

Table S2.6.4. Form for the preparation of the course information sheets				
Name of the subject	<i>Precision agriculture</i>			
Code of the subject	Status of the subject	Semester	Number of ECTS credits	Class load
	Elective	II	10 ECTS	2+0+2
STUDY PROGRAMME FOR WHICH IT IS ORGANIZED: <i>PhD study in sustainable development</i>				
DEPENDENCY BY OTHER SUBJECTS: Basic knowledge of bio-geo sciences and ICT technologies				
OBJECTIVES OF STUDYING THIS SUBJECT: This course will provide an intermediate level to Precision Agriculture (PA) technologies, covering both the applications and the different technologies (e.g. geographic information systems (GIS), global positioning systems (GPS), remote sensing systems, sensing, variable rate application, Internet of Things (IoT) etc that make precision farming possible. The students will acquire an inside to PA in order to apply multidisciplinary knowledge in this field.				
Contents of the subject (teaching units, forms of students' individual work, forms of testing) presented per working weeks in the academic calendar:				
Preparatory week	Interview and survey of interested PhD students, checking their level of entrepreneurial knowledge as well as area of interest, transferable and soft skills etc			
I week	Importance of Precision Agriculture and mapping in farming for decision making. What is "Precision Agriculture"? Decision making process. Sensing and signal processing. Value of maps in making decision.			
II week	Benefits of Precision Agriculture. Economic benefits. Environmental benefits. Farm management improvement. Recordkeeping improvement. Improving interdisciplinary skills.			
III week	Geographical concepts of PA. Coordinate systems. Scales. Projection. Resolution. Spatial data. Time data.			
IV week	Geographical Position System (GPS). GPS Basics (Space Segment, Receiver Segment, Control Segment). Error and correction. Function and usage of GPS. GPS technologies and devices.			
V week	Topic 2 Introduction to GIS. Basics of GIS. Function of GIS. Use of GIS for decisions. GIS Browsers.			
VI week	Intelligent Devices and Implement (IDI) devices usage in Precision Agriculture. Yield monitor. VR Application (fertilizers, seed, chemicals), vegetation index, different types of the sensing. Examples of sensor and actuators systems.			
VII week	Remote sensing. Aerial and satellite imagery. Above ground (non-contact) sensors. Different radars.			
VIII week	Data collection. Methods of data collection (traditional and new). Data Collection by Grid Sampling. Collecting Data by Yield Monitor. Remote Sensing. Using of sensors for data collection			
IX week	Data analysis. Concepts of data analysis. Resolution. Surface analysis. Computer systems for data analysis. Different signal processing algorithms.			
X week	Internet of Things (IoT) concept in precision agriculture.			
XI week	Machine vision concept in precision agriculture.			
XII week	Case studies in precision agriculture.			
XIII week	Guest lectures of the experts from local community dealing with PA.			
XIV week	Project task. Discussion.			
XV week	Project task. Discussion.			
METHODS OF EDUCATION: Lectures. Interactive exercises Guest lectures. Team and individual project. Presentation of acquired knowledge.				
STUDENTS' LOAD				

<p>Weekly</p> <p>10 credits x 40/30 = 13.33 hours</p> <p>Structure:</p> <ul style="list-style-type: none"> 2 hours of lectures 2 hours of exercises 9.33 hours of individual work 	<p>In semester</p> <p>Lectures and final exam: (13.33 hours) x 16 = 213.33 hours</p> <p>Necessary preparation before the start of the semester (administration, enrolment, verification):</p> <p style="text-align: right;">(13.33 hours) x 2 = 26.66 hours</p> <p>Total workload for the course: 10 x 30 = 300 hours</p> <p>Additional work for preparing correction of the final exam, including taking the exam:</p> <p>0 - 60 hours (remaining time from the first and the second item to the total workload for the course of 300 hours)</p> <p>Structure of the workload:</p> <p>213.33 hours (lectures and final exam) + 26.66 hours (preparation) + 60 hours (additional work)</p>
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<p>STUDENTS' OBLIGATIONS DURING THE TEACHING:</p> <ul style="list-style-type: none"> - regularly attends classes and exercises, - conscientiously and independently realize seminars or homework, - works in a team, - scientifically and methodologically performs course obligations and systematizes appropriate material, - independently completes the practical part of the exam, with the help of literature - presents the acquired knowledge and achieved results.
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<p>LITERATURE:</p> <ol style="list-style-type: none"> 1. Introduction to Precision Agriculture, https://atecentral.net/downloads/1254/International%20Precision%20Agriculture%20Instructional%20Module.doc 2. Precision Agriculture: Sensors Drive Agricultural Efficiency. Sensors and Systems, Making Sense of Global Change, https://sensorsandsystems.com/precision-agriculturesensors-drive-agricultural-efficiency/, 2013. 3. Grisso, R.B., Precision Farming Tools: Global Positioning System (GPS). Publications and Educational Resources http://pubs.ext.vt.edu/442/442-503/442-503.html, 2009. 4. Chris Anderson, "Agricultural Drones Relatively cheap drones with advanced sensors and imaging capabilities are giving farmers new ways to increase yields and reduce crop damage.", MIT Technology Review, May/June, 2014. Retrieved December 21, 2016 5. Available from: https://www.researchgate.net/publication/322156374_PRECISION_AGRICULTURE [accessed Jul 21 2020]. 6. Prof. dr Radovan Stojanović , Developing a smart ICT solutions in agriculture, design challenges, VIRAL – Conference, Banja Luka, Januaru 2020. http://hightech-hub.me/literatura/pametna-poljoprivreda/ 7. N. Latinović at all, Architecting an IoT-enabled platform for precision agriculture andecological monitoring: A case study. Available from: https://www.researchgate.net/publication/317670755_Architecting_an_IoT-enabled_platform_for_precision_agriculture_and_ecological_monitoring_A_case_study
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<p>LEARNING OUTCOMES (COMPLIED WITH THE OUTCOMES FOR THE STUDY PROGRAMME):</p> <ul style="list-style-type: none"> - Define precision agriculture from the managerial technological and social perspectives. - Understand the overall scope of PA. - Understand how GPS works and how this technology is used in PA. - Explore the role of GIS in precision farming and site-specific crop production. - Understand the role of database management system in precision agriculture, including the role of centralized farm management data warehouse. - Define remote sensing and characterize its role in precision farming. - Identify the soil and management factors that influence crop yield. - Understand the concept of spatial variability and soil sampling. - Identify key issues in variable rate application technology, including the different options for implementing variable rate technology. - Understand the application of variable rate technology in agriculture. - Identify the various methods for measuring grain yield. - Understand the potential benefits and limitations of yield maps. - Generate a vision for precision agriculture in the future
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- Understand the concept of IoT and its application in industry.

FORMS OF TESTS AND EVALUATION:

- Seminar-colloquial work / project, after series of lectures and exercises.
- Seminar-colloquial papers will be performed in groups, which will be formed respecting the principle of heterogeneity (interdisciplinary).
- The final grade will contain two criteria:
 - a. assessment of group work 50%,
 - b. assessment of individual contribution of 50%. Individual contribution is assessed according to the description of each author's contribution to the overall project and the thematic interview with the candidate..
- The above items of knowledge assessment can be replaced by publishing a paper presented at doctoral colloquium (the paper should briefly describe the content of the paper / project)

NAME AND SURNAME OF TEACHER AND ASSOCIATE:

Prof. dr Radovan Stojanović and Prof. dr Nedeljko Latinović

PARTICULARITIES NEEDED TO BE EMPHASIZED FOR THE SUBJECT:

The course is also recommended for a lower form of study, MSc, with certain modifications

NOTE (IF NEEDED):