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Online Resources as a Support for Teaching STEM Courses in Secondary Vocational Schools and in Faculties

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Abstract: *The paper provides a systematic review of a plethora of online resources that can be used as a support for teaching various STEM courses that are usually taught in secondary vocational schools or in faculties. These resources have been utilized by the author of this paper on a regular basis, especially during the pandemic and post-pandemic period. The majority of the resources are related to the field of power engineering, but they also comprise other examples from Physics and other related disciplines.*

Keywords: *online resources; technical courses; secondary vocational schools; faculties*

1. INTRODUCTION

In the last few years, online teaching has been necessary and for many months the only possible way of delivering instruction in schools and colleges. As every cloud has a silver lining, the digital competence of teachers and professors has significantly increased in a short period of time, which was due to the sudden necessity that the teachers get familiar with new software packages and programs for online communication. Unfortunately, most of the teachers had neither any training nor a systematic approach to learning new tools.

In the last two years, a significant number of scientific and professional papers have been published that analyzed online teaching during the COVID19 pandemic [1, 2, 3]. Those studies analyzed the teaching methods applied, the platforms used, the achieved effects, as well as advantages and disadvantages of the instruction.

The distribution of online activity is given in [1]:

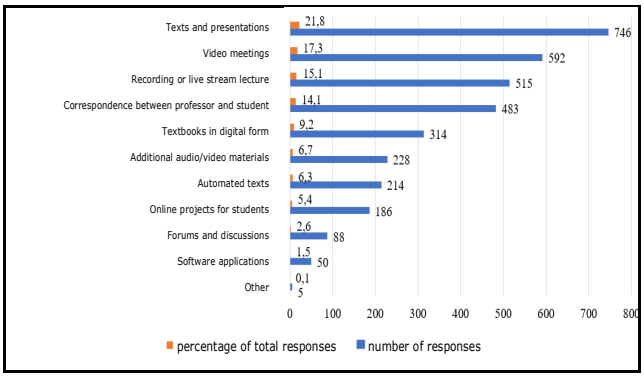


Figure 1. *Distribution of online activities [1]*

The findings of the research (Figure 1) imply that there was an extremely low percentage of the use of additional audio and video materials (6.7%) and software applications (1.5%). For that reason, in this paper special attention is paid to these apparently underused online resources. Thus, the paper is an attempt to systematize those computer resources.

Since the author of the paper is a professor of power engineering, most of the listed examples come from the electric machines and electromotive drives scientific field. Of course, with a little additional interest and effort, one could easily also find adequate content from most other technical disciplines.

The goal of this paper is to introduce teachers and professors of STEM subjects to the easy accessible online resources, so that they start using them in their teaching activities.

2. ADVANTAGES AND DISADVANTAGES OF ONLINE TEACHING

After the abrupt transition to online teaching, without the preparation and training for both students and teachers, distance learning has shown all its downsides and upsides.

The advantages of online classes are as follows:

- increase in digital literacy of both students and teachers,
- saves time and money,
- delivered from homes, in a more relaxed atmosphere,
- allows the use of new resources that have not been used much before.

The downsides of online classes are as follows:

- lack of socialization and networking,
- there is no closeness, no exchange of emotions, alienation occurs,
- not everyone has equal conditions or opportunities,
- families with several children studying online at the same time are a special problem,
- there are big differences from city to city, from school to school, and even from class to class. In some schools, students are required to be online during every lesson, while in others they are free for several days,
- physical activity is worsened or neglected,
- far greater engagement of teachers, of course of those who seriously and responsibly undertook the preparation of online classes.

3. LITERATURE AVAILABLE ON THE INTERNET

There is an abundance of technical literature available online - from the explanation of elementary laws of physics to the explanation of the latest technical achievements. There are also many sites that specialize in certain scientific fields with excellently presented content. The only possible limitation can be of the linguistic nature since most of the displayed content is presented in English. In the following part of the paper, some of those contents have been selected and presented that can be used in teaching activities.

The following list provides an overview of several excellent websites (classified by the paper author) that specialize in certain scientific fields:

• **SCRIBD** [4]

Scribd is a vast digital library filled with ebooks, audiobooks, podcasts, magazines & news articles, sheet music, documents, and more. For a low monthly fee, subscribers gain access to the SCRIBD library.

• **TECHNICAL BOOKS PDF 1** [5]

Technical Books PDF provides Free Download PDF Books, PDF Manuals and Notes for students, related to Engineering, Science, Mathematics and other.

• **TECHNICAL BOOKS PDF 2** [6]

This site lists free online computer science, engineering and programming books, textbooks and lecture notes, all of which are legally and freely available on the Internet.

• **TECHNICAL BOOKS PDF 3** [7]

Freebookcentre.net contains links to thousands of free online technical books. The book collection is either downloadable or can be viewed online. Their collections include core Computer Science, Electronics, Science, Medical and many more. You are welcome to follow the following links for the free books tour.

Something special, but not from the scientific field:
- http://www.digitalna.nb.rs/ Treasury of medieval written monuments. Old printed books.
- https://www.rastko.rs/ The Library of Serbian Culture.

You should be very careful when using Internet resources since not all available content is legal, i.e. they were posted without the knowledge and approval of the authors. In other words, their use is not approved. In this paper, only two of the widely used sites will be listed, of course without the links given.

Illegal sites:

- **Sci-hub,** search and download pdf files, and scientific articles with DOI number.
- **LibraryGenesis**, download PDF books.

4. TUTORIALS, LESSONS, TESTS

There are numerous specialized sites on the Internet with prepared lessons from certain STEM disciplines. In the abundance of the available material, the biggest problem is to find the one that best suits students in terms of the content and complexity of the presented material.

It used to be more difficult to find high-quality professional literature. Nowadays the problem is to choose the best quality from the abundance of materials. Of course, most of the available content is related to learning programming languages and specialized software (because the Internet and online classes are based on them) or general education subjects, e.g. physics.

The following list gives an insight into some of them:

• **On-line tutorials** [8]

JavaTpoint is a Delhi/NCR-based leading IT Company established in 2011. The development of JavaTpoint began with a motto to spread technical knowledge and help students learn efficiently. Today, JavaTpoint is a global platform that provides remote and free access to learning to students. JavaTpoint has over 150 million users.

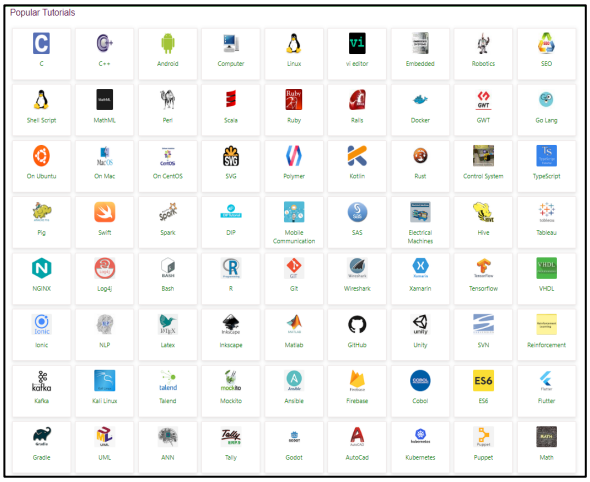


Figure 2. *Showing part of the icons of the software packages whose tutorials are offered*

• **On-line matlab** [9]

This tutorial has been prepared for the beginners to help them understand basic to advanced functionality of MATLAB. After completing this tutorial you will have a moderate level of expertise in using MATLAB from which you can proceed to the next levels.

• **On-line physics lessons** [10]

HyperPhysics is an exploration environment for concepts in physics which employs concept maps and other linking strategies to facilitate smooth navigation. For the most part, it is laid out in small segments or "cards", true to its original development in HyperCard. The entire environment is interconnected with thousands of links, reminiscent of a neural network. CD or DVD versions have been sent to 86 countries to date, and translations into German, Italian, Chinese, and Español have been licensed and are underway.

• **Tests**

There are several specialized programs for testing knowledge. One of the most popular is Moodle.

For students who take courses on Electrical machines and Electric motors at FTS Čačak, several moodle tests were created for practice and mid-term exam preparation. Thus, students have access to tests that can best test their knowledge as they can learn from their mistakes. In that way, they can better prepare for the exam preparatory classes in which their test responses are analyzed. The tests are designed in a way that they are more difficult than the questions expected at the mid-term exam.

This method of preparing for mid-term exams which has been used for many years has given excellent results and is especially suitable for ''better'' students, i.e. those who want to achieve a good mid-term result that would exempt them from taking the oral part of the exam.

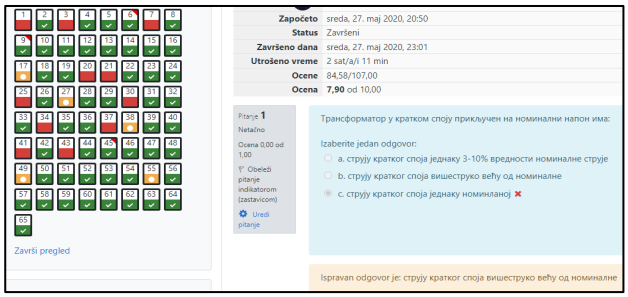


Figure 3. *An example of a test question created in Moodle*

5. ASYNCHRONOUS AND SYNCHRONOUS ONLINE LESSONS

5.1 ASYNCHRONOUS ONLINE LESSONS

In this type of teaching, the teacher communicates with the students DIRECTLY via the Internet, but they are not in direct communication. The teacher uploads his teaching materials, assignments and questions, and the students download the material, learn from it, complete the set tasks and assigments, which they also post/upload on specialized websites.

The most popular and relatively evenly used programs are the following: MICROSOFT TEAMS, ZOOM, MOODLE, GOOGLE CLASSROOM [1].

This type of instruction can be very successful, if the teacher makes an effort to record his material, either as a lesson held in front of the blackboard or as a recorded video with numerous integrated multimedia contents, which the students will be able to review and re-use later. The advantage of this way of teaching is that there is a possibility for the teachers to review their material, and subsequently complement and/or correct it.

On the other hand, many teachers replaced their classes with scanned pages of books or their notebooks and left the students to process them independently. Some of them provided students with additional office hours. This way of "teaching" is the worst, since teachers replace their teaching activity with teaching contents, which are usually abridged versions of textbooks, scripts or other materials, which should already be available to the students.

Examples of good asynchronous online teaching, with a choice of various models for presenting teaching content, are as follows:

• **ONLINE RTS SCHOOL** [11]

After analyzing these materials, one can notice a huge disparity in their quality. Some teachers created a PPT presentation with a few static slides and read the text from the textbook. Some, on the other hand, recorded their class using a whiteboard without computer support. Some of them recorded their lectures with the support of computer resources: presentations, films, and animations. For elementary school students, these contents were broadcasted on the RTS TV channel, daily, in a scheduled time frame.

• **PHYSICS** [12]

This channel contains the complete lectures: Physics I: ClassicalMechanics (autumn 1999), Physics II: ElectricityandMagnetism (spring 2002) and Physics III: VibrationsandWaves (autumn 2004) on MIT.

These lectures are very thoroughly prepared, with integrated physics experiments. They were realized in an amphitheatre in the presence of students and with all the technical support that was used at that time, about 20 years ago. A lot of collaborators participated in the preparation of the lecture and the preparations lasted for days with organized "final rehearsals". All the lectures of these 3 courses were completely recorded and are available on the Internet on the YouTube page of Professor Lewin, who is still active to this day, continuously

posting weekly program assignments. It has over 1,300,000 followers.

Figure 4. *Pictures from Professor Lewin's classes*

• **ELECTRICAL ENGINEERING** [13]

Recorded video lessons by Professor Navaez with an interesting virtual whiteboard display.

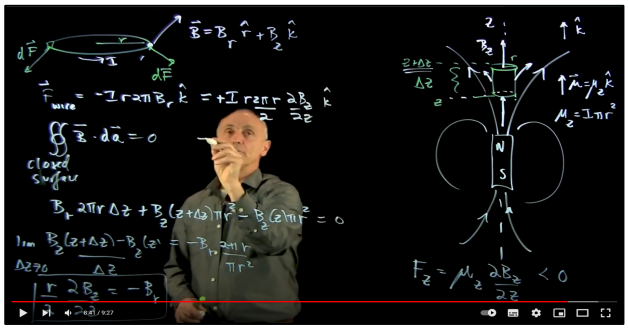


Figure 5. *Appearance of the virtual whiteboard during the lecture*

• **MATHEMATICS** [14]

This is a YouTube channel of professor Voo Sydney that contains over a hundred playlists, each of which has several to several hundred videos of recorded lectures in the field of mathematics.

• **INTRODUCTION TO POWER ELECTRONICS** [15]

Excellent whiteboard lectures by professor Katherine A. Kim, National Taiwan University.

• **SIMLE ELECTRONICS** [16],

Recorded videos of using the SymplyElectronics software package, very useful for simulating electrical and electronic circuits.

Figure 6. *Videos (left) and software (right)*

• **ELECTRICAL MACHINES COURSE** [17]

Video lectures of the course prof. AdelGasti, Department of Electrical Engineering at Qatar University from electrical machines: magnetic circuits (6 video lectures), transformers (8), DC machines (5), Induction machines (5), Synchronous machines (6). Presentations, videos, animations and simulation programs are integrated into the videos.

• **ELECTRIC MACHINE DESIGN** [18]

Lectures from the University of Minnesota. PPT presentations are recorded, where the author can

be seen and heard in the corner of the screen video. Contains 36 video lectures.

• **BASIC ELECTRIC DRIVE** [19], University of Minnesota:

By the same principle as the previous lectures. Contains 14 video lectures.

4.2 SYNCHRONOUS ONLINE LESSONS

This type of teaching implies DIRECT communication with students. It is best if it is achieved by mutual use of a webcam and a microphone. Online communication by exchanging online messages is also possible. It is important that the teacher or student can communicate directly. This type of communication is the most demanding and requires a lot of preparation time. The class is held at the exact time.

It is possible to record the lessons and subsequently reproduce them. The disadvantage is that if the class is recorded, all unwanted situations in the class remain permanently recorded (professor's lapsus, possible mistakes made during performance, technical problems caused by poor quality of the internal connection or inability to display the selected content). Also, the possibility of misuse of the recorded video cannot be ignored. For this reason, many professors avoided this type of teaching, some of them not wanting to be filmed while teaching. For this reason, there is a ban on carrying mobile phones in classes in many schools.

One of the compromise solutions, which the author of this paper used in his lectures, was to use a mobile phone aimed at the desk instead of a web camera, which has a lower resolution. In doing so, the IP Webcam program was used on a mobile phone.

Figure 7 shows a screen view from a mobile phone (right) with the ability to adjust image parameters: resolution, cropping, orientation etc. (left).

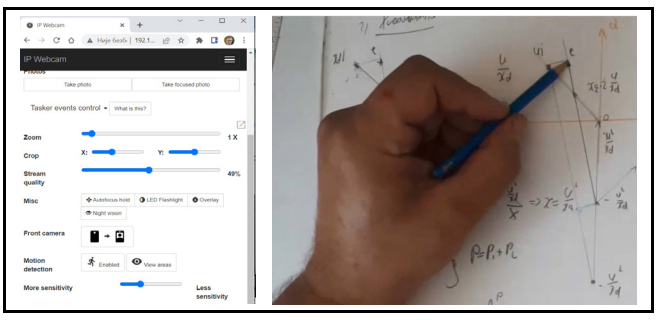


Figure 7. *View program IP Webcam.*

In the described way, participants of the online course could listen to the lecturer and follow the content he wrote on his desk. Of course, the web camera could be turned on at any time, through which the teacher would also be visible.

6. ANIMATION IN CLASS

Graphic animations can be an excellent resource in teaching. It is said that a picture is worth a thousand words. Animated moving images allow a better understanding of physical phenomena, principles of operation, construction and arrangement of components etc. The following list contains a selection of several excellent addresses used (mainly posted via the YOUTUBE platform) that illustrate the power of using animation in teaching.

- **LESICS** [20]

Lesics was founded by Sabin Mathew, an IIT Delhi post graduate in 2012. At Lesics, with aim to provide quality engineering education. The videos are designed to clear misconceptions, create a passion for engineering and explain complicated technologies in a simple way.
Contains 13 playlists. It has over 5 million followers! The number of followers confirms the fact that it is one of the best YOUTUBE channels with animations in the field of technology.

The excellent quality of the animations, the expertise with which the content was carefully selected and explained, the topicality of new video animations make this site exceptional. Within a few hours of the publication of new content, tens of thousands of views are achieved.

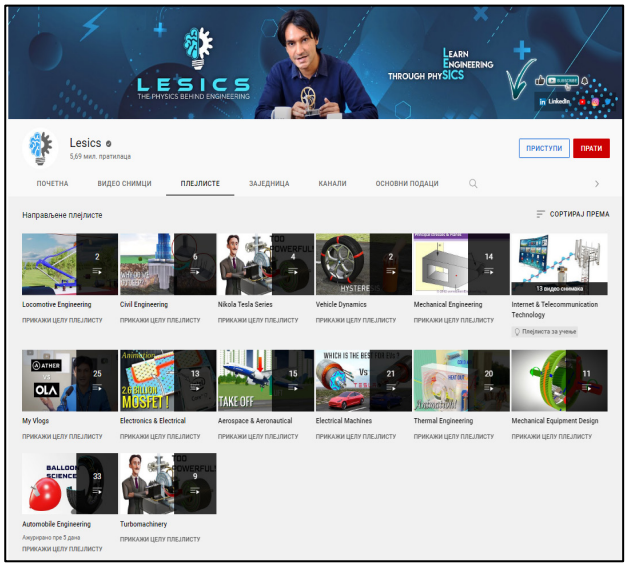


Figure 8. *Playlists of youtube channels LESICS (former name Learn Engineering)*

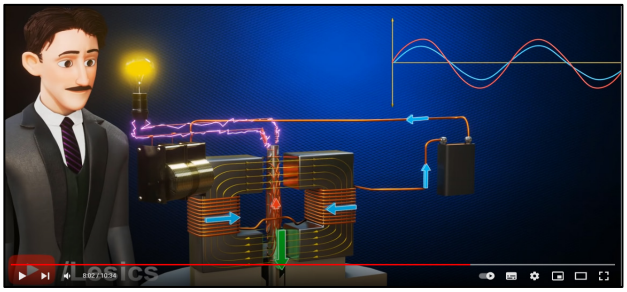


Figure 9. *One slide animation about Nikola Tesla*

- **THE ENGINEERING MINDSET** [21]

The Engineering Mindset was started in 2015 by its founder, Paul Evans. The mission was to help students, engineers and like-minded people learn technical engineering topics through short, simplified tutorials. Number of playlists 16, number of followers over 2 million.

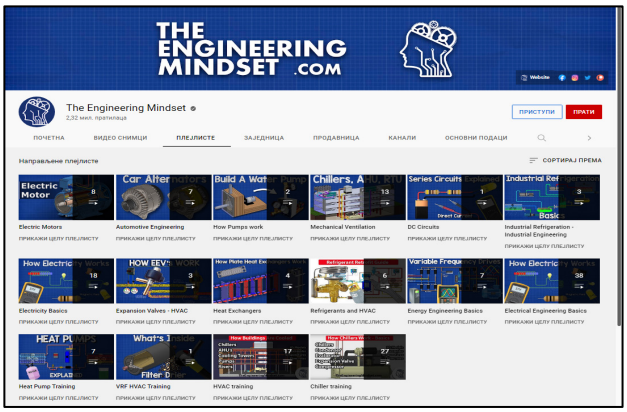


Figure 10. *Playlists of youtube channels The Engineering mindset*

- **PHYSICS** [22]

Physics YouTube channel made and run by Eugene Khutoryansky.
Most of the video animations are from electronics, where it is effectively used to illustrate the different potentials of network nodes with different heights. Very illustrative and easy to understand phenomena in electrical engineering. The analogy used successfully visualized and explained the basic electrical parameters: resistor, capacitor, coil, transistor, voltage and current source etc.

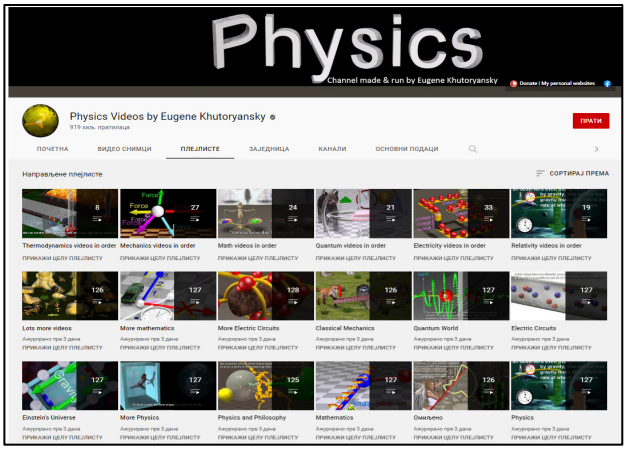


Figure 11. *Playlists of youtube channels Physics*

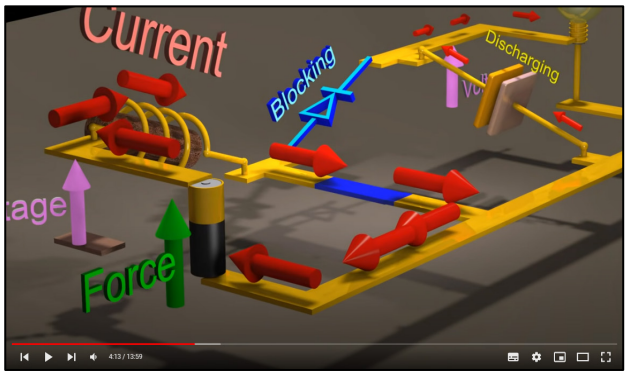


Figure 12. *Screenshot from an animation explaining an electronic circuit using analog quantities*

- **LEARNCHANNEL** [23]

Electrical Engineers Tutorial Video Channel: Topics covered: Automation, Electric engineering, Robotics, Hydraulics, Pneumatics, Electric motors, Closed-loop controls. Great animations with great explanations. As an illustration of the extraordinary animations, the image below shows a part of the video from the electrical machines.

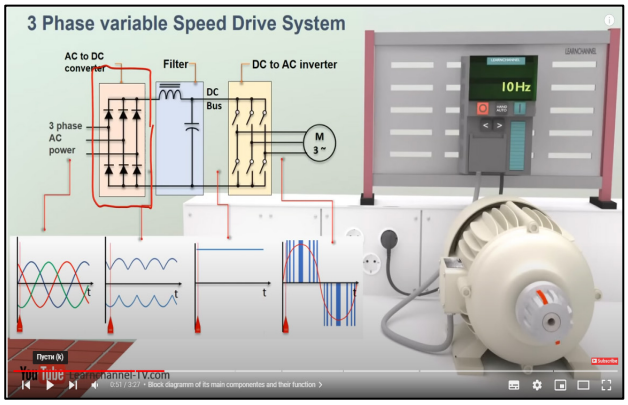


Figure 13. *With an explanation of the operating principle of the frequency converter*

- **HOW TO MECHATRONICS** [24]

Mechatronic systems: Arduino Projects and Tutorials, DIY Projects, How It Works, Electronics, Robotics, CNC, 3D Printers, Tips & Tricks, Arduino Source Codes, Circuit Schematics, Download files and much more can be found at this site.

7. TV SHOWS, DOCUMENTARY AND FEATURE SERIES IN THE FIELD OF TECHNOLOGY

On the Internet (YOUTUBE) you can watch many TV shows in the field of technology. From the abundance of that content, only a few were selected, according to the author of a very popular and watched series on the Discovery channel:

- **SCIENCECHANNEL** [25]

From the 58 playlists, only a few very popular shows were selected:

- ***How it was made***: 287 videos of very popular scientific and educational shows. (in 15 days of following these contents, the number of videos increased by 30)
- ***How the* Universe *Works***: 120 videos
- **MythBusters**: 44 videos
- ***Street Science***: 30 videos
- **Imposible *Engineering***: 42 videos

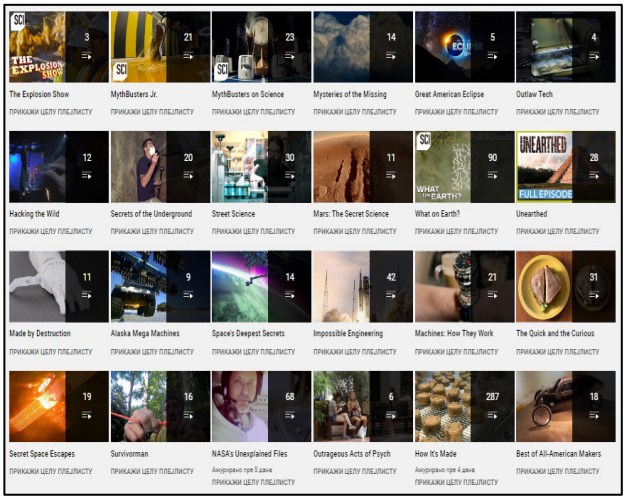


Figure 14. *Playlists of youtube channels SCIENCECHANNEL*

- **HOW IS MADE, DISCOVERY UK** [26]

121 videos from the TV Discovery channel.

8. LABORATORIES FOR ELECTRICAL MACHINES, DRIVES AND AUTOMATICS (EMPA) YOUTUBE CHANNEL

In the laboratory for electrical machines, drives and automatics at the FTN in Čačak, many laboratory setups have been designed and implemented for decades, which follow the teaching content of several subjects in the bachelor, master and doctoral studies in the field of power engineering. Since the recording of video contents became available using mobile phones, an effort has been made to record more interesting laboratory experiments and make them available to all interested parties. One of the reasons for recording video content is that the number of performed laboratory exercises far exceeded the possibilities of performing them with students within the limited fund of working hours in the laboratory.

In this way, a larger number of performed experiments are shown in classes, and interested students can perform them outside of the regular hours of work in the laboratory.

Currently, the YOUTUBE channel contains 48 lists with over 600 selected videos uploaded. The videos have been collected over the years and are sorted by fields. Videos by other authors are specially marked, sorted by topic, and especially videos recorded in the laboratory, whose playlists start with the label EMDA lab etc.

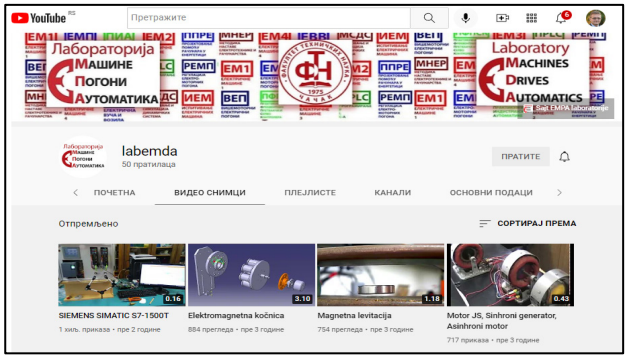


Figure 15. *Home screen of the EMDA laboratory youtube channel*

8.1 Standard electrical machines, electronics, automation:

The following playlists of standard electric machines have been created:

- Transforamtors
- Electromechanical energy conversion
- DC machines
- Induction machines
- Synhronous machines
- Electric drives
- Power electronics
- Automatics

8.2 Special electrical machines:

Special electrical machines are studied in the courset Electrical Machines 4, whose playlists are given in the following list:

- Single-phase asynchronous motors
- Universal motors
- Step motors
- BLDC motors
- Servo motors
- Csynhronous reluctance motors
- Axial motors
- Electric vehicles
- Linear motors
- Torque motors
- Special electric machines

8.3 Other

- Basic terms
- The simplest electric motors
- Autoelectrics
- Does Korkoch's second law apply?
- FEMM
- Electrical machine laboratories
- History of electrical engineering and electrical machines
- Nikola Tesla – animations
- Experiments in magnetism by Professor Lewin
- Sensors and actuators

From the Nikola Tesla series, sequences in which laboratory experiments are performed have been selected. They were performed on replicas identical to the original equipment that Tesla worked with: EMDA lab. parts of tv series Nikola Tesla.

9. RECORDED VIDEO EXPERIMENTS

9.1 EMDA laboratory video experiments:

Sixteen playlists have been created in EMDA laboratory, with over 100 videos:

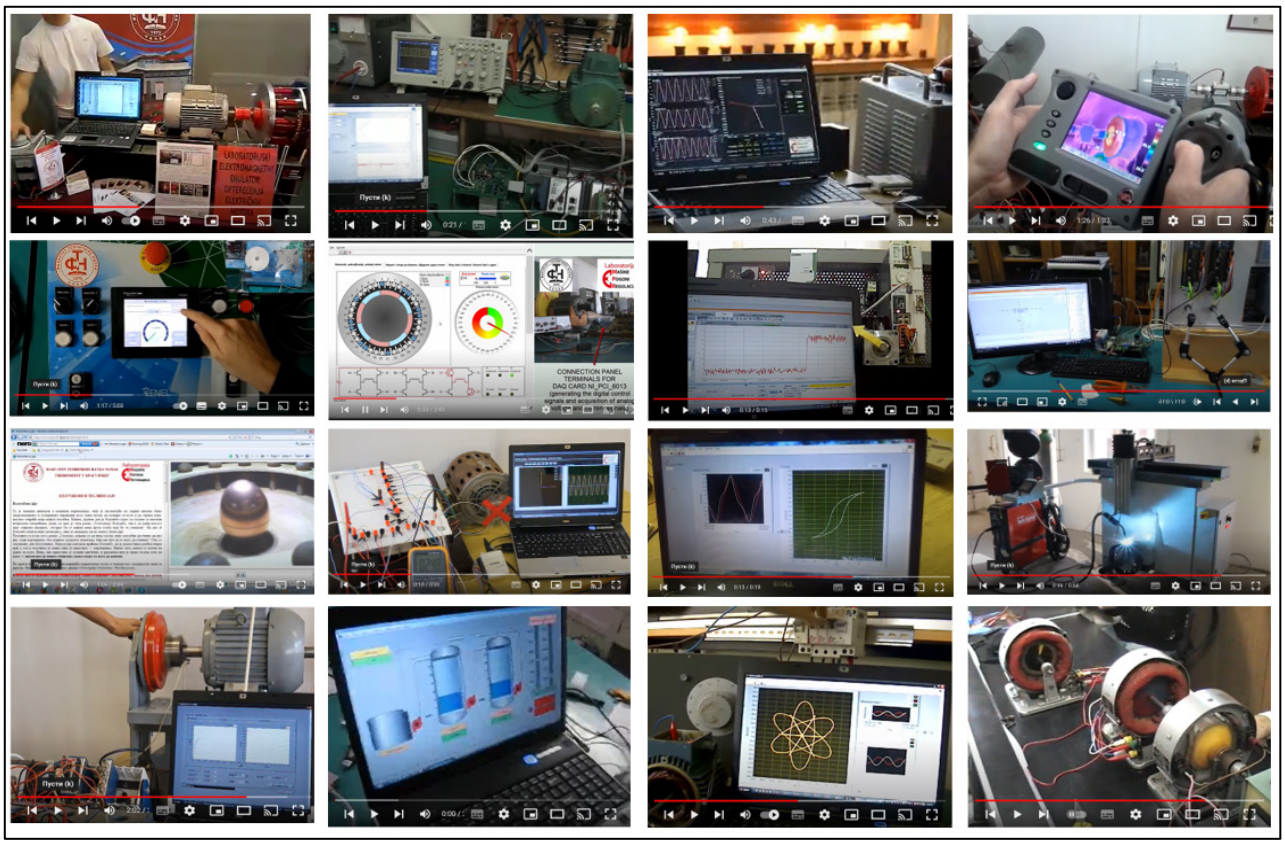


Figure 16. *Screenshots of several recorded videos from the EMDA lab*

1. EMDA lab. Demonstration laboratory experiments
2. EMDA lab. Magnetic circuit, transformers
3. EMDA lab. Electromechanical energy conversion
4. EMDA lab. DC machines
5. EMDA lab. Induction machines
6. EMDA lab. Synhronous machines
7. EMDA lab. Recording the characteristics of electric motors
8. EMDA lab. Winding of electric machines
9. EMDA lab. DC motor inductance winding
10. EMDA lab. Stator winding of a three-phase asynchronous motor
11. EMDA lab. NeReLa remote experiments.
12. EMDA lab. Simulation program of FTS Čačak
13. EMDA lab. Special electric machines
14. EMDA lab. Technical solutions
15. EMDA lab. Videos from the Technical School G. Milanovac
16. EMDA lab. Automation

9.2 Video experiments by other authors

Recently, more and more recorded samples from the laboratory can be found. In the field of electrical machines, drives and regulation, there are dozens of Internet sites where you can view the performed and recorded experiments. Only some of the more interesting ones are given:

- **Electrical Machines Laboratory** [27],

Recorded experiments, Jamshoro, Pakistan Lectures on Different Electrical Engineering Subjects By Engr. Shoaib Ahmed Dayo.

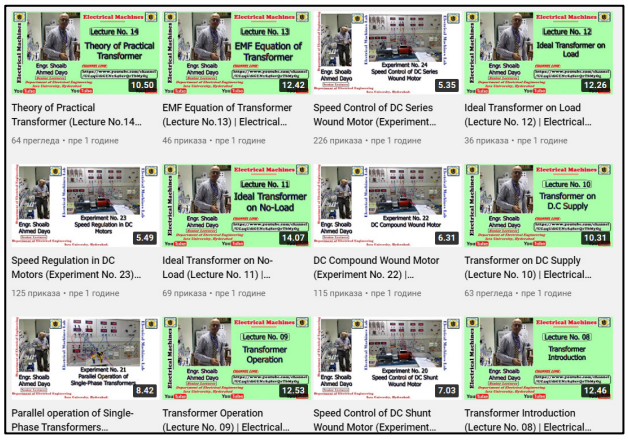
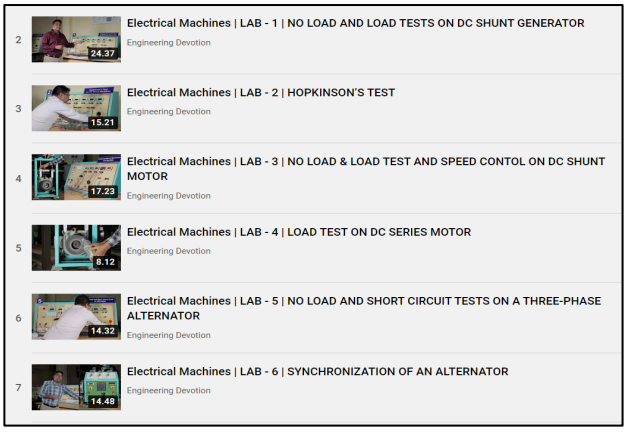


Figure 17. *Playlists of youtube channels Lectures on Different Electrical Engineering Subjects*

- **Recorded 10 settings from electrical machines** [28]

College Secunderabad, India: In addition, there are recorded laboratory settings from the following areas; Electrical & Electronics Engineering Devotion channel: Power Systems, Control Systems, Circuit theory, Power Electronics, etc.



- **Experiments in Physics for 2nd, 3rd and 4th grade of secondary vocational school**

Tomislav Đuran [29], recorded video, Electric machines and drives:

- **Energy electronics** [30],

Machines and Drives, Saša Skoko, Mihailo Pupin High School Novi Sad:

9.3 Youtube technical contents

Since the conference at which this paper is presented is not strictly specialized in the field of electrical machines and drives, in this part of the paper several links to excellent videos in the field of technology - especially electrical engineering - will be provided.

Kathy Loves Physics [31]

Kathy Joseph uses primary sources and talk about real physics and the real, quirky history to tell where our scientific universe came from.

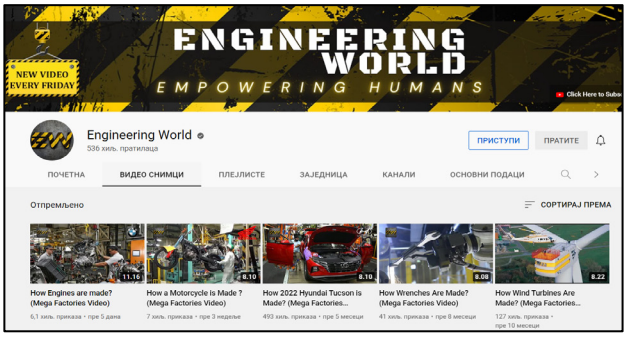
- **ElectroBOOM** [32]

Attractive videos by electrical engineer MehdiSadaghdar with over 5 million followers

- **Engineering World** [33]

The channel features videos so as to be a learning tool for those interested in the engineering field by providing a platform for discussion and sharing ideas.

Every week, a new video is posted, usually from the factory facilities, in which the principle of operation of the selected device is explained.



- **Amazing Technology** [34]

- **CARinfo3d** [35]

Educational channel about the device and the principle of operation of the car, in an easy-to-understand - 3D animation.

10. FRAUD ON THE INTERNET

The Internet is an inexhaustible source of a wide variety of information. The problem used to be the lack of information and how to get it. Today, the problem is how to find the appropriate one from the abundance of information.

Anyone can upload content to the Internet. There are no restrictions, or if there are, they refer to the display of inappropriate content, insults on different renewals, etc. In most cases, there is no restriction based on the criterion of the accuracy of the posted information, especially in the field of technology. This is why the Internet is flooded with content with various types of scams. Of the many, there are very popular sites that offer a way to get the so-called "free energy" i.e. devices and constructions that achieve perpetual mobile.

Since there are a lot of gullible people, these contents are very visited and cause a lot of damage. No matter how hard the professors try to explain that energy cannot be created by itself, there are always those who fall for the scam. Especially if all this is accompanied by videos that "confirm" that such systems have already been built and are working.
As an example, two links will be provided. The first shows a generator that produces free energy, and the second is an excellent video listing and debunking such devices.

- **Example of the Internet fraud** [36]

The video (picture 21) shows, although the author tried to hide it with the angles of the presentation, the shadow of the wire that connects the apparatus to the external source of electricity.

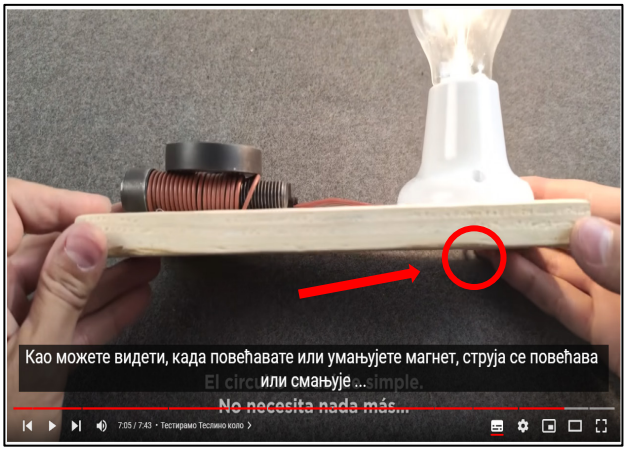


Figure 21. *A part of the video where the fraud is revealed through the carelessness of the author*

- **Examples of free energy [37]**

Description and explanation (from 6 min. 30 sec. the author exposes all the previously shown scams of free energy exchange).

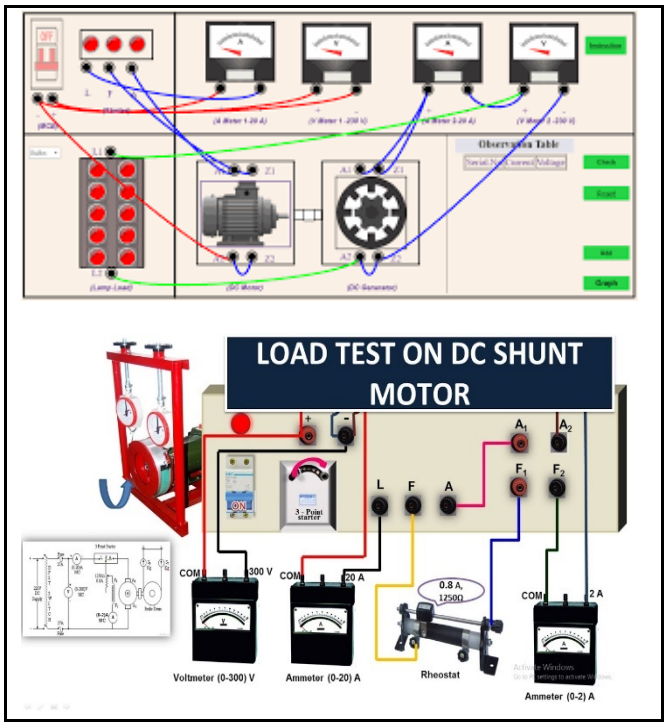
11. VIRTUAL LABORATORIES

Virtual laboratories are an excellent way to prepare students before working in the laboratory itself. By using them, students are trained and equipped to work without fear that any mistakes made will cause damage or danger to the persons who perform them. In addition, virtual laboratories allow students to simulate the phenomena they are examining. Of course, despite the excellent possibilities, virtual reality must not be replaced by concrete, practical work in the laboratory.

In the following list, several virtual laboratories in the field of electrical machines and drives are given.

- **Virtual Laboratory in Electrical Machines**, New Delhi, India [38]:

Virtual Labs project is an initiative of Ministry of Human Resource Development (MHRD), Government of India. Under Virtual Labs project, over 100 Virtual Labs consisting of approximately 700+ web-enabled experiments were designed for remote-operation and viewing. The intended beneficiaries of the projects are: all students and Faculty Members of Science and Engineering Colleges who do not have access to good lab-facilities and/or instruments, high-school students, whose inquisitiveness will be triggered, possibly motivating them to take up higher-studies.



- **Laboratory of Power Electronics and Drives**, Gljivice, Poland [39]

The aim of the project is to increase the teaching potential of the applicant in the field of electrical drives. The results of the project will be as follows: interactive, bilingual teaching materials published through a dedicated web site and create two new laboratory testing sets equipped with modern industrial drive solutions.

12. APLETS

An applet (little application) is a small software program that supports a larger application program. Ten years ago, applets were a widely used way of simulating phenomena and processes. The Internet was full of great little apps integrated into websites. There were especially many programs from the field of physics and those applets had a special name - **Fhyslet**. But, since most of these programs were programmed in the Java programming language, all the problems that accompanied Java applications were reflected on these programs as well. Namely, due to security reasons, some web browsers have disabled the possibility of starting java programs. This prevented the use of thousands and thousands of programs that were excellent teaching material for years.

However, some applets can still be used today. The following, very narrow selection, provides an overview of them:

- **Set of applets from electrical machines** [40]
- **Applets from physics** [41]

Translated into Serbian (translation by Prof. Dr. Zlatan Šoškić, The faculty of Mechanical and Civil Engineering in Kraljevo)

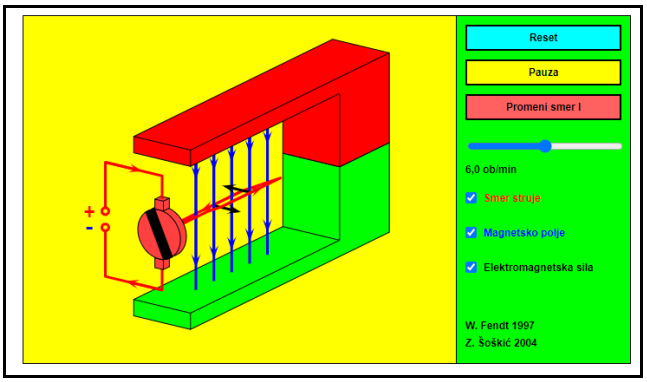
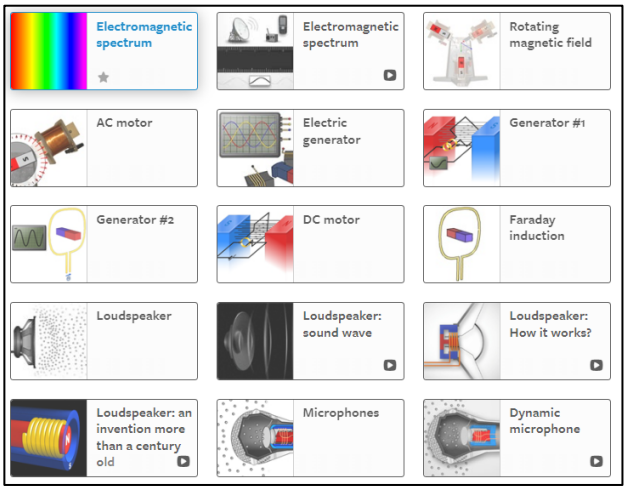


Figure 23. *An applet demonstrating the role of commutators in DC motors*

- **Set of applets from electrical machines** [42]
- **Applets from the field of electromagnetism** [43]

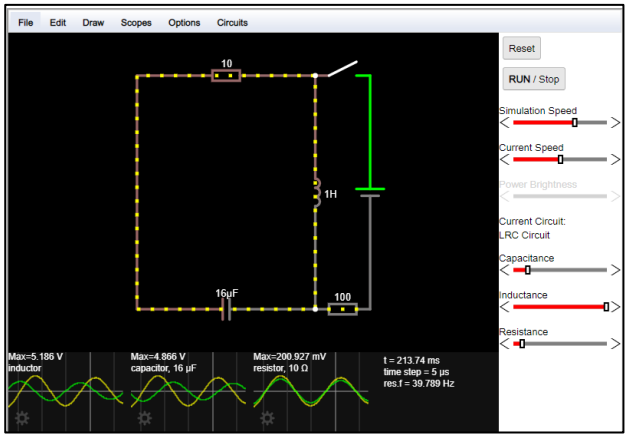


- **Applets from electrical machines**, e.g. Riaz, University of Minnesota [44]:

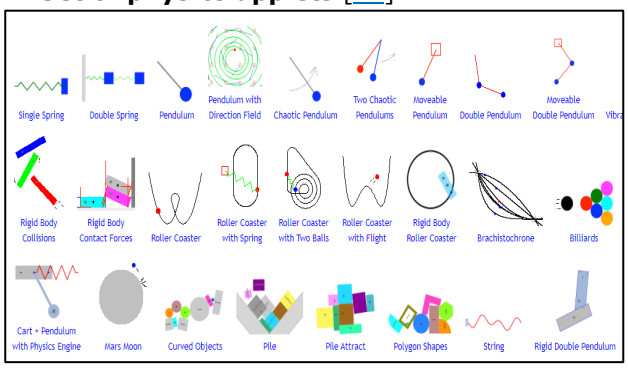
Excellent simulation examples are created in Simulink software packages. Part of the program was translated with the permission of the author and is used in the Master's studies in the course Regulation of Electric Motor Drives at FTS Čačak.

Excellent math and physics applets [45]

- **The electric circuit simulator is from the same author** [46]



- **Set of physics applets** [47]



- **Set of applets in Serbian language** [48]

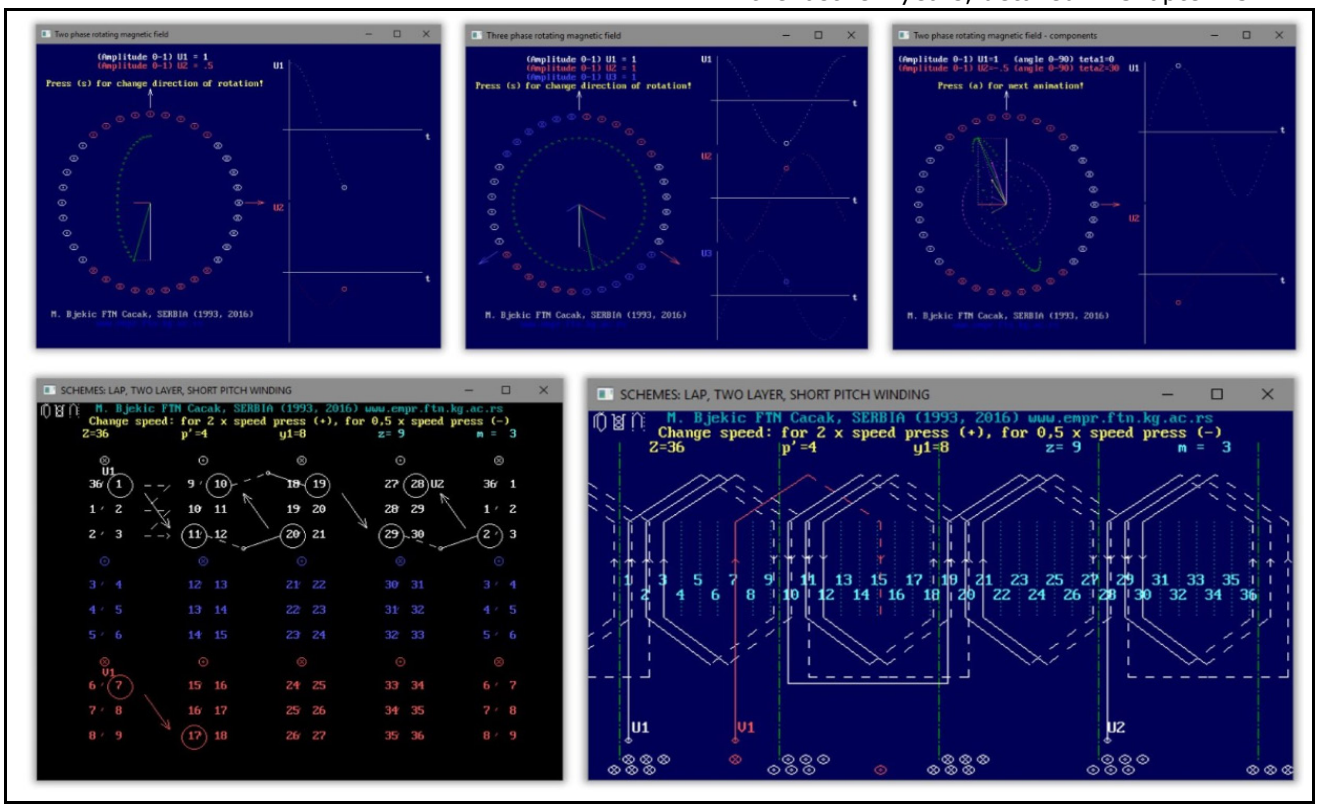
13. SPECIALIZED SIMULATION PROGRAMS

- **Educational software created at FTNS Čačak** [49]

Since 1994, educational software in the field of electrical machines and drives has been created at FTS in Čačak. In accordance with the then available technology, computer characteristics and available programming languages, dozens of educational software were created.

These software can be classified into the following units:

a. Software created in the programming language QBASIC: magnetic fields, windings of single-shift and asynchronous machines, Lissajous figures, created in 1993 and 1994 (Figure 28)
b. Software created in Simulink: Characteristics of electric motors and generators. Translations of programs by prof. Riaz.
c. Software created in the Geogebra software package. Over 30 programs have been created in the last few years, detailed in Chapter 15.



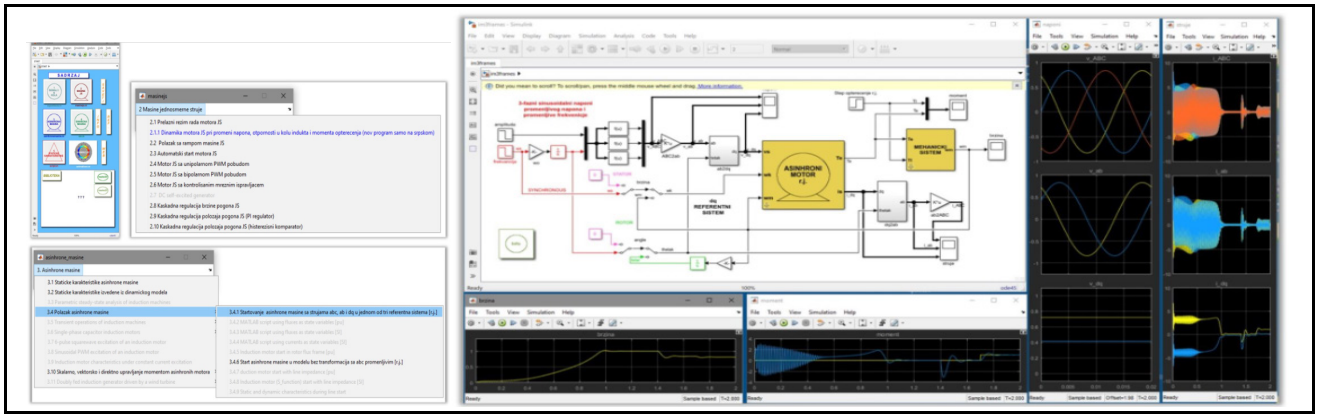


Figure 29. *b) A screenshot of the translated software with a demonstration of one of them*

50].

FEMM is a suite of programs for solving low frequency electromagnetic problems on two-dimensional planar and axisymmetric domains. The program currently addresses linear/nonlinear magnetostatic problems, linear/nonlinear time harmonic magnetic problems, linear electrostatic problems, and steady-state heat flow problems.

FEMM is divided into three parts:

1. **Interactive shell** (**femm.exe**). This program is a Multiple Document Interface pre-processor and a post-processor for the various types of problems solved by FEMM. It contains a CAD-like interface for laying out the geometry of the problem to be solved and for defining material properties and boundary conditions.

2. **triangle.exe**. Triangle breaks down the solution region into a large number of triangles, a vital part of the finite element process.

3. **Solvers** (fkn.exe for magnetics; belasolv.exe for electrostatics); hsolv.exe for heat flow problems; and csolv.exe for current flow problems. Each solver takes a set of data files that describe problem and solves the relevant partial differential equations to obtain values for the desired field throughout the solution domain.

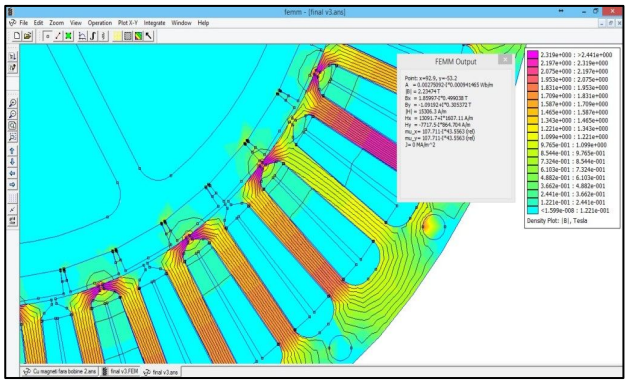


Figure 30. *An example of a FEM analysis of an AC machine stator*

- **Matlab – Simulink** [51].

Matlab is a programming platform designed specifically for engineers and scientists to analyze and design systems and products that transform our world. The heart of MATLAB is the MATLAB language, a matrix-based language allowing the most natural expression of computational mathematics.

Matlab has become one of the most used programming languages in the world in the field of technology. It is intended for engineering calculations. It has a large number of toolboxes, of which Simulink stands out, which enables dynamic, electrical, mechanical simulations thermal, hydraulic and other processes. In particular, a few years ago, the SIMSCAPE block was created, which can combine these processes into one model.

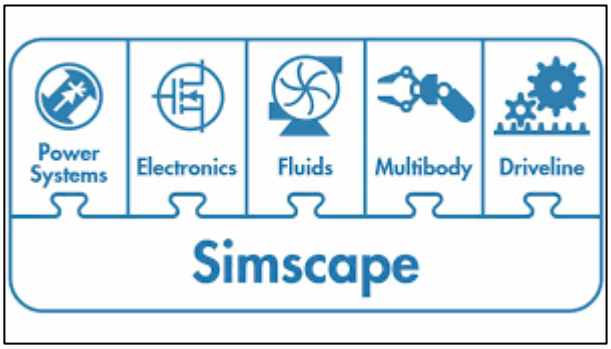


Figure 31. *Simscape components*

- **On-line algorithms and programming** [52]

Flowgorithm features the following: easy to understand output, graphical variable watch window, interactively generate code (for 16+ languages), Safe recursion, loops, arrays, and flexible expressions, multilingual support etc.

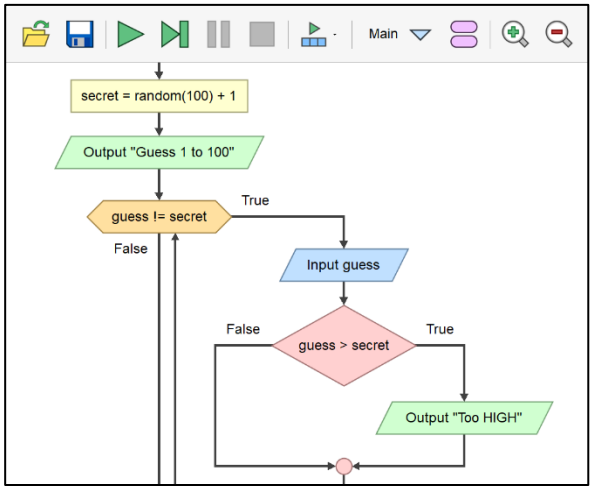


Figure 32. *Flowgorithm program*

14. REMOTE EXPERIMENTS

In the gradation of content applicable in the teaching of technique from the lowest level to the highest, the following order could be defined: images, videos, animations, simulations, remote experiments.

- **Set of remote experiments of 4 universities in Serbia created within the NERELA project** [53]:

LiReX (Library of Remote Experiments) is Web repository of remote experiments developed under Tempus project NeReLa. The Library of Remote Experiments contains set of remote experiments and exercises developed and set up in the labs of four project partner universities in Serbia: University of Kragujevac, University of Belgrade, University of Nis and University of Novi Sad. Each partner university has their own sub-repository with remote experiments developed and installed in their labs.

- **Remote experiments created at FTN Čačak** [54]:

Five remote experiments were created in the EMDA laboratory:

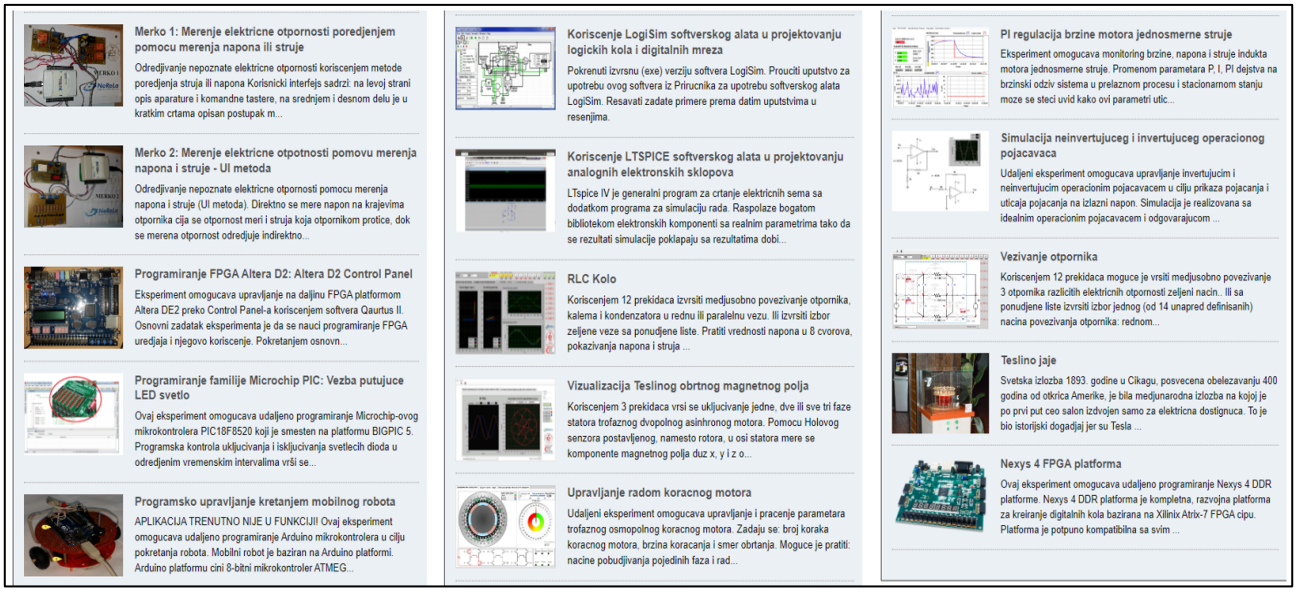


Figure 33. *Remote experiments created at FTS Čačak within the NERELA project*

- **Visualization od Teslas rotating magnetic field** [55]:

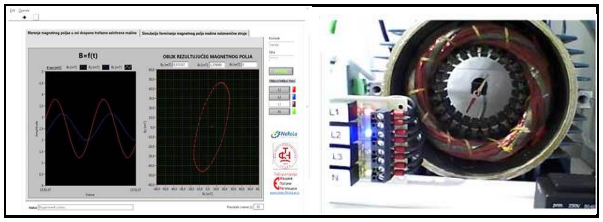


Figure 34. *Screenshot with a webcam image*

- **Resistors connections** [56]:

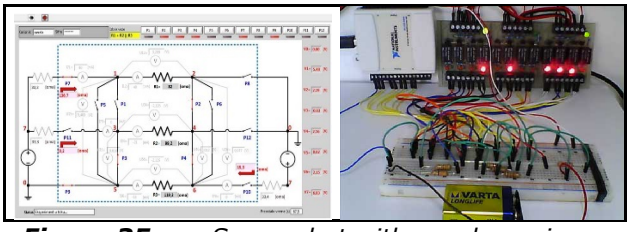


Figure 35. *Screenshot with a webcam image*

- **Series and parallel RLC circuit** [57]

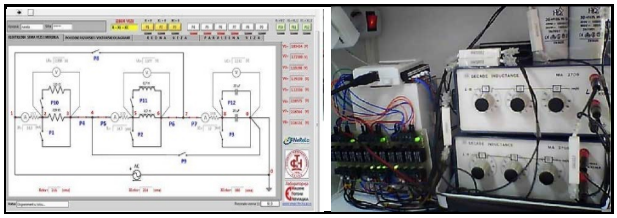


Figure 36. *Screenshot with a webcam image*

- **Controlling a step motor** [58]

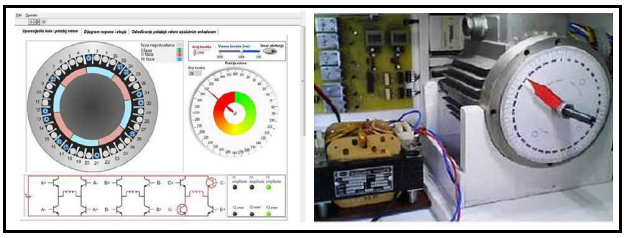


Figure 37. *Screenshot with a webcam image*

15. GEOGEBRA

Although primarily intended as a mathematical tool, it is very useful for displaying 2D and 3D functions, graphically performing characteristics and procedures used in technical disciplines.

Geogebra programs by M. Bjekić [59]:

The author of this paper has created 30 programs for the purposes of teaching several courses at undergraduate and master's studies in electrical engineering.

The many possibilities of the Geogebra program are used: simple drawing of functions with the possibility of easy parameter changes, animations, generic display of graphic performance etc.

Screenshots of some of those programs are given in Figure 38.

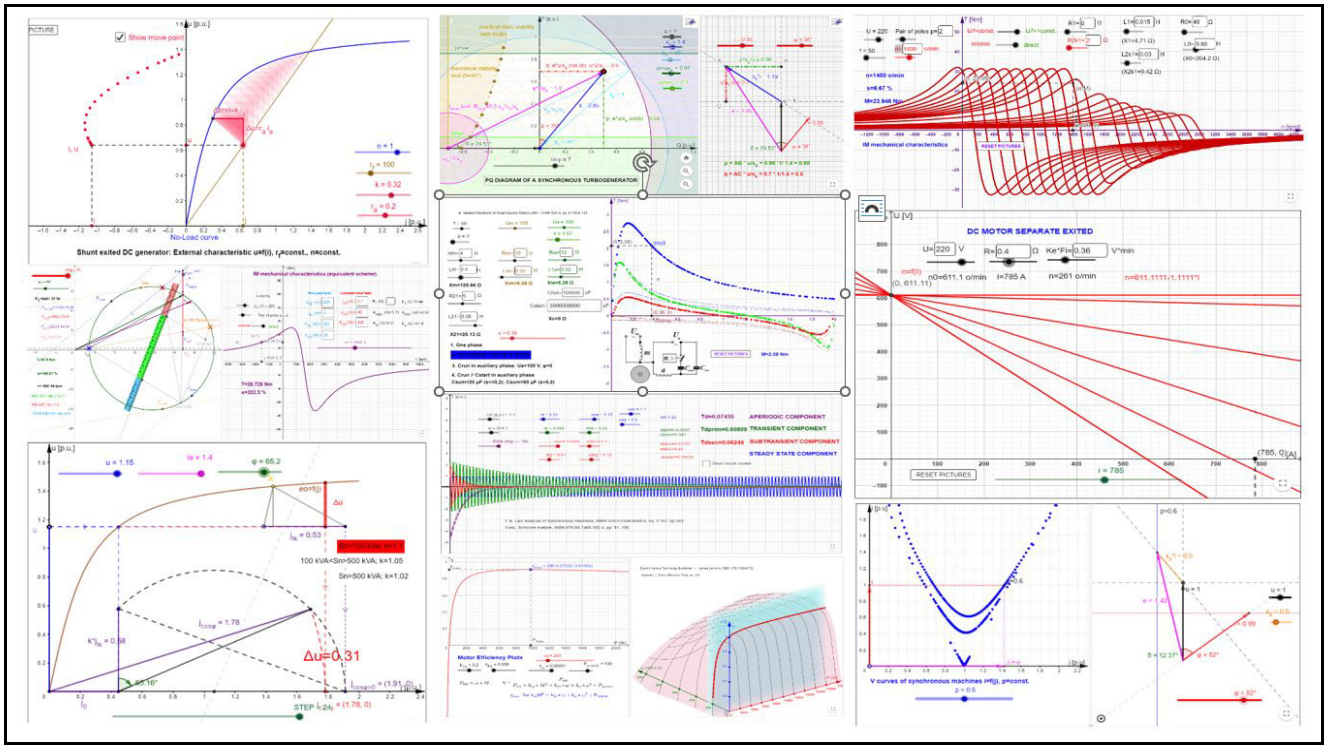


Figure 38. *Part of the Geogebra program in the field of electrical machines and drives, authored by M. Bjekić*

- **Geogebra programs of other authors**:

Searching Geogebra content in the field of Electrical Machines and Drives found 38 authors (data from 2021) with more than 150 programs [60].

- **Geogebra books**:

An example of the possibility of using Geogebra textbooks can be seen in [61]. No geogebra textbook was found in the area of Electrical machines. Once a large base of programs is created the plan of the author of this paper is to create an interactive textbook, that will include first his own programs, but also programs of other authors.

16. EXAMPLE OF AN ONLINE CLASS AT FTS ČACAK RECORDED IN THE TIME OF THE PANDEMIC

At the time of the COVID-19 in the 2020/21 academic year, due to circumstances, online classes were the only means of delivering instruction. This unplanned and unwanted teaching method was a challenge, athough it it was possible and much easier to integrate online content into lectures. The preparation for the online classes took much longer than the preparation of a classical class. A total of 57 online two-hour lectures and exercises were held in 5 courses (Electrical machines 1-4 and Testing of electrical machines). All classes were recorded and are available to current and future generations of students.

As a demonstration of the teaching method, several screenshots from the recorded lessons will be shown, from which you can see which online teaching materials were used.

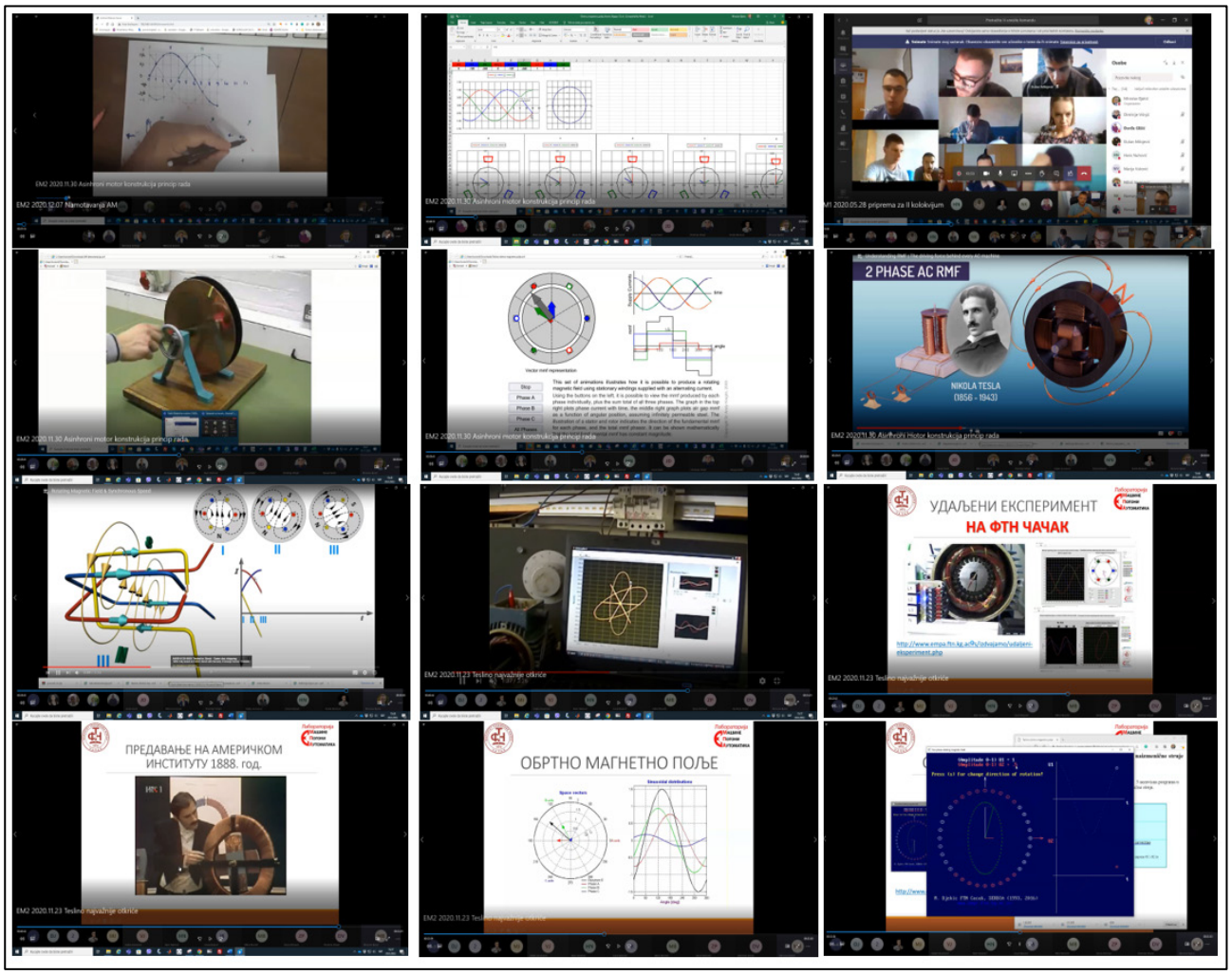


Figure 39. *Screenshots of recorded online classes in the subject Electrical Machines*

A quick recording of a given class can be seen at the following link [62].

17. CONCLUSION

The paper attempts to systematize the online content that can be used in classes. In doing so, the author presented the teaching content that he has used for more than 30 years in the teaching of the subjects Electric machines and Electric motors.

Everything is illustrated with videos of several online classes realized and recorded at FTN Čačak in the 2020/21 school year.

ACKNOWLEDGEMENTS

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[16] https://www.youtube.com/c/sutty6SimplyElectronics/playlists

[17] https://www.youtube.com/playlist?list=PLt7mkiJmDd6azg6E6TkkcxIJlp8xm6IUX

[18] https://www.youtube.com/playlist?list=PLR3pRvvCj_Y_jcg_Ia6ARvzefov05c7vf

[19] https://www.youtube.com/playlist?list=PLR3pRvvCj_Y_sONKEu-kKmrs_qExmTrBm

[20] https://www.youtube.com/c/Lesics/playlists

[21] https://www.youtube.com/c/Theengineeringmindset/playlists

[22] https://www.youtube.com/user/EugeneKhutoryansky/playlists

[23] https://www.youtube.com/c/learnchannel/playlists

[24] https://www.youtube.com/c/HowToMechatronics/playlists

[25] https://www.youtube.com/watch?v=WFOic_MQIkE&list=PL39_ud5aKSvnYDhKdB7wTDUZRiE8RaJat&ab_channel=ScienceChannel

[26] https://www.youtube.com/playlist?list=PLLb4Aujw26R6FsJJ3py4ponBlBxp0UnRA

[27] https://www.youtube.com/playlist?list=PLcnl7B--91l6Rs1Y0fIXHAIl5HgA8UDEE

[28] https://www.youtube.com/playlist?list=PL5TKV1tzb09lx62sPBmho6WJZX5WWFzUr

[29] https://www.youtube.com/user/td41467/playlists

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[31] https://www.youtube.com/playlist?list=PLepnjl2hm9tHcapb3u2RAXQP9ag1Y1vIp

[32] https://www.youtube.com/c/Electroboom/videos

[33] https://www.youtube.com/c/RahilbaigBlogspot/playlists

[34] https://www.youtube.com/channel/UCbzx8XAYwMO4j3yWMPV50gw/videos

[35] https://www.youtube.com/c/CARinfo3d/videos

[36] https://www.youtube.com/watch?v=UDMBgmuZqwk&list=PLsLEJ2KxMM7Nzi3S7-dBbEj-kPjcf2MTf&index=11&ab_channel=HiddenTechnology

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[56] https://www.youtube.com/watch?v=Uasup-ecrQU&list=PLsXBNMuIU-4uoHQUNU4rfqc0fbMdCNEpa&index=7

[57] https://www.youtube.com/watch?v=b5Ip2mzmlYM&list=PLsXBNMuIU-4uoHQUNU4rfqc0fbMdCNEpa&index=6

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