester (Master Program).

6 Implementation of ECTS

The procedure of implementation of European Credit Transfer and Accumulation System (ECTS) into educational process at PetrSU are based on best practices of the leading Russian universities as well as recommendations of the Russian Ministry of Education. According to these regulations the scale A, B, C, D, E, FX, and F is used at PetrSU”. At the same time, traditional grading system (“excellent”, “good”, “satisfactory”, and “unsatisfactory” for exams; “passed” and “failed” for tests) is used as well. The correspondence between total rating of a student, traditional grades, and ESCT grades is shown in Table 8. The total rating is a sum of points obtained by a student during the studying of a certain subject. Points can be

obtained for a student's work on mini-projects, laboratory tasks, practical lessons, seminars, etc.

Table 8

Total Rating (TR)	ECTS Grades	Traditional Grades	
		For Exams	For Tests
$95 \leq TR \leq 100$	A	Excellent	Passed
$85 \leq TR < 94$	B	Good	
$75 \leq TR < 84$	C		
$65 \leq TR < 74$	D	Satisfactory	
$60 \leq TR < 64$	E		
$0 \leq TR < 60$	Fx	Unsatisfactory	Failed
Learning activities haven't been completed	F	Not admitted	

According to current educational system one academic year corresponds to 60 ECTS credits that are equivalent to 2160 academic hours of study, i.e. 1 ECTS credit corresponds to 36 academic hours (1 academic hour is equal to 45 minutes). Usually one subject includes from 2 to 5 ECTS credits (72-180 academic hours). However either less or more number of ECTS credits is acceptable as well. An average subject of 3 ECTS credits (108 academic hours) includes typically 36 academic hours of lectures, 18 academic hours of practical lessons (laboratory lessons), and 54 academic hours of student's self work.

7 Evaluation system

According to the rules used at PetrSU, evaluation is a part of teacher's documentation prepared for every subject of the curriculum. This evaluation system description includes detailed information about components of student's rating, criteria of evaluation, rules of rating calculation, etc.

This existing document can be simply adapted for implementation of the evaluation system proposed by EU partners. To achieve this objective as well as to satisfy demands of the PetrSU rules" the following actions should be fulfilled for every subject of MEDIS section of the curriculum:

Key factors to be defined

1. The set of student's activities should be defined.
2. The maximum number of points of the final score should be defined.
3. The maximum number of points within the maximum final score should be assigned for every activity.
4. Clear and mono-semantic criteria of evaluation should be formulated for every component of the evaluation system.

Learning activities within MEDIS methodology:

- Lecture

- Problems for individual work of a student
- Laboratory session
- Seminar
- Mini-project,

they are used as a basic set of student's activities for every subject of MEDIS section of the curriculum. To obtain a final set of activities, the proposed proportion between the different sections to ensure a fair rating for differentiating individual acquisition of knowledge and skills against the student group work should be taken into consideration:

- The evaluation of the student attitude (**A**) a 20% of the final score.
- The evaluation of the miniproject represents (MP) a 20% of the final score.
- The evaluation of the Laboratory (**L**): 20% of the final score.
- The evaluation of the Problems (**P**): 20% of the final score.
- The evaluation of the Seminars (**S**): 20% of the final score.

Lecture (A) can be applicable to "Lecture" activity in the basic set, what gives us the final activity to be evaluated – "Active attitude of the student on lectures", what means student's questions and participation in discussions during a lecture. The maximum number of points for activity is 20, what is 20% of 100 points.

Mini-project (MP) The evaluation of the mini-project representation (MP) is applicable to "Mini-project" activity in the basic set, what gives us the final activity to be evaluated – "Fulfilment and presentation of mini-project", what allows to evaluate a student's work from the very beginning of the work on the mini-project to presentation of this project. The maximum number of points for activity is 20, what is 20% of 100 points.

Laboratory work (L) The evaluation of the Laboratory (L) can be applicable to "Laboratory session" activity in the basic set, what gives us the final activity to be evaluated – "Quality of student's work during laboratory sessions", what includes different aspects of the student's work during laboratory session. The maximum number of points for activity is 20, what is 20% of 100 points

Problems (P) The evaluation of the Problems (P) can be applicable to "Problems for individual work of a student" activity in the basic set, what gives us the final activity to be evaluated – "Quality of student's individual work on given problems", what means quality student's solution of given individual tasks. The maximum number of points for activity is 20, what is 20% of 100 points.

Seminars (S) The evaluation of the Seminars (S) can be applicable to "Seminar" activity in the basic set, what gives us the final activity to be evaluated – "Active attitude of the student on seminars", what means student's participation in discussions during a seminar. The maximum number of points for activity is 20, what is 20% of 100 points. The criteria of evaluation for this activity can be the following:

The final score of the student is calculated as a sum of his or her individual score for every of 5 evaluation elements. The final student's grade is defined according to Table 6.

8 Conclusion

There are two options for the integration of AIISM courses into curricula at PetrSU:

As Option 1

AIISM courses can be integrated into Curricula as a chain:

1st year, autumn semester – one introductory course (4 credits)

1st year, spring semester – 2 courses (8 credits in the sum)

2nd year, autumn semester – 2 residuary courses (8 credits in the sum).

As Option 2

AIISM courses (except one of them) could be taught in one semester (autumn of 2nd year). Introductory course should be given earlier (e.g. in the spring of the 1st year).

As additional option we could try to integrate several of that courses in another master programs of Petrozavodsk State University, e.g. the new master program “Intelligent robots design and programming” which is elaborated now.

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