Schola Europaea

Office of the Secretary-General
Pedagogical Development Unit

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Electronics laboratory – Complementary course (S6-S7)

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on 1 September 2019 for S7

Attainment descriptors: on 1 September 2019 for S6
on 1 September 2020 for S7

1. General Objectives of the European Schools

The European Schools have the two objectives of providing formal education and of encouraging pupils' personal development in a wider social and cultural context. Formal education involves the acquisition of competences (knowledge, skills and attitudes) across a range of domains. Personal development takes place in a variety of spiritual, moral, social and cultural contexts. It involves an awareness of appropriate behaviour, an understanding of the environment in which pupils live, and a development of their individual identity.

These two objectives are nurtured in the context of an enhanced awareness of the richness of European culture. Awareness and experience of a shared European life should lead pupils towards a greater respect for the traditions of each individual country and region in Europe, while developing and preserving their own national identities.

The pupils of the European Schools are future citizens of Europe and the world. As such, they need a range of competences if they are to meet the challenges of a rapidly-changing world. In 2006 the European Council and European Parliament adopted a European Framework for Key Competences for Lifelong Learning. It identifies eight key competences which all individuals need for personal fulfilment and development, for active citizenship, for social inclusion and for employment:

1. *Communication in the mother tongue*
2. *Communication in foreign languages*
3. *Mathematical competence and basic competences in science and technology*
4. *Digital competence*
5. *Learning to learn*
6. *Social and civic competences*
7. *Sense of initiative and entrepreneurship*
8. *Cultural awareness and expression*

The European Schools' syllabuses seek to develop all of these key competences in the pupils.

2. Didactic Principles

The general **aim** of this course is to develop the **skills**, **knowledge** and **understanding** to carry out experiments, research and practical investigations. This will emphasise the principles and practice of investigative science and its communication. Learners will do this through investigation of scientific method, scientific literature and communication.

Projects will provide an opportunity to develop planning and organising skills. Learners will research issues and apply scientific skills which will develop their scientific literacy.

The course covers the **key areas** of: scientific principles and process; experimentation; critical evaluation of scientific research.

Through this Course, learners will develop important skills, attitudes and attributes related to science, including: developing scientific and analytical thinking skills in a scientific context; developing understanding of scientific issues; and acquiring and applying knowledge and understanding of science. These skills enable learners to develop an informed and ethical view of complex issues.

Learners will be able to develop their written and oral communication and collaborative working skills and be able to apply critical thinking in new and unfamiliar contexts to solve problems. This will enable learners to become scientifically literate citizens, who are able to make rational decisions that are based on evidence and interpretation of scientific information.

The order, nature and number of experiments is not fixed as there are many variables to be considered such as the availability of equipment and material.

As laboratory work requires considerable time the lab course should be timetabled as a double period and the last 2 periods of the day should be avoided to allow the continuation of experiments.

3. Learning Objectives

By the end of year seven pupils should be able to:

- Use scientific knowledge to analyse problems and apply it to new situations;
- Process and both, quantitatively and qualitatively, analyse scientific information/data from a variety of sources including scientific publications and media reports;
- Plan and design projects, using reference materials and including risk assessments, to test a hypothesis or to illustrate particular effects;
- Produce, describe and analyse different kinds of graphs;
- Draw valid conclusions and giving explanations supported by evidence/justification;
- Communicate clearly, using scientific vocabulary correctly;
- Demonstrate very good presentation skills;
- Work constructively in a team.

4. Contents

The following are suggestions only and over the 2 years the teacher should try to include practicals from each of the following two Topics. These Topics should be explored both in S6 and S7.

Topic 1: MICROELECTRONICS-Digital and analog electronics

This course has a high practical content with considerable "hands on" experience for the student especially later in the sixth and in the seventh years.
Fundamental properties of LOGIC GATES and their later inclusion in circuits provide "logical solutions" for everyday practical problems e.g. a washing machine filling with water, heating the water and finally beginning the wash cycle.
Another simple example could be the activation of an alarm triggered for example by a window or a door opened or a light beam broken or pressure is exerted on a hidden sensor under a carpet.
Investigation by students of the possibility of making any gate out of NAND or NOR gates should be made in a lab environment. Students should show that any logic circuit with various gate types may always be reduced to a single gate type. Further simplification of logic expressions is studied using the laws of Boolean Algebra.
The second semester is devoted to sequential logic, starting with basic RS flip-flops , both negative and positive edge triggered versions investigated from cross coupled NAND and NOR gates respectively. Applications such as debouncing a switch are investigated. An extension to D-type and T-type flip-flops allows an appreciation of the function mechanism of shift registers (latches) and counters.

In the second year of this course (Year 7), logic systems (with low current requirements) are used to drive transistors and relays via various physical sensors e.g. light, temperature, humidity sensors. This allows devices with much larger current requirements to be operated - an example could be to design a circuit which will automatically switch on the heating in a greenhouse at night if the temperature falls below a certain value; a much more demanding simulation and one which provides a stimulating challenge is for a circuit which will simulate a car windscreen wiper with time variable intermittent wipe. The windscreen wipe starts automatically when it starts raining.
In all labs, an approach `by kit' is recommended which makes circuit construction much easier. Initially the various Input boards (physical sensors), then processor units (transistors, latches, delays and counters), and finally output units (motors, buzzers, lights and solenoids) are individually studied and the relevant operating parameters entered in look-up tables. These look up tables then provide the essential starting point for the design and subsequent construction of the simulation circuits.
Subsequently analog as well as digital systems are also studied. Of paramount importance in this respect is the OPERATIONAL AMPLIFIER which is investigated in detail; its function in automatic control situations e.g. not simply switching on a light automatically when it gets dark but making the light get brighter as it gets darker. Other examples include position control and servo-mechanisms.

THEMES	CONTENTS
Mechanical switch circuits – logic gates	Comparison of switch (open or closed) with logic levels (0 or 1) Logic level 0 corresponds to low voltage (0 V) – logic level 1 corresponds to high voltage (5 V) Each single gate type: NOT, AND, OR, NAND,NOR Symbols for gates (traditional and IEC) Very simple examples of gate logic circuits (combination of gates) Combinations of switches, equivalent logic gate diagrams and truth tables: concept and construction Logic equations for combination of gates Determining final output logic level with given input levels for a combination of gates Logic diagram Equivalence of logic circuits by comparing respective truth tables Logic equation (which can be simplified) always obtainable from truth table Any gate can be made from a single type usually NAND (can be proved using Boolean algebra) Everyday applications (burglar alarm, coffee machine, corridor switches, …) demonstrable practically (simulation) Logic circuits = low current circuits unable to drive externa high current devices ⇒ need of amplification (transistor)
Basic concept of diodes and transistors	Simple circuits to demonstration properties of diodes and transistors
Boolean (logic) algebra	Fundamental rules; De Morgan’s laws Simplification of logic circuits (from corresponding logic equation) to produce an equivalent circuit with fewer gates

THEMES	CONTENTS
Sequential logic circuits (flip-flop or bistable)	Basic RS flip-flop (cross-coupled NAND or NOR gates) Contact bounce ; Important application for RS flip-flop to debounce a switch Development of RS flip-flop to obtain D-type flip-flop D-type flip-flop as a shift-register (transfers information from D-input to Q-output on receipt of a clock pulse): positive edge or negative edge triggered D-type converted to T-type flip flop: now behaves as a binary counter and frequency divider Applications: reaction timer, accurate measurement of short intervals of time…
Input sensor in voltage divider circuits	Heat, light, sound. Charge and discharge of a capacitor introducing delay

THEMES	**CONTENTS**
Automatic control	Input sensors connected to processors and finally to output device with or without logic system Processing device (transistor alone or used to activate relay) Output (activation of visual or audible warning system, activation of single or continuous movement by solenoid or motor) Numerous applications possible Occasional necessary use of a comparator (where voltage of input sensor changes only gradually)
Operational amplifier	Practical verification of the various operations possible (inverting and noninverting amplifiers, differential amplifier, adders and substractors, integrator) Importance of negative feedback Using integrators to solve differential equations and simulate for example radioactive decay, simple harmonic motion with or without damping, etc. Operational amplifier as comparator Servomechanisms Position control Analogue to digital and digital to analog converters

Topic 2 : Electronics – Robotics

This course must be based on the learner's own discovery of 'physical signal processing' by practical labs, projects, and active learning activities.
In order to approach this, IT skills must be developed (C, C++, Python, or any other programming language suitable to the use in a lab), in order to feed into the overall topics or electronics.
Students should interact with analog and digital sensors; such as temperature, light, motion sensors. The data acquired through those should then be treated and used to control different types of actuators (motors, servos, solenoids, relay switches to name a few). One example of such control flow would be the design of a small robot using motion sensors to guide its way around a floor, or a robot using a light sensor to follow a path.
Students should also get accustomed to data transfer between subparts of their projects; either locally with serial ports, or over the Internet and Cloud-based platforms (MQTT server for instance).
The IT skills developed in year 6 should but put to use in the study of Connected Objects in year 7.
They should also acquire analysis skills to be able to improve their projects or to fix their flaws.

THEMES	CONTENTS
BASICS of ELECTRONICS	- Passive components : resistors, capacitors, inductors - Simple Circuits, resistors in pull-up/pull-down - Active components: diode/led, transistor (bipolar/mosfet) - Logic Gates - Measurements : multimeter, oscilloscope
SIGNAL PROCESSING VIA COMPUTERS and PROGRAMMING LANGUAGES	- Basics of Input / Output - OS uses for Signal Processing - Basics of Programming - Simple circuits controlled via I/O
SENSORS ACTUATORS	- Introduction and Use of Sensors (switches, motion sensor, gyroscope, accelerometer, …) - Introduction and Use of motors (DC, servo, stepping motor, …) - Basics Filter circuits (average, « debouncing »)

THEMES	CONTENTS
COLLABORATIVE WORK IN OPEN SOURCE SETTINGS	One of three sub-themes: - Software Versioning tools (git,…) - Tools to design circuits, or printed boards - « Instructables » : step by step method for a project (video, slideshow, …)
DATA SHARING NETWORKS	- Local Data sharing (serial ports, IIC, SPI) - Wireless Data (smartphone,…) - TCP/IP Network - Cloud-based networking (MQTT, Connected objects)
ROBOTICS	-In increasing order of difficulty : “Line follower” robot Robotic arm Robot controlled by Wireless interface Collision avoidance systems Itinerary via GPS Room mapping

5. Assessment

Evidence can be drawn from a variety of sources and formats including participation, reports, projects (long term and research based) and presentations/communication skills etc.
Formal written long tests are not to be used for assessment of pupils.

5.1 Suggested assessment activities for A and B marks.

5.1.1 An A mark is awarded for each semester and should be arrived at using some/all of the following:

• Observation of students during practical activities:

- o Participation in class: individual and collaborative working skills, during and after practical activities
- o Attention to health and safety
- o Use of material and equipment

• Written reports should include:

- o Aims/Hypotheses
- o Procedures/methods
- o Results in an appropriate format
- o Appropriate Conclusions

• Presentation skills

5.1.2 A B mark is awarded for each semester and should be arrived at using a project with a short report written over two periods.

5.2 Attainment descriptors

	A	B	C	D	E	F	FX
	9,0 - 10 Excellent	8,0 - 8,9 Very good	7,0 - 7,9 Good	6,0 - 6,9 Satisfactory	5,0 - 5,9 Sufficient	3,0 - 4,9 Failed/Weak	0 - 2,9 Failed/ Very Weak
Experimental work	Designs an experimental work completely autonomously with respect to a given protocol while being aware of security issues.	Designs an experimental work mostly autonomously with respect to a given protocol while being aware of security issues.	Designs an experimental work with respect to a given protocol while being aware of security issues.	Needs help to design an experimental work with respect to a given protocol while being aware of security issues.	Needs constant help to design an experimental work with respect to a given protocol while being aware of security issues.	Has difficulty following instructions.	Is not able to follow a written procedure.
Analysis	Is able to collect and critically analyse data thoroughly to improve his project.	Is able to collect and analyse data thoroughly to improve his project.	Is able to collect and analyse data to understand the underlying concepts of his project.	Roughly analyses and explains the underlying concepts of his project.	Shows some abilities to use data to partly understand the underlying concepts of his project.	Is not able to use data without help and needs considerable help to partly understand the underlying concepts of his project.	Is not able to use data adequately and shows a very weak understanding of the underlying concepts of his project.
Communication (oral and written)	Communicates logically and concisely using scientific vocabulary correctly. Demonstrates excellent presentation skills.	Communicates clearly using scientific vocabulary correctly. Demonstrates very good presentation skills.	Communicates clearly most of the time using scientific vocabulary correctly. Demonstrates good presentation skills.	Uses basic scientific vocabulary, and descriptions show some structure. Demonstrates satisfactory presentation skills.	Uses basic scientific vocabulary, but descriptions may lack structure or clarity. Demonstrates satisfactory presentation skills	Generally, produces descriptions that are insufficient or incomplete with a poor use of scientific vocabulary. Lacks acceptable presentation skills.	Has very poor communication and presentation skills.

Teamwork	Shows initiative and Works constructively in a team.	Works constructively in a team.	Works well in a team.	Works satisfactorily in a team.	Can participate in team work.	Needs assistance when working in a team.	Does not work in a team.

6. Appendix

Appendix 1. Project example.

Building a computer mouse:
Using a microcontroller ability to act as a USB gadget to build a mouse directed by a joystick for example.

Serial Data Sharing :
Linking the serial ports on two microcontrollers (RX/TX).
The goal of the first project is to make the LED blink on a microcontroller, using the input of the other. This implies the need to build a simple communication protocol (a few characters would suffice).

Bluetooth Data Sharing:
A microcontroller controls a simple setup (it could be just LEDs or a robotic arm,…). The microcontroller is itself controlled by an app/protocol on a smartphone.

Path following Robot:
Simple Robot with three wheels and two motors. Using reflectivity sensors to control the motors speeds to guide the path of the robot (this needs a clear line on a dark ground for enough contrast).