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Work Package 2: University-enterprise cooperation and modernization of Telecommunications Engineering study programs

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Leading organizations: UNTZ, UNS

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Dissemination level	<input type="checkbox"/> Department / Faculty <input type="checkbox"/> Local <input type="checkbox"/> National <input type="checkbox"/> Institution <input type="checkbox"/> Regional <input checked="" type="checkbox"/> International	
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3	1.8.2020	N. Suljanović	UNTZ	Second version
4	1.9.2020	T.Lončar-Turukalo	UNS	Third version
5	10.9.2020	M. Koprivica	UB	Fourth version
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7	14.1.2021	E. Schneider	UNI-KLU	Grammar/formatting corrections
8	18.1.2021	D. Righini	UNI-KLU	Revision

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# 1 Introduction

This deliverable “Delivery of new study programmes and report on study programme changes” reports the implementation of the modernized study programmes and the delivery of the new and upgraded classes in all WB universities.

The overall result reached with the implementation of BENEFIT project is documented with the description of the modernized and new classes. For each course, the report presents the main information about it, points to the web repository where the complete course material can be retrieved and a final part on how the study offer has been changed throughout the project. This deliverable was a living document, updated throughout the project lifetime and finalized and completed at the end of the project.

## 2 Objectives of the Deliverable

The objective of this deliverable is:

- The improvement of existing study programs in accordance with the objectives of BENEFIT project.
- The presentation of new and modernized courses with connection to educational materials posted on the project web portal
- The description of the new study programs and how the study offer has been changed throughout the project.

## 3 Description of the modernized and new classes and material repository

Within the defined BENEFIT framework aimed at boosting University-Enterprise cooperation and modernization of telecommunications engineering studies in the WB region and wider, the University of Tuzla coordinated the tasks related to the delivery of new study programmes and led the preparation of the report on study programme changes.

For each course, this report presents the main information and content of the course, points to the web repository where the complete course materials can be retrieved and a final part on how the study offer has changed throughout the project. The teaching materials developed under BENEFIT are freely accessible on the project's e-platform in the respective page of each course. Some new course materials are not a direct result of BENEFIT and are protected with a password. The password in order to download these materials can be obtained by contacting the responsible teacher of that course (indicated in the e-platform course page).

### 3.1 University of Banja Luka

#### 3.1.1 Description of courses at the first cycle of studies

### 3.1.1.1 Electrical Measurements

The course Electrical Measurements was one of the existing courses that has been modernized through the BENEFIT project. The modernization steps included: revision of the existing syllabus, updating existing lab exercises according to the latest events in the field (i.e. introduction of new definitions of SI units), adding new lectures and lab exercises to the course, addressing the influence of the instrumentation on the measuring results, analysing multiple methods and addressing the causes of random and systematic errors, more detailed oscilloscope-based and spectral analysis of signals, etc. The lab exercises were updated and revised so that students can easily recognize realistic scenarios that are used in practice. The materials were presented to students through the Lab Exercise Workbook, extended with significant number of theoretical examples as well with preparation and exercise tasks. The Workbook covers all significant aspects of Electrical measurements, Magnetic measurements, Oscilloscope and Spectrum analysis, Non-electrical measurements with electrical methods Uncertainty analyses and measurement methodology.

### 3.1.1.2 Digital Signal Processing

The course modernization consisted in introducing an electronic textbook, presentation slides and a practicum with updated laboratory exercises using the new equipment, as well as new teaching methodologies. The teaching materials for the course Digital signal processing are available on the BENEFIT web portal at following link <https://www.project-benefit.eu/eplatform/?courses=20#view>, as well as on the Faculty's Moodle platform: <https://el.etfbl.net/course/view.php?id=280>. The enhanced course has been delivered to students in the winter semesters of the academic years 2019/20 and 2020/21. A screenshot of the Moodle pages of Digital Signal Processing with teaching materials and participants can be seen in Figure 1-1 and Figure 1-2.

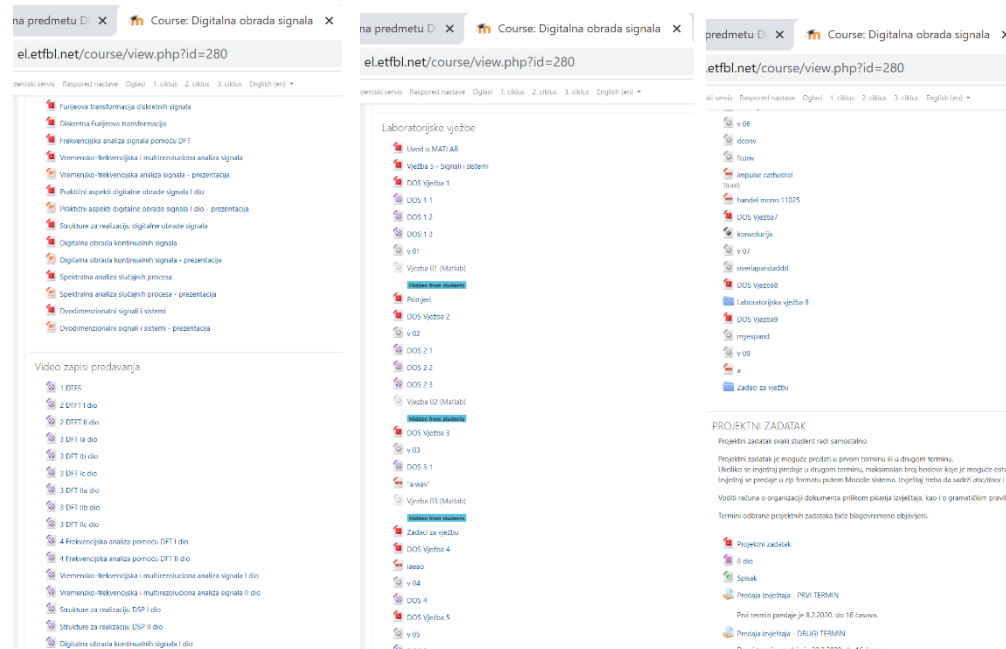


Figure 1-1

Spisak studenata na predmetu x DOSig: Participants

el.ftbl.net/user/index.php?page=0&perpage=20&contextid=0&id=280&newcourse

ETFB

Digitálna obrada signala

Participants

No filters applied

Search keyword or select filter

Number of participants: 28

First name: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Surname: A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

First name / Surname	Email address	Roles	Groups	Last access to course	Status
Zdenka Babic	zdenka@etfb.net	Predavac	No groups	11 secs	Active
Daniela Petrovic	petkovic2010@yahoo.com	Student	No groups	1 min 39 secs	Active
Vlado Rosic (1209/17)	vlado_rosic@yahoo.com	Student	No groups	23 mins 15 secs	Active
Minja Zeric (1202/17)	minjazeric98@gmail.com	Student	No groups	23 mins 25 secs	Active
Vanja Starcevic	vanja.starcevic@etfb.net	Predavac	No groups	1 hour 47 mins	Active
Nemanja Smirani 1212/16	nemanja.smirani7@gmail.com	Student	No groups	12 hours 54 mins	Active
Dragana Lukic 1237/16	dragana.lukic93@gmail.com	Student	No groups	14 hours 17 mins	Active
Vladimir Kurdzia 1226/16	vladimirkurdzia@yahoo.com	Student	No groups	14 hours 20 mins	Active
Nemanja Cobic 1220/15	nemanjacobic@gmail.com	Student	No groups	16 hours 44 mins	Active
Marko Petkovic 1223/15	markopetkovic96@yahoo.com	Student	No groups	18 hours 56 mins	Active
Zarko Vukenovic (1230/18)	zarkov99@gmail.com	Student	No groups	22 hours 58 mins	Active
Vedran Jovanovic	vedran.jovanovic@etfb.net	Predavac	No groups	1 day 2 hours	Active
Dijana Petkovic 1266/16	petkovicdijana@yahoo.com	Student	No groups	1 day 4 hours	Active
Milan Miličević 1225/16	lemi487@gmail.com	Student	No groups	1 day 5 hours	Active
Ivana Popovic 1229/16	ivanapopovic77@hotmail.com	Student	No groups	1 day 5 hours	Active

Figure 1-2

### 3.1.1.3 Telecommunication Networks

This course represents is part of the existing study program and has been modernized within the BENEFIT project. The course modernization focused on creating laboratory sessions and student tasks using the new equipment purchased thanks to BENEFIT project. The newly prepared teaching materials for this course are available on the web portal via the link provided below:

<https://www.project-benefit.eu/eplatform/?courses=22>

This enhanced course has been delivered to students in the summer semester of the academic year 2019/2020.

### 3.1.1.4 Antennas and Radio Wave Propagation

The Antennas and Radio Wave Propagation course was also in the existing study curriculum at University of Banja Luka and within BENEFIT this course has been proposed for modernization. The course modernization focused on making presentations and introducing modernized laboratory sessions using the new equipment that has been purchased thanks to BENEFIT. Until now three existing laboratory exercises have been updated with more detailed simulation software tools and using already existing laboratory equipment such as: Hertz dipole and half-wave dipoles, EZNEC simulator, determining the input impedance of the antenna by measuring the coefficient of standing waves, introduction to the operation and use of the instrument - Handheld Cable & Antenna Tester N9330B, Agilent Keysight N9330B, and other ways to connect them. Thereafter, a procedure for determining and measuring radiation patterns on the example of a small loop antenna (loop) using an Agilent N9310A RF Signal Generator and an N 9000A CXA Signal Analyzer is demonstrated.

The newly prepared teaching materials for this course are available on the web portal via <https://www.project-benefit.eu/eplatform/?courses=13>

This enhanced course should be fully modernized and ready for students in the summer semester of academic year 2021/22.

### 3.1.1.5 Fundamentals of RADAR Systems

So far three existing laboratory exercises have been upgraded with more detailed simulation software tools and using existing laboratory equipment. Those briefly covers: 1. to activate students'

independent learning (i.e. pre-lectured teaching method, self-learning and teaching support via web site and social media), at the beginning of labs is a link to an exemplary MIT University's course where the basics of RADAR Systems are excellently covered. Also, the use of the powerful software packages MATLAB and NI AWR is shortly presented in the laboratory exercises because of the educational academic free and time-limited TRIAL licenses that was used. ARDUINO platforms were also mentioned in labs. Stating an implementation of ultrasonic RADAR. The prepared teaching materials for this course are available on the web portal via <https://www.project-benefit.eu/eplatform/?courses=19>. The enhanced course should be fully modernized and available in the summer semester of academic year 2021/22.

#### 3.1.1.6 *Wireless Sensor Networks*

The course Wireless Sensor Network was modernized with additional lab exercises. In these exercises, the communication of the open-source microcontroller board ARDUINO with LAN (Local Area Network) network, Internet and the mobile network was implemented. Moreover, wireless communication between two ARDUINO boards using the NRF24L01 transceiver module was implemented. Materials include detailed instructions for the required hardware and software, as well as relevant codes.

The prepared materials for these lab exercises (pdf) are available on the web portal via the link (Password protected):

<https://www.project-benefit.eu/eplatform/?courses=23#view>

#### 3.1.1.7 *Multimedia signals and systems*

The course Multimedia signals and systems has been modernized as part of BENEFIT project. The course modernization consisted in introducing a new textbook, presentation slides and laboratory exercises using new equipment purchased during the project.

The teaching materials for this course are available on the course web portal: <https://www.project-benefit.eu/eplatform/?courses=20#view>.

The modernized course was delivered in the summer semester of the 2019/20 academic year as an online course using Moodle platform, Big Blue Button for remote video lectures, Piazza for online discussions, and Google Colab for computation resources. Some of the laboratory equipment was made available to the students for individual work. There were 5 students enrolled in this course.

#### 3.1.1.8 *3.1.1.3 Systems for digital signal processing*

The course modernization of Systems for digital signal processing focused on making teaching presentations and a new practicum with lab sessions.

The prepared teaching materials for this course are available on the web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=21>

The enhanced course has been delivered in the winter semesters of academic years 2019/20 and 2020/21.

A screenshot of the Moodle page of Systems for digital signal processing with teaching materials is shown in the Figure 1-3.



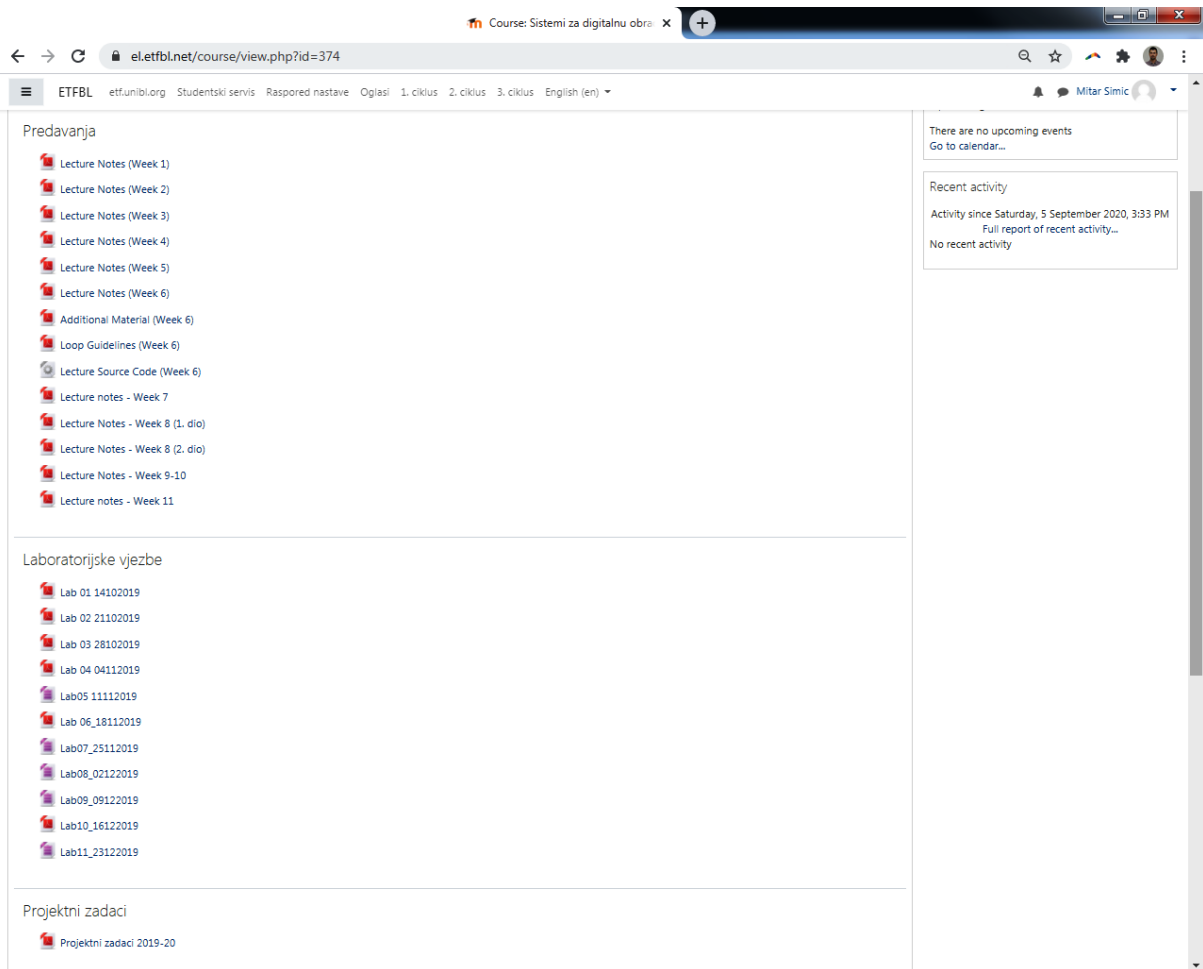


Figure 1-3

A screenshot of the Moodle list of participants of Fundamentals of Electrical Engineering I is shown in the Figure 1-4.

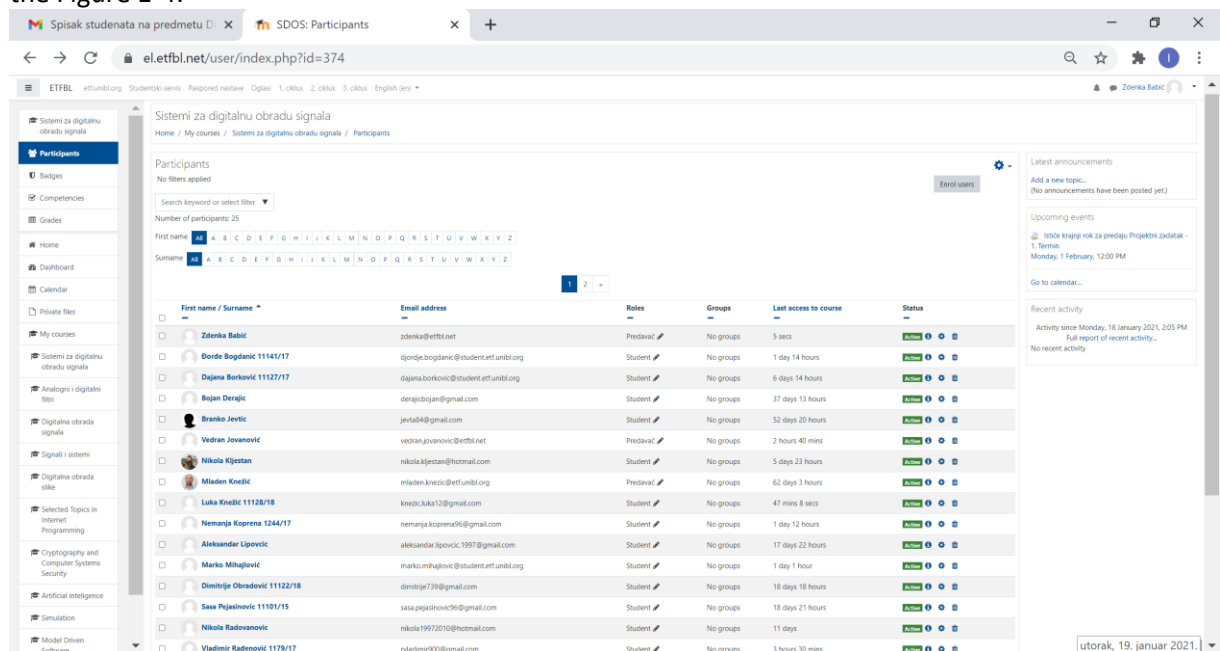


Figure 1-4

### 3.1.1.9 Fundamentals of Electrical Engineering I

The course modernization of Fundamentals of Electrical Engineering I focused on making video content (lab sessions-instructions) using the new video/audio equipment purchased thanks to BENEFIT.

The prepared teaching materials for this course are available on the web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=17>

This enhanced course has been delivered in the winter semester of academic year 2019/20.

A screenshot of the Moodle page of Fundamentals of Electrical Engineering I with uploaded video lab instructions is shown in the Figure 1-5.

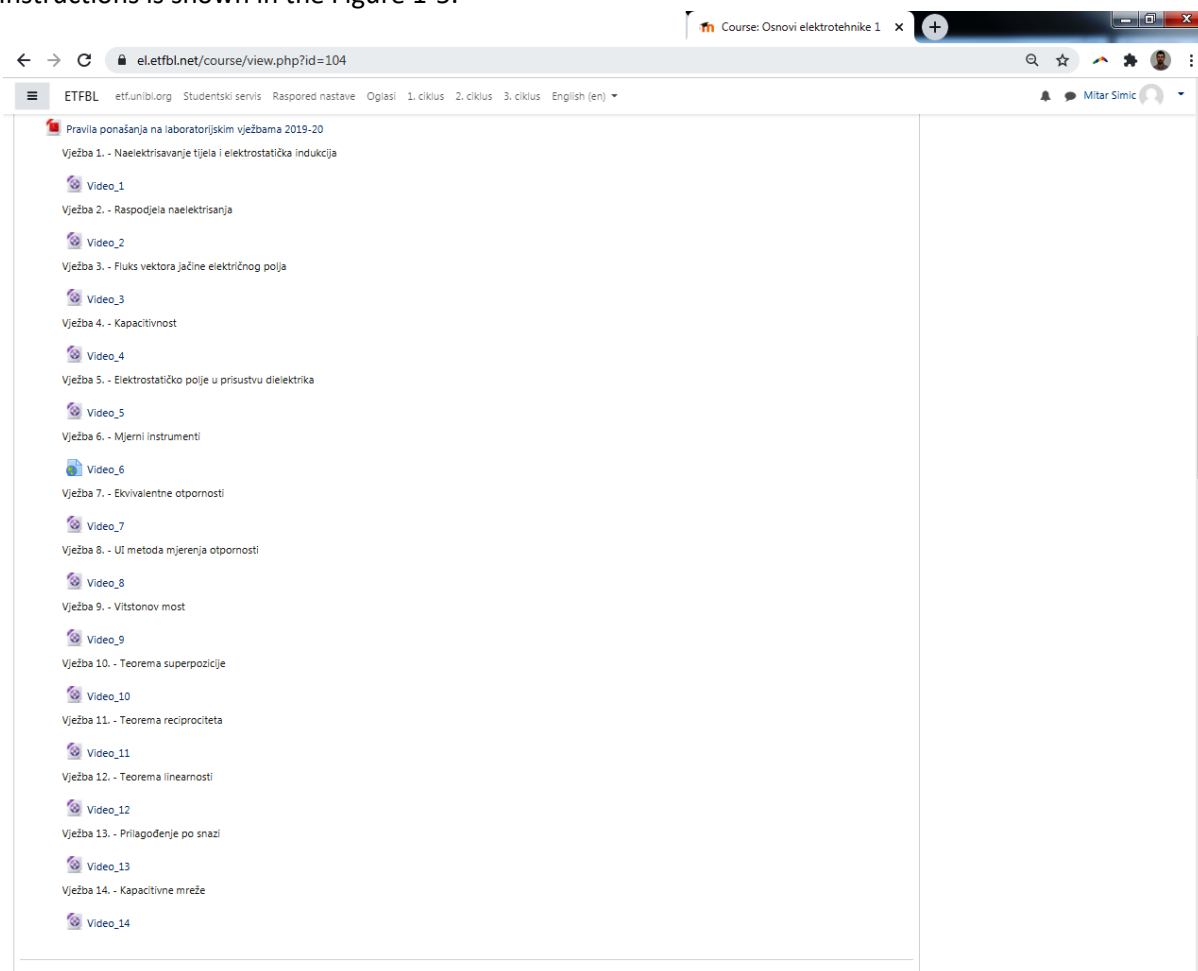


Figure 1-5

A screenshot of the Moodle list of participants of Fundamentals of Electrical Engineering I is shown in the Figure 1-6.

Participants

No filters applied

Search keyword or select filter

Number of participants: 1468

First name: All A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

Surname: All A B C D E F G H I J K L M N O P Q R S T U V W X Y Z

First name / Surname	Email address	Roles	Groups	Last access to course	Status
Vukovic (1322/19)	sarjavukovic124@gmail.com	Student	No groups	195 days 15 hours	Active
Jelena Kalaba 1126/10	kalaba_jelena@yahoo.com	Student	No groups	7 years 14 days	Active
Dusan Antic 1128/16	duca997@yahoo.com	Student	No groups	343 days 1 hour	Active
Tina Lazarević 12124/14	tinalazarevic77@yahoo.com	Student	Drugi kolokvijum	4 years 73 days	Active
Jelena Aleksić 1217/14	jelena95alexic@hotmail.com	Student	Drugi kolokvijum	2 years 70 days	Active
Ilic Zeljko 1276/15	ilic_zeljko@hotmail.com	Student	No groups	2 years 149 days	Active
Andjela Adamovic (1211/19)	andjela.adamovic2000@gmail.com	Student	No groups	86 days 5 hours	Active
Filip Adamović 11130/16	fadamovic@gmail.com	Student	No groups	2 years 212 days	Active
Brankica Adžić 1205/15	brankicaa1997@yahoo.com	Student	No groups	2 years 185 days	Active
mahyar afshari	mahyar.afshari@gmail.com	Student	No groups	7 years 214 days	Active
zoran aleksic	zoranaleksic@gmail.com	Student	No groups	9 years 197 days	Active
Boris Aleksić (1143/19)	borisaleksic@gmail.com	Student	No groups	58 days 13 hours	Active
Milos Amidzic	milosoneshot@gmail.com	Student	No groups	7 years 202 days	Active
Srdjan Amidzic 1187/14	srdjan305@gmail.com	Student	No groups	5 years 166 days	Active
Milijana Andjic	milijanaandjic@hotmail.com	Student	No groups	6 years 124 days	Active
Zoran Anđelić 1118/17	andjelic.zoran25@gmail.com	Student	No groups	1 year 363 days	Active
Milan Anđelić 1356/14	andjelicmilan32@gmail.com	Student	Drugi kolokvijum	2 years 212 days	Active

Search forums

Advanced search

Latest announcements

Add a new topic...

Upcoming events

Drugi termin (14.9.2020.): Registracija je moguća do 11. septembra u 9 h closes Friday, 11 September, 9:00 AM

Go to calendar...

Recent activity

Activity since Saturday, 5 September 2020, 3:18 PM

Full report of recent activity...

No recent activity

Calendar

September 2020

Mon	Tue	Wed	Thu	Fri	Sat	Sun
	1	2	3	4	5	6
7	8	9	10	11	12	13
14	15	16	17	18	19	20
21	22	23	24	25	26	27
28	29	30				

Hide site events

Hide category events

Hide course events

Hide group events

Hide user events

Figure 1-6

### 3.1.1.10 Fundamentals of Electrical Engineering II

The course modernization of Fundamentals of Electrical Engineering II focused on making video content (lab sessions-instructions) using the new video/audio equipment purchased thanks to BENEFIT project.

The prepared teaching materials for this course are available on the web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=18>

This enhanced course has been delivered in the summer semester of academic year 2019/20.

A screenshot of the Moodle page of Fundamentals of Electrical Engineering II with uploaded video lab instructions is shown in the Figure 1-7.

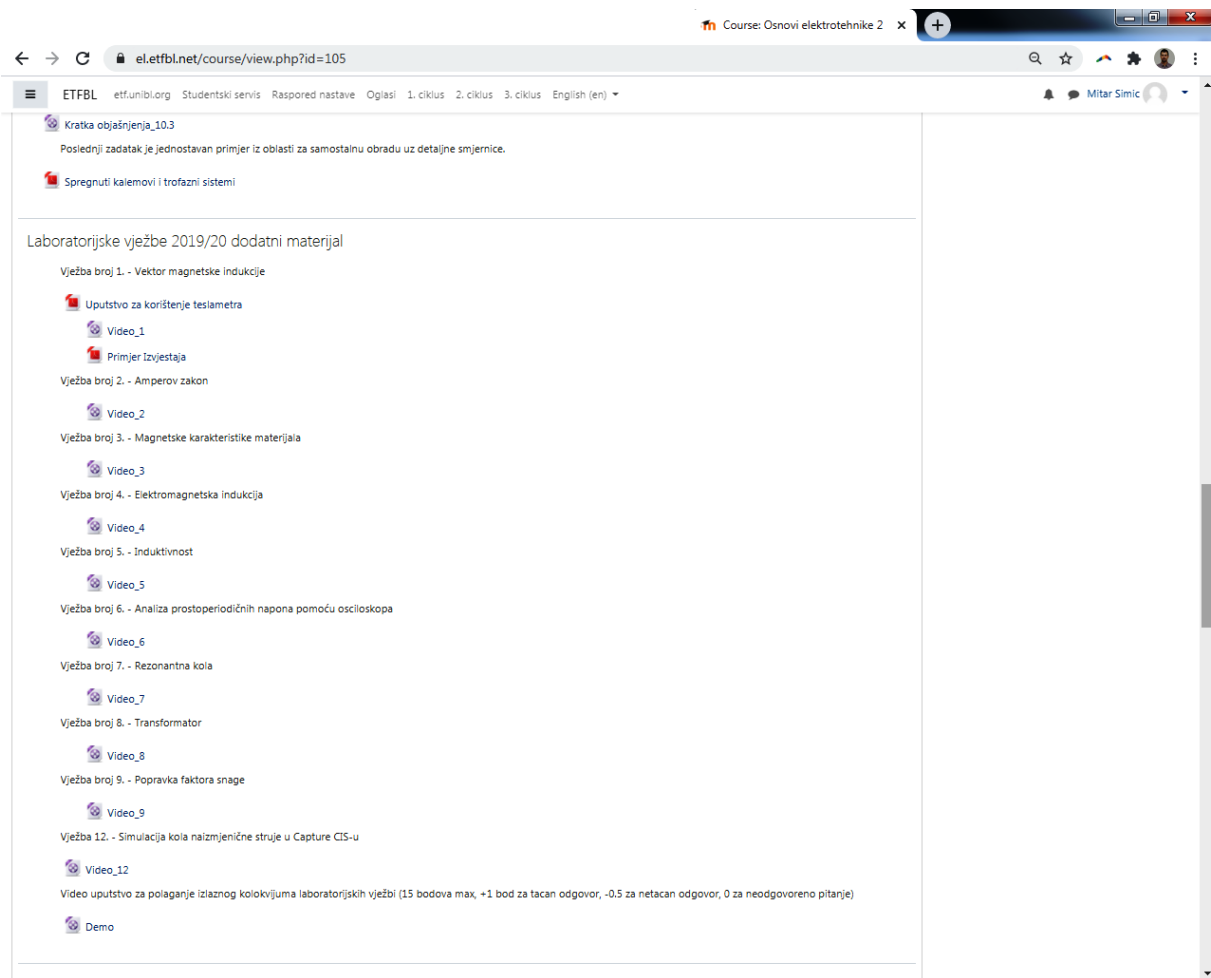


Figure 1-7

A screenshot of the Moodle list of participants of Fundamentals of Electrical Engineering I is shown in the Figure 1-8.

Participants

No filters applied

Search keyword or select filter

Number of participants: 1059

First name: [All] [A] [B] [C] [D] [E] [F] [G] [H] [I] [J] [K] [L] [M] [N] [O] [P] [Q] [R] [S] [T] [U] [V] [W] [X] [Y] [Z]

Surname: [All] [A] [B] [C] [D] [E] [F] [G] [H] [I] [J] [K] [L] [M] [N] [O] [P] [Q] [R] [S] [T] [U] [V] [W] [X] [Y] [Z]

First name / Surname	Email address	Roles	Groups	Last access to course	Status
Vukovic (1322/19)	sanjavukovic124@gmail.com	Student	No groups	102 days 19 hours	Active
Dusan Antic 1128/16	duca997@yahoo.com	Student	No groups	343 days 1 hour	Active
Tina Lazarević 12124/14	tinalazarevic77@yahoo.com	Student	Drugi kolokvijum	4 years 73 days	Active
Jelena Aleksić 1217/14	jelena95alexic@hotmail.com	Student	No groups	1 year 319 days	Active
Ilic Zeljko 1276/15	ilic_zeljko@hotmail.com	Student	No groups	1 year 198 days	Active
Bojana Acimovic	acimovicbojana0@gmail.com	Student	No groups	77 days 2 hours	Active
Andjela Adamovic (1211/19)	andjela.adamovic2000@gmail.com	Student	No groups	46 days 1 hour	Active
Filip Adamović 11130/16	fadamovic@gmail.com	Student	No groups	193 days 21 hours	Active
Brankica Adžić 1205/15	brankicaa1997@yahoo.com	Student	No groups	2 years 123 days	Active
Boris Aleksić (1143/19)	borisalexic6@gmail.com	Student	No groups	66 days 15 hours	Active
Srdjan Amidžić 1187/14	srdjan305@gmail.com	Student	No groups	5 years 84 days	Active
Zoran Anđelić 1118/17	andjelic.zoran25@gmail.com	Student	No groups	278 days 19 hours	Active
Milan Anđelić 1356/14	andjelicmilan32@gmail.com	Student	No groups	1 year 80 days	Active
Sandra Aničić	sandra.anicic2@gmail.com	Student	No groups	3 years 98 days	Active
Igor Aničić (1148/19)	igoranicic@yahoo.com	Student	No groups	101 days 6 hours	Active
Miloš Aničić (1301/18)	milos.anicic99@gmail.com	Student	No groups	334 days 3 hours	Active
Đorđe Antešević	rendyjohnrey@hotmail.com	Student	No groups	1 year 86 days	Active

Figure 1-8

### 3.2 University of Sarajevo

At the Faculty of Electrical Engineering, University of Sarajevo, within the framework of BENEFIT project seven courses at the first and second cycle of studies were modernized.

A list of courses with modernized educational materials is available on the project web portal.

For the first cycle of studies, a list of courses and materials can be found via the web link:

<https://www.project-benefit.eu/eplatform/?programmes=13#view>.

For the second cycle of studies, the list of courses and materials are available via the web link:

<https://www.project-benefit.eu/eplatform/?programmes=18#view>.

At the Faculty of Electrical Engineering Sarajevo, the Moodle courseware system is used for publishing learning materials, and for communication with the students and administration of the course work – including homework publishing, submissions (and automatic grading for programming assignments) in-house developed information system is used: Zamger - “ZAdaća (Homework) ManaGER”, that is integrated with the University of Sarajevo students information system ISSS.

Due to the COVID-19 pandemic these e-learning platforms are extended with use of the Google Suite apps as the Google classroom and the Google meet for online delivery and session recordings.

It is important to note that during the implementation of the BENEFIT project the Department of Telecommunications at UNSA was going through a significant change in the academic staff composition. We have suffered the loss of the Head of the Department late prof. dr. Hadžialić, due to illness, and three professors retired. In this period, two young academics returned after completing doctoral studies abroad, and three academic staff members defended their doctoral thesis at the Department and were elected Assistant Professors.

### 3.2.1 Description of courses at the first cycle of studies

#### 3.2.1.1 *Antennas and Wave Propagation*

Research area: Radio Communications

2018/2019

Assistant prof. Dr Moamer Hasanović

Senior teaching assistant Mirza Hamza

Number of students: 22

2019/2020

Assistant prof. Dr Moamer Hasanović

Assistant prof. Dr Mirza Hamza

Teaching assistant Maida Islamagić

Number of students: 19

The teaching materials for this course are available on the BENEFIT web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=38>

In addition to materials the short report on course implementation during the project is provided.

#### 3.2.1.2 *Software Engineering for Telecommunications*

Research area: Software Engineering

The course Software Engineering for Telecommunications is elective course, delivered for the first time during the BENEFIT project implementation in 2018/2019. The course was delivered (both lectures and labs) by prof. Dušanka Bošković who designed also the course materials. The course will be in future delivered by the recently promoted assistant professor and the new topics will be included and the modernisation will be continued.

The teaching materials for this course are available on the BENEFIT web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=39>

### Softverski inženjering - (Svi studenti)

Ime i prezime	Broj indeksa	Ko- men- tar	Prisustvo	Zadaci			Ispiti			UKUPNO	Konačni ocjena
			BOD.	Zivotni ciklus softvera Download	UML model Download	Projekat Download	I parc. 22.11.	II parc. 22.01.	Usmeni 05.02.		
1. Hasanbegović Selma	1574/17753		10	3	3	4	18	20	/	58	10
2. Ibragić Edin	1637/17802		10	3	3	4	16	14	/	50	9
3. Kerla Almedina	1638/17805		10	3	3	4	13	18	/	51	9
4. Tanković Amina	1565/17926		10	3	3	4	15.5	17	/	52.5	9
5. Tarahija Haris	1636/17366		10	3	3	4	16	18	/	54	10

Prikaži dugmad za kreiranje zadataka \* Refresh  
 Vi ste administrator ovog predmeta.

Copyright (c) 2006-2020 Vedran Ljubović i drugi  
 Elektrotehnički fakultet Sarajevo

Figure 3-1. List of enrolled students – Software engineering

#### 3.2.1.3 Communication Protocols and Networks

Research area: Communication Networks

The course Communication Protocols and Networks is mandatory course. The course existed in previous study program. It was updated within BENEFIT project. The modernisation includes changes to content and form of course. New updated topics related to current computer networks and Internet are added. New labs were prepared and delivered that are more practical work oriented. The project that includes creating a small network is now part of course. New continuous assessment method is introduced. The course was delivered by associate prof. Sasa Mrdovic and TA Nejra Selimovic. Number of students attending course in 2019/2020 was 13.

In addition to materials the short report on course implementation is available at.  
<https://zamger.etf.unsa.ba/index.php?sta=izvjestaj/predmet&predmet=123&ag=15&skрати=da>

# Komunikacijski protokoli i mreže

## Akadska 2019/2020 godina - Izvještaj o predmetu

**Napomena:** Radi zaštite privatnosti studenata, imena će biti prikazana samo ako ste prijavljeni kao nastavnik/saradnik.

### 1

R.br.	Br. indexa	Zadaće	Projekat	Ispiti							UKUPNO	Konačna ocjena
				I parc 29.11.	II parc 03.02.	Int 03.02.	Završni 06.02.	II parc 17.02.	Int 17.02.	Završni 20.02.		
1.	17548	9.6	28	15	10	/	5	/	/	/	67.6 (67.59%)	7
2.	16221	4	0	/	/	/	/	/	/	/	4 (4%)	/
3.	17106	9.2	26	8	/	/	/	/	/	/	43.2 (43.2%)	/
4.	17422	9.5	28	11	11	/	13	/	/	/	72.5 (72.5%)	7
5.	17996	9.2	26	/	/	/	/	/	/	/	35.2 (35.2%)	/

### 2

R.br.	Br. indexa	Zadaće	Projekat	Ispiti							UKUPNO	Konačna ocjena
				I parc 29.11.	II parc 03.02.	Int 03.02.	Završni 06.02.	II parc 17.02.	Int 17.02.	Završni 20.02.		
1.	17804	9.6	28	10	13	/	/	/	/	15	75.6 (75.59%)	8
2.	17927	10	28	13	14	/	20	/	/	/	85 (85%)	9
3.	17957	9	26	13	14	/	13	/	/	/	75 (75%)	8
4.	18247	10	28	13	19	/	/	/	/	15	85 (85%)	9
5.	17808	9.7	28	/	/	13	/	/	25	17	79.7 (79.7%)	8

### Ponovci

R.br.	Br. indexa	Zadaće	Projekat	Ispiti							UKUPNO	Konačna ocjena
				I parc 29.11.	II parc 03.02.	Int 03.02.	Završni 06.02.	II parc 17.02.	Int 17.02.	Završni 20.02.		
1.	17847	9	27	13	13	/	/	/	/	/	62 (62%)	6
2.	16349	10	28	10	6	/	/	11	/	/	59 (59%)	6
3.	16603	10	23	17	15	/	16	/	/	/	81 (81%)	8

The teaching materials for this course are available on the BENEFIT web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=40>

#### 3.2.2 Description of courses at the second cycle of studies

##### 3.2.2.1 Image and Video Compression

Research area: Signal Processing

Image and Video Compression course is an elective course offered at the Department of the Telecommunications. Academic staff responsible for delivering the course are prof. dr. Emir Turajlić and Vedran Karahodžić (teaching assistant). This existing course has been improved by preparation of new teaching materials, including presentations and a textbook. The course textbook is published in 2018. The teaching materials for this course are available on the BENEFIT web portal via the link:

ERASMUS+ PROJECT BENEFIT  
585716-EPP-1-2017-1-AT-EPPKA2-CBHE-JP



<https://www.project-benefit.eu/eplatform/?courses=65>.

In addition to materials the short report on course implementation during the project is provided. Lab materials are available with limited access through the Faculty of Electrical Engineering (UNSA) platform. The *flipped classroom method and project based learning* are used in order to create an interactive learning environment and to give students the opportunity to develop knowledge and skills through engaging projects.

The course is delivered in the summer semester. A screenshot of the web platform (used by the Faculty of Electrical Engineering) showing a list of enrolled students on Image and Video Compression course for the 2019/20 academic year is shown in Figure 3-3. The course was attended by 20 students. Fifteen students were registered for the course during the 2018/19 academic year.

## Kompresija slike i videa

### Akadska 2019/2020 godina - Spisak grupa

(SVI STUDENTI)	
R. br.	Prezime i ime
1	Ajdinović Nadina
2	Bećirbašić Admir
3	Čutahija Zerina
4	Džanko Benjamin
5	Handanagić Hatidža
6	Ibragić Edin
7	Kerla Almedina
8	Mahovac Nerman

Figure 3-2. Classroom view of enrolled students

#### 3.2.2.2 Telecommunication Network Management

Research area: Communication Networks

2018/2019

Assistant prof. Dr Miralem Mehić

Teaching assistant Enio Kaljić

Number of students: 13

2019/2020

Assistant prof. Dr Miralem Mehić

Teaching assistant Amna Kopic

Number of students: 11

The teaching materials for this course are available on the BENEFIT web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=65>

#### 3.2.2.3 Advanced Telecommunication Protocols and New Generation Networks

Research area: Communication Systems

The course Advanced Telecommunication Protocols and New Generation Networks is mandatory course. The course existed in previous study program. It was updated within BENEFIT project. The modernisation includes changes to content and form of course. New updated topics related to current developments in multimedia delivery over Internet and closed computer networks are added. New labs were prepared and delivered that are more practical work oriented. The project that includes creating a small triple-play system is now part of course. New continuous assessment method is

introduced. The course was delivered by associate prof. Sasa Mrdovic and TA Meliha Dulic. Number of students attending the course in 2019/2020 was 14.

The teaching materials for this course are available on the BENEFIT web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=67>

In addition to materials the short report on course implementation is available at:

<https://zamger.etf.unsa.ba/index.php?sta=izvjestaj/predmet&predmet=196&ag=15&skrti=da>

## Napredni telekomunikacijski protokoli i mreže nove generacije

### Akadska 2019/2020 godina - Izvještaj o predmetu

**Napomena:** Radi zaštite privatnosti studenata, imena će biti prikazana samo ako ste prijavljeni kao nastavnik/saradnik.

#### [Bez grupe]

R.br.	Br. indexa	Zadaće	Projekat	Ispiti										UKUPNO	Konačna ocjena
				I parc 22.04.	II parc 03.06.	Uvid u radove 05.06.	Završni 08.06.	I parc 23.06.	II parc 23.06.	Završni 23.06.	I parc 06.07.	Završni 14.07.			
1.	1553/17072	8	30	13.6	13.3	/	17	/	/	/	/	/	81.9 (81.9%)	8	
2.	1268/16108	10	30	18.8	17.7	/	20	/	/	/	/	/	96.5 (96.5%)	10	
3.	1555/16906	10	30	18.7	16.9	/	17	/	/	/	/	/	92.6 (92.6%)	9	
4.	1440/17035	10	30	18.9	18.3	/	19	/	/	/	/	/	96.2 (96.2%)	10	
5.	1552/16371	8	30	16.5	16.9	/	14	/	/	/	/	/	85.4 (85.4%)	9	
6.	1550/17271	8	30	18.6	12.5	/	0	/	/	/	/	/	69.1 (69.09%)	7	
7.	1522/16831	5	28	10	4.8	/	/	/	12	0	/	/	55 (55%)	6	
8.	1476/17083	10	30	18.1	17.6	/	0	/	/	/	/	/	75.7 (75.7%)	8	
9.	1445/17141	8	30	18.8	17.8	/	20	/	/	/	/	/	94.6 (94.6%)	10	
10.	1549/17058	10	30	16.9	13	/	0	/	/	/	/	/	69.9 (69.9%)	7	
11.	1542/17368	6	30	16.6	13.5	/	0	/	/	/	/	/	66.1 (66.09%)	7	
12.	1521/16945	10	28	17.9	12.3	/	0	/	/	/	/	/	68.2 (68.2%)	7	
13.	1475/16315	10	30	17.7	14.1	/	0	/	/	/	/	/	71.8 (71.8%)	7	
14.	1398/16585	0	20	7.5	10	/	/	/	/	/	13	12	55 (55%)	6	

#### 3.2.2.4 Human Computer Interaction

Research area: Software Engineering

Human Computer Interaction (HCI) course is an elective course offered at the Department of Control and Electronics, and the course is regularly elected by students from the Department of the Telecommunications.

Academic staff delivering course is prof. dr. Dušanka Bošković, dr. Nihad Borovina – expert from industry (BH Telecom), and Dr. Almir Salihbegović, Teaching Assistant.

The central topic of the HCI course is a fully functional application development, where a particular emphasis is placed on interaction design. Students work in teams and work through all steps of product development.

Very important topics for software development as user research, understanding of user needs, and user tasks were found less attractive and too theoretical. These skills are familiar to entrepreneurs, product managers, and marketing experts. The changes in the modernized HCI course introduced Product Market Fit canvas in order to bridge the gap between “theoretical” and “practical” part of the course. Product Market Fit (PMF) canvas was introduced in 2018/2019 with objective to engage students with the problem they need to solve. The main guidelines for Product Market Fit canvas use

within the HCI course are: (1) to submit the project proposal, (2) for discussion and project approval process, (3) during the consultancies and for the final project evaluation.

With this improvement we wanted to stimulate a range of entrepreneurial skills that successful interaction designer requires: critical thinking, multidisciplinary orientation, creative problem solving.

Academic year	Number of students enrolled (from the TK master study programme)	Total number of students at the TK master study programme	Total number of students
2017/2018	6	21	76
2018/2019	5	29	93
2019/2020	14	23	102

The teaching materials for this course are available on the BENEFIT web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=72>

### 3.3 University of Tuzla

At the Faculty of Electrical Engineering, University of Tuzla, modernization of courses at the first and second cycle of studies was performed. New courses have been proposed and some content has been prepared for these courses. It is planned to include them in the new study program.

A list of courses with all prepared educational materials is available on the project web portal. For the first cycle of studies, a list of courses and materials can be found via the web link:

<https://www.project-benefit.eu/eplatform/?programmes=14#view>.

For the second cycle of studies, the list of courses and materials are available via the web link:

<https://www.project-benefit.eu/eplatform/?programmes=18#view>.

At the Faculty of Electrical Engineering in Tuzla, Google Classrooms has been established for all courses and is used for communication with students, distribution of teaching materials and other activities that are implemented in the scope of the course.

#### 3.3.1 Description of courses at the first cycle of studies

##### 3.3.1.1 *Analog Integrated Electronics*

The Analog Integrated Electronics course was in the existing study program and within the BENEFIT project this course has been modernized. Course modernization is focused on making presentations and introducing modernized lab sessions using new equipment and software purchased under this project.

Prepared teaching materials for this course are available on the web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=42>

The enhanced course has been delivered in the summer semester of academic year 2019/20. Screenshot of the Google Classroom page of Analog Integrated electronics is shown in the Figure 3-3. The course was attended by 70 students.

## Nastavnici



Administrator Ucionica



Aljo Mujčić



Amera Sinanović



Prikaži sve

## Učenici

70 učenika



Radnje

A-Z



Mirza Bajrić



Namik Bajrić



Figure 3-3. Google Classroom page of Analog Integrated electronics course

### 3.3.1.2 Digital Communications

This course represents the continuity if the course Fundamentals of Communications. The course has been improved by providing new content related to the implementation of digital signal processing and communication algorithms on digital platforms. New presentations have been developed and are available at: <https://www.project-benefit.eu/eplatform/?courses=43>

The course has been delivered as online in academic year 2019/20 as online course, and students didn't have an access to the lab. Lab sessions were implemented virtually. Video contents related to the problem solving sessions as well as lectures were recorded, but are not publicly available.

The faculty uses Google Classroom portal as a virtual classroom. Figure 3-4 shows Classroom view for teaching materials and homework. In Figure 3-5 we can observe that 32 students have been enrolled to this course.

TK301 - Digitalne komunikacije 2019  
2019/20

Stream Školska zadaća Osobe Ocjene

### AV

AV8 - Priprema	Objavljeno: 23. tra
AV6 - Priprema	Objavljeno: 23. tra
AV7 - Priprema	Objavljeno: 23. tra
AV5 - Priprema	Objavljeno: 8. tra
AV 4 - Priprema	Objavljeno: 8. tra
AV 3 - Priprema	Objavljeno: 26. ožu
AV 1 - Priprema	Uređeno 18. ožu
AV 2 - Priprema	Objavljeno: 18. ožu

### LV

LV 8 - Priprema	Uređeno 15. svi
LV 7 - Priprema	Objavljeno: 3. svi
LV6 - Priprema	Objavljeno: 16. tra
LV4 & LV5 - Priprema	Rok: 17. tra
LV 3 - Priprema	Rok: 17. tra
LV 1 i LV 2 - Priprema	Rok: 3. tra 23.59

Figure 3-4 Classroom view showing the available literature – Digital communications

TK301 - Digitalne komunikacije 2019  
2019/20

Stream Školska zadaća Osobe Ocjene

### Nastavnici

Administrator Ucionica	⋮
Amera Sinanović	⋮
Asmir Gogić	⋮

Prikaži sve

### Učenici

27 učenika

<input type="checkbox"/> Radnje	Až
<input type="checkbox"/> Edis Avdićbegović	⋮
<input type="checkbox"/> Ermina Bandić	⋮
<input type="checkbox"/> Adnan Bašić	⋮
<input type="checkbox"/> Selma Beganović	⋮
<input type="checkbox"/> Dino Bošnjak	⋮
<input type="checkbox"/> Velid Čamdžić	⋮
<input type="checkbox"/> Nadia Čosić	⋮
<input type="checkbox"/> Mirsad Dautović	⋮
<input type="checkbox"/> Mersudin Hajdarević	⋮

Figure 3-5 Classroom view of enrolled students – Digital communications

### 3.3.1.3 Fundamentals of Communications

This is a fundamental course in Telecommunications as well as in ICT Engineering. The course content has been changed approx. for 20% (what is allowed in accordance with B&H laws) to provide more insight into the practical aspects of communication system implementation. Lab equipment, purchased in the scope of the project BENEFIT, has been used in the delivery of the lab sessions. New presentations have been prepared and they are publicly available at: <https://www.project-benefit.eu/eplatform/?courses=44>

The enhanced course has been delivered as in-classroom in the winter semester of academic year 2019/20. The faculty uses Google Classroom portal as a virtual classroom. Figure 3-6 and Figure 3-9 show the Classroom view for teaching materials and homework. In Figure 3-7, Figure 3-10 we can observe that 32 students have been enrolled to this course.

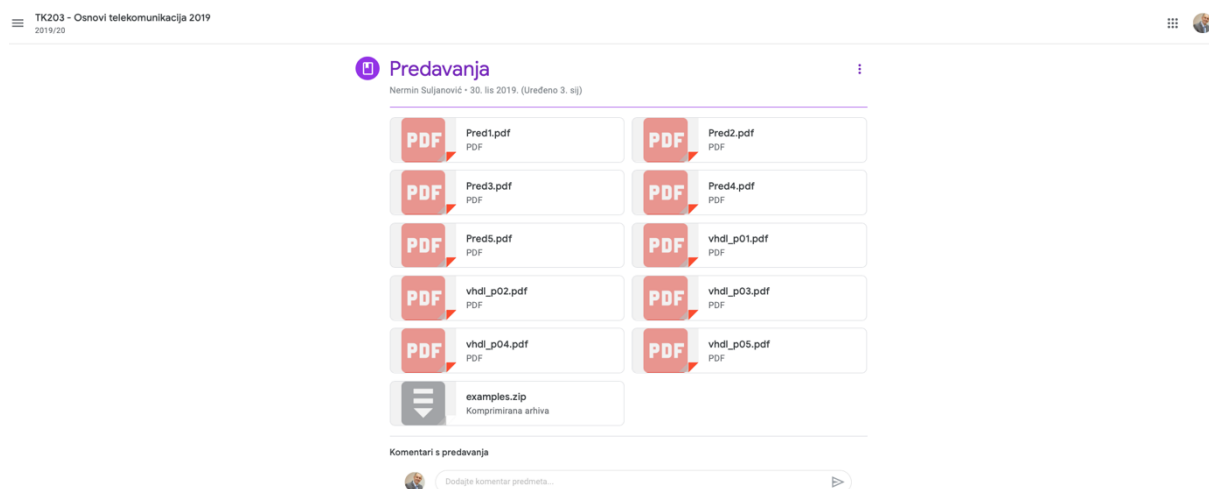


Figure 3-6 Classroom view showing the available literature - Fundamentals of communications

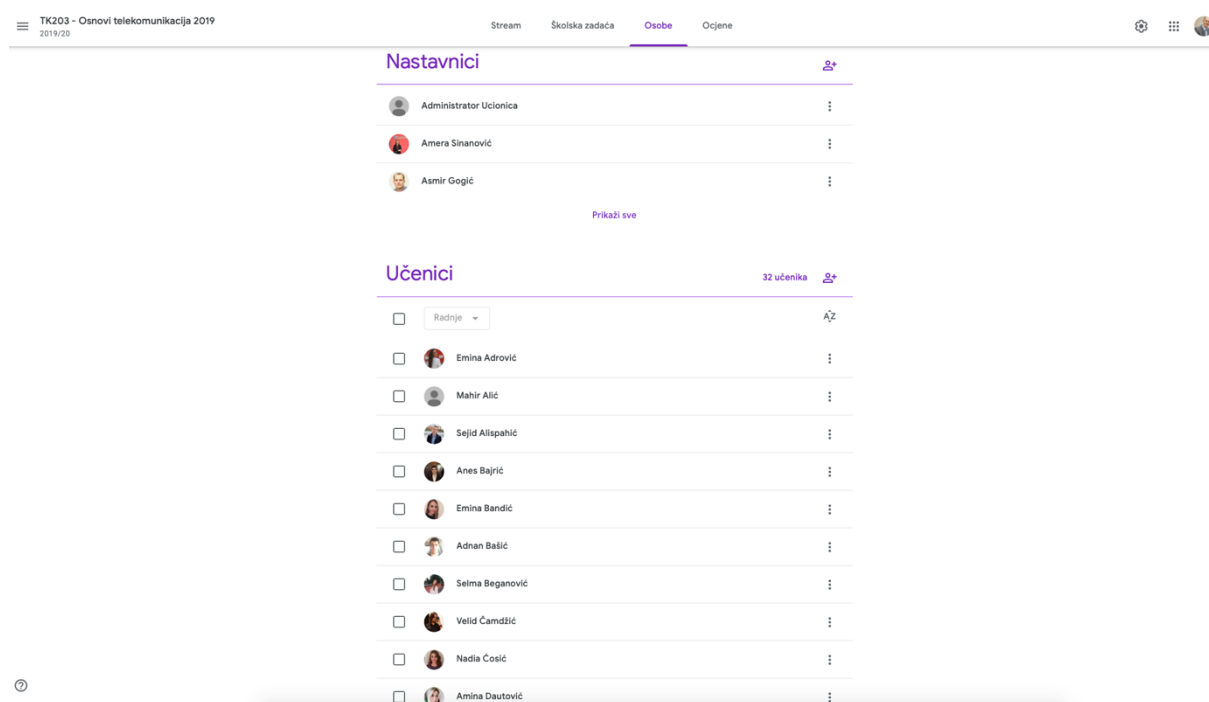


Figure 3-7 Classroom view of enrolled students – Fundamentals of communications

#### 3.3.1.4 Introduction to Electronics

The Introduction to electronics course has been modernized by introducing new presentations, improving lab sessions and preparing a book with solved problems. New measuring equipment and TINA software package were used during the realization of the course of the academic year 2019/2020. Teaching materials for this course can be found on the web platform via the link:

<https://www.project-benefit.eu/eplatform/?courses=45>

The enhanced course has been delivered in the winter semester of academic year 2019/20. Screenshot of the Google Classroom page of Introduction to electronics is shown in the Figure 3-8. The course was attended by 265 students.

## Nastavnici



Administrator Ucionica



Aljo Mujčić



Demir Mahmutović

[Prikaži sve](#)

## Učenci

265 učenika



Radnje

A-Z



Aladin Abadžić



Ahmed Abdurahmanović



Figure 3-8. Google Classroom page of Analog Integrated electronics course

### 3.3.1.5 Microprocessor Systems in Telecommunications

Within this course (modernized in BENEFIT project), microprocessor/microcontroller architecture is analysed which includes: initialization and clock system and control of peripheral modules, interrupts and DMA, communication interfaces. Course also deals with the problems and obstacles when Implementing DSP operations such as: filters (FIR, IIR) and discrete Fourier transformation (FFT algorithms). Principles behind implementation of basic operations within the telecommunication system (modulations, correlation receiver, equalization) are also analysed. In order to implement the whole system, hardware design techniques using microcontrollers, PCB design techniques are presented.

### 3.3.1.6 Sequential Circuits

Sequential circuits being an unavoidable part of every modern digital processing system are systematically analysed and synthesized within the sequential circuits course. This ongoing course was modernized within the BENEFIT project. The introductory part includes topics such as: digital logic, logic circuits, combination and sequential logic circuits based on logic gates, flip flops, registers, counters and memory. The major part of course deals with the languages for hardware description with focus on VHDL. FPGA & CPLD architectures and applications of aforementioned within the telecommunication and embedded systems.

### 3.3.1.7 Signals and Systems

Signals and systems is a fundamental course present in almost all Electrical Engineering and ICT Engineering study programs. This existing course has been improved by preparatory of new teaching materials, including presentations, lab session practicum and a textbook with solved examples. Some video materials have also been prepared to demonstrate usage of the lab equipment. The content and delivery of the lab sessions has been improved using new laboratory equipped in the scope of the project BENEFIT. All teaching materials (besides for preparation of lab sessions – available with limited

access through UNTZ platform) are available without restrictions at the BENEFIT portal: <https://www.project-benefit.eu/eplatform/?courses=48>

The enhanced course has been delivered as in-classroom in the winter semester of academic year 2019/20. The faculty uses Google Classroom portal as a virtual classroom. Figure 3-9 shows Classroom view for teaching materials and homework. In Figure 3-10 we can observe that 139 students have been enrolled to this course.

The screenshot shows the Google Classroom interface for the course 'TK101 - Signali i sistemi 2019'. The top navigation bar includes 'Stream', 'Školska zadaća' (selected), 'Osobe', and 'Ocjene'. The left sidebar shows 'Sve teme', 'Nadoknada', 'Test br.1', and 'Literatura'. The main content area displays a list of assignments under the 'Školska zadaća' tab. The assignments are: 'Prijava za uvid' (Rok: 5. sep 23:59), 'Prijava za Završni ispit' (Rok: 13. velj 12:00), 'Prijava za završni ispit' (Rok: 30. sij 11:59), 'Prijava za Test br. 2!' (Rok: 3. sij 23:59), and 'Prijava za Lab-test (za ponovce)!' (Rok: 6. sij 23:59). Below these, there is a section for 'Predavanja' (Lectures) with a due date of 'Uređeno 26. pro 2019.'. Further down, there are sections for 'Nadoknada' (Makeup), 'Test br.1', and 'Literatura'.

Figure 3-9 Classroom view with available literature - Signals and systems

The screenshot shows the Google Classroom interface for the course 'TK101 - Signali i sistemi 2019'. The top navigation bar includes 'Stream', 'Školska zadaća', 'Osobe' (selected), and 'Ocjene'. The left sidebar shows 'Sve teme', 'Nadoknada', 'Test br.1', and 'Literatura'. The main content area displays the 'Osobe' (People) tab. It lists the 'Nastavnici' (Teachers) and 'Učenci' (Students). The 'Nastavnici' section lists Administrator Ucionica, Amira Sinanović, and Asmir Gogić. The 'Učenci' section shows 139 enrolled students, with a list of names including Aladin Abadžić, Ahmed Abdurahmanović, Aisha Ahmetović, Ajdin Ahmić, Haris Aličić, Enes Alomerović, Adnan Arslanović, Avdo Avdić, and Samra Avdić.

Figure 3-10 Classroom view of enrolled students - Signals and systems



#### 3.3.1.8 *Telemedicine*

The Telemedicine course is a new course and its inclusion in the new study program is planned. During the implementation of the BENEFIT project, this course was not implemented. Presentations have been prepared for this course, which can be found on the project web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=49>

### 3.3.2 Description of courses at the second cycle of studies

#### 3.3.2.1.1 *IoT Networks*

IoT Networks is a new course and is planned to be included in the new study program. During the realization of the project, the preparation of materials for this course was done. The Electronic System Design course is being implemented in the existing study program. Prepared content for the IoT Networks course is partially implemented in the Electronic System Design course.

Prepared teaching materials for this course are available on the web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=68>

#### 3.3.2.2 *Network Security*

The Network Security course has been modernized and presentations have been prepared for this course. The course was realized with new lessons in the winter semester of the 2019/2020 academic year. For this course, lab sessions were realized in the new "VoIP services Lab" laboratory using network equipment, computers and servers procured within the BENEFIT project.

Prepared teaching materials for this course are available on the web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=69>

#### 3.3.2.3 *Telecommunication System Programming*

Telecommunication system programming is a course designed and improved to introduce the concept of SoCa (System on Chip) and its role in development of telecommunication systems. Besides the SoCa concept, students are also introduced to role of microcontroller programming in telecommunication systems. Examples of implementation is IEEE 802.11 b/g/n, IEEE 802.15.1 and IEEE802.15.4 In addition to that, SoCa based telecommunication systems and dedicated communication modules are analysed within the sensor networks. The benefit of using DSP supported microcontrollers for implementation of OFDM based transceiver and super heterodyne receiver are also analysed. Its goal is to enable students to decide which communication protocol, modulation and encryption algorithm is suitable for specific embedded telecommunication system and to enable the analysis of available protocols/modulations and encryption cyphers from the standpoint if SoC/MCU is analysed.

Prepared teaching materials for this course are available on the web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=75>

## 3.4 University of Belgrade

In the scope of BENEFIT project and the study program modernization at the School of Electrical Engineering, University of Belgrade, the Chair of Telecommunications considered and realized the enhancement of four courses at the undergraduate level (the first cycle of studies) and the introduction of two more courses at this level. At the second cycle of studies, the enhancement of two

courses and the introduction of the one new course has been realized through the BENEFIT project. The new study program at both level of studies (the first cycle of studies, i.e. bachelor studies that last four years, and the second cycle of studies, i.e. master studies that last one year), that includes all the enhanced and the introduced (new) courses, has been accredited in 2019, and officially starts in 2020/2021 for the both cycles of studies. Therefore, the new (introduced) master level courses according to the study program accredited in 2019 are expected to be realized for the first time in 2020/2021, while the new courses at the undergraduate level will be thought for the first time with some delay, depending on the corresponding semester. However, the all enhanced courses have already been fully or partially delivered in 2019/2020, in the extent possible according to the previous study program accredited in 2013, so that the modernization of these courses at the first and second cycle of studies was mostly performed. Also, the one new course at first cycle of studies, and the one new course at the second cycle of studies have already been introduced as elective courses in the previous study program accredited in 2013, and were delivered in 2019/2020. Thus, only the one new course planned to be introduced at the first cycle of studies has not been delivered so far, but it was included in study program accredited in 2019, and some materials have been prepared for this course.

A list of courses with all prepared educational materials is available on the BENEFIT project web portal. For the first cycle of studies, a list of courses and materials can be found via the web link:

<https://www.project-benefit.eu/eplatform/?programmes=1#view>

For the second cycle of studies, the list of courses and materials are available via the web link:

<https://www.project-benefit.eu/eplatform/?programmes=10#view>

At the School of Electrical Engineering, University of Belgrade, the first e-platform intended for the communication with students, distribution of teaching materials, study group support and discussion, and the other activities that are implemented in the scope of the courses, was introduced more than fifteen years ago (based on the mailing list server). This platform (in somewhat enhanced form) is still operational and available for the all courses at the faculty (<https://lists.etf.bg.ac.rs/www/>). From 2017, the Office365 cloud platform was implemented, within which students (and teachers) are able to use a large number of free online services. At the beginning of 2020, the faculty has adopted Microsoft Teams online platform as the main platform, and was used for online classes, exercises, consultations, student research and project presentations, various assignments, online quizzes for self-evaluation and so on. The platform also supports posting of course materials (including audio, video and other multimedia formats), recording of online classes and different form of communications with students and study groups. However, the usage of other platforms is also encouraged, such as Cisco Webex, Zoom, Kahoot, Skype, Google services, and so on. Finally, the Chair of Telecommunications maintain official web site for study module Telecommunications and Information Technologies which enables delivery of basic information and course materials for the all courses delivered by teachers of this chair (<http://telit.etf.bg.ac.rs/>).

### 3.4.1 Description of courses at the first cycle of studies

#### 3.4.1.1 *Telecommunications 1*

This mandatory course formed the set of three courses (Telecommunications 1, Telecommunications 2 and Telecommunications 3) that cover fundamentals of communications in the study program accredited in 2013. The content of these courses is fundamental in Telecommunications studies, as well as in ICT Engineering. According to the targeted BENEFIT project curriculum, these courses were significantly reorganized (with the certain areas being shifted or interchanged between courses, course Telecommunication 3 is cancelled and its content was divided between courses Telecommunications 2 and Communication Technologies), and their content enhanced and modernized.

The enhanced course Telecommunications 1 was delivered in the summer semester 2019/2020, with the 154 students enrolled. The course content has been significantly changed (in amount allowed in

accordance with Serbian laws), in order to cover fundamentals of digital baseband transmission, while the content related to signal and system modelling was modernized and enhanced. The enhancements were also intended to provide better insight into the practical aspects of digital communication systems. Also, the active learning and the project-based learning methods were introduced. The enhancement of laboratory exercises has been prepared, mostly by using some of the laboratory equipment purchased in the scope of the BENEFIT project. The first part of course has been delivered in-classroom in the summer semester 2020, while the rest of the course was delivered online by using Microsoft Teams platform for online classes, exercises, and consultations (all classes have been recorded and are available for students at MS Teams platform). Microsoft Teams platform was also used for consultations and support of students engaged in project-based learning, as well as for online presentation of project results (presented by students). Presentations (lecture slides) and laboratory exercises used to deliver enhanced course in the summer semester 2019/2020 have been prepared and will be available in September 2020 at: <https://www.project-benefit.eu/eplatform/?courses=10>. The enhanced course Telecommunications 1 has been included in the new study program accredited in 2019, which officially starts in 2020/2021. The presentations will be modified and updated according to the experiences from the course delivery in 2019/2020, with the additional laboratory exercises, and will be available at: <https://www.project-benefit.eu/eplatform/?courses=10>.

#### 3.4.1.2 *Telecommunications 2*

This mandatory course formed the set of three courses (Telecommunications 1, Telecommunications 2 and Telecommunications 3) that cover fundamentals of communications in the study program accredited in 2013. The content of these courses is fundamental in Telecommunications studies, as well as in ICT Engineering. According to the targeted BENEFIT project curriculum, these courses were significantly reorganized (with the certain areas being shifted or interchanged between courses, course Telecommunication 3 is cancelled and its content was divided between courses Telecommunications 2 and Communication Technologies), and their content enhanced and modernized.

The partly enhanced course Telecommunications 2 (due restrictions imposed by current accreditation and content overlap with still ongoing course Telecommunications 3) was delivered in the winter semester 2019/2020, with the 109 students enrolled, and again in winter semester 2020/2021, with the 138 students enrolled. The course content has been significantly changed (as allowed in accordance with Serbian laws), to cover different aspects of analog and digital passband transmission, and to provide more insight into the practical aspects of communication system implementation. The laboratory exercises were significantly enhanced (with more than 50% of the new exercises), and with the certain laboratory equipment purchased in the scope of the project BENEFIT used for laboratory sessions delivery. Enhanced presentations (lecture slides) used to deliver partly enhanced course in winter semester 2019/2020 have been prepared and are available at: <https://www.project-benefit.eu/eplatform/?courses=11>. The exercises textbook has been prepared, reviewed and accepted by the School council, and is now in publishing stage (as soon as possible the details will be available at: <https://www.project-benefit.eu/eplatform/?courses=11>). The partly enhanced course has been delivered as in-classroom in the winter semester of academic year 2019/2020. The active learning and the project-based learning (including multi-subject projects related to course Signal Processing 1) methods were introduced. As the project-based learning activities were partly realized during Covid-19 pandemic, Microsoft Teams platform was used for consultations and support of students engaged in project-based learning, as well as for public online presentation of project results (by students).

The fully enhanced and modernized course Telecommunications 2 has been included in the new study program accredited in 2019, which officially starts in 2020/2021, and will be delivered for the first time in the final form in winter semester 2022/2023. The presentations and additional laboratory exercises for this fully enhanced course have been prepared and will be available at: <https://www.project-benefit.eu/eplatform/?courses=11>.

### 3.4.1.3 *Signal Processing 2*

Signal Processing 2 is an elective course for the students of ICT submodule, and a mandatory course for the students of Audio and video technologies, modernized within the BENEFIT project. The content of the course covers advanced topics of classical DSP themes (advanced spectrum analysis, filters in multirate systems, digital filter banks, adaptive signal processing, analytical signals, and Hilbert transformers). The course is moved from the 6<sup>th</sup> semester (accreditation 2013) to the 7<sup>th</sup> semester (accreditation 2019). According to the targeted BENEFIT project curriculum, the course was reorganized to improve understanding of the importance of the DSP topics to ICT field of studies.

The enhanced course Signal Processing 2 was delivered in summer semester 2018/2019 with the 42 students enrolled (partly enhanced), and in summer semester 2019/2020, with the 24 students enrolled. The course content has been changed (in the amount allowed by Serbian laws) and modernized. Also, the project-based learning method was reorganized by the introduction of two-subject projects (joint projects with Telecommunications 2). The enhancement of laboratory exercises, based on the laboratory equipment purchased in the scope of the BENEFIT project, has been prepared. However, due to the Covid-19 pandemic, the laboratory exercises were not delivered in 2019/2020 (classical laboratory exercises were substituted by software simulations and implementations provided as additional materials for students). The first part of the course has been delivered as in-classroom in the summer semester 2020, while the rest of the course was delivered online by using the Microsoft Teams platform for online classes, exercises, and consultations. Microsoft Teams platform was also used for consultations and support of students' teams engaged in project-based learning, as well as for the online presentation of students' projects.

The fully enhanced and modernized course Signal Processing 2 has been included in the new study program accredited in 2019, which officially starts in 2020/2021, and will be delivered for the first time in the final form in the winter semester 2023/2024. The teaching material for this enhanced subject has been prepared and is available at <https://www.project-benefit.eu/eplatform/?courses=8>.

### 3.4.1.4 *Fundamentals of Speech Communications*

Fundamentals of speech communications is an elective course, accredited in 2013, for the students of ICT submodule and students of Audio and video technologies, modernized within the BENEFIT project. The content of the course covers fundamentals of speech communications (the mechanisms of speech generation with parameters that describe the speech signal in the time and frequency domain, all phases of speech communication, voice signal transmission - telephony, internet, machine speech recognition, text-to-speech, etc., basic principles on which speech coding, synthesis and the basic principles of speech recognition).

The enhanced course Fundamentals of Speech Communications was delivered in the summer semester 2018/2019 with the 17 students enrolled (partly enhanced), and in the summer semester 2019/2020, with the 26 students enrolled. The course content has been changed (in the amount allowed by Serbian laws) and modernized. Also, the project-based learning method was reorganized by the introduction of two-subject projects. Enhanced presentations (lecture slides) used to deliver partly enhanced course in the summer semester 2019/2020 have been prepared and are available at <https://www.project-benefit.eu/eplatform/?courses=4>. The new exercises textbook has been prepared and reviewed, and is now in the publishing stage (as soon as possible the details will be available at <https://www.project-benefit.eu/eplatform/?courses=4>). The partly enhanced course has been delivered in the summer semester of the academic year 2019/2020, with the first part of course delivered as in-classroom, while the rest of the course was delivered online by using Microsoft Teams platform for online classes, exercises, and consultations (all classes have been recorded and are available for students at MS Teams platform). The active learning and the project-based learning (including multi-subject projects related to course Signal Processing 2) methods were introduced. As the project-based learning activities were partly realized during the Covid-19 pandemic, the Microsoft

Teams platform was used for consultations and support of students engaged in project-based learning, as well as for the public online presentation of project results (by students).

The fully enhanced and modernized course Fundamentals of Speech Communications has been included in the new study program accredited in 2019, which officially starts in 2020/2021, and will be delivered for the first time in the final form in the summer semester 2022/2023. The presentations and additional laboratory exercises for this fully enhanced course have been prepared and will be available at <https://www.project-benefit.eu/eplatform/?courses=4>.

#### 3.4.1.5 *IoT Networks*

This is the new elective course intended to introduce students with the theoretic principles of Internet of Things (IoT), as well as the state-of-the art in IoT technologies, applications and development. The course covers design and operation of smart devices (objects), different communication technologies for connection of smart objects to the network and important networking technologies, the basic of application development, and the specific issues regarding security and data processing principles in IoT networks. The course should enable students to acquire different competences and skills in order to prepare students for networking and implementation of smart devices, platforms and smart environments, and to participate in development of solutions for different IoT application areas. The developed course incorporates practical classes and exercises within the laboratory, as well as the independent and team work on project development (project-based learning). Also, the flipped or inverted classroom teaching method is introduced in which students (in form of team work) are expected to cover different subject based on the given materials, prepare and deliver public presentation (short lecture) for the whole class.

The new course IoT Networks was delivered as in-classroom in the winter semester 2019/2020, with the 51 students enrolled, and again in the winter semester 2020/2021, with the 61 students enrolled, as an elective course introduced in study program accredited in 2013. The new laboratory exercises have been prepared and delivered, as well as the hardware related projects in scope of project-based learning activities, by using laboratory equipment purchased in the scope of the BENEFIT project (located in new Network and IoT Laboratory established as part of BENEFIT project). Presentations (lecture slides) used to deliver novel course in the winter semester 2019/2020 have been prepared and are available at: <https://www.project-benefit.eu/eplatform/?courses=5>. The flipped or inverted classroom and the project-based learning (including multi-subject projects related to course Internet Architectures) teaching methods were introduced. As the project-based learning activities were partly realized during Covid-19 pandemic, Microsoft Teams platform was used for consultations and support of students engaged in project-based learning, as well as for public online presentation of project results (presented by students).

The novel course IoT Networks has been included in the new study program accredited in 2019, which officially starts in 2020/2021. The final presentations (modified and updated according to the experiences from the course delivery in 2019/202) and additional laboratory exercises for this fully developed course have been prepared and will be made available in September 2020 at: <https://www.project-benefit.eu/eplatform/?courses=5>.

#### 3.4.1.6 *Smart Devices and Communications*

Smart Devices and Communications is new course introduced in the scope of the project BENEFIT and accredited in 2019. The course will be realized for the first time in summer semester 2020/2021, i.e. after the end of the BENEFIT project. It is elective course at the first year of the first cycle of studies and it can be elected by students of all modules (not just Information and communications technology module). The course aims to familiarize students with the modern communication environments for online collaboration and e-learning, the fundamentals of smart devices and their networking into smart communication systems, and the use of mobile applications for practical needs. Practical part of the course is based on laboratory exercises and involves the networking of smart devices and the



development of a basic communication system in the laboratory environment, working with mobile applications and the practical use of Internet collaboration tools. The new laboratory exercises will be implemented using laboratory equipment purchased in the scope of the BENEFIT project (located in new Networks and IoT Laboratory established as part of BENEFIT project). Presentations (lecture slides) and practicum for laboratory exercises will be prepared until the end of the BENEFIT project and will be available at: <https://www.project-benefit.eu/eplatform/?courses=9>.

### 3.4.2 Description of courses at the second cycle of studies

#### 3.4.2.1 *Multirate Systems*

Multirate systems is an elective course for the students of ICT and Audio and video submodules, modernized within the BENEFIT project. The subject is moved to the recommended group of subjects for the ICT submodule (accreditation 2019). According to the targeted BENEFIT project curriculum, the subject was reorganized to improve understanding of the importance of the DSP topics to the ICT field of studies.

The enhanced course multirate systems was delivered in the winter semester 2019/2020, with the 2 students enrolled. The subject content has been changed and modernized. Also, research-based learning was introduced. As the final result, a master thesis related to the implementation of the system for the suppression of clipping effects in the discretized signal is in preparation.

The fully enhanced and modernized course multirate systems has been included in the new study program accredited in 2019, which officially starts in 2020/2021, and will be delivered for the first time in the final form in the winter semester 2020/2021. The teaching material for this enhanced subject has been prepared and is available at <https://www.project-benefit.eu/eplatform/?courses=74>

#### 3.4.2.2 *Wireless Sensor Networks*

The existing course, which is already incorporated in study program accredited in 2013, has been modified and enhanced according to targeted BENEFIT curriculum. The fully enhanced and modernized course Wireless Sensor Networks (WSN) has been included in the new study program accredited in 2019, which officially starts in 2020/2021, and will be delivered for the first time in the final form in the summer semester 2020/2021.

The enhanced course has been already delivered in the summer semester 2019/2020, with 67 students enrolled, as the fully enhanced course in study program accredited in 2013. The course content has been changed approximately 20% (which is allowed in accordance with local rules), in order to cover novel topics such as data aggregation and data fusion, cooperative processing, different aspects of localization in WSN and the application of WSN technology as an integral part of Internet of Things (IoT) concept. Also, the complete content of the previously offered course has been reviewed and modernized, e.g. the content that covers particular short-range wireless communication technologies, such as IEEE 802.15.1 and IEEE 802.15.4 based technologies like Bluetooth, ZigBee, 6LoWPAN or WirelessHART. The practical work in laboratory should also be enhanced, based on the existing and the new laboratory equipment purchased in the scope of the BENEFIT project (located in new Network and IoT Laboratory established as part of BENEFIT project). The practical teaching will be enhanced partly through the enhanced and modernized laboratory exercises and more importantly by the significantly improved conditions for the implementation of research-related and project-based learning planned as the mandatory in the enhanced course (due to the acquired laboratory equipment purchased in the scope of the BENEFIT project).

The enhanced presentations (lecture slides) used to deliver course in the summer semester 2019/2020 have been prepared and are available at: <https://www.project-benefit.eu/eplatform/?courses=51>.

Due to the Covid-19 pandemic, enhanced laboratory exercises were not delivered in 2019/2020. The first part of course has been delivered as in-classroom in summer semester 2020, while the rest of the course has been delivered online by using Microsoft Teams platform for online classes, exercises, and

consultations (all classes have been recorded and are available for students at MS Teams platform). The practical teaching (exercises) was covered by providing additional software demos for individual practice and through the individual research-based and project-based learning activities (including multi-subject projects related to course IoT Networks). Microsoft Teams platform was also used for consultations and support of students engaged in project-based learning, as well as for public online presentation of project results (presented by students).

The enhanced course Wireless Sensor Networks has been included in the new study program accredited in 2019, which officially starts in 2020/2021. The presentations (lecture slides) will be modified and updated according to the experiences from the course delivery in 2019/2020, and with the additional laboratory exercises, will be available in September 2020 at: <https://www.project-benefit.eu/eplatform/?courses=51>. Additionally, which was not planned in BENEFIT projects, the new textbook that completely covers content of enhanced course is expected to be prepared and published until the end of 2020, while the details regarding this will be available at: <https://www.project-benefit.eu/eplatform/?courses=51>.

#### *3.4.2.3 IoT Networks Architecture (in 2019/2020 delivered under name IoT Networks)*

This is the new elective course intended to introduce students to the basics of IoT network architecture, from the concept of end IoT devices, through the basics of communication in IoT networks, to the development of fundamental applications, including security issues and data processing principles. The course is devoted to train students to use standard (including open) communications technologies and platforms in order to implement IoT solutions and deploy IoT technologies. It is expected that students acquire basic knowledge on IoT networks architecture, principles of intelligent device development, platforms and networks, and acquire knowledge and skills for further work and research in the field of IoT networks (to work on IoT device and application development projects, intelligent environment design and end solutions in IoT applications). The developed course incorporates practical classes and exercises within the laboratory, as well as independent and team work on project development (project-based learning). Also, the research-based learning is introduced in which students (as team work) are expected to cover different subject, compose research report for teachers and prepare and deliver public presentation (short lecture) for the whole class.

The new course under name IoT Networks was delivered as in-classroom in the winter semester 2019/2020, with the 16 students enrolled, as an elective course introduced in the study program accredited in 2013, while in the winter semester 2020/2021 the course was delivered (under its final name), with the 10 students enrolled, as an elective course in the study program accredited in 2019. The new laboratory exercises have been prepared and delivered, as well as the hardware related and network-based projects in scope of research-based and project-based learning activities, by using laboratory equipment purchased in the scope of the BENEFIT project (located in new Network and IoT Laboratory established as part of BENEFIT project). Presentations (lecture slides) used to deliver novel course in the winter semester 2019/2020 have been prepared and are available at: <https://www.project-benefit.eu/eplatform/?courses=50>. The research-based and the project-based teaching methods (including multi-subject projects related to course Wireless Sensor Networks) were introduced. As the project-based learning activities were partly realized during Covid-19 pandemic, Microsoft Teams platform was used for consultations and support of students engaged in project-based learning, as well as for public online presentation of project results (by students).

The novel course has been included in the new study program accredited in 2019 under the name IoT Networks Architecture (due to formal reasons), which officially starts in 2020/2021, and will be delivered for the first time in the final form in the winter semester 2020/2021. The final presentations (modified and updated according to the experiences from the course delivery in 2019/2020) and complete laboratory exercises for this fully developed course have been prepared and will be available in September 2020 at: <https://www.project-benefit.eu/eplatform/?courses=50>.

### 3.5 University of Niš

At the University of Niš, Faculty of Electronic Engineering accreditation process for Bachelor and Master academic study programmes was completed in 2019. Study program at the first cycle of study (Bachelor study) named Electrical Engineering and Computing includes module *Communications and Information Technologies* with two submodules: 1. *System Engineering and Radio-communications* and 2. *Communications and Information Processing*. Bachelor new accredited study programmes will be implemented for the first time at 2020/21 school year.

The enhanced courses during the project BENEFIT included at submodule *System Engineering and Radio-communications* and *Communications* are **Mobile Communication Systems, Microwave Design for IoT and Measurements in Telecommunications** while novel specified courses are **Computer Communications and Internet access (II)**, as well as **Smart Systems and IoT**. In submodule *Communications and Information Processing*, the course **Data Analysis and Compression** has been modified and also course **Advanced RFIC for Telecommunication Systems** has been developed within BENEFIT project.

Accredited study programme at the Master level (the second cycle) is *Communications and Information Technologies* with two modules: 1. *System Engineering and Radio-communications* and 2. *Communications and Information Processing*. The Master study was implemented in 19/20 school year.

Within project BENEFIT, two courses have been modernized at module *System Engineering and Radio-communications*: **Circuit Design for 5G systems** and **Broadband access networks** whereas two new courses have been included into the study programme: **Wireless power transfer and energy harvesting** and **Artificial Intelligence and Machine Learning for communication systems**. At module *Communications and Information Processing* the course **Principles of Software Radio** has been modified and improved and five new courses have been developed **Intelligent audio algorithms, Statistical Learning in Signal Processing, Computing for IoT Communications, Telecommunication and Information Technologies in telemedicine** and **Big Data Analysis**.

A list of courses, their short description and developed teaching materials are posted on the project web platform:

for the first cycle of studies

<https://www.project-benefit.eu/eplatform/?programmes=6#view>,

<https://www.project-benefit.eu/eplatform/?programmes=7#view>,

and for the second cycle of studies

<https://www.project-benefit.eu/eplatform/?programmes=11#view>,

<https://www.project-benefit.eu/eplatform/?programmes=15#view>.

The teaching material for some courses will be developed after the project finish, since those courses will start in a few years.

#### 3.5.1 Description of courses at the second cycle of studies

##### 3.5.1.1 Mobile Communication Systems

Having in mind fast changes and development of mobile communications, the course “Mobile Communication Systems” has been modernised within the scope of this project. The old course is still being realized according to the accreditation accomplished in 2013. The modernized course is included in the study program accredited in 2019 and will be held for the first time in the academic year 2022/23.



The biggest change in the modernized curriculum is related to involving 5G technology and proportional reduction of contents related to older technologies like 2G and 3G. In addition, some of new topics included in the curriculum are: mobile communications market in Serbia and abroad, policies, safety and regulatory issues, monitoring of the key performance indicators of mobile networks, etc.

As one of realized activities within the scope of the project BENEFIT, 11 ppt presentations have been prepared and posted to the BENEFIT website,

<https://www.project-benefit.eu/eplatform/?courses=27#view>.

The detailed description of the course can be found on the website of the Department of Telecommunications:

[http://kit.elfak.ni.ac.rs/wp-content/uploads/2020/06/3OEK6O07\\_Mobilni\\_komunikacioni\\_sistemi.pdf](http://kit.elfak.ni.ac.rs/wp-content/uploads/2020/06/3OEK6O07_Mobilni_komunikacioni_sistemi.pdf)

It should be noted that even now, without waiting for the official start of the accredited program, the outdated contents of the course "Mobile Communication Systems" are being replaced by more modern ones.

The detailed description of this course can be found at

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK6O07-mobilni-komunikacioni-sistemi.pdf>

#### 3.5.1.2 *Microwave Design for IoT*

This course represents modified existing course Microwave electronics realized according to the accreditation acquired in 2013. Modified course is as obligatory included in Bachelor level of study at module *Communications and Information Technologies* /submodule *System Engineering and Radio-communications*. It extends the knowledge obtained in the obligatory course Microwave technique that offers theoretical knowledge in the analysis of passive microwave circuits, active microwave components-diodes and transistors and fundamentals of microwave amplifier analysis. The practical aspect of the design, analysis and optimization of microwave circuits according to the needs of the Internet of Things (IoT) is covered by the course Microwave Circuit Design for IoT to train student for the design process.

It is accredited in 2019 and will be realized in 2023/24 school year in spring semester. Power point presentations prepared during the project BENEFIT are posted on BENEFIT platform:

<https://www.project-benefit.eu/eplatform/?courses=26>.

Detailed description related to this course can be found at:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK8O04-projektovanje-mikrotalasnih-kola-za-iot.pdf>.

#### 3.5.1.3 *Smart Systems and IoT*

This course is a novel course in accredited Study programme in 2019, on Bachelor level, at module *Communications and Information Technologies* /submodule *System Engineering and Radio-communications*. It is obligatory course in winter semester and will be firstly realized in 2023/24 school year.

Students will get the basic knowledge about the smart system concept, sensors and actuators as well as about communication techniques and data processing for IoT. Moreover, they will understand basics related to security and power management issues in smart systems. Also, student will get knowledge about different platforms for IoT, to understand of possible applications, development trends and social aspects of IoT systems.

Teaching material for this course including novel methods and new equipment has been in the process of development and will be completed after the project end. Detailed description related to this course can be found at:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK7O05-pametni-sistemi-i-iot.pdf>.

#### 3.5.1.4 *Measurements in Telecommunications*

This course, included in accredited curriculum since 2008, is modernized and as such it is included in the study program at the first cycle of studies accredited in 2019. It will be held for the first time in the academic year 2023/24.

The biggest change in the modernized curriculum is related to NI USRP software defined platform, which will be used as wireless prototyping platform for different kind of analog and digital modulation schemes. At the laboratory exercises students will use this platform for transmitting and receiving different type of analog and digital modulated signals as well as to analyze and determine the parameters of the measured signals. In addition to that, presentations used during the lecture hours are updated to include some new topics related to software defined radio, algorithms and techniques for control of measurement equipment and receiving and processing of different types of communication signals, etc.

As one of realized activities within the scope of the project BENEFIT, 15 ppt presentations, together with the pdf script for this course, have been prepared and posted to the BENEFIT website,

<https://www.project-benefit.eu/eplatform/?courses=25#view>.

The detailed description of the course can be found on the website of the Department of Telecommunications:

[http://kit.elfak.ni.ac.rs/wp-content/uploads/2020/06/3OEK7O04\\_Merenja\\_u\\_telekomunikacijama.pdf](http://kit.elfak.ni.ac.rs/wp-content/uploads/2020/06/3OEK7O04_Merenja_u_telekomunikacijama.pdf)

as well as on the web site of the Faculty of Electrical Engineering:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK7O04-merenja-u-telekomunikacijama.pdf>

#### 3.5.1.5 *Computer Communications and Internet access (II)*

This course is a novel course in accredited Study programme in 2019, on Bachelor level, at module *Communications and Information Technologies* / submodule *System Engineering and Radio-communications*. It is elective course in winter semester and will be firstly realized in 2023/24 school year. It extends the knowledge obtained in the elective course Computer Communications and Internet access (I) that offers theoretical and practical knowledge in the field of application of computers and network equipment in the realization of advanced communication and network architectures for Internet access. Students will learn to apply modern methods and techniques for connecting and properly configuring network equipment to establish advanced TCP/ P network architectures for Internet access. Also, students will gain the ability to apply modern switches and routers with dynamic routing protocols in the implementation of heterogeneous networks for Internet access based on IEEE standard 802.3/802.1 /802.15 and ability to administer heterogeneous networks for Internet access.

Up to this moment, the teaching material has been prepared for the acquisition of knowledge related to the practical implementation of IP architectures based on CISCO network equipment. In accordance with that, a text book containing examples for practical and laboratory exercises was realized, which is intended to support the teaching within this course. In these exercises, the emphasis is on working with network devices in the CISCO Packet Tracer program and preparing for practical work with the CISCO Training Kit. Teaching material for this course will be completed after the project end.

Detailed description related to this course can be found at:  
<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK7F01-racunarske-komunikacije-i-pristup-internetu-ii.pdf>

#### 3.5.1.6 *Advanced RFIC for Telecommunication Systems*

The course is a new one, aimed at introducing students to design of advanced RF devices and circuits used in telecommunications. Wireless and mobile networks present constantly updated ongoing requirements for low power, high performance, and low cost RF designs. The course is intended to reflect proven concepts and discuss recent advances for next generation radio platforms. This course is an elective in undergraduate level of study at module of *Communications and Information Technologies* / submodule *Communications and Information Processing*.

It is accredited in 2019 and will be realized in 2023/24 school year in spring semester. Currently, the preparation of slides is ongoing, and online materials will be available at BENEFIT platform:

<https://www.project-benefit.eu/eplatform/?courses=29>.

Complete materials, including the planned lab sessions, will be ready before the official start of course. Detailed description related to this course can be found at:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK8B03-napredna-rf-integrisana-kola.pdf>

#### 3.5.1.7 Data Analysis and Compression

The existing course has been partially modified and it has been accredited in 2019. It will be realized for the first time under this title in 2022/23 school year and will be held in VI semester. The enhanced course under the former title Signal Compression was in realization in 2019/20 and is scheduled for the winter semester 2020/21. During the project new presentations have been created and posted on the BENEFIT portal: <https://www.project-benefit.eu/eplatform/?courses=30#view>. By using these materials students will be able to understand the basic principles of data analysis and compression, to gain theoretical knowledge in the field of lossless and loss compression and to develop ability to process different signals and data using various compression techniques, which could be of great importance for their final projects and bachelor thesis from this field.

This course is also an elective course in the second semester of the Study Programme (Accreditation 2019), the Undergraduate study level at module *Communications and Information Technologies*/submodule *Communications and Information Processing*:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/oas/kit/3OEK6B02-analiza-i-kompresija-podataka.pdf>.

#### 3.5.2 Description of courses at the second cycle of studies

##### 3.5.2.1 Circuit Design for 5G systems

Within the activities of project BENEFIT, the course Design of RF and Microwave Devices, accredited in 2013, has been modernized and improved in course Circuit Design for 5G systems accredited in 2019 as elective course on Master study programme - *Communications and Information Technologies* /module *System Engineering and Radio-communications*. It was realized for the first time in 2019/20 school year in the first semester.

Power point presentations as well as student textbook prepared during the project BENEFIT are posted on BENEFIT platform: <https://www.project-benefit.eu/eplatform/?courses=54>.

Detailed description related to this course can be found at:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit-eng/circuit-design-for-5g-systems.pdf>

This course trains students for work in modern software packages for design, analysis and optimization of microwave and millimetre-wave circuits. The students get knowledge of topology, principles of operation and procedure for designing passive and active circuits for use in microwave and millimetre-wave range applications in 5G systems and also learn to design planar microwave and millimetre-wave circuits and perform their characterization in the measurement procedure using laboratory

equipment. The equipment purchased within project BENEFIT and organized within the Machine to Machine Communication laboratory, can be widely used for required calculations for the circuit design, for test signal generation, measurement process etc.

#### 3.5.2.2 Broadband access networks

This course, included in accredited curriculum since 2008, is modernized and as such it is included in the study program at the second cycle of studies accredited in 2019. It will be held for the first time in the academic year 2020/21.

The biggest change in the modernized curriculum is related to an introduction of all-IP approach in access networks and use of software-defined access network (SDAN) concept for virtualization of access-network control and management functions for broadband access and network optimization. The new topics in the presentation slides as well as in the lab session materials are included such as: multiservice access node (MSAN), next-generation networks (NGN) all-IP concept in access networks, Software-defined access networks (SDAN), etc.

As one of realized activities within the scope of the project BENEFIT, the pdf script for this course has been prepared and posted to the BENEFIT website,

<https://www.project-benefit.eu/eplatform/?courses=53#view> .

The detailed description of the course can be found on the web site of the Faculty of Electrical Engineering:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit/sirokopojasne-mreze-za-pristup.pdf>

#### 3.5.2.3 Principles of Software Radio

The existing course is improved with the introduction of PowerPoint presentations. Presentations have been prepared and posted on the BENEFIT E-platform (<https://www.project-benefit.eu/eplatform/?courses=71#view>). The course was a part of the previous MS study programme and it is also a part of the new study programme accredited in 2019. Also, the laboratory exercises are now using new equipment obtained within the BENEFIT. USRP devices (NI-2791) will be used to create software-based transmitters and receivers, spectrum analyzer will be used for the monitoring of the transmitted and the received signals, and the signal generator will be used to generate test signals for the receivers.

This course is also an obligatory course in the first semester of the Study Programme *Communications and Information Technologies* at the Master Academic Studies (Accreditation 2019/module *Communications and Information Processing*):

<https://www.elfak.ni.ac.rs/en/courses/master-academic-studies/communications-and-information-technologies>

#### 3.5.2.4 Wireless power transfer and energy harvesting

This course is a new course on Master study programme - *Communications and Information Technologies* /module *System Engineering and Radio-communications* accredited in 2019. It is elective course in the first semester of Master study. This school year there was no student on this course. Teaching material for this course is in the process of preparation and will be completed after the project end. Detailed description related to this course can be found at:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit-eng/wireless-and-efficient-energy-transfer.pdf>.

Students will get knowledge of near- and far-field wireless power transfer solutions. They also will learn about energy harvesting systems. Students should know components and circuits that are included

into systems, their functions and topologies. Understanding the importance of WPT and EH systems in modern technologies they should be able to design the simple circuit concepts.

#### 3.5.2.5 Artificial Intelligence and Machine Learning for Communication Systems

This course is a novel course at Master level, included in the accredited in 2019 within the Study program *Communications and Information Technologies* - module *System Engineering and Radio-communications*. It is an elective course in fall semester. The aim of the course is to introduce the basic and more advanced techniques from the field of artificial intelligence and machine learning and their applications for solving different problems in modern communication systems.

The course was realized for the first time in the fall semester of the 2019/20 academic year. The course was elected by 4 students. The teaching was combination of lectures and practical exercises in MATLAB software environment (licence purchased within the BENEFIT project), as well as case studies of the existing applications. The part of the course work were individual projects on applying artificial neural networks for solving problems in the field of RF and microwave communication systems.

The lecture slides are available at the BENEFIT web portal:

<https://www.project-benefit.eu/eplatform/?courses=52>

Detailed description related to this course can be found at:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit-eng/artificial-intelligence-and-machine-learning-for-communication-systems.pdf>

#### 3.5.2.6 Intelligent audio algorithms

Development in the field of audio has been rapid recently. This is mainly a consequence of development in the artificial intelligence, digital signal processing and embedded devices. Following this trend, the course *Intelligent audio algorithms* is proposed as a new one, that has been accredited in 2019, and since then it has been in the curriculum of the master studies. The course deals with principles and tools used in digital processing of audio signals. The focus is on intelligent algorithms in analysis and classification of audio signals, spatial audio and speech processing. The topics include audio signal processing, audio features engineering, machine learning and artificial intelligence in audio, audio compression, speech technologies, etc. Within the BENEFIT project, the presentations (lecture slides) for the *Intelligent audio algorithms* course were prepared, and posted on the portal at <https://www.project-benefit.eu/eplatform/?courses=59>.

#### 3.5.2.7 Computing for IoT Communications

This is a newly developed elective course in master level of study at module of Communications and Information Technologies / submodule *Communications and Information Processing*. Its aim is to introduce telecommunication students with computing skills required for IoT applications, and make use of the newly -equipped M2M lab. In accordance with project goals, the prepared draft of the textbook (320 pages in its current version) has been prepared and uploaded to BENEFIT online platform:

<https://www.project-benefit.eu/eplatform/?courses=57>

Preparation of slides for online teaching sessions is also ongoing, and the materials will be made available in the platform, as soon as they are ready.

The course is accredited in 2019, and detailed description of this course can be found at:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit-eng/computing-for-iot-communication.pdf>

### 3.5.2.8 Big Data Analysis

Big Data Analysis is a novel course designed to introduce big data analytic tools and algorithms as well as statistical models and neural networks in solving communication problems. This course was not implemented yet, but presentations and lab exercises had been uploaded on the project web portal:

<https://www.project-benefit.eu/eplatform/?courses=58&id=212>

Big data analysis is also an obligatory course in the second semester of the Study Programme *Communications and Information Technologies* at the *Master Academic Studies (Accreditation 2019)* /module *Communications and Information Processing*:

<https://www.elfak.ni.ac.rs/en/courses/master-academic-studies/communications-and-information-technologies>

The courses will be realized during 2020/21 interactively in real-time using Zoom, WebEx, Skype.

### 3.5.2.9 Statistical Learning in Signal Processing

The novel specific-knowledge course has been accredited in 2019. During the implementation of the BENEFIT project this course was not implemented. The new presentations have been created and posted on the BENEFIT portal: <https://www.project-benefit.eu/eplatform/?courses=56> By using these materials students will be able to better understand the theory of machine learning, to highlight the key advantages of statistical learning algorithms and to develop ability to apply gained knowledge in various real-life problems in the field of compression. Also, due to the fact that research-related teaching has been opted as one of the learning methods, research tasks have been shortly specified within the course materials. Solving these research problems could be beneficial for students' further research in this field.

Statistical Learning in Signal Processing is an elective course in the first semester of the Study Programme *Communications and Information Technologies* at the *Master Academic Studies (Accreditation 2019)* /module *Communications and Information Processing* and its detailed description can be found at:

<https://www.elfak.ni.ac.rs/en/courses/master-academic-studies/communications-and-information-technologies>.

### 3.5.2.10 Telecommunication and Information Technologies in Telemedicine

The course of Telecommunication and information technologies in telemedicine is a new course that was accredited in 2019. Because of that it has not implemented during duration of BENEFIT project. Since the course is implemented in Master programme, it is project-based course. The short movie describing the course was recorded, and detail students' project descriptions were prepared. The students are directed to basic references needed for project realizations or a short ppt presentation is prepared.

Description of the course and digital materials are available at:

<https://www.project-benefit.eu/eplatform/?courses=60>

Also, more detailed description of this course is on the link:

<https://www.elfak.ni.ac.rs/downloads/akreditacija-2019/mas/kit-eng/telecommunications-and-information-technologies-in-telemedicine.pdf>.

## 3.6 University of Novi Sad

At the Faculty of Technical Sciences, University of Novi Sad, the Chair of Telecommunications and Signal Processing has enhanced three courses at undergraduate level and introduced three more courses at this level. At the second cycle of studies three new courses have been developed through



the BENEFIT project, all accredited in 2019. The new study program officially starts in 2020/21 for both study cycles, so that most of the new master level courses will be realized in 2020/2021, while the new courses at undergraduate level will be thought for the first time with some delay, depending on the corresponding semester. All the enhanced courses have already been fully or partially realized in 2019/2020.

A list of courses with all prepared educational materials is available on the project web portal. For the first cycle of studies, a list of courses and materials can be found via the web link:

<https://www.project-benefit.eu/eplatform/?programmes=12#view>

For the second cycle of studies, the list of courses and materials are available via the web link:

<https://www.project-benefit.eu/eplatform/?programmes=16#view>

The Chair of Telecommunications and Signal Processing has the Moodle LMS (KTIOS) for several years, where for all courses teaching materials, homework and project assignments are distributed and communication with the students is done efficiently. The Faculty of Technical Sciences has developed Moodle LMS (SOVA) which was activated in March 2020, and through the institution they have enabled the access to the Microsoft Office 365 (Microsoft Teams, OneNote, etc.). These tools will be available in the 2020/2021, while during the 2019/2020 most of the courses have been realized using Zoom, WebEx, Skype, or Big Blue Button, and supported by Viber and Discord for efficient communication with the students in real-time.

### 3.6.1 Description of courses at the first cycle of studies

#### 3.6.1.1 *Modelling and Simulation of Communication Systems*

The existing course is partially modified according to the targeted BENEFIT curriculum. In 2020/21 there will be the last realization of the (partially) updated course in IV semester. The targeted course will be held in VII semester, starting from 2023/24.

During the project, new presentations were developed and posted to the BENEFIT portal: <https://www.project-benefit.eu/eplatform/?courses=35#view>. The course page at KTios Moodle LMS is shown in Figure 3-11.

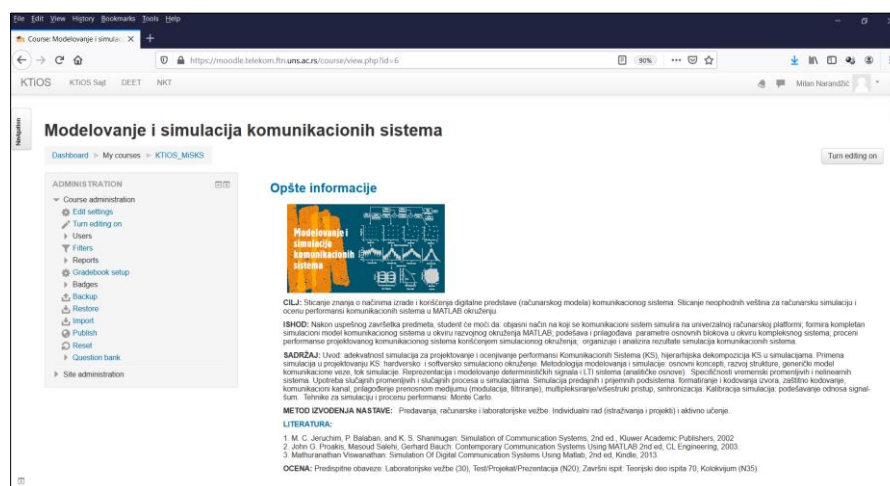


Figure 3-11 *Modelling and Simulation of Communication Systems – the course page at KTios Moodle*

Recordings of lectures, i.e. video sessions were provided during the summer semester of 2019/20. In that semester lectures were mainly held online using WebEx and Zoom, and total of 30 students were attending lectures. Starting from mid-March there were between 4 and 26 attendees per online event. In the current version of course, simulations are performed in MATLAB environment, using the PC environment. In 2019/20 laboratory exercises were realized from home, using online tutoring and

partially online evaluation. In the target version, simulation environment will be extended to USRP software defined radios.

### 3.6.1.2 Machine Learning 1

This course has been accredited in 2019 and will be realized for the first time under this title in 23/24 academic year. This enhanced course under the former title *Pattern recognition* was last in held in 19/20, and also planned for the winter semester 20/21. Presentations for the Pattern recognition course are being improved, and posted on the BENEFIT we portal at <https://www.project-benefit.eu/eplatform/?courses=33#view>. A practicum with the lab sessions has been prepared and is currently under review by external experts. The expected publication on the e-platform is beginning of 2021. The course has been followed actively by 30 students in 19/20 (with additional 29 students from previous generations active in homework and project segments only), lab sessions were held in Python environment, aligned with the developed practicum. Students were able to use GPU (procured by the BENEFIT project) for their final projects and bachelor thesis from this field. The Pattern Recognition page on the Moodle platform of the Chair for Telecommunications and Signal processing (KTIOS) holds the lecture slides, instructions for lab sessions, list of topics for the final projects, recommended reading list, and its serves for efficient communication with the enrolled students (Figure 3-12)

Figure 3-12 Machine learning 1 – Lecture notes at KTIOS Moodle course page

### 3.6.1.3 Software in Telecommunication Systems

The course was accredited for the first time in 2013 for the second cycle of studies. A significantly improved course was accredited in 2019 and will be realized for the first time under the same title in the 23/24 academic year. Presentations for lectures are available along with a practicum for laboratory exercises. This course introduces fundamental concepts of hardware and software virtualization, clustering, cloud computing, and software-defined networks to students. In addition to these concepts, students get to know about the fundamentals of data warehousing technologies. Examples of solutions based on these concepts are presented during lab sessions to enable students to independently choose and implement fitting technologies according to their needs for designing modern and smart environments. The course will have a strong application emphasis and will utilize the equipment obtained through the BENEFIT project: SUPERMICRO SYS-7049A-001 and SYS-7049GP-002 servers (one possesses an NVIDIA TITAN Xp Graphics Card) and QNAP STORAGES NAS TVS-682-i3-8G. The aforementioned hardware is connected to the academic network via a 1 Gbps link. The teaching materials for this course are available on the BENEFIT web portal and KTIOS Moodle (Figure 3-13 ) via the following links:



<https://www.project-benefit.eu/eplatform/?courses=75>  
<https://moodle.telekom.ftn.uns.ac.rs/course/view.php?id=78#section-4>

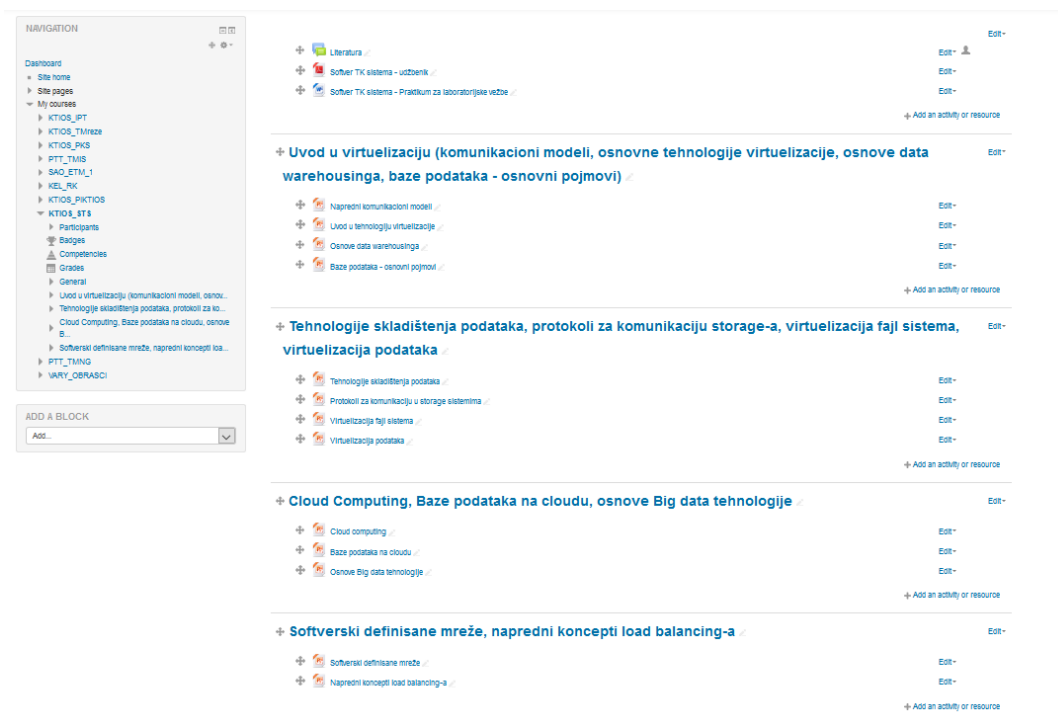


Figure 3-13 Software in Telecommunication Systems– the learning materials at KTIOS Moodle course page

#### 3.6.1.4 Machine learning 2

The Machine learning 2 builds upon Machine learning 1 to offer more advanced topics and cover the advances in the fast evolving field of machine learning. The course has been accredited in 2019 and will be realized for the first time in 23/24 school year. The teaching materials will be developed after the BENEFIT project is officially completed, since the subject relates to the area of intensive research. As the numerous topics cannot be covered in a single course, this course will offer a more in depth lectures on neural networks and deep learning, probabilistic graphical models, unsupervised and semi-supervised learning. Promotional video for this course will be recorded by 2020/10.

#### 3.6.1.5 Wireless Communication Systems

Wireless Communication Systems course will focus on system and technology aspects of modern wireless communication systems, both mobile cellular systems standardized by 3GPP, and wireless local area networks (LAN) standardized by IEEE under 802.11 working group. The course is accredited in 2019 and will be realized for the first time in 22/23 school year. The teaching materials are currently under development and will be fully completed after the BENEFIT project is officially completed. Parts of the course material will be available at the BENEFIT web portal at the link: <https://www.project-benefit.eu/eplatform/?courses=37>. The course will mainly cover mobile cellular technologies focusing on 4G LTE and 5G NR technology details. In addition, the course will cover modern WLAN systems such as IEEE 802.11ac standard.

#### 3.6.1.6 Design of Industrial IoT Systems

The course has been accredited in 2019 and will be realized for the first time in the 23/24 school year. Presentations for lectures are prepared, and the recommended literature is available. The course is

designed to provide students with knowledge about the Internet of Things (IoT) and its underlying principles, focusing on real-time systems. It covers Industrial IoT, including its reference models, architecture, and convergence of IT/OT technologies, and includes specific industrial IoT systems and protocols. Examples of solutions based on these concepts are presented during lab sessions to enable students to cooperate in groups. The student must be able to do the final project, which can be related to different applications such as PlantWeb architecture, Building Automation, Power Systems Automation (Smart Grid), and wireless-based applications (Narrowband IoT, Lora, Wireless HART). The course will have a strong application emphasis and will utilize the equipment obtained through the BENEFIT project: SUPERMICRO SYS-7049A-001 and SYS-7049GP-002 servers (one possesses an NVIDIA TITAN Xp Graphics Card), QNAP STORAGES NAS TVS-682-i3-8G..., and in the domain of wireless IoT development, it will make use of National Instruments USRP 2901/2920 platforms.

The teaching materials for this course are available on the BENEFIT web portal:

<https://www.project-benefit.eu/eplatform/?courses=32#view>

### 3.6.2 Description of courses at the second cycle of studies

#### 3.6.2.1 *Big Data - Management and Analysis*

The course has been accredited in 2019 and will be realized for the first time in 20/21 school year. Presentations have been prepared and posted on the BENEFIT E-platform (<https://www.project-benefit.eu/eplatform/?courses=61#view>). This first version of lecture slides will be modified and updated according to experiences from the first course edition. The lectures are partly covered by a textbook developed for the course Software in Telecommunication Systems and will follow the book "Mining Massive Datasets" (available [online](#)). The first set of laboratory exercises has already been posted on e-platform. The course will have a strong application emphasis and will exploit the equipment obtained through the BENEFIT project. Namely, SUPERMICRO SYS-7049A-001 and SYS-7049GP-002 servers (only one possesses an NVIDIA TITAN Xp Graphics Card) and QNAP STORAGES NAS TVS-682-i3-8G. The aforementioned hardware is connected to a 1 Gbps link.

#### 3.6.2.2 *Cognitive Radio*

This is the new course that is accredited in 2019 and will be given for the first time in 2020/21. During the project, presentations are prepared and posted to BENEFIT portal: <https://www.project-benefit.eu/eplatform/?courses=62#view>. The course page at KTIOS Moodle LMS is shown in Figure 3-14.

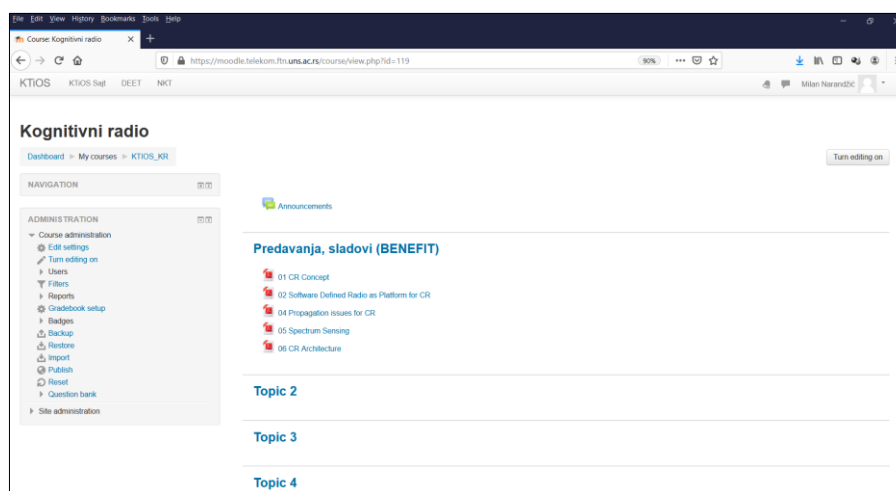


Figure 3-14 Cognitive Radio– the learning materials at KTIOS Moodle course page

The practicum for the lab exercises is under development: initial draft was made. GNU Radio and MATLAB software environments are being used. Laboratory exercises are based on USRP software defined radio equipment that is procured during the BENEFIT project.

#### 3.6.2.3 *Network Science*

Network science is a novel course at UNS, included in the newly accredited program that will start in Fall 2020 semester. (Due to pregnancy leave of the course instructor D. Bajovic in September 2020, the first edition of the course itself is planned for Fall 2021 semester.) Part of the lectures (Week 1: Introduction to Network science and examples of student projects) was presented within the course Wireless ad hoc networks (4th year, first cycle of studies at UNS).

Detailed syllabus and prepared teaching materials for this course are available on the web portal via the link:

<https://www.project-benefit.eu/eplatform/?courses=63>

#### 3.6.2.4 *Security and Cryptography*

The course Security and Cryptography will be held (online) in the fall semester of 2020/2021 for the first time. The outline of the course and the literature on which it is based are ready. The presentations have not yet been completed; they will be prepared and posted on the project web portal and the course webpage in due time.

## 4 Conclusion

This deliverable has presented the implementation of the modernized study programmes and the delivery of the new and upgraded classes in all Western Balkan universities.

As part of the project activities, teacher trainings have been organised in 2019 and 2020 as a full or multiple day workshop at the University of Ljubljana, University of Banja Luka, University of Osijek, University of Niš and the University of Sarajevo.

At **first cycle** level **32 courses were modernized** and **8 new courses were introduced**. These courses covered 10 knowledge areas. At **second cycle** degree level **11 courses were modernized** and **13 new courses were introduced**. These courses fit into 8 knowledge areas. **The total is 64 courses**.