USAEE

University Studies of Agricultural Engineering in Europe;
a Thematic Network

Education and Culture

Core Curricula of Agricultural / Biosystems Engineering for the First Cycle Pivot Point Degrees of the Integrated M.Sc. or Long Cycle Academic Orientation

by

USAEE TN

University Studies of Agricultural Engineering in Europe; a Thematic Network

Table of Contents

Foreword

Agricultural engineering is under-going rapid changes as a result of the technological innovation, the dramatic structural changes in the Higher Educational system of Europe and also because of major inherent problems associated with the traditional field of Agricultural Engineering studies in Europe and the emerging relevant societal needs. Many universities now use new terms related to agricultural engineering, in order to cover the demands of the society. The traditional term of agricultural engineering is in several cases substituted by the term “bio-engineering” or “resource systems engineering”, while more and more universities include new discipline oriented rather than object oriented courses.

In response to these dramatic changes, the thematic network USAEE - University Studies of Agricultural Engineering in Europe has been established in the framework of the Erasmus programme of the EU, Directorate-General Education and Culture. The need for a European Thematic Network on Agricultural Engineering and related University study programs stemmed from the contemporary chaotic situation of the relevant programs of study as this was clearly described in the relevant report of AFANET-WP3 [1]. One of the main objectives of this project is to identify the new trends within Agricultural Engineering, and suggest ways in which to incorporate these in the Agricultural Engineering curricula. The basic goal in this network is the development of basic core curricula in Agricultural Engineering to be used as benchmark and recognised at a European level. The establishment of a benchmark serves the purpose of determining a set of criteria/requirements against which any curriculum can be tested and decided whether or not it meets the criteria for its admission as a particular programme of Agricultural Engineering studies in Europe.

The major objectives of USAEE are to:

- Define the core curricula to be used as benchmarks for Agricultural Engineering studies in Europe. The on-going development is based on the following requirements:
    - It must meet the FEANI criteria for being an Engineering program of studies: this requirement will be elaborated in synergy with FEANI
    - It must meet the ‘Agricultural Science’ core curricula requirements in Agricultural Engineering. This requirement will be achieved in synergy with EurAgEng.
- Establish a benchmark core curriculum that serves the purpose of determining a set of minimum criteria/requirements against which any curriculum can be tested and decided whether or not it meets the criteria for its admission as a particular programme of Agricultural Engineering studies

- Define common accreditation strategies and procedures and establish the bodies/committees to carry out the accreditation of the departments, which are to meet the core curricula requirements.

For these reasons six Workshops have already been held. More specifically:

A first Workshop ("*Current Structure of European University Studies in Agricultural Engineering*", Madrid, March 28–29, 2003) [2] was dedicated to present the results of a survey aiming at defining and classifying some fundamental issues in the area of the Agricultural Engineering studies in Europe. The results of the first workshop support the conclusion that the picture of the Agricultural Engineering studies in Europe varies drastically from country to country. Furthermore the introduction of the dramatic changes through the recent developments in the higher educational system in Europe has created even more problems and confusion, especially in the higher Engineering education, because of the peculiarities of this area. The combination of the chaotic situation in the Agricultural Engineering studies in Europe along with the Bologna convention related major changes of the European higher Education system has led to the current crucial transient phase of the Agricultural Engineering studies in Europe, as this is depicted in the ongoing restructuring of the programs of studies.

A second Workshop ("*Research Activities in European University Institutes of Agricultural Engineering",* Palermo, September 26-27, 2003) [3] was dedicated to present the results of a systematic survey on the current status of the research activities carried out in Agricultural Engineering University departments/institutions within Europe. The second workshop and relevant survey supports the conclusion that the picture of the Agricultural Engineering research activities in Europe varies from country to country mainly within the broader traditional area of Agricultural Engineering research. Most differences, however, concern the funding schemes that differ very much between the various countries and institutions. In addition, some new contemporary and emerging research areas, representing the most recent developments in Agricultural Engineering research activities in Europe, are directly related to the dramatic changes in the Agricultural Engineering university studies in Europe and worldwide.

A third Workshop ("*A Review on the ECTS System*", Dijon, March 27-28, 2004) [4] was dedicated to ECTS and the Bologna implementation in Agricultural Engineering studies in Europe. It becomes apparent that the combination of the ECTS official adoption along with the implementation of the Bologna system in the framework of the recent dramatic developments in restructuring the higher educational system in Europe has created serious problems of comparability and equivalency and also complications in assessment of typically similar but essentially drastically different programs of studies, as well as of ECTS units and titles offered. It is characteristic that the ECTS system adaptation has not led to an analogous harmonisation but, in many cases, to a major confusion hidden under a unique nominal credits system: the ECTS.

A forth Workshop (“*Agricultural Sciences part of core curricula in Agricultural Engineering University Studies*”, Leuven, September 17–18, 2004) [5] was devoted to outlining a variety of virtual programs of studies in Agricultural/ Biosystems Engineering adopted to the various partner-countries educational systems and based in part or in total on the proposed core curriculum, which at that time had been submitted to FEANI for comments and possible approval. These virtual programs of studies related to the intermediate pivot-point 1st cycle degree offered towards an integrated MSc or a classical long cycle program of studies. This scheme ensures that a University level strong theoretical background is offered to students of such University programs of studies (in contrast to technological studies of practical orientation).

A fifth Workshop (“*Accreditation of Agricultural Engineering Studies*”, Dresden, April 8-9, 2005) [6] was devoted to the presentation of: (a) the most recent developments on the creation of national frameworks and an overarching European framework for qualifications of the European higher education area and their relation with the current USAEE work and (b) the overall picture about various aspects of accreditation practices in network partners’ countries. Next to this, presentations from each partner separately described the picture of the existing accreditation systems along with their envision of a EurAgEng “recognition” procedure in view of the current evaluation process in their own Institution/University process, but also assuring comparability among Agricultural/Biological engineering curricula across Europe.

The sixth Workshop (“*Agricultural Engineering programmes meeting the FEANI and EurAgEng criteria*”, Budapest, September 19-20, 2005) [7] was dedicated to the presentation of administrative changes/modifications (in the framework of the Bologna process) which took place in the partners’ Institutions/Universities from the status described in the 1st USAEE Workshop. The effects of these changes/modifications on the coherence of the running study program and the quality of studies were determined. Furthermore, a brief reference was made to changes/modifications regarding the ECTS credit system used since the 4th USAEE Workshop. Their effect on the study program and upon several related issues (i.e. Diploma Supplement, student workload, etc.) were also described. Adjustments, alterations or differences, if any, concerning the quality assurance scheme used in each country that occurred since the 5th USAEE Workshop were described, along with the possible consequences. Finally, Network partners presented in table format the currently running program of studies concerning the 1st and 2nd cycles, along with the corresponding courses and ECTS credits for both cycles and proposed a revised virtual program of studies, guided by the FEANI report.

In view of the evolving dramatic changes in the European higher Engineering Education and in parallel with the critical changes in the Agricultural Engineering programs of studies, the relevant trends in the USA are considered to be of exceptional interest for the corresponding restructuring of the university studies of Agricultural Engineering in Europe. These challenges are already incorporated in the main objective of the USAEE project, which is the establishment of the core curricula requirements for the so evolving Agricultural, Biosystems and Biological Engineering University studies in Europe. As the weak part of the current Agricultural Engineering studies in Europe is the inadequate engineering foundation of the corresponding curricula the main goals of USAEE are to:

- Enhance the Engineering part of the European core curricula in Agricultural/Biosystems Engineering so that it meets the FEANI criteria for being an Engineering program of studies
- Reduce significantly the Agricultural or Biological Sciences part of the European core curricula in Agricultural/Biosystems Engineering to meet the basic -fundamental- knowledge of the corresponding subjects without extending to, or competing against, or overlapping with the classical Agronomy programs of studies.

The present draft is a revision of the original document submitted to FEANI in September 2004, in compliance to the comments received by EMC in November of 2005. The revisions made meet all suggestions made by the EMC of FEANI.

It is reminded that this revised version concerns the Core Curricula of Agricultural / Biosystems Engineering for the First Cycle Degrees of Integrated First and Second cycles (i.e. Pivot Point Degree) or for Long Cycle Academic Orientation Programs of Studies. As far as the First Cycle B.S. Degrees Programs of Studies the proposed Core Curricula of Agricultural/ Biosystems Engineering allows for 18 ECTS units to be devoted to applied Agricultural Engineering subjects while most of the Agricultural Engineering specialisation subjects will be offered during the second cycle program of studies.

References

1. Briassoulis, D., H. Papadiamandopoulou and B. S. Bennedsen. 2001. Towards a European Standard for Agricultural Engineering Curricula. AFANet; Workpackage 3; Agricultural Engineering. KVL, AgroTechnology, Agrovej 10, DK-2630 Taastrup, Denmark
2. Briassoulis D and Panagakis P (editors) 'Current Structure of European University Studies'. *Proceedings of the 1st USAEE Workshop*, Madrid, March 28 – 29, 2003.
3. Briassoulis D. and P. Panagakis (editors) 'Research Activities in European University Institutes of Agricultural Engineering', *Proceedings of the 2nd USAEE Workshop*, Palermo, September 26–27, 2003
4. Briassoulis D. and P. Panagakis (editors) '*A Review on the ECTS System*', *Proceedings of the 3rd USAEE Workshop*, Dijon, March 27-28, 2004
5. Briassoulis D. and P. Panagakis (editors) '*Agricultural Sciences part of core curricula in Agricultural Engineering University Studies*', *Proceedings of the 4th USAEE Workshop*, Leuven, September 17- 18, 2004
6. Briassoulis D. and P. Panagakis (editors) '*Accreditation of Agricultural Engineering Studies*', *Proceedings of the 5th USAEE Workshop*, Dresden, April 8-9, 2005
7. Briassoulis D. and P. Panagakis (editors) '*Agricultural Engineering programmes meeting the FEANI and EurAgEng criteria*', *Proceedings of the 6th USAEE Workshop*, Budapest, September 19-20, 2005

General Background

Objectives

- Define the core curricula to be used as benchmarks for Agricultural Engineering studies in Europe.
- The establishment of a benchmark core curriculum serves the purpose of determining a set of minimum criteria/requirements against which any curriculum can be tested and decided whether or not it meets the criteria for its admission as a particular programme of Agricultural Engineering studies
- Define common accreditation strategies and procedures and establish the bodies -committees to carry out the accreditation of the departments which are to meet the core curricula requirements.

Core curricula criteria

The development of benchmarks for basic European core curricula in Agricultural Engineering will be based on the following requirements:

- It must meet the FEANI criteria for being an Engineering program of studies: this requirement will be elaborated in synergy with FEANI
- It must meet the 'Agricultural Science' core curricula requirements in Agricultural Engineering. This requirement will be finalised in synergy with EurAgEng.

Engineering core curricula

The weak part of the current Agricultural Engineering studies in Europe is the inadequate engineering foundation of the corresponding curricula. Therefore:

- The main goal of USAEE is to enhance the Engineering part of the European core curricula in Agricultural/Biosystems Engineering so that it meets the FEANI criteria for being an Engineering program of studies
- The main goal of USAEE is to reduce significantly the Agricultural or Biological Sciences part of the European core curricula in Agricultural/Biosystems Engineering to meet the basic – fundamental - knowledge of the corresponding subjects without extending to, or overlapping with the classical Agronomy programs of studies.

Learning outcomes

The Socrates financed Tuning Project (Tuning Educational Structures in Europe) started their outcome-oriented model from a concept based on competencies, applying somehow the attributes idea:

- "By learning outcomes we mean the set of competences including knowledge, understanding and skills a learner is expected to know/ understand/demonstrate after completion of a process of learning - short or long.
- They can be identified and related to whole programmes of study (first or second cycle) and for individual units of study (modules).
- Competences, can be divided into two types: generic competences, which in principle are subject independent, and subject specific competences.
- Competences are normally obtained during different course units and can therefore not be linked to one unit, but they can also be linked to one unit.
- It goes without saying that competences and learning outcomes should correspond to the final qualifications of a learning programme."

LEARNING OUTCOMES AND COMPETENCES IN STUDY PROGRAMMES

An illustrative example adopted from the Tuning Project:

Course unit/ learning outcome	Competence A	B	C	D	E	F	G	H	I	J
Unit 1			X			X				
Unit 2	X				X				X	
Unit 3		X					X			
Unit 4	X			X						

X = THIS COMPETENCE IS DEVELOPED AND ASSESSED AND IS MENTIONED IN THE LEARNING OUTCOME OF THIS UNIT

Distinction between different programs or specialisations

The basic goal of the core curricula to be developed by USAEE-WG1 is to ensure that an essential minimum fundamental engineering knowledge is offered to all Agricultural Engineering (Biosystems Engineering, and similar) programmes of studies at a University level. Given that differentiations among the existing programmes and the educational systems is enormous, and as the potential developments in these programmes are unpredictable (and very drastic in several cases, as reported during the first workshop of USAEE in Madrid), the objectives of the USAEE TN do not include any kind of intervention in the various specialisations in support of one or another scheme or programme of studies. The Engineering part of the core curricula should not be confused with the whole program of studies offered by a particular Department. The main aim of the USAEE TN is to provide the basic foundation in terms of Engineering knowledge particularly since the current developments support a highly interdisciplinary approach cutting across all traditional diplomas in Agricultural Engineering. In other words USAEE intends, to specify the minimum amount of engineering content that is acceptable in any curriculum representing itself as agricultural (biosystems, and similar) engineering.

Distinction between modules and courses

The idea of the modules, as well as several other ideas may be attractive under certain perspectives. However, when the basic goal to set-up a well recognised core curricula system at a European but also at an international level, adopted to all possible educational systems and programmes of studies, there is only one way to proceed: define the core curricula requirements in terms of course units. Even more, define courses which are internationally well recognised in terms of content and avoid any confusing mixtures.

"Relevant for the Job Market" or a Pivot Point?

A really important point raised by SEFI is the conclusion that: '*in most countries, where an intermediate degree 3-year is introduced, this degree will primarily be something that facilitates for the student to move, either to a new university, to a new country or to a new line of study. The employers may of course also accept the degree, but it cannot really be seen to fulfill the Bologna requirement of being in itself "relevant for the European job market" Degrees introduced or being introduced in Switzerland, Denmark,* *the Netherlands Belgium (both the French speaking and the Flemish Communities), Iceland seem to fit this description of a "Pivot Point"*.

Application-oriented curricula

Another crucial question raised by SEFI concerns the more application-oriented education: '*How these should fit into the Bologna scheme and how these can survive side by side with new intermediate "Bachelor's" degrees is far from obvious. Different countries have different solutions, each based on the history, industrial and social structure and established traditions of each individual country. Much work has to be done before we can talk about anything like a European harmonisation of these curricula and degrees. This work is important for many reasons, one being the fact that in most countries the number of graduates from these programmes exceeds the number of graduates from the long cycle education'.*

The final conclusion of the SEFI report [1] is that '*the main challenge is to agree on certain minimum standards and to create a system to describe, in a commonly understood way, the various competencies for professional and academic use. The work done by the Thematic Network E4, run by University of Florence in cooperation with SEFI and other organisations, is of interest in this context'*. It is therefore considered very important that <u>the work of the USAEE Thematic Network on European University Studies of Agricultural Engineering has established from the beginning strong synergies with both SEFI and E4 TN towards a common goal</u>.

Distinction between Engineering profiles

- Traditionally different types of engineers have received their education in institutions giving them different profiles
- One such clear distinction can be drawn between the "Fachhochschule" and Universities in Germany, and between previous "Polytechnics" and Universities in the UK.
- Other countries have similar arrangements
- Consider the new intermediate degree primarily as a point of mobility;
- Make a very clear distinction between the new "intermediate degree" (or "pivot point" first 3 years cycle degrees aimed at the continuation of the studies to the completion of the integrated 5 years –2 cycles- programs of studies) and the Applied Engineering 3 year degrees (degrees aimed at the graduation of the student and direct employability);

Basic Principles of Developing the Core Curricula

The main objective

The main objective of the USAEE TN is to establish the core curricula requirements for Agricultural Engineering University studies in Europe (as well as Biosystems and Biological Engineering, or similar titles). The current trend and developments concerning the change (of name and contents) from the traditional Agricultural Engineering to Biosystems Engineering (mostly without including human-biomedical engineering) will be considered in this effort (refer to the overview of the Proceedings of the 2nd workshop in Palermo). The core curricula structure should aim at developing the foundation for Engineering studies, specialising in designing solutions to problems in systems involving (all or combinations of):

- plants (production agriculture that includes power and machinery)
- animals (animal production which includes structures and environment)
- humans (health and biomedical engineering)
- environment (bioenvironmental engineering which includes soil and water engineering, waste management, *etc*.)

All of these areas require proficiencies in instrumentation, information technology and many other disciplines.

The main objective of USAEE does not include the classical programs offering basically studies in Agronomy (or Agricultural Sciences) with some specialisation in Agricultural Engineering

Define output descriptors

A first approach to the basic coursework requirements for the Engineering part of the core curricula are summarised as follows:

1. Define core basis: classical Engineering courses that will provide a minimum set of Engineering output descriptors of the core.
2. Courses are the basic units in most European Universities as well as in the USA; modules may combine the basic core engineering courses and other additional courses to build any possible module content
3. Core basis: consider courses that cover the very basic general Engineering background. Do not include discipline-specific courses for different diplomas and specialisations in the core basis
5. Additional different specialisation-specific Engineering courses may be added beyond the core basis, and defined depending on the specialisation etc, beyond the core curricula.

Schematically this concept is shown in Figure 1:

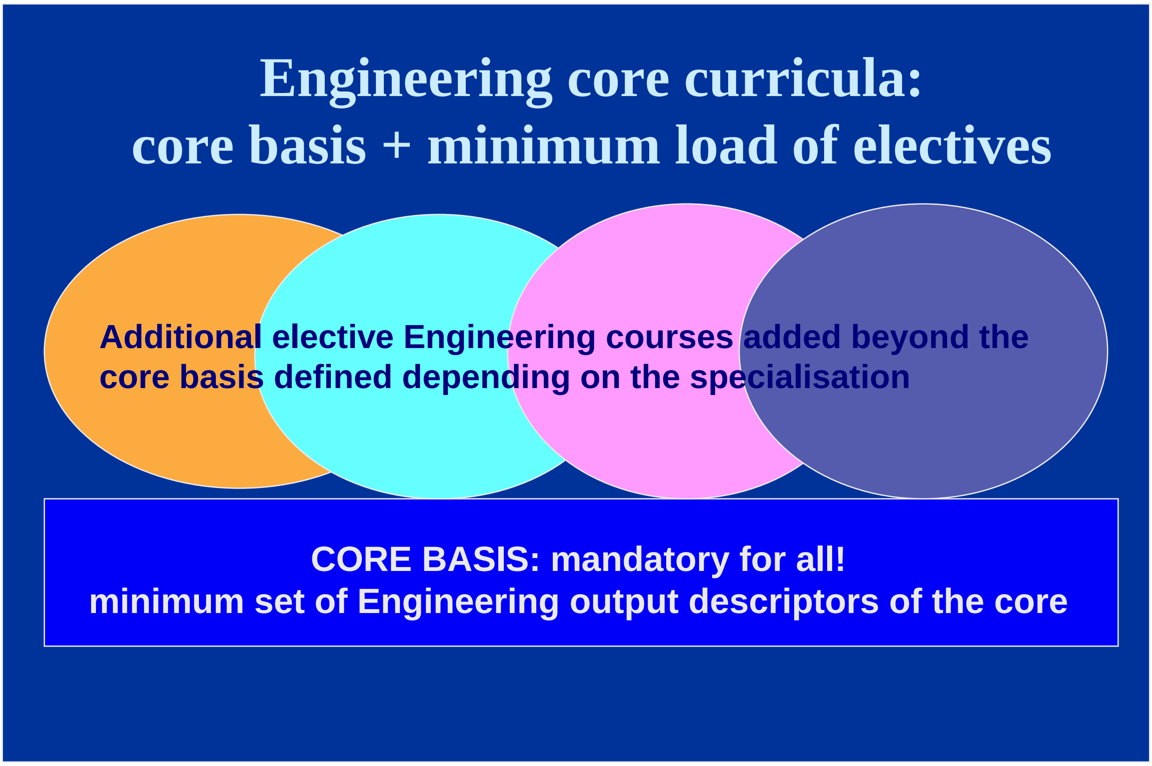


Figure 1. The Engineering part of the core curricula structure for Agricultural/ Biosystems Engineering studies in Europe

Level of studies

The first level of studies is considered in the present stage of the core curricula development of USAEE. Two different schemes will be defined at this level:

<u>Scheme A: Academic orientation</u>

- Core curricula for University studies leading to a **long cycle degree** following integrated five years programs of studies
- Core curricula for integrated two-cycles programs of University studies leading to a **pivot-point first cycle degree** (e.g. B.Sc.) following three years programs of studies

<u>Scheme B: Applications-technological orientation</u>

- Core curricula for University studies leading to a **professional B.Sc. level degree** following at most three years programs of studies

Note that only the title name (B.Sc.) may be the same for schemes A and B (first degree), but surely not the contents of studies (not always so however: 5-years programs of studies do not offer a B.Sc. degree but a 5-years diploma, while in other cases the first level program of studies may lead to a pivot point degree with a different title, etc.). The main problem is that all these first level degrees may represent completely different programs of studies and so very much different backgrounds…

<u>The programs of studies for the first cycle of the Academic integrated two cycles degrees have to be distinguished from the Technological-applications oriented first cycle degrees.</u>

Developing the Core Curricula for the First Cycle Pivot Point Degrees of the Integrated **two cycles Programs of Studies** or Long Cycle Academic Orientation Programs of Studies

Engineering part of the core curricula: Basic principle: The Engineering part of the Agricultural/ Biological/ Biosystems Engineering program of studies is composed of two Core Curricula components (Engineering part of core curricula) plus a general competences background.

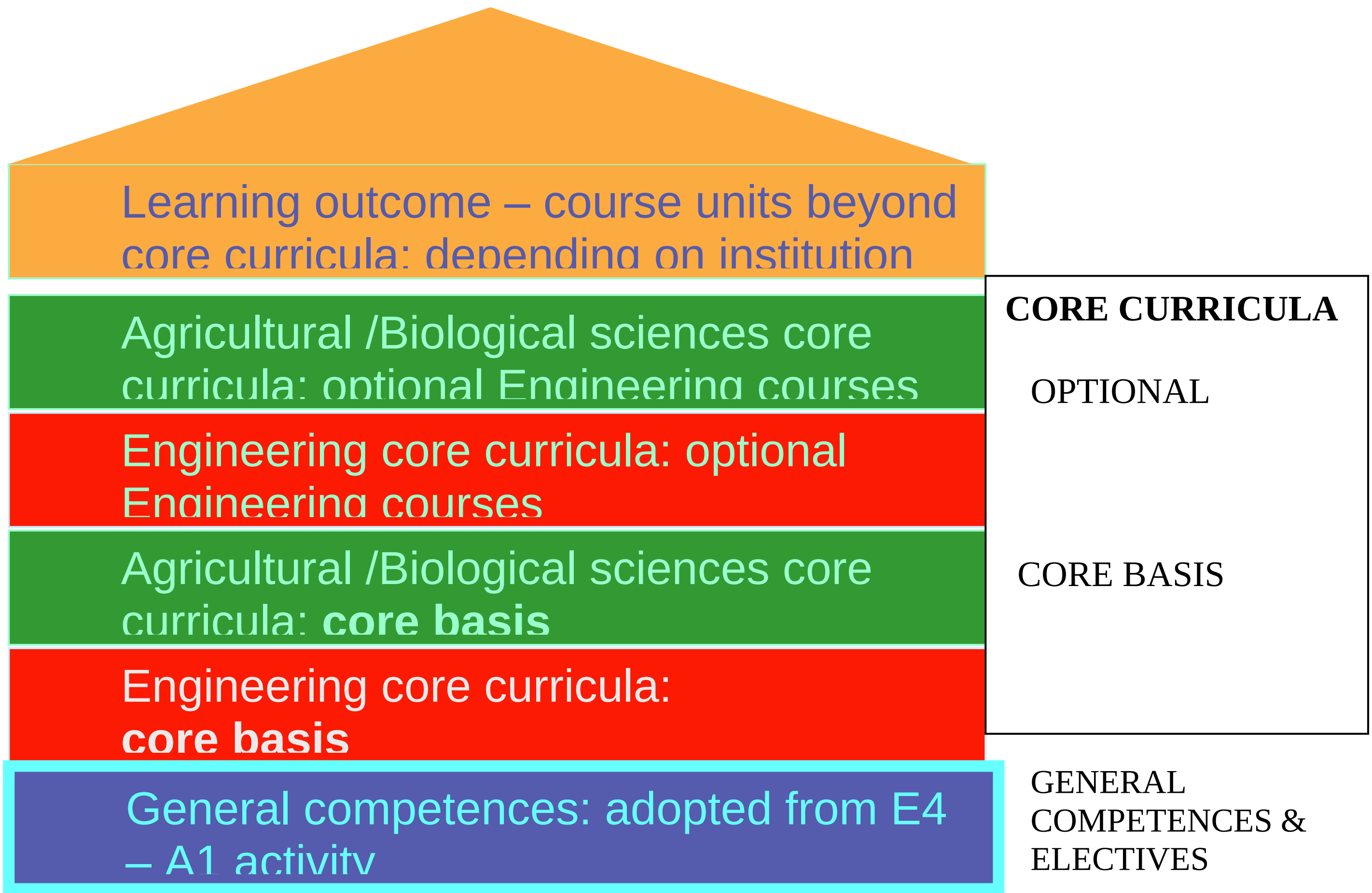
1. Engineering core curricula: the fundamental core basis
2. Engineering core curricula: optional specialisation-specific Engineering courses

- General competences: adopted from E4 – A1 activity

Agricultural /Biological Sciences part of the core curricula: A similar structure applies to the Agricultural /Biological Sciences part of the core curricula: it is composed of two basic components:

3. Agricultural /Biological Sciences core curricula: the fundamental core basis
4. Agricultural /Biological Sciences core curricula: optional Agricultural /Biological Sciences courses

Figure 2. Schematic presentation of the core curricula for the first cycle pivot point degrees of the integrated MS or long cycle academic orientation programs of studies of Agricultural/Biosystems Engineering



Core Curricula of Agricultural/ Biosystems Engineering for the First Cycle Pivot Point Degrees of the Integrated **two cycles Programs of Studies** or Long Cycle Academic Orientation Programs of Studies

General competences: adopted from E4 – A1 activity

The general competences are adopted from the corresponding report of A1 activity of the Thematic Network E4 and they appear in Appendix A.

Engineering part of core curricula: core basis

The minimum set of the outcome descriptors of the Engineering part of core curricula should include the contents of fundamental Engineering subjects mandatory for all modules (or specializations) of Agricultural /Biosystems Engineering. These contents are expressed in terms of well-defined and recognized internationally basic Engineering courses.

Agricultural /Biological Sciences part of core curricula: core basis

The minimum set of the outcome descriptors of the Agricultural /Biological Sciences part of core curricula should include the outcome learning of fundamental knowledge of Agricultural /Biological Sciences subjects mandatory for all modules (or specializations) of Agricultural /Biosystems Engineering. These contents are expressed in terms of basic Agricultural /Biosystems Sciences course units following the example of the Tuning Project. These course units should represent fundamental basic knowledge and should not include Agronomy-applications oriented specialized subjects.

Engineering part of the core curricula: optional specialisation-specific courses of Engineering Sciences

Optional Engineering courses to be included in the Engineering part of the core curricula are be determined as follows:

- Modules of Agricultural Engineering programs of studies are defined
- Each module may include several Engineering courses and each Agricultural Engineering programme may choose a minimum number of courses from one or several modules, as needed by the individual programme

Agricultural /Biological Science part of the core curricula: optional specialisation-specific courses of Agricultural /Biological Science

Optional Agricultural /Biological Science courses to be included in the Agricultural /Biological Science part of the core curricula are determined as follows:

- Modules of Agricultural Engineering programs of studies are defined (same as above)
- Each module may include several Agricultural /Biological Science courses and each Agricultural Engineering programme may choose a minimum number of courses from one or several modules, as needed by the individual programme (same as above)

Agricultural Engineering part beyond the core curricula: module or specialisation-specific courses of Agricultural Engineering.

In the present draft, only an indicative list is presented since the development of the full programs of studies is beyond the scope of the USAEE Thematic network. On the other hand the indicative list will offer an insight to the FEANI members of the perspectives of the corresponding programs of studies in Agricultural/Biosystems Engineering.

Appendix A:

Draft Core Curricula Overview of Agricultural/Biosystems Engineering

Basic Sciences - Electives

BASIC SCIENCES – ELECTIVES	BASIC SCIENCES & ELECTIVES 54-72 ECTS CREDITS: equal to 30-40% of total 180 ECTS CREDITS *(assuming 14-20 course units with 5 or 4 ECTS credits per unit, respectively or equivalent)* BASIC SCIENCES: TO COVER THE COMPETENCES DESCRIBED IN APPENDIX A (Adopted by the report of E4, Activity 1; Appendix D) 36-45 ECTS CREDITS: equal to 20-25% of total 180 ECTS CREDITS • Mathematics (24 ECTS minimum) • Computer Science/Informatics • Physics • Chemistry ELECTIVES: TO COVER THE NEEDS OF THE INDIVIDUAL PROGRAMS OF STUDY DEPENDING ON THE LEVEL OF THE INCOMING STUDENTS AND THE ORIENTATION OF THE PROGRAM (e.g. may include Humanities and Economics or additional Basic Sciences) 18-27 ECTS CREDITS: equal to 10-15% of total 180 ECTS CREDITS • Engineering Economics • Agricultural Economics • Introduction to Philosophy • Introduction to Justice and Law • Introduction to Sociology • Technical and Financial Management of Infrastructures • Engineering Ethics

Agricultural Engineering Fundamental Core Basis

AG. ENG. FUNDAMENTAL CORE BASIS	ENGINEERING PART OF THE CORE CURRICULA: THE FUNDAMENTAL CORE BASIS 44-51 ECTS CREDITS: equal to 24.5-28.3% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 9 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Engineering Graphics and Design - CAD 2. Mechanics-Statics 3. Strength of Materials 4. Mechanics-Dynamics 5. Fluid Mechanics 6. Applied Thermodynamics 7. Heat and Mass Transfer 8. Electricity and Electronics 9. System Dynamics	AGRICULTURAL /BIOLOGICAL SCIENCES PART OF THE CORE CURRICULA: THE FUNDAMENTAL CORE BASIS 20-25 ECTS CREDITS: equal to 11-14% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 5 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Plant Biology 2. Animal Biology 3. Introduction to Soil Science 4. Introduction to Agricultural Meteorology and Micro-meteorology 5. Understanding the Environment and its interaction with Living Organisms

Proposed Modules or Specialisations within the First Cycle Pivot Point Degree

WATER RESOURCES ENGINEERING	ENGINEERING PART OF THE CORE CURRICULA: OPTIONAL COURSES 28-30 ECTS CREDITS: equal to 15.5-16.7% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 6 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Open Channel Flow 2. Pipe Flow 3. Surface Hydrology 4. Hydrogeology 5. Fluid Rheology 6. Remote Sensing 7. Engineering Surveying – GIS 8. Instrumentation and Measurements 9. Pollutant Behaviour and Transport in the Environment	AGRICULTURAL /BIOLOGICAL SCIENCES PART OF THE CORE CURRICULA: OPTIONAL COURSES 16-20 ECTS CREDITS: equal to 8.9-11.1% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 4 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Crop Science and Management 2. Crop Protection 3. Soil Physics 4. Agro-chemicals 5. Environmental Impact Assessment 6. Introduction to Aquaculture

MECHANICAL SYSTEMS AND MECHANISMS USED IN AGRICULTURAL AND BIOPROCESS ENGINEERING	ENGINEERING PART OF THE CORE CURRICULA: OPTIONAL COURSES 28-30 ECTS CREDITS: equal to 15.5-16.7% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 6 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Kinematics of Mechanisms 2. Power Generation Engines 3. Mechatronics 4. Soil Mechanics 5. Electrotechnics 6. Electronic Circuits 7. Instrumentation and Measurements 8. Engineering Surveying - GIS	AGRICULTURAL /BIOLOGICAL SCIENCES PART OF THE CORE CURRICULA: OPTIONAL COURSES 16-20 ECTS CREDITS: equal to 8.9-11.1% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 4 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Crop Science and Management 2. Crop Protection 3. Agro-chemicals 4. Animal Science and Management 5. Environmental Impact Assessment

STRUCTURAL SYSTEMS AND MATERIALS IN AGRICULTURAL AND BIOPROCESS ENGINEERING	ENGINEERING PART OF THE CORE CURRICULA: OPTIONAL COURSES 28-30 ECTS CREDITS: equal to 15.5-16.7% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 6 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, <u>or equivalent</u>:* 1. Design of Steel Structures 2. Design of Concrete Structures 3. Design of Timber Structures 4. Soil Mechanics 5. Introduction to Material Science & Engineering 6. Computational Mechanics 7. Electrotechnics 8. Instrumentation and Measurements 9. Electronic Circuits 10. Engineering Surveying - GIS	AGRICULTURAL /BIOLOGICAL SCIENCES PART OF THE CORE CURRICULA: OPTIONAL COURSES 16-20 ECTS CREDITS: equal to 8.9-11.1% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 4 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, <u>or equivalent</u>:* 1. Animal Science and Management 2. Crop Science and Management 3. Introduction to Aquaculture 4. Fish Production 5. Environmental Impact Assessment

WASTE MANAGEMENT IN AGRICULTURAL AND BIOPROCESS ENGINEERING	ENGINEERING PART OF THE CORE CURRICULA: OPTIONAL COURSES	AGRICULTURAL /BIOLOGICAL SCIENCES PART OF THE CORE CURRICULA: OPTIONAL COURSES
	28-30 ECTS CREDITS: equal to 15.5-16.7% of total 180 ECTS CREDITS	16-20 ECTS CREDITS: equal to 8.9-11.1% of total 180 ECTS CREDITS
	Learning outcomes and contents follow this table	*Learning outcomes and contents follow this table*
	Assuming 6 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:	*Assuming 4 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:*
	1. Surface Hydrology 2. Hydrogeology 3. Fluid Rheology 4. Liquid Waste Management 5. Solid Waste Management 6. Remote Sensing 7. Engineering Surveying – GIS 8. Instrumentation and Measurements 9. Waste Management and Environmental Quality	1. Plant Science and Management 2. Animal Science and Management 3. Biological Process in Waste Management 4. Environmental Impact Assessment 5. Environmental Engineering Microbiology 6. Soil Physics 7. Soil Chemistry

BIOPROCESSING	ENGINEERING PART OF THE CORE CURRICULA: OPTIONAL COURSES 28-30 ECTS CREDITS: equal to 15.5-16.7% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 6 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Food Process Engineering 2. Food Manufacturing Systems 3. Food Process Technologies 4. Fluid Rheology 5. Electrotechnics 6. Instrumentation and Measurements 7. Electronic Circuits 8. Mechatronics	AGRICULTURAL /BIOLOGICAL SCIENCES PART OF THE CORE CURRICULA: OPTIONAL COURSES 16-20 ECTS CREDITS: equal to 8.9-11.1% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 4 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Plant Science and Management 2. Introduction to Food Science 3. Post-harvest Physiology 4. Food Quality 5. Food Microbiology

ENERGY SUPPLY AND MANAGEMENT IN AGRICULTURAL AND BIOPROCESS ENGINEERING	ENGINEERING PART OF THE CORE CURRICULA: OPTIONAL COURSES 28-30 ECTS CREDITS: equal to 15.5-16.7% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 6 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Renewable Energy Resources & Technologies 2. Energy Production and Supply 3. Environmental Pollution from Energy Production 4. Remote Sensing 5. Electrotechnics 6. Instrumentation and Measurements Electronic Circuits 8. Engineering Surveying - GIS	AGRICULTURAL /BIOLOGICAL SCIENCES PART OF THE CORE CURRICULA: OPTIONAL COURSES 16-20 ECTS CREDITS: equal to 9-11% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 4 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Plant Science and Management 2. Animal Science and Management 3. Environmental Impact Assessment 4. Environmental Engineering Microbiology

INFORMATION TECHNOLOGY AND AUTOMATION IN AGRICULTURAL AND BIOPROCESS ENGINEERING	ENGINEERING PART OF THE CORE CURRICULA: OPTIONAL COURSES 28-30 ECTS CREDITS: equal to 15.5-16.7% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 6 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Control Systems and Automation 2. Information Systems 3. Expert Systems 4. Image Processing 5. Advanced Programming 6. Robotics 7. Remote Sensing	AGRICULTURAL /BIOLOGICAL SCIENCES PART OF THE CORE CURRICULA: OPTIONAL COURSES 16-20 ECTS CREDITS: equal to 9-11% of total 180 ECTS CREDITS *Learning outcomes and contents follow this table* *Assuming 4 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework, or equivalent:* 1. Plant Science and Management 2. Animal Science and Management 3. Environmental Impact Assessment 4. Introduction to Food Science

Agricultural Engineering Courses

(NOTE: THE FOLLOWING LIST IS ONLY INDICATIVE, IT IS NOT COMPLETE AND IT IS NOT PART OF THE CORE CURRICULA; AGRICULTURAL ENGINEERING COURSES, UP TO A MAXIMUM OF 18 ECTS, ARE TO BE DEVELOPED BY EACH UNIVERSITY ACCORDING TO THE ORIENTATION OF THE PROGRAMS OF STUDIES OFFERED AND TO THE INSTITUTION'S STRATEGIC GOALS)

This list illustrates the possible synthesis of an integrated (3+2) or long cycle program of studies in Agricultural Engineering, composed of:

- ⇒ BASIC SCIENCES & ELECTIVES
- ⇒ CORE CURRICULA
- ⇒ AGRICULTURAL ENGINEERING COURSES

Water resources engineering

1. GIS and Natural Recourses Management
2. Irrigation System Design
3. Drainage System Design
4. Agricultural Water Quality Engineering
5. Soil-Water Conservation Systems Design
6. Small Watershed Engineering
7. Contaminant Hydrogeology
8. Soil Erosion
9. Landscape Planning
10. *Free Technical or Agricultural/Biological Elective*

Mechanical systems and mechanisms used in agricultural and bioprocess engineering

1. Agricultural Machinery Design
2. Farm Power Units
3. Farmstead Equipment
4. Analysis and Design of Biomachinery
5. Techniques in Precision Agriculture
6. Automatic Controls
7. Computer Control of Machines and Processes
8. Ergonomics, Health and Safety
9. Design Methods for Machines for Biosystems
10. Remote Sensing
11. Soil Erosion
11. Landscape Planning
12. *Free Technical or Agricultural/Biological Elective*

Structural systems and materials in agricultural and bioprocess engineering

1. Livestock Housing
2. Protected Plant Production
3. Environmental Control for Animals and Plants
4. Indoor Air Contaminant Measurement and Control
5. Manure Treatment and Bioconversion
6. Ergonomics, Health and Safety
7. Landscape Planning
8. *Free Technical or Agricultural/Biological Elective*

Bioprocessing

1. Post-harvest Technologies
2. Post-harvest Management
3. Material Properties of Biological Systems
4. Crop preservation
5. Ergonomics, Health and Safety
6. Unit Operations
7. *Free Technical or Agricultural/Biological Elective*

Waste management in agricultural and bioprocess engineering

1. Manure Treatment and Bioconversion
2. Ergonomics, Health and Safety
3. Agricultural Water Quality Engineering
4. GIS and Natural Recourses Management
5. Farmstead Equipment
6. Soils and Hazardous Waste
7. Environmental Engineering Chemistry
8. Contaminant Hydrogeology
9. Soils and Environmental Quality
10. Soil Microbiology and Biochemistry
11. *Free Technical or Agricultural/Biological Elective*

Energy supply and management in agricultural and bioprocess engineering

1. Solar Energy Utilization
2. Biomass Energy
3. Ergonomics, Health and Safety
4. Automatic Controls
5. Energy and Environment
6. Landscape Planning
7. *Free Technical or Agricultural/Biological Elective*

Information technology and automation in agricultural and bioprocess engineering

1. Techniques in Precision Agriculture
2. Techniques in Precision Livestock Farming
3. Machine vision in Agriculture
4. Decision-support Systems for Agriculture
5. Spatial Information Technology (GPS, GIS, RS) for Agriculture
6. Information Technology for Food Quality, Safety and Traceability
7. *Free Technical or Agricultural/Biological Elective*

Appendix B:

Fundamental Core Basis Learning Outcomes & Contents of Course Units

Engineering Part of the Core Curricula

Course unit:	Engineering Graphics and Design - CAD
Learning outcome:	The graduate should be able to: • Apply classical technical design tools to prepare drawings of objects, parts and models • Use computer aided design software to prepare 2D and 3D drawing models
Course content:	Basics of technical design. Use of computer-aided design (CAD) software to model parts and assemblies. Use of parametric and non-parametric solids, surface and wireframe models. Part editing, two-dimensional documentation of models. Planar projection theory, including sketching of perspective, isometric, multiview, auxiliary and section views. Spatial visualization exercises. Dimensioning guidelines, tolerancing techniques. Team design project

Course unit:	Mechanics-Statics
Learning outcome:	After completing the course the student is expected to: • Become proficient with the use of free-body diagrams. • Fully understand the implementation of vector algebra in force analysis. • Develop the ability to produce a clear solution write-up as a form of stand-alone technical communication. • Develop problem solving strategies and the ability to apply the principles of statics to advanced applications. • Develop a high level of understanding of the fundamental principles of applied mechanics and the modeling of force systems in engineering statics
Course content:	Vector approach to the solution of equilibrium problems involving particles, rigid bodies, and multi-membered structures: Forces, moments, couples; distributed forces, resultants of force systems; centroids and center of mass; equilibrium analysis and free-body diagrams; analysis of forces acting on members of trusses, methods of joint and sections; multi-force members, frames, etc.; shear-force and bending-moment distributions; applications of statics in design.

Course unit:	Strength of Materials
Learning outcome:	After completing the course the student is expected to: • Become Familiar with the concepts of stress and strain. • Be able to calculate stresses under uni-axial, torsion, and bending loads. • Be able to calculate deflections under uni-axial, torsion, and bending • Design simple structures and machine components for strength and allowable deflections
Course content:	Basic concepts of stress and strain. Relationship between internal stresses and deformations produced by external forces acting on deformable bodies, and design principles based on mechanics of solids: normal stresses, shear stresses, and deformations produced by tensile, compressive, torsional and bending loading of members; uniaxial loading and deformation: Statically determinate and indeterminate problems; design based on yield strength, ultimate strength beam deflections; Torsion of circular shafts and thin-walled sections: Geometry of deformation, stress, distribution, statically determinate and indeterminate systems, design of shafts. Stresses due to bending: Geometry of deformation, stress distribution, symmetric elastic beams, transverse shear, design of beams. Beam deflections: Differential equations,

	double integration, direct integration, method of superposition. Elastic energy. Multi-axial stress and strain states: Transformation of stress and strain, Mohr's circle representations, principal stresses and strains, states of plane stress and plane strain, two-dimensional elastic stress-strain relations, yield criteria, design problems for combined states of stress. Buckling of members in compression: Euler theory, design of members in compression.

Course unit:	Mechanics-Dynamics
Learning outcome:	The graduate should be able to: • Model a system composed of rigid bodies. • Pose and analyze dynamical problems involving systems of particles and rigid bodies by applying the first principles of Newtonian mechanics. • Model a mechanical system and solve its governing equations. • Interpret mathematical solution to a dynamical rigid body problem.
Course content:	Kinematics and dynamics of the three-dimensional motion of particles; Newton's laws, applications; kinematics and dynamics of the plane motion of rigid bodies; methods of work-energy and impulse-momentum; moving reference frames: Overview / Introduction, Particle kinematics. Rectilinear motion, Curvilinear motion. Newton’s laws of motion. Particle kinetics (work & energy). Impulse & momentum. Rigid body planar kinematics. Planar relative motion. Planar kinetics (forces & acceleration). Principle of work & energy. Conservation of energy. Special topics such as noninertial reference frames may be introduced

Course unit:	Fluid Mechanics
Learning outcome:	The graduate should be able to: • Understand fundamental concepts (e.g. fluid properties, fluid statics) • Use the control volume approach in developing principles of conservation of mass, energy and momentum
Course content:	Fluid statics: Pressure, pressure variation, manometry, forces on plane and submerged surfaces, buoyancy; Flow kinematics: Velocity, acceleration, flow visualization, control-volume concepts, continuity principles, flow nets continuity; Fluid dynamics: momentum and energy principles via control volumes; Euler and Bernoulli equations; ideal and real fluid flow; separation, cavitation; introduction to the Navier–Stokes equation; similitude; Closed-conduit flow; Laminar and turbulent flows, pipe roughness and friction, the Moody diagram, minor (fitting) losses, hydraulic and energy gradelines, pipe systems and branching flows laminar and turbulent. Boundary layers; Laminar and turbulent layers, growth, local shear relations, total drag transition. Flow around a body: Lift, drag, vortex shedding, separation, streamlining. Open-channel flows: Uniform flow, specific energy critical depth, gradually varying flow, free-surface profiles, hydraulic jump; statistical/stochastic flow fields Turbomachinery: pumps, turbines (impulse, reaction), turbosimilitude, specific speed.

Course unit:	Applied Thermodynamics
Learning outcome:	The graduate should be able to: • Understand fundamental concepts and use the thermodynamic laws • Comprehend issues such as reversibility, irreversibility and entropy • Calculate thermal properties and evaluate the performance of thermal systems. • Apply the first and second law of thermodynamics to vapour power and refrigeration systems, gas power systems, applications concerning humidification, dehumidification, evaporative cooling systems and combustion processes.
Course content:	Review of Thermodynamics: Properties of pure substances, Ideal models, First law, second law, irreversibility, Carnot cycle. Gas power systems: Internal combustion engines (Otto, Diesel, and Stirling Cycles), Gas turbines (Brayton Cycle), Jet propulsion. Vapor power systems: Rankine cycle, Superheat, Reheat and regenerative cycles, applications that involve imperfect gases, Losses in actual systems. Refrigeration systems: ideal and actual vapor-compression refrigeration systems, refrigerants, absorption and gas refrigeration cycles. Gas-vapor mixtures and air-conditioning: properties of ideal gas mixtures, gas-vapor mixtures, psychrometrics, air-conditioning processes. Chemical reactions: stoichiometry, enthalpy of formation, first and second laws for reacting systems, adiabatic flame temperature, combustion efficiencies.

Course unit:	Heat and Mass Transfer
Learning outcome:	The graduate should be able to: • Formulate energy conservations equations • Understand dimensionless heat and mass transfer numbers
Course content:	Fundamentals of heat transfer: Conduction (i.e. one-dimensional, two-dimensional, transient), convection (i.e. free and forced, external and internal flow), heat exchangers, radiation (i.e. emission, irradiation, blackbody radiation, exchange between surfaces), mass-transfer by convection. Relevance to engineering applications.

Course unit:	System Dynamics
Learning outcome:	The graduate should be able to: • Build continuous time dynamical models of simple biological, agricultural and technical systems and represent them as ordinary differential equations and in state space • Analyse linear dynamical systems in the time domain, frequency domain and in state space • Have a notion about the qualitative theory of linear and nonlinear dynamical systems
Course content:	Mathematical modelling of simple dynamic systems: technical systems (mechanical, electrical, thermal, chemical, etc.); biological and agricultural systems (microbial, plant and animal, human, food). Representation of dynamic models as ordinary differential equations, state space models, systems transfer functions. Linear systems analysis in the time domain (first order, second order, higher order responses to different inputs, etc.), the frequency domain and s-domain (bode analysis, root locus analysis, stability (Routh-Hurwitz, Nyquist)) and in state space (solutions, controllability and observability, minimal realizations, etc.). Introduction to qualitative theory of linear and nonlinear dynamic systems.

Course unit:	Electricity and Electronics
Learning outcome:	The graduate should be able to: • Understand the fundamentals of electricity and electronics • Apply principles so as to design components and analyse DC circuits • Comprehend the meaning of various quantities and their measurment
Course content:	Mathematics for electronics, Components/Quantities/Units, Voltage, current, and resistance, Ohm's law, Energy and power, Series circuits, Kirchhoff's voltage law, Voltage dividers, Parallel circuits, Kirchhoff's current law, Series-parallel circuits, Superposition method, Thevenin's theorem, Norton's theorem, Capacitors in DC circuits, Inductors in DC circuits

Agricultural /Biological Sciences Part of the Core Curricula

Course unit:	Plant Biology
Learning outcome:	The graduate should be able to understand: • Plant cytology & morphology (so as to understand plant physiology) • Construction and physiology of plants • Growth, development and reproduction of plants
Course content:	Cytology: Instrumental analysis of plant cells and tissues. Plant cell: sizes, morphology, chemical components. Cell organization and organelles, vacuoles, and cell walls. Cell division (meiosis, mitosis). Morphology-Anatomy: Embryo development. Seeds of higher plants, germination. Organization of the plant body. Meristems. Histology (epidermal, fundamental (parenchyma), mechanical contactive tissues, secretory structures). Organography. Stem, apical organization, roots, apical meristems, histogenesis, leaf organization, abscission. The sexual reproduction of plants. Chemical composition of plants. Physiological characteristics of the principal organic compounds. Principles of higher plant metabolism (biophysical phenomena, enzymes, allostery, inhibition, membranes). Respiratory metabolism of higher plants. Exchange of materials, active and passive transport, water absorption, water potential of cells and tissues. Inorganic nutrition of higher plants, absorption, transport and translocation. Laws of plant yield. Metabolism and symbiotic fixation of nitrogen. Metabolism of other mineral nutrients. Photosynthesis, carbon assimilation and biosynthesis of organic compounds. Plant growth and development. Phytohormones. Environmental factors affecting growth and development. Thermoperiodism. Photoperiodism. Dormacy. Transiration. Stress Physiology.

Course unit:	Animal Biology
Learning outcome:	The graduate should be able to: • Understand elements of animal anatomy and physiology • Understand elements of animal reproduction • Understanding elements of animal nutrition and feedstuffs • Issues of animal behaviour and welfare
Course content:	Introduction to Anatomy and Histology. Animal cell and tissues. Elements of Anatomy. The molecular and cellular basis of physiological regulation. Homeostatic control (neural and endocrine control mechanism). Regulation of gastrointestinal function, digestion and absorption. Physiology of reproduction in the male and the female. Respiratory system, gas exchange and thermoregulation. Basic principles of nutritional physiology and postabsorptive nutrient utilization. Digestion: The non-fermentative processes and the fermentative processes. Introduction to feedstuffs. Fundamental processes in behaviour. Organization of behaviour in the individual animal. Social and reproductive behaviour. Early and parental behaviour. Welfare measurement. Humane control of livestock. Welfare and behaviour in relation to disease.

Course unit:	Introduction to Soil Science
Learning outcome:	The graduate should have: • Elementary understanding of the basic soil characteristics with respect to plant growth • Elementary understanding of the relation between soil, water and plant growth
Course content:	Overview of soil systems (historical review, soil systems, soil genesis). Soil particle-size analysis (classification of soil particles and their role in nature, soil textural classes). Soil minerals (primary minerals: structure, physicochemical properties, weathering; secondary minerals: structure, physicochemical properties of clay-silicate minerals; Fe and Al oxides and hydroxides). Chemical properties of soils (cation exchange and its role in plant nutrition, base saturation, Z-electric potential, clay flocculation-deflocculation, soil acidity and its role, management of acid soils, soil buffering capacities). Soil organic matter (humic and organometalic complexes, clay-humic complexes, the role and properties of organic matter). Soil physical properties (structure, porosity, structure improvement, soil solution and electrolytes, soil temperature and its role). Soil morphology (soil profile, color, soil catenas and their description; soil horizons and epipedons; soil taxonomy; soil maps and description of soil map units). Water properties. Water retention and movement in soil. The water thermal regime. Soil aeration. Solute transport. Soil deformation & compaction

Course unit:	Introduction to Agricultural Meteorology and Micro-meteorology
Learning outcome:	The graduate should be able to understand: • Interactions between climate and/or (micro) climate and plants
Course content:	About climate. Climate classification, Types of climate zones. Agricultural microclimates. Radiation, temperature, humidity, precipitation and wind velocity regimes near the ground. Climate and vegetation. Frost and frost protection.

Course unit:	Understanding the Environment and its interaction with Living Organisms
Learning outcome:	The graduate should be able to: • Explore concepts important to the understanding of the biological components of the earth system, interactions between living organisms, and the interaction between living organisms and the non-living elements of their environment • Having insight in the relation between animals and plants and the environment • Having insight in different aspects of sustainability
Course content:	Study of evolution, development of interrelationships between organisms and their environment. The biological basis of behaviour. Basic principles of ecology as they apply to environmental problems. Factors which control distribution and population dynamics of organisms, structure and function of biological communities, Energy flow and nutrient cycling in ecosystems; contrasts among the major biomes, principles governing ecological responses to global climatic and other environmental changes.

Appendix C:

Modules or Specializations Learning Outcomes & Contents of Course Units

Water Resources Engineering

Engineering course units

Course unit:	Open Channel Flow
Learning outcome:	The graduate should be able to: • Understand principles of uniform and varied flow. • Understand channel design for uniform flow, gradually varied flow profiles, channel transitions, hydraulic jumps, flow in prismatic and non-prismatic channels
Course content:	Steady state open-channel flow. Specific energy, critical state of flow. Froude number. Uniform flow. Gradually varied flow. Analysis, classification, methods of computation of surface water flow profiles. Rapidly varied flow. Hydraulic jump. Hydraulic structures. Introduction to unsteady flow in open channels. Gradually and rapidly varied unsteady flow. Applications in surface irrigation. Open channel networks, furrow, border and basin irrigation systems. Elements of natural open-channels hydraulics.

Course unit:	Pipe Flow
Learning outcome:	The graduate should be able to understand: • The principles of pipe flow hydrauliocs, networks, pumps and valves
Course content:	Introduction. Flow in branching pipes, Equivalent pipes. Pipe networks. Pump characteristics. Affinity laws. Net positive suction head. Pumped lines and flow regulating valves.

Course unit:	Surface Hydrology
Learning outcome:	The graduate should be able to: • Evaluate surface processes and watershed responses. • Relate role of water in natural processes, such as shaping the surface of the Earth. • Make informed decisions concerning water allocation and protection of natural resources
Course content:	Introduction, background, orientation. Hydrologic cycle and water balance. Frequency, intensity, duration analysis. Precipitation processes and measurement. Snow on the ground. Snowmelt and water yield. Infiltration and soil moisture. Evaporation and transpiration. Hillslope hydrology. Stream-flow processes and measurement. Empirical stream-flow models. Hydrograph analysis. Flow routing.

Course unit:	Hydrogeology
Learning outcome:	The graduate should be able to: • Understand the fundamental principles of ground-water flow and chemistry. • Appreciate the quantitative evaluation of ground-water resources, and environmental problems relating to ground water.
Course content:	Hydrologic cycle. The movement of groundwater. Flow problems under steady conditions. Flow problems under unsteady flow conditions. Partially penetrating wells. Group of boreholes. The principle of superposition. Bounded aquifers. The principle of images. The method of imaginary variables. Seawater encroachment in coastal aquifers. Technical recharge of aquifers.

Course unit:	Fluid Rheology
Learning outcome:	The graduate should be able to: • Identify the basic forces that give rise to complex fluid behavior. • Understand the theory behind mechanical rheometry and interpret rheological results. • Use state of the art techniques for characterization of complex fluid structure. • Understand the physics behind polymeric and colloidal systems.
Course content:	Complex fluids – examples, pertinent length scales, common features & applications. Mechanical rheology – techniques, pitfalls & interpretation of data. Forces – basics forces that drive the dynamics and behavior – steric, van der Waals, electrostatic etc. Polymeric Systems - Polymer Solutions – overlap, reptation, scaling laws, nonlinear behavior. Polymer Gels – yielding behavior, transient network models. Suspensions Colloidal fluids – dilute, concentrated, filled systems. Emulsions & Blends – interfaces, viscoelasticity, drop dynamics. Mesoscopic Systems, Self-assembling and liquid crystal systems – phases, structural characterization. Block copolymers – structures, rheology.

Course unit:	Pollutant Behaviour and Transport in the Environment
Learning outcome:	The graduate should be able to: • Recognise and be aware how pollution is transported. • Assess the risks to the environment from various activities. • Understand the current legislation and codes of practice, which aims to control pollution and soil erosion.
Course content:	Agri-Environment schemes, aims and objectives. Pollution risks from different farming systems. Pollution legislation. European and international codes of good practice for environmental protection.

Course unit:	Remote Sensing
Learning outcome:	The graduate should be able to: • Understand how to collect and interpret information about the earth's surface through non-contact methods.
Course content:	Maps, photos, and orthophotography. Location of principal points, conjugate principal points, and flight lines. Use of a stereoscope. Determination of scale. Measurement diameter of tree crowns. Area determination using dot grids, transects, and planimeters. Use of compass bearings and azimuths to locate section corners and plot locations. Determination of horizontal distance. Estimation stand DBH, crown closure, and stand stocking level. Cover type delineation. Transfer of photo locations to a map base. Advantages/disadvantages of film/filter/camera combinations. Photo acquisition and mission planning. A basic understanding of the electromagnetic spectrum. Describing and defining the relative merits of digital and analog remote sensing. Techniques for transfer of photo data into a GIS.

Course unit:	Instrumentation and Measurement
Learning outcome:	The graduate should be able to: • Have fundamental and integrated knowledge in designing engineering measurement systems and performing engineering measurements
Course content:	Elementary electronics. Application of instrumentation concepts and systems to the measurement of environmental, biological and agricultural phenomena. Measurement of temperature, pressure, strain, humidity, flow, etc. Analysis and interpretation of data (i.e. concepts of errors, accuracy and precision). Signal conditioning, system response, data acquisition, interfacing microcomputers for data acquisition. Construction and characterization of electronic sensors and transducers.

Course unit:	Engineering Surveying – GIS
Learning outcome:	Upon successful completion of this course, the student will be able to: • Understand the fundamentals of surveying • Explain the principles of distance measuring and levelling • Apply the principles of surveying and theodolites • Perform transverse surveys and computations • Apply the principles of surveying in building construction • Demonstrate knowledge of GIS and ArcView
Course content:	Land and topographic surveying with global position systems and geographic information systems (GIS). Fundamentals of distance, levelling angles, theodolites, transverse surveys and computations. Laser systems and advantages of laser systems in land levelling. Hands-on with ArcView GIS to understand the basic GIS concepts and applications in land planning.

Agricultural/biological course units

Course unit:	Crop Science and Management
Learning outcome:	The graduate should be able to: • Elements of field crop production • Elements of arboriculture • Elements of horticulture
Course content:	Soil tree and its parts (physiology and functions). Fruit variety improvement cultivation: types and targets, impact on plant and soil characteristics, tools and machinery, timing, reduced and no-tillage. Crop rotation: aims and general principles, monoculture, fallow, rotations in rain-fed and irrigated areas, double cropping. The fruit. Dormacy. Flowering. Pollination and fruit set. Thinning of fruits. Nutrition of fruit trees. Propagation. Rootstocks. Hormones and growth regulators. Crop maturity. Harvest. Orchard management. Introduction to horticulture. Types of horticultural enterprises. Nutrition: nutritional elements, soil analysis, fertilizer application, organic and green fertilization. Vegetable propagation, substrates, germination, dormacy, micro-propagation. Plant density, establishment, cultivation practices, crop protection. The mechanization of vegetable propagation, harvest, storage and marketing vegetables. Vegetable seed production, storage and marketing of seed. Principles of the biological and hydroponic cultivation vegetables.

Course unit:	Crop Protection
Learning outcome:	The graduate should be able to: • Elements of plant pathology • Elements of entomology • Elements of agricultural zoology • Elements of weed control
Course content:	Objectives, significance and history of plant pathology. Plant disease expression and symptomatology. Indicators of plant disease. Phytopathogenic fungi: general introduction, reproduction, pathogenesis, release and dispersal of fungal inocula. Selected specific fungal diseases. Phytopathogenic prokaryotes: general introduction, reproduction, epidemiology. Plant viruses: introduction, properties of plant viruses, transmission epidemiology and control. Plant diseases caused by parasitic higher plants: dodders and broomrapes. Principles of plant disease diagnosis and disease control. Economic importance of entomology. Morphology-anatomy-physiology (Metamorphosis of insects). Biology, ecology and control (chemical, biological and other) of some main species of cultivated plants. Economic importance of agricultural zoology. Concepts and terms from general zoology. Nomenclature and systematic zoology. Pests of plants (morphology, biology, ecology, control of plant parasitic nematodes, mites and mollusks).

Course unit:	Soil Physics
Learning outcome:	The graduate should be able to: • Understand the physical properties of soil with emphasis on water retention and flow and on ion movement in unsaturated soils
Course content:	Introduction. Definitions and bulk density measurements. Evaluation of procedures by error analysis. Water content measurements. Theory and discussion of the neutron technique, gamma-ray techniques and time-domain reflectometry. Water potentials. Units of measurement. Matric potential and tensiometers. Capillary rise assignment. The water retention curve. Similar Media concept. Derivation of the equation relating water potential to relative humidity. Measurement devices for water potential. Water Flow Equations. Review of Darcy's law (saturated and unsaturated). Derivation of the equation of continuity, Laplace's equation. Richard's equation and other equations for water flow in soil. Infiltration and Evaporation. Green and Ampt Equation. Steady state unsaturated flow. Layered soils. The effect of crusts and clogging on infiltration. Numerical simulation of infiltration. Isothermal, steady state evaporation from a water table. Hydraulic Conductivity and Soil Variability. Measurements of hydraulic conductivity in field soils. Measurement of unsaturated hydraulic conductivity. Calculation of hydraulic conductivity. Soil variability. Semivariance and autocorrelation. Solute transport. Mass flow. Diffusion and hydrodynamic dispersion. Macropore flow. The transfer function model.

Course unit:	Agro-chemicals
Learning outcome:	The graduate should be able to understand: • The basic principles of mode of function, application and effects on the environment and living organisms • Elements & management of Ago-chemicals
Course content:	• Reaction of nitrogen, potassium and phosphorus in soil, herbicides and pesticides, methods to assess mobility and availability of nutrients and pollutants, pollution mechnisms, root-agrochemicals interactions, approaches for reductions of agrochemicals pollution. Selection and timing of ground & airborne application. Safety precautions.

Course unit:	Environmental Impact Assessment
Learning outcome:	The graduate should be able to: • Design an impact assessment technique • Calculate and assess pollutant loading on the environment • Evaluate the socioeconomic impact
Course content:	Introduction and environmental policy acts, The environmental assessment process, Broad evaluation methods, Fundamentals of air pollution impact, Point and area sources of air pollution impact, Fundamentals of noise impact, Water impact: prediction and standards, Socioeconomic impact and public attitudes, Biological impacts and wetlands, cultural and land-use impacts, Decision making, Economic analysis and public participation

Course unit:	Introduction to Aquaculture
Learning outcome:	The graduate should be able to: • Principles of hydrobiology • Issues of aquaculture production
Course content:	Principles of aquaculture (comparison between aquaculture products, biological basis of aquaculture, water's main characteristics appropriate for aquaculture, site selection for aquaculture, relationship between physical-water, biological-organism and financial-production conditions, selection standards of appropriate for controlled production aquatic organisms). Aquaculture production systems: Systems according to the level of human interference (extensive, simple semi-extensive, semi-extensive, semi-intensive, intensive, super-intensive). Systems according to type of water manipulation and constructions. Factors related to mass production of fish, crustacean, molluscs, phytoplankton, zooplankton and aquatic plants. Stages of controlled production of aquatic animals (brood stock manipulation and maintenance, genital maturation, artificial fertilization, incubation and hatching, survival and rearing of early stages, on-growing period). Principles of aquaculture farms management: Selection of organisms, farm's size, determination of production level, growth rate of cultivable fish, crustaceans, bivalve molluscs, aquatic plants and plankton. Fish, crustacean and bivalve mollusc nutrition (natural food habits, types of artificial diets). Determination of productivity of natural and semi-natural aquatic bodies (seawater, brackish water and inland water-lakes and rivers). Types of production of aquaculture farms (hatcheries, on growing farms etc.).

Mechanical Systems and Mechanisms used in Agricultural and Bioprocess Engineering

Engineering course units

Course unit:	Kinematics of Mechanisms
Learning outcome:	The graduate should be able to: • Learn analytical and computational methods in kinematics and synthesize basic mechanisms. • Design the desired motion of the subject mechanical parts and mathematically compute the positions, velocities, and accelerations, which those motions will create on the parts.
Course content:	Kinematics fundamentals. Position analysis. Velocity analysis. Acceleration analysis. Linkage synthesis. Cam design, Gear trains.

Course unit:	Power Generation Engines
Learning outcome:	The graduate should be able to: • Model and analyze energy systems, both analytically and numerically, including refrigerators, heat pumps, gas turbines, and internal combustion engines.
Course content:	Introduction. Ideal and real Rankine cycles. Reheat cycle. Modelling of refrigerators and air conditioners. Modelling of heat pumps. Modelling of internal combustion engines, air standard Otto cycle. Combustion, reaction equations, stoichiometry. Energy release from combustion: enthalpy of formation, First law for reacting mixtures. Energy release from combustion, heating value. Adiabatic combustion temperature. Diesel engines, Diesel cycle, real Diesel cycles. Modeling gas turbines for power generation – Brayton (closed) cycles. Modeling gas turbines for power generation with internal combustion (open cycles). Exergy – in analysis of energy systems, exergy change for system.

Course unit:	Mechatronics
Learning outcome:	After completing the course the student is expected to be able to: • Analyse and optimise complex processes in which technical, agricultural and biological systems and constraints are integrated.
Course content:	Modelling of complex systems: methodologies for integrating models of simple subsystems; model reduction techniques, modelling equality and inequality constraints. Dynamic optimisation: systems with fixed and variable final time, the Hamilton-Jacobi-Bellman equation, sufficient conditions for a minimum, inequality constraints, direct and indirect solutions. Classical design of feedback control systems: performance specifications of controlled systems, sensitivity of controlled systems, design in the s-domain (root-locus), frequency response design (Bode, Nyquist, Nichols). Modern design of feedback control systems: state space design (state feedback and pole placement, stabilizability, observer design), advanced state space methods and optimal control (linear quadratic regulator problem (LQR), optimal observers - the Kalman filter, linear quadratic Gaussian problem (LQG), performance and stability robustness, loop transfer recovery (LTR), H-two and H-infinity control).

Course unit:	Soil Mechanics
Learning outcome:	The graduate should be able to: • Practically determine properties of soil in question through specific laboratory tests and site examinations • Understand the practical significance of different soil behaviour for the problems of foundations design and construction. • Understand the fundamental behaviour of soil with regard to applications in agricultural engineering
Course content:	Geotechnical Exploration. The Nature of Soil. Soil Identification/Phase Relationships. Index Properties of Soil. Soil Classification. Soil Compaction. Permeability and Seepage. Oedometer Test. Effective Stress Concept. Direct Shear Test. Stresses in Soil. Unconfined Compression Test. Consolidation and Settlement. Shear Strength of Soil. Slope Stability. Bearing Capacity of Soil. Earth Retaining Structure. Design of fills and dikes, foundations and dams.

Course unit:	Electronic Circuits
Learning outcome:	The graduate should be able to: • Understand the basics of electronic circuit analysis and design. • Comprehend a working knowledge of the characteristics and operation of circuits containing passive elements, diodes, BJTs, FETs, and op-amps. • Design, simulate and implement electronic circuits, both through simulation and by construction in a laboratory environment.
Course content:	Review of network theory. The design process and a systems view of instrumentation. Operational amplifiers, useful models, and example circuits. Diodes and diode circuits. BJTs, useful models, and typical circuits. FETs, useful models, and typical circuits. Frequency response and frequency-dependent behavior. Practice (basic construction techniques, basic troubleshooting techniques, basic measurement practice, documentation, etc.). Simulation. Electrical safety, grounding, and shielding.

Course unit:	Electrotechnics
Learning outcome:	Upon successful completion of this course, students will be able to: • Use methods and algorithms for the linear and more complex circuit analysis in the time and in the frequency domain. • Demonstrate knowledge of network theorems, magnetic circuits, transformers and d.c. generators and motors.
Course content:	Delta/Star transformation. Hysteresis, eddy current and leakage losses. Magnetic circuits. The ideal transformer. Three-phase systems. The d.c. motor and d.c. generator: series wound, shunt and compound wound.

Course unit:	Instrumentation and Measurement
Learning outcome:	The graduate should be able to: • Have fundamental and integrated knowledge in designing engineering measurement systems and performing engineering measurements
Course content:	Elementary electronics. Application of instrumentation concepts and systems to the measurement of environmental, biological and agricultural phenomena. Measurement of temperature, pressure, strain, humidity, flow, etc. Analysis and interpretation of data (i.e. concepts of errors, accuracy and precision). Signal conditioning, system response, data acquisition, interfacing microcomputers for data acquisition. Construction and characterization of electronic sensors and transducers.

Course unit:	Engineering Surveying – GIS
Learning outcome:	Upon successful completion of this course, the student will be able to: • Understand the fundamentals of surveying • Explain the principles of distance measuring and levelling • Apply the principles of surveying and theodolites • Perform transverse surveys and computations • Apply the principles of surveying in building construction • Demonstrate knowledge of GIS and ArcView
Course content:	Land and topographic surveying with global position systems and geographic information systems (GIS). Fundamentals of distance, levelling angles, theodolites, transverse surveys and computations. Laser systems and advantages of laser systems in land levelling. Hands-on with ArcView GIS to understand the basic GIS concepts and applications in land planning.

Agricultural/biological course units

Course unit:	Crop Science and Management
Learning outcome:	The graduate should be able to: • Elements of field crop production • Elements of arboriculture • Elements of horticulture
Course content:	Soil tree and its parts (physiology and functions). Fruit variety improvement cultivation: types and targets, impact on plant and soil characteristics, tools and machinery, timing, reduced and no-tillage. Crop rotation: aims and general principles, monoculture, fallow, rotations in rain-fed and irrigated areas, double cropping. The fruit. Dormacy. Flowering. Pollination and fruit set. Thinning of fruits. Nutrition of fruit trees. Propagation. Rootstocks. Hormones and growth regulators. Crop maturity. Harvest. Orchard management. Introduction to horticulture. Types of horticultural enterprises. Nutrition: nutritional elements, soil analysis, fertilizer application, organic and green fertilization. Vegetable propagation, substrates, germination, dormacy, micro-propagation. Plant density, establishment, cultivation practices, crop protection. The mechanization of vegetable propagation, harvest, storage and marketing vegetables. Vegetable seed production, storage and marketing of seed. Principles of the biological and hydroponic cultivation vegetables.

Course unit:	Crop Protection
Learning outcome:	The graduate should be able to: • Elements of plant pathology • Elements of entomology • Elements of agricultural zoology • Elements of weed control
Course content:	Objectives, significance and history of plant pathology. Plant disease expression and symptomatology. Indicators of plant disease. Phytopathogenic fungi: general introduction, reproduction, pathogenesis, release and dispersal of fungal inocula. Selected specific fungal diseases. Phytopathogenic prokaryotes: general introduction, reproduction, epidemiology. Plant viruses: introduction, properties of plant viruses, transmission epidemiology and control. Plant diseases caused by parasitic higher plants: dodders and broomrapes. Principles of plant disease diagnosis and disease control. Economic importance of entomology. Morphology-anatomy-physiology (Metamorphosis of insects). Biology, ecology and control (chemical, biological and other) of some main species of cultivated plants. Economic importance of agricultural zoology. Concepts and terms from general zoology. Nomenclature and systematic zoology. Pests of plants (morphology, biology, ecology, control of plant parasitic nematodes, mites and molluscs).

Course unit:	Agro-chemicals
Learning outcome:	The graduate should be able to understand: • The basic principles of mode of function, application and effects on the environment and living organisms • Elements & management of Ago-chemicals
Course content:	• Reaction of nitrogen, potassium and phosphorus in soil, herbicides and pesticides, methods to assess mobility and availability of nutrients and pollutants, pollution mechnisms, root-agrochemicals interactions, approaches for reductions of agrochemicals pollution. Selection and timing of ground & airborne application. Safety precautions.

Course unit:	Animal Science and Management
Learning outcome:	The graduate should be able to understand: • Issues of animal husbandry
Course content:	Breeds. Allometry. Cattle production: types of cattle enterprises. Milk production. Calf fattening. Sheep production: sheep farming systems. Milk production. Goat production: goat-farming systems. Milk production. Milking. Poultry production: Layers and Broilers. Pig production: types of swine enterprises. Reproduction, growth, fattening. Rabbit production: growth, animal handling.

Course unit:	Environmental Impact Assessment
Learning outcome:	The graduate should be able to: • Design an impact assessment technique • Calculate and assess pollutant loading on the environment • Evaluate the socioeconomic impact
Course content:	Introduction and environmental policy acts, The environmental assessment process, Broad evaluation methods, Fundamentals of air pollution impact, Point and area sources of air pollution impact, Fundamentals of noise impact, Water impact: prediction and standards, Socioeconomic impact and public attitudes, Biological impacts and wetlands, cultural and land-use impacts, Decision making, Economic analysis and public participation

Structural Systems and Materials in Agricultural and Bioprocess Engineering

Engineering course units

Course unit:	Design of Steel Structures
Learning outcome:	The graduate should be able to: • Explain the behaviour of basic structural components of steel structures. • Use AISC and LRFD code design procedures to design the principal structural elements of steel structures.
Course content:	Introduction. Design philosophy. LRFD method vs. ASD method. Tension Members, bolted & welded connections. Structural stability and compression members. Columns. Laterally supported beams. Lateral torsional buckling of beams, Stability. Virtual work, mechanisms, Continuous beams. Combined loads, bending and axial loads. Connections.

Course unit:	Design of Concrete Structures
Learning outcome:	The graduate should be able to: • Design simple reinforced concrete structures.
Course content:	Design philosophy and concepts, codes of practice. Loads, load factors, and safety factors. Structural properties of concrete and steel. Flexural analysis and design. Analysis and design for shear. Analysis and design of short columns. Analysis and design of long columns. Analysis and design of footings. Serviceability.

Course unit:	Design of Timber Structures
Learning outcome:	The graduate should be able to: • Know the properties of wood and wood related products. • Understand the vertical and lateral force systems in structures and the associated load paths. • Deal with wood related codes and specifications. • Understand the behaviour of various wood components and systems including beams, tension members, columns, beam-columns, horizontal and vertical diaphragms. • Understand the behaviour of simple connections of wood members.
Course content:	Introduction. Examples of wood buildings. Codes: BOCA, NBC, UBC. International Building Code. Specifications: ASD (NDS) vs. LRFD. Building loads, ASCE 7-02 and IBC. Dead, live, snow, rain, wind and seismic loads. Lateral loads on buildings, load paths. Load combinations. Behaviour of timber structures under loads. Properties of wood and lumber grades. Adjustment factors. Structural glued laminated timber. Behaviour of beams, tension members, columns, beam columns. Structural wood panels. Horizontal diaphragms, vertical diaphragms (shearwalls). Nailed and bolted connections. Special topics

Course unit:	Soil Mechanics
Learning outcome:	The graduate should be able to: • Practically determine properties of soil in question through specific laboratory tests and site examinations • Understand the practical significance of different soil behaviour for the problems of foundations design and construction. • Understand the fundamental behaviour of soil with regard to applications in agricultural engineering
Course content:	Geotechnical Exploration. The Nature of Soil. Soil Identification/Phase Relationships. Index Properties of Soil. Soil Classification. Soil Compaction. Permeability and Seepage. Oedometer Test. Effective Stress Concept. Direct Shear Test. Stresses in Soil. Unconfined Compression Test. Consolidation and Settlement. Shear Strength of Soil. Slope Stability. Bearing Capacity of Soil. Earth Retaining Structure. Design of fills and dikes, foundations and dams.

Course unit:	Introduction to Material Science & Engineering
Learning outcome:	The students will have an understanding of: • Atomic and crystal structure and chemical bond types, and understand how these affect material properties. • The unique characteristics of ceramics, polymers and metallic materials
Course content:	Atomic Structure and Bonding in Solids. Crystal Structures. Imperfections in Solids. Diffusion. Mechanical properties of Metals. Phase Diagrams and Phase Transformations. Thermal processing of Metal alloys. Ceramics: Structure, Properties and Processing. Polymers: Structure, Characteristics and processing. Corrosion and Degradation of Materials. Thermal properties. Magnetic Properties. Electrical properties. Optical properties. Materials Selection and Design Consideration.

Course unit:	Computational Mechanics
Learning outcome:	The students will have an understanding of: • Underlying concepts of numerical solution techniques and specific methodologies for solving fundamental problems via computer algorithms. • Basic analysis techniques used to discretize continuous systems, as well as common methods to solve the resulting equations. • Modern computer-based analyses, such as matrix equation solution techniques, least-squares fitting, numerical integration, finite difference and minimization approaches.
Course content:	Linear systems of equations: matrices and solutions to linear matrix equations. Non-linear scalar equations: solution techniques. Non-linear matrix equations: Newton-Raphson methods and Jacobian approximations. Interpolation and curve fitting: polynomials, least-squares and splines. Numerical integration. Finite difference techniques. Time-integration. Ordinary differential equations: iterative and matrix solutions of linear problems. Energy methods and minimization techniques. Introduction to static finite element analysis in solids. Introduction to control volume approaches in fluid flow. Introduction to dynamic analyses: lumped mass models.

Course unit:	Electronic Circuits
Learning outcome:	The graduate should be able to: • Understand the basics of electronic circuit analysis and design. • Comprehend a working knowledge of the characteristics and operation of circuits containing passive elements, diodes, BJTs, FETs, and op-amps. • Design, simulate and implement electronic circuits, both through simulation and by construction in a laboratory environment.
Course content:	Review of network theory. The design process and a systems view of instrumentation. Operational amplifiers, useful models, and example circuits. Diodes and diode circuits. BJTs, useful models, and typical circuits. FETs, useful models, and typical circuits. Frequency response and frequency-dependent behavior. Practice (basic construction techniques, basic troubleshooting techniques, basic measurement practice, documentation, etc.). Simulation. Electrical safety, grounding, and shielding.

Course unit:	Engineering Surveying – GIS
Learning outcome:	Upon successful completion of this course, the student will be able to: • Understand the fundamentals of surveying • Explain the principles of distance measuring and levelling • Apply the principles of surveying and theodolites • Perform transverse surveys and computations • Apply the principles of surveying in building construction • Demonstrate knowledge of GIS and ArcView
Course content:	Land and topographic surveying with global position systems and geographic information systems (GIS). Fundamentals of distance, levelling angles, theodolites, transverse surveys and computations. Laser systems and advantages of laser systems in land levelling. Hands-on with ArcView GIS to understand the basic GIS concepts and applications in land planning.

Course unit:	Electrotechnics
Learning outcome:	Upon successful completion of this course, students will be able to: • Use methods and algorithms for the linear and more complex circuit analysis in the time and in the frequency domain. • Demonstrate knowledge of network theorems, magnetic circuits, transformers and d.c. generators and motors.
Course content:	Delta/Star transformation. Hysteresis, eddy current and leakage losses. Magnetic circuits. The ideal transformer. Three-phase systems. The d.c. motor and d.c. generator: series wound, shunt and compound wound.

Course unit:	Instrumentation and Measurement
Learning outcome:	The graduate should be able to: • Have fundamental and integrated knowledge in designing engineering measurement systems and performing engineering measurements
Course content:	Elementary electronics. Application of instrumentation concepts and systems to the measurement of environmental, biological and agricultural phenomena. Measurement of temperature, pressure, strain, humidity, flow, etc. Analysis and interpretation of data (i.e. concepts of errors, accuracy and precision). Signal conditioning, system response, data acquisition, interfacing microcomputers for data acquisition. Construction and characterization of electronic sensors and transducers.

Agricultural/biological course units

Course unit:	Animal Science and Management
Learning outcome:	The graduate should be able to understand: • Issues of animal husbandry
Course content:	Breeds. Allometry. Cattle production: types of cattle enterprises. Milk production. Calf fattening. Sheep production: sheep farming systems. Milk production. Goat production: goat-farming systems. Milk production. Milking. Poultry production: Layers and Broilers. Pig production: types of swine enterprises. Reproduction, growth, fattening. Rabbit production: growth, animal handling.

Course unit:	Crop Science and Management
Learning outcome:	The graduate should be able to: • Elements of field crop production • Elements of arboriculture • Elements of horticulture
Course content:	Soil tree and its parts (physiology and functions). Fruit variety improvement cultivation: types and targets, impact on plant and soil characteristics, tools and machinery, timing, reduced and no-tillage. Crop rotation: aims and general principles, monoculture, fallow, rotations in rain-fed and irrigated areas, double cropping. The fruit. Dormacy. Flowering. Pollination and fruit set. Thinning of fruits. Nutrition of fruit trees. Propagation. Rootstocks. Hormones and growth regulators. Crop maturity. Harvest. Orchard management. Introduction to horticulture. Types of horticultural enterprises. Nutrition: nutritional elements, soil analysis, fertilizer application, organic and green fertilization. Vegetable propagation, substrates, germination, dormacy, micro-propagation. Plant density, establishment, cultivation practices, crop protection. The mechanization of vegetable propagation, harvest, storage and marketing vegetables. Vegetable seed production, storage and marketing of seed. Principles of the biological and hydroponic cultivation vegetables.

Course unit:	Introduction to Aquaculture
Learning outcome:	The graduate should be able to: • Principles of hydrobiology • Issues of aquaculture production
Course content:	Principles of aquaculture (comparison between aquaculture products, biological basis of aquaculture, water's main characteristics appropriate for aquaculture, site selection for aquaculture, relationship between physical-water, biological-organism and financial-production conditions, selection standards of appropriate for controlled production aquatic organisms). Aquaculture production systems: Systems according to the level of human interference (extensive, simple semi-extensive, semi-extensive, semi-intensive, intensive, super-intensive). Systems according to type of water manipulation and constructions. Factors related to mass production of fish, crustacean, mollusks, phytoplankton, zooplankton and aquatic plants. Stages of controlled production of aquatic animals (brood stock manipulation and maintenance, genital maturation, artificial fertilization, incubation and hatching, survival and rearing of early stages, on-growing period). Principles of aquaculture farms management: Selection of organisms, farm's size, determination of production level, growth rate of cultivable fish, crustaceans, bivalve mollusks, aquatic plants and plankton. Fish, crustacean and bivalve mollusk nutrition (natural food habits, types of artificial diets). Determination of productivity of natural and semi-natural aquatic bodies (seawater, brackish water and inland water-lakes and rivers). Types of production of aquaculture farms (hatcheries, on growing farms etc.).

Course unit:	Fish Production
Learning outcome:	The graduate should be able to: • Appropriately manage fish culture operations (i.e. setup and operate a recirculating system, monitor and adjust water quality, sample and assess fish condition without excessively stressing sampled fish, compute appropriate feeding rates and effective methods of feed presentation, compute and properly apply prescribed treatments to control parasites and pathogens • Culture algae and zooplankton as a food for immature finfish and shellfish • Monitor and maintain shellfish • Harvest and prepare fish for marketing
Course content:	Setup re-circulating system. Stock-fish and shellfish. Manage fish and shellfish. Pond management. Fish and shellfish anatomy. Quantify algae and zooplankton. Spawn fish and shellfish. Incubation of eggs. Nursery. Disease prevention, diagnosis and treatment. Harvest system and Data analyses.

Course unit:	Environmental Impact Assessment
Learning outcome:	The graduate should be able to: • Design an impact assessment technique • Calculate and assess pollutant loading on the environment • Evaluate the socioeconomic impact
Course content:	Introduction and environmental policy acts, The environmental assessment process, Broad evaluation methods, Fundamentals of air pollution impact, Point and area sources of air pollution impact, Fundamentals of noise impact, Water impact: prediction and standards, Socioeconomic impact and public attitudes, Biological impacts and wetlands, cultural and land-use impacts, Decision making, Economic analysis and public participation

Waste Management in Agricultural and Bioprocess Engineering

Engineering course units

Course unit:	Fluid Rheology
Learning outcome:	The graduate should be able to: • Identify the basic forces that give rise to complex fluid behavior. • Understand the theory behind mechanical rheometry and interpret rheological results. • Use state of the art techniques for characterization of complex fluid structure. • Understand the physics behind polymeric and colloidal systems.
Course content:	Complex fluids – examples, pertinent length scales, common features & applications. Mechanical rheology – techniques, pitfalls & interpretation of data. Forces – basics forces that drive the dynamics and behavior – steric, van der Waals, electrostatic etc. Polymeric Systems - Polymer Solutions – overlap, reptation, scaling laws, nonlinear behavior. Polymer Gels – yielding behavior, transient network models. Suspensions Colloidal fluids – dilute, concentrated, filled systems. Emulsions & Blends – interfaces, viscoelasticity, drop dynamics. Mesoscopic Systems, Self-assembling and liquid crystal systems – phases, structural characterization. Block copolymers – structures, rheology.

Course unit:	Liquid Waste Management
Learning outcome:	The graduate should be able to: • Understand the scientific principles determining the properties of wastes and pollutants in liquids • Appreciate the types of such wastes and pollutants and of their sources. • Understand the classification of liquid wastes and the means of their management (both 'hardware' and 'software') • Comprehend terms such as: waste and pollutant avoidance, minimization treatment, reuse and disposal.
Course content:	Introduction to microbiology and biochemistry of liquid wastes. Properties, sources and effects of such wastes and pollutants. Classification. Contamination of water and soil. Water supply treatment. Sewerage. Avoidance, minimisation, recycling and reuse. Physical, chemical and biological treatments

Course unit:	Waste Management and Environmental Quality
Learning outcome:	The graduate should be able to: • Make informed decisions about personal and societal waste management issues. • Understand the complex socio-political, economic, and legal, as well as technical aspects of waste management.
Course content:	Introduction. Sources and categories of waste materials. Source reduction and recycling. Waste management technology options: Composting, Incineration, Pyrolysis and Energy Recovery. Landfilling. Other management options. Regulatory aspects of waste management: overview. Environmental law and waste management. Major waste management legislation. Environmental and health impacts of waste management. Economics of waste management. Socio-political issues related to waste management.

Course unit:	Solid Waste Management
Learning outcome:	The graduate should be able to: • Identify key sources, typical quantities generated, composition, and properties of solid wastes. • Identify waste disposal or transformation techniques (landfills and incinerators). • Recognize the relevant regulations that apply for facilities used for disposal, and destruction of waste. • Conduct invasive and non-invasive site investigation and understand permitting process for constructing landfills, • Identify and design Solid and Hazardous Waste Landfills including closure, post-closure, and rehab issues. • Estimate typical waste disposal costs. • Identify recycling and reuse options (composting, source separation, and reuse of shredded tires, recycled glass, fly ash, etc.).
Course content:	Sources, quantities generated, and physicochemical properties of municipal solid waste. Solid waste management pyramid. Key technologies for SWM (collection, handling, transformation, landfills, incinerators, composting). Relevant environmental regulations for waste disposal, site investigations. Site investigations, Site selection. Regulatory permitting process. Incineration, composting. Types of landfills, basic geotechnical considerations, earthen liners for waste disposal. Clay mineralogy, factors controlling hydraulic conductivity, methods to measure k in the lab and field, compatibility of liner materials to chemicals in leachate. Contaminant and liquid transport in soil liners (advection and diffusion). Geo-synthetics for waste disposal – overview. Geo-membranes-leakage, transport, and structural stability. Geo-synthetic clay liners. Design of leachate collection system for landfills. Operational aspects of MSW landfills. Landfill gas collection system and leachate recirculation system design. Landfill final cap design and water balance.

Course unit:	Remote Sensing
Learning outcome:	The graduate should be able to: • Understand how to collect and interpret information about the earth's surface through non-contact methods.
Course content:	Maps, photos, and orthophotography. Location of principal points, conjugate principal points, and flight lines. Use of a stereoscope. Determination of scale. Measurement diameter of tree crowns. Area determination using dot grids, transects, and planimeters. Use of compass bearings and azimuths to locate section corners and plot locations. Determination of horizontal distance. Estimation stand DBH, crown closure, and stand stocking level. Cover type delineation. Transfer of photo locations to a map base. Advantages/disadvantages of film/filter/camera combinations. Photo acquisition and mission planning. A basic understanding of the electromagnetic spectrum. Describing and defining the relative merits of digital and analog remote sensing. Techniques for transfer of photo data into a GIS.

Course unit:	Instrumentation and Measurement
Learning outcome:	The graduate should be able to: • Have fundamental and integrated knowledge in designing engineering measurement systems and performing engineering measurements
Course content:	Elementary electronics. Application of instrumentation concepts and systems to the measurement of environmental, biological and agricultural phenomena. Measurement of temperature, pressure, strain, humidity, flow, etc. Analysis and interpretation of data (i.e. concepts of errors, accuracy and precision). Signal conditioning, system response, data acquisition, interfacing microcomputers for data acquisition. Construction and characterization of electronic sensors and transducers.

Course unit:	Engineering Surveying – GIS
Learning outcome:	Upon successful completion of this course, the student will be able to: • Understand the fundamentals of surveying • Explain the principles of distance measuring and levelling • Apply the principles of surveying and theodolites • Perform transverse surveys and computations • Apply the principles of surveying in building construction • Demonstrate knowledge of GIS and ArcView
Course content:	Land and topographic surveying with global position systems and geographic information systems (GIS). Fundamentals of distance, levelling angles, theodolites, transverse surveys and computations. Laser systems and advantages of laser systems in land levelling. Hands-on with ArcView GIS to understand the basic GIS concepts and applications in land planning.

Agricultural/biological course units

Course unit:	Crop Science and Management
Learning outcome:	The graduate should be able to: • Elements of field crop production • Elements of arboriculture • Elements of horticulture
Course content:	Soil tree and its parts (physiology and functions). Fruit variety improvement cultivation: types and targets, impact on plant and soil characteristics, tools and machinery, timing, reduced and no-tillage. Crop rotation: aims and general principles, monoculture, fallow, rotations in rain-fed and irrigated areas, double cropping. The fruit. Dormacy. Flowering. Pollination and fruit set. Thinning of fruits. Nutrition of fruit trees. Propagation. Rootstocks. Hormones and growth regulators. Crop maturity. Harvest. Orchard management. Introduction to horticulture. Types of horticultural enterprises. Nutrition: nutritional elements, soil analysis, fertilizer application, organic and green fertilization. Vegetable propagation, substrates, germination, dormacy, micro-propagation. Plant density, establishment, cultivation practices, crop protection. The mechanization of vegetable propagation, harvest, storage and marketing vegetables. Vegetable seed production, storage and marketing of seed. Principles of the biological and hydroponic cultivation vegetables.

Course unit:	Animal Science and Management
Learning outcome:	The graduate should be able to understand: • Issues of animal husbandry
Course content:	Breeds. Allometry. Cattle production: types of cattle enterprises. Milk production. Calf fattening. Sheep production: sheep farming systems. Milk production. Goat production: goat-farming systems. Milk production. Milking. Poultry production: Layers and Broilers. Pig production: types of swine enterprises. Reproduction, growth, fattening. Rabbit production: growth, animal handling.

Course unit:	Biological Processes in Waste Management
Learning outcome:	The graduate should be able to understand: • The basics of waste characteristics, biological reactions • The biological treatment alternatives • Solid processing and biological processing design
Course content:	Basic concepts: equivalence, oxidation state, half reactions, Wastewater characteristics, BOD, & COD. Energetics and stoichiometry of biological reactions and growth. Maintenance. Kinetics of suspended-growth biological processes. Cell growth rates. Substrate utilization rates. Kinetic coefficients. Reactors without recycle: chemostat and lagoons. Reactors with recycle. Activated sludge process. Process configurations. Loading criteria. Microbiology and bulking. Clarifier design. Kinetics of attached-growth biological processes. Immobilized/ Attached-Growth/Fixed-Film Reactors. Basic kinetic relationships. Steady-state biofilm model. Biofilm detachment. Non-steady state biofilms. Aerobic fixed-film processes. Nitrification and denitrification. Biological phosphorus removal. Methanogenesis. Anaerobic process ecology. pH control. Toxicity and inhibition. Biotransformation of hazardous compounds. Contaminants, cometabolism, biostimulation and bioaugmentation. Solids processing. Process types and design methods.

Course unit:	Environmental Impact Assessment
Learning outcome:	The graduate should be able to: • Design an impact assessment technique • Calculate and assess pollutant loading on the environment • Evaluate the socioeconomic impact
Course content:	Introduction and environmental policy acts, The environmental assessment process, Broad evaluation methods, Fundamentals of air pollution impact, Point and area sources of air pollution impact, Fundamentals of noise impact, Water impact: prediction and standards, Socioeconomic impact and public attitudes, Biological impacts and wetlands, cultural and land-use impacts, Decision making, Economic analysis and public participation

Course unit:	Environmental Engineering Microbiology
Learning outcome:	The graduate should be able to: • Know how to take basic microbiological principles and use them to design engineered microbiological systems, such as water and wastewater treatment and remediation of environmental pollutants.
Course content:	Basic microbiology and biochemistry. Stoichiometry and kinetics of biochemical reactions. Cell growth and reproduction. Environmental factors controlling their growth rates. Mathematical descriptions of biological reactors. Models to explore large-scale engineered systems and applications.

Bioprocessing

Engineering course units

Course unit:	Food Process Engineering
Learning outcome:	The graduate should be able to: • Use basic engineering principles and mathematical methods applicable to a wide range of food engineering and food processing situations. • Illustrate the uses of engineering concepts in industrial food processing applications.
Course content:	Basic principles of food process engineering - mass and energy. Food composition, physical properties. Introduction to food processing. Material balances. Batch and continuous processes. General mass balance equation, algebraic unknowns, tie substance, basis for calculation. Principles of thermodynamics, fluid mechanics, heat and mass transfer as applied to food processing.

Course unit:	Food Manufacturing Systems
Learning outcome:	The graduate should be able to understand: • Preservation concepts, processing alternatives and design • Aseptic processing, freezing, concentration of liquid foods
Course content:	Dehydration. Preservation concepts; kinetic parameters, influence of temperature on inactivation of microbial populations. Process calculations; general methods, applications to pasteurization and commercial sterilization. Applications to aseptic processing systems; design criteria for continuous liquid food systems. Refrigeration; system components, refrigeration properties, thermodynamics of mechanical refrigeration. Introduction to freezing systems. Freezing of foods; system description, freezing time prediction, freezing system design. Concentration of liquids foods; introduction to evaporation systems. Membrane separations; basic concepts and membranes.

Course unit:	Food Process Technologies
Learning outcome:	The graduate should be able to: • Present detailed scientific knowledge in food engineering with emphasis on post harvest, food processing and food preservation. • Analyse and solve complex problems in the field of food technology as applied in the production of foodstuffs.
Course content:	Food processing and quality. Processes applied in the production of foodstuffs. Quality aspects of food technology. Calculation of process intensities. Sensorial quality. (Physico)chemical stability. Ingredient and additive functionality related to microstructure formation of foods. Product development.

Course unit:	Fluid Rheology
Learning outcome:	The graduate should be able to: • Identify the basic forces that give rise to complex fluid behavior. • Understand the theory behind mechanical rheometry and interpret rheological results. • Use state of the art techniques for characterization of complex fluid structure. • Understand the physics behind polymeric and colloidal systems.
Course content:	Complex fluids – examples, pertinent length scales, common features & applications. Mechanical rheology – techniques, pitfalls & interpretation of data. Forces – basics forces that drive the dynamics and behavior – steric, van der Waals, electrostatic etc. Polymeric Systems - Polymer Solutions – overlap, reptation, scaling laws, nonlinear behavior. Polymer Gels – yielding behavior, transient network models. Suspensions Colloidal fluids – dilute, concentrated, filled systems. Emulsions & Blends – interfaces, viscoelasticity, drop dynamics. Mesoscopic Systems, Self-assembling and liquid crystal systems – phases, structural characterization. Block copolymers – structures, rheology.

Course unit:	Electronic Circuits
Learning outcome:	The graduate should be able to: • Understand the basics of electronic circuit analysis and design. • Comprehend a working knowledge of the characteristics and operation of circuits containing passive elements, diodes, BJTs, FETs, and op-amps. • Design, simulate and implement electronic circuits, both through simulation and by construction in a laboratory environment.
Course content:	Review of network theory. The design process and a systems view of instrumentation. Operational amplifiers, useful models, and example circuits. Diodes and diode circuits. BJTs, useful models, and typical circuits. FETs, useful models, and typical circuits. Frequency response and frequency-dependent behavior. Practice (basic construction techniques, basic troubleshooting techniques, basic measurement practice, documentation, etc.). Simulation. Electrical safety, grounding, and shielding.

Course unit:	Mechatronics
Learning outcome:	After completing the course the student is expected to be able to: • Analyse and optimise complex processes in which technical, agricultural and biological systems and constraints are integrated.
Course content:	Modelling of complex systems: methodologies for integrating models of simple subsystems; model reduction techniques, modelling equality and inequality constraints. Dynamic optimisation: systems with fixed and variable final time, the Hamilton-Jacobi-Bellman equation, sufficient conditions for a minimum, inequality constraints, direct and indirect solutions. Classical design of feedback control systems: performance specifications of controlled systems, sensitivity of controlled systems, design in the s-domain (root-locus), frequency response design (Bode, Nyquist, Nichols). Modern design of feedback control systems: state space design (state feedback and pole placement, stabilizability, observer design), advanced state space methods and optimal control (linear quadratic regulator problem (LQR), optimal observers - the Kalman filter, linear quadratic Gaussian problem (LQG), performance and stability robustness, loop transfer recovery (LTR), H-two and H-infinity control).

Course unit:	Electrotechnics
Learning outcome:	Upon successful completion of this course, students will be able to: • Use methods and algorithms for the linear and more complex circuit analysis in the time and in the frequency domain. • Demonstrate knowledge of network theorems, magnetic circuits, transformers and d.c. generators and motors.
Course content:	Delta/Star transformation. Hysteresis, eddy current and leakage losses. Magnetic circuits. The ideal transformer. Three-phase systems. The d.c. motor and d.c. generator: series wound, shunt and compound wound.

Course unit:	Instrumentation and Measurement
Learning outcome:	The graduate should be able to: • Have fundamental and integrated knowledge in designing engineering measurement systems and performing engineering measurements
Course content:	Elementary electronics. Application of instrumentation concepts and systems to the measurement of environmental, biological and agricultural phenomena. Measurement of temperature, pressure, strain, humidity, flow, etc. Analysis and interpretation of data (i.e. concepts of errors, accuracy and precision). Signal conditioning, system response, data acquisition, interfacing microcomputers for data acquisition. Construction and characterization of electronic sensors and transducers.

Agricultural/biological course units

Course unit:	Crop Science and Management
Learning outcome:	The graduate should be able to: • Elements of field crop production • Elements of arboriculture • Elements of horticulture
Course content:	Soil tree and its parts (physiology and functions). Fruit variety improvement cultivation: types and targets, impact on plant and soil characteristics, tools and machinery, timing, reduced and no-tillage. Crop rotation: aims and general principles, monoculture, fallow, rotations in rain-fed and irrigated areas, double cropping. The fruit. Dormacy. Flowering. Pollination and fruit set. Thinning of fruits. Nutrition of fruit trees. Propagation. Rootstocks. Hormones and growth regulators. Crop maturity. Harvest. Orchard management. Introduction to horticulture. Types of horticultural enterprises. Nutrition: nutritional elements, soil analysis, fertilizer application, organic and green fertilization. Vegetable propagation, substrates, germination, dormacy, micro-propagation. Plant density, establishment, cultivation practices, crop protection. The mechanization of vegetable propagation, harvest, storage and marketing vegetables. Vegetable seed production, storage and marketing of seed. Principles of the biological and hydroponic cultivation vegetables.

Course unit:	Introduction to Food Science
Learning outcome:	The graduate should be able to: • Understand the complexities of the “world of food”, with the emphasis on basic science principles involved in industrial processing, preservation and food safety. • Appreciate the interactions between food and nutritional sciences • Critically evaluate the current production, processing, distribution and marketing issues facing the modern food industry and the consumers.
Course content:	General overview and principles; food constituents and properties; quality and safety; preservation methods; processing animal and plant products. Sources and types of biological contamination and its control during harvesting, processing and storage of foods; food fermentation; biotechnology sanitation; HACCP methods used to examine foods for microbial content. Commodities selected for human consumption and the methods used by food technologists to prolong shelf life, retard spoilage and ensure quality. Principles upon which the various processing methodologies are based.

Course unit:	Post-harvest Physiology
Learning outcome:	The graduate should be able to: • Understand various physiological phenomena affecting post-harvest life of agricultural commodities, with emphasis on horticultural crops. • Appreciate proper harvesting, handling and storage procedures. • Relate physiological and biochemical processes to shelf life of fresh and processed commodities.
Course content:	General background-indices of maturity, the ripening process, product quality and post-harvest losses. Biological aspects-physiological processes vs. consumer appeal, gross structure and morphology, compositional changes. Maintenance of quality-harvesting procedures, factors enhancing quality. Physiology of ripening-events involved, hormonal interaction. Respiration and transpiration-definitions, characterization of processes, comparative rates, significance. Ethylene-history, biosynthesis, role in fruit ripening. Fruit ripening and the climacteric-climacteric vs. non-climacteric crops, effects of post-harvest handling. Temperature-field heat removal, cooling practices, effect of atmospheric moisture. Physiological disorders-chilling injury, freezing injury, pre- and post-harvest determinants. Post-harvest pathology-common diseases, control methods. Post-harvest losses. Commercial practices-storage techniques, cooling, packaging.

Course unit:	Food Quality
Learning outcome:	The graduate should be able to: • Present good knowledge of Hazard Analysis and Critical Control Points (HACCP).
Course content:	What is quality. Organization of quality assurance / quality control. Total quality management. Hazard Analysis and Critical Control Points (HACCP): Program background, Benefits / limitations, conduct hazard analysis, determine critical control points, establish critical limits, monitor critical control points. Quality standards and specifications: specifications, ISO 9000 programs.

Course unit:	Food Microbiology
Learning outcome:	The graduate should be able to: • Become familiar with methods used to determine micro-organisms and their products in foods and understand the causes of food spoilage and predict the micro-organism that can spoil a given food, when prepared, processed and stored under given conditions. • Understand the causes of food-borne microbial diseases and predict the pathogens that can grow in a given food, when prepared, processed and stored under given conditions. • Be able to predict the necessary measures to control the spoilage and pathogenic micro-organisms in food. And be able to apply information concerning a food and its environment to an analysis of the microbiological hazard associated with that food.
Course content:	Basics: introduction, history, organism types, anatomy, physiology. Methods to detect and enumerate organisms. Microbial standards: indicator organisms, sampling plans, sanitation. Microbial growth and Food preservation: factors affecting growth, preservation methods. Food-borne illness: food-borne intoxications. Mycotoxins. Food-borne infections: bacteria, viruses, protozoa, multi-cellular parasites. Food spoilage. Water microbiology.

Energy Supply and Management in Agricultural and Bioprocess Engineering

Engineering course units

Course unit:	Renewable Energy Resources and Technologies
Learning outcome:	The graduate should have: • A through knowledge of the renewable energy resources (solar, wind, biomass, hydro, geothermal, tidal power, wave), technologies and systems and how they can be applied and integrated into the conventional energy systems
Course content:	Introduction. Definitions. Energy supplies. Energy problems. Renewable energy sources. Solar Energy. Fundamentals of solar radiation. Wavelength of solar radiation. Direct and Diffuse radiation. Solar radiation angles and direction of beam. Radiation on tilted angles. Estimate of average solar radiation. Estimate of clear sky radiation. Beam and diffuse components of hourly and monthly average radiation. Radiation transmission through glazing. Transmittance absorptance product. Incident angle effect. Flat plate collector. Energy-balance equation. Collector efficiency equation. Collector-performance test. Air heaters. Active and passive solar heating. Low temperature solar energy application. Solar ponds. Solar distillation. Energy storage in solar process systems. Water storage. Concentrating collectors. Solar thermal engines and electricity generation. Solar photovoltaics. Basics of PV. Types of PV cells. Electrical characteristics of PV cells. Types of PV systems. Wind Energy. Energy and power in the wind. Biomass and bioenergy. Terms and units used in biomass production and relating to biomass conversion to bioenergy. Biomass fuel characterisation. The biomass resource, (forest residues, energy plantations, animal wastes, municipal wastes, cost of biomass). The supply chain (harvesting systems, chipping and chunking, drying). Thermodynamic conversion by combustion and the steam cycle (the combustion process, co-firing of biomass, the steam cycle). Thermochemical conversion by gasification and pyrolysis (gasification, pyrolysis). Biochemical conversion of wet biomass (anaerobic digestion, Landfill gas). Cogeneration of combined heat and power (co-generation technology). Biofuels for transport (biodiesel, bioethanol). Economics of biomass for energy production. Wind turbines. Aerodynamics of wind turbines. Power and energy from wind turbines. Hydroelectric Power. Types of hydroelectric plants. Maximizing the efficiency. Propellers. Pumped storage. Tidal Energy. Basics of tidal phenomena. Power generation from tidal energy. Wave Energy. Principles of wave energy. Types of wave energy converter. Geothermal Energy. Locations of geothermal energy. Thermal gradient and heat flow. Technologies for geothermal energy. Economics of Renewable Energy.

Course unit:	Energy Production and Supply
Learning outcome:	The graduate should be able to: • Understand basic terminology and fundamental conversion principles. Get thorough knowledge on the production of thermal, mechanical and electrical energy and the associated systems and their components and energy storage systems.
Course content:	Energy classification. Energy sources, utilisation, economics and terminology. Principal fuels for energy conversion (fossil fuels, nuclear fuels, biomass, solar energy). Production of thermal energy (conversion of chemical energy – combustion). Fossil-fuel systems (fluid moving systems, combustion methods and systems, steam generators). Nuclear reactor design and operation. Production of mechanical energy (conversion of thermal energy, turbines, electromechanical conversion). Production of electrical energy (conversion of thermal energy into electricity, conversion of chemical energy into electricity, conversion of nuclear energy into electricity, conversion of mechanical energy into electricity). Energy storage (storage of mechanical, electrical, chemical and thermal energy). Energy transmission (electric power transmission, thermal power transmission-district heating).

Course unit:	Environmental Pollution from Energy Production
Learning outcome:	The graduate should be able to: • Get thorough knowledge on the relationship between energy usage and environmental degradation and the means and ways of improving energy use efficiency and conservation of natural resources for a healthier and safer environment and sustainable development.
Course content:	Transportation (internal combustion engines for highway vehicles, engine power and performance, fuel efficiency, vehicle emissions and reduction of vehicle emissions). Environmental effects of fossil fuel use (Air pollution – standards, health and environmental effects of fossil-fuel-related air pollutants, air-quality modelling, photo-oxidants, acid deposition, water pollution, land pollution). Nuclear power plants (Radioactivity, nuclear reactors, nuclear fuel cycle, waste disposal). Global warming (greenhouse effect, greenhouse gas emissions, controlling CO_2 emissions). Renewable energy (renewable energy technologies and the environment). Conclusions (energy resources, regulating the environmental effects of energy use, global warming).

Course unit:	Remote Sensing
Learning outcome:	The graduate should be able to: • Understand how to collect and interpret information about the earth's surface through non-contact methods.
Course content:	Maps, photos, and orthophotography. Location of principal points, conjugate principal points, and flight lines. Use of a stereoscope. Determination of scale. Measurement diameter of tree crowns. Area determination using dot grids, transects, and planimeters. Use of compass bearings and azimuths to locate section corners and plot locations. Determination of horizontal distance. Estimation stand DBH, crown closure, and stand stocking level. Cover type delineation. Transfer of photo locations to a map base. Advantages/disadvantages of film/filter/camera combinations. Photo acquisition and mission planning. A basic understanding of the electromagnetic spectrum. Describing and defining the relative merits of digital and analog remote sensing. Techniques for transfer of photo data into a GIS.

Course unit:	Electronic Circuits
Learning outcome:	The graduate should be able to: • Understand the basics of electronic circuit analysis and design. • Comprehend a working knowledge of the characteristics and operation of circuits containing passive elements, diodes, BJTs, FETs, and op-amps. • Design, simulate and implement electronic circuits, both through simulation and by construction in a laboratory environment.
Course content:	Review of network theory. The design process and a systems view of instrumentation. Operational amplifiers, useful models, and example circuits. Diodes and diode circuits. BJTs, useful models, and typical circuits. FETs, useful models, and typical circuits. Frequency response and frequency-dependent behavior. Practice (basic construction techniques, basic troubleshooting techniques, basic measurement practice, documentation, etc.). Simulation. Electrical safety, grounding, and shielding.

Course unit:	Electrotechnics
Learning outcome:	Upon successful completion of this course, students will be able to: • Use methods and algorithms for the linear and more complex circuit analysis in the time and in the frequency domain. • Demonstrate knowledge of network theorems, magnetic circuits, transformers and d.c. generators and motors.
Course content:	Delta/Star transformation. Hysteresis, eddy current and leakage losses. Magnetic circuits. The ideal transformer. Three-phase systems. The d.c. motor and d.c. generator: series wound, shunt and compound wound.

Course unit:	Instrumentation and Measurement
Learning outcome:	The graduate should be able to: • Have fundamental and integrated knowledge in designing engineering measurement systems and performing engineering measurements
Course content:	Elementary electronics. Application of instrumentation concepts and systems to the measurement of environmental, biological and agricultural phenomena. Measurement of temperature, pressure, strain, humidity, flow, etc. Analysis and interpretation of data (i.e. concepts of errors, accuracy and precision). Signal conditioning, system response, data acquisition, interfacing microcomputers for data acquisition. Construction and characterization of electronic sensors and transducers.

Course unit:	Engineering Surveying – GIS
Learning outcome:	Upon successful completion of this course, the student will be able to: • Understand the fundamentals of surveying • Explain the principles of distance measuring and levelling • Apply the principles of surveying and theodolites • Perform transverse surveys and computations • Apply the principles of surveying in building construction • Demonstrate knowledge of GIS and ArcView
Course content:	Land and topographic surveying with global position systems and geographic information systems (GIS). Fundamentals of distance, levelling angles, theodolites, transverse surveys and computations. Laser systems and advantages of laser systems in land levelling. Hands-on with ArcView GIS to understand the basic GIS concepts and applications in land planning.

Agricultural/biological course units

Course unit:	Crop Science and Management
Learning outcome:	The graduate should be able to: • Elements of field crop production • Elements of arboriculture • Elements of horticulture
Course content:	Soil tree and its parts (physiology and functions). Fruit variety improvement cultivation: types and targets, impact on plant and soil characteristics, tools and machinery, timing, reduced and no-tillage. Crop rotation: aims and general principles, monoculture, fallow, rotations in rain-fed and irrigated areas, double cropping. The fruit. Dormacy. Flowering. Pollination and fruit set. Thinning of fruits. Nutrition of fruit trees. Propagation. Rootstocks. Hormones and growth regulators. Crop maturity. Harvest. Orchard management. Introduction to horticulture. Types of horticultural enterprises. Nutrition: nutritional elements, soil analysis, fertilizer application, organic and green fertilization. Vegetable propagation, substrates, germination, dormacy, micro-propagation. Plant density, establishment, cultivation practices, crop protection. The mechanization of vegetable propagation, harvest, storage and marketing vegetables. Vegetable seed production, storage and marketing of seed. Principles of the biological and hydroponic cultivation vegetables.

Course unit:	Animal Science and Management
Learning outcome:	The graduate should be able to: • Issues of animal husbandry
Course content:	Breeds. Allometry. Cattle production: types of cattle enterprises. Milk production. Calf fattening. Sheep production: sheep farming systems. Milk production. Goat production: goat-farming systems. Milk production. Milking. Poultry production: Layers and Broilers. Pig production: types of swine enterprises. Reproduction, growth, fattening. Rabbit production: growth, animal handling.

Course unit:	Environmental Impact Assessment
Learning outcome:	The graduate should be able to: • Design an impact assessment technique • Calculate and assess pollutant loading on the environment • Evaluate the socioeconomic impact
Course content:	Introduction and environmental policy acts, The environmental assessment process, Broad evaluation methods, Fundamentals of air pollution impact, Point and area sources of air pollution impact, Fundamentals of noise impact, Water impact: prediction and standards, Socioeconomic impact and public attitudes, Biological impacts and wetlands, cultural and land-use impacts, Decision making, Economic analysis and public participation

Course unit:	Environmental Engineering Microbiology
Learning outcome:	The graduate should be able to: • Know how to take basic microbiological principles and use them to design engineered microbiological systems, such as water and wastewater treatment and remediation of environmental pollutants.
Course content:	Basic microbiology and biochemistry. Stoichiometry and kinetics of biochemical reactions. Cell growth and reproduction. Environmental factors controlling their growth rates. Mathematical descriptions of biological reactors. Models to explore large-scale engineered systems and applications.

Information Technology and Automation in Agricultural and Bioprocessing Engineering

Engineering course units

Course unit:	Control Systems and Automation
Learning outcome:	The graduate should be able to: • Understand principles of process control. • Mathematical modeling of dynamic systems. • Standard feedback control formulation. • Design automation systems employing programmable logic controllers (PLCs).
Course content:	Mathematics review. Models of physical systems. System response. Control system characteristics. Stability analysis. Root locus. Frequency response analysis. Frequency response design. Selection of hardware including processor architecture, I/O module wiring, programming, controller installation and system troubleshooting. Proportional, Integral and Derivative (PID) principles, software implementation of PID control and tuning for optimizing automation applications are explored. Plant floor communication architectures such as Ethernet, Data Highway, and DeviceNet in industrial networks, as well as basic robot concepts and their applications in process automation are included.

Course unit:	Information Systems
Learning outcome:	The graduate should be able to: • Conceptualize information systems as *Systems* of *Information;* i.e., be able to apply basic concepts of *Systems Theory* and *Information* to real-world management information systems. • Conceptualize information systems as complexes of hardware and software technologies and represent these complexes in system theoretical terms. • Provide a brief overview of programming languages, their categories and current trends.
Course content:	Information Systems, Hardware & binary systems, Relational Databases, Open Source Software, Systems Development Life Cycle

Course unit:	Expert Systems
Learning outcome:	The graduate should be able to: • Implement rule-based systems. • Understand methods of inference, reasoning under uncertainty and inexact reasoning, • Comprehend expert systems shells, learning, and alternate approaches to expert systems, including neural networks.
Course content:	Course overview; introduction to foo. Decision trees. Chaining, Planning, and Jess. Bayes, Planning, and more Jess. Uncertainty, diagnosis and certainty factors. Cognitive models. More ES implementation, Neural Nets, Implementing an ES shell. Intelligent interface agents.

Course unit:	Image Processing
Learning outcome:	The graduate should be able to: • Understand time signals, and systems. • Comprehend sampling, reconstruction, and quantization. • Apply digital image representation. • Apply digital image fundamentals (i.e. transforms, enhancement, restoration, segmentation and description, etc.).
Course content:	The digitized image and its properties. Data structures for image analysis. Image pre-processing. Segmentation. Shape representation and description. Mathematical morphology. Linear discrete image transforms. Image data compression. Texture.

Course unit:	Advanced Programming
Learning outcome:	The graduate should be able to: • Implement advanced programming techniques using Java. • Use C++ to introduce explicit memory allocation and the use of pointers.
Course content:	Objects in JAVA. Instance data and methods. Constructors and Destructors. Inheritance (simple and multiple Polymorphism). Overloaded functions. Comparison with object system in C++. Graphical user interface programming. Writing swing user interfaces. User interface components. Data structures in C++. C++ language. Structures and arrays. Classes and objects. References and pointer manipulation.

Course unit:	Robotics
Learning outcome:	The graduate should be able to: • Form and defend opinions related to the history and societal impact of robots and the moral/ethical implications of artificial intelligence • Apply a basic knowledge of structural engineering to create strong structural frameworks • Relate torque and RPM of a motor • Design mechanisms using various forms of gears and cams • Design algorithms and write programs for accomplishing various common tasks
Course content:	Introduction, What is a Robot? Introduction to programming: the RCX Brick and Robolab. Introduction to motors (RPM and torque). Introduction to Gears. LEGO gear train assignment. Engineering process. Combining programming and mobility. Introduction to Structures. Rotary to Linear motion via rack & pinion. Belt drives. Walking motion & CAMS.

Course unit:	Remote Sensing
Learning outcome:	The graduate should be able to: • Understand how to collect and interpret information about the earth's surface through non-contact methods.
Course content:	Maps, photos, and orthophotography. Location of principal points, conjugate principal points, and flight lines. Use of a stereoscope. Determination of scale. Measurement diameter of tree crowns. Area determination using dot grids, transects, and planimeters. Use of compass bearings and azimuths to locate section corners and plot locations. Determination of horizontal distance. Estimation stand DBH, crown closure, and stand stocking level. Cover type delineation. Transfer of photo locations to a map base. Advantages/disadvantages of film/filter/camera combinations. Photo acquisition and mission planning. A basic understanding of the electromagnetic spectrum. Describing and defining the relative merits of digital and analog remote sensing. Techniques for transfer of photo data into a GIS.

Agricultural/biological course units

Course unit:	Crop Science and Management
Learning outcome:	The graduate should be able to: • Elements of field crop production • Elements of arboriculture • Elements of horticulture
Course content:	Soil tree and its parts (physiology and functions). Fruit variety improvement cultivation: types and targets, impact on plant and soil characteristics, tools and machinery, timing, reduced and no-tillage. Crop rotation: aims and general principles, monoculture, fallow, rotations in rain-fed and irrigated areas, double cropping. The fruit. Dormacy. Flowering. Pollination and fruit set. Thinning of fruits Nutrition of fruit trees. Propagation. Rootstocks. Hormones and growth regulators. Crop maturity. Harvest. Orchard management (establishing and managing an orchard, pruning and training of fruit trees). Introduction to horticulture. Types of horticultural enterprises. Nutrition: nutritional elements, soil analysis, fertilizer application, organic and green fertilization. Vegetable propagation, substrates, germination, dormacy, micro-propagation. Plant density, establishment, cultivation practices, crop protection. The mechanization of vegetable propagation, harvest, storage and marketing vegetables. Vegetable seed production, storage and marketing of seed. Principles of the biological and hydroponic cultivation vegetables.

Course unit:	Animal Science and Management
Learning outcome:	The graduate should be able to understand: • Issues of animal husbandry
Course content:	Breeds. Allometry. Cattle production: types of cattle enterprises. Milk production. Calf fattening. Sheep production: sheep farming systems. Milk production. Goat production: goat-farming systems. Milk production. Milking. Poultry production: Layers and Broilers. Pig production: types of swine enterprises. Reproduction, growth, fattening. Rabbit production: growth, animal handling.

Course unit:	Environmental Impact Assessment
Learning outcome:	The graduate should be able to: • Design an impact assessment technique • Calculate and assess pollutant loading on the environment • Evaluate the socioeconomic impact
Course content:	Introduction and environmental policy acts, The environmental assessment process, Broad evaluation methods, Fundamentals of air pollution impact, Point and area sources of air pollution impact, Fundamentals of noise impact, Water impact: prediction and standards, Socioeconomic impact and public attitudes, Biological impacts and wetlands, cultural and land-use impacts, Decision making, Economic analysis and public participation

Course unit:	Introduction to Food Science
Learning outcome:	The graduate should be able to: • Understand the complexities of the "world of food", with the emphasis on basic science principles involved in industrial processing, preservation and food safety. • Appreciate the interactions between food and nutritional sciences • Critically evaluate the current production, processing, distribution and marketing issues facing the modern food industry and the consumers.
Course content:	General overview and principles; food constituents and properties; quality and safety; preservation methods; processing animal and plant products. Sources and types of biological contamination and its control during harvesting, processing and storage of foods; food fermentation; biotechnology sanitation; HACCP methods used to examine foods for microbial content. Commodities selected for human consumption and the methods used by food technologists to prolong shelf life, retard spoilage and ensure quality. Principles upon which the various processing methodologies are based.

Appendix D:

(Adopted from the report of Activity 1,
of the Thematic Network E4)

Personal Requirements for all Programmes at Bachelor level (3 years)

The graduate should be able to:

communicate information, ideas, problems, and solutions to both specialist and non-specialist audiences.
adapt to a changing technology and new techniques as part of a life long learning process.
function efficiently in project groups and teamwork.
understand the interaction process between people working in teams, and be able to adapt to the requirements of the working environment.
display an understanding of the influence of engineering activity on all life and the environment, and demonstrate a high moral and ethical approach to engineering tasks.
apply the learning ability to undertake appropriate further training of a professional or academic nature
critically evaluate arguments, assumptions, abstract concepts and data, in order to make judgements and to contribute to the solution of complex issues in a creative process
show an appreciation of the uncertainty, ambiguity and limitations of knowledge

Additional Personal Requirements for all Programmes at Master level (+ 2 years)

The graduate should be able to:

assume an analytical approach to work based on broad and in-depth scientific knowledge
function in leading roles, including management roles, in companies and research organisations, and to contribute to innovation
plan, supervise and carry out research and development projects
explain ideas and projects to a team of co-workers
find a solution of particular technical and human problems arising in the working environment
apply skills and qualities necessary for employment requiring personal responsibility and decision-making
work in an international environment with appropriate consideration for differences in culture, language, and social and economic factors
communicate information, ideas, problems and solutions to both specialists and non specialists
accept accountability for related decision-making including use of supervision
show awareness and relate to connections with other disciplines and engage in interdisciplinary work

Academic requirements for all programmes at Bachelor level (3 years)

General: The graduate should be able to:

apply knowledge of mathematics, science and engineering appropriate to his discipline
design and conduct experiments, analyse and interpret data
identify, formulate and solve engineering problems
recognise the interaction between engineering activities and design, fabrication, marketing, user requirements, and product destruction.
Computer Science/Informatics: The graduate should be able to:
use common computer tools to produce documents, make presentations, carry out calculations and simulations.
design and maintain an Internet presentation of his work.
carry out computer based tasks using object oriented programming and expert systems.
use professional computer codes to prepare data, and obtain reasonable results from calculations.

Mathematics: The graduate should be able to:

construct a mathematical model of a given problem using differential calculus.
Apply the technique used for setting up definite integrals.
Classify, set up for solution and solve a selection of ordinary differential equations.
Use mathematical tools to report the results of his work
use intelligent software tools applied to the solution of mathematical problems.
Understand and use the concept of sets and classes and be familiar with Boolean algebra.
Manipulate complex numbers in Cartesian and polar form.
Use Matrix algebra and its application in solving systems of linear equations.
Understand the concepts of vectors representing lines and planes in 3-D space.
Explain topics like Fourier series and Laplace-transforms and their applications in problem solving.
Apply linear transformations.
Understand and interpret information in statistical information.
Use statistical methods for planning, control, interpretation and decisions

Physics: The graduate should be able to:

use the relevant laws of kinematics and dynamics to solve problems of rotational and lateral movement.
explain harmonic oscillations, damped oscillations and forced oscillations and treat such oscillations mathematically.
describe waves mathematically and explain the concept of wave lore
explain the first and second law of thermodynamics and solve problems applying these laws
explain the principles of electric and magnetic fields and apply the basic laws of electric circuits
explain the basic priciples of quantum theory

Chemistry: The graduate should be able to:

display basic knowledge of general chemistry, organic and inorganic chemistry
assess the environmental influence and use this knowledge in solving technical problems.

Environment: The graduate should be able to:

understand the influence of technical activities or processes on the environment, and outline possible ways of reducing such influence.
display a clear understanding of the interaction between environmental issues and technological issues and on the basis of this knowledge be able to make independent recommendations on topics of work environment.

Additional academic requirements for all programmes at Master level (+ 2 years)

The graduate should be able to:

demonstrate an in-depth understanding of his subject area as part of a general engineering technology
demonstrate in-depth knowledge and understanding of a specialised area related to his field of study
plan, supervise and carry out research in his specialised field

Mathematics: The graduate should be able to:

Formulate mathematically and to solve practical problems related to designing and exploitation of a real technical systems.

Computer Science/Informatics: The graduate should be able to:

Understand the algorithms of professional codes, their limitations and requirements, to prepare the data for the code in the proper way and to analyse obtained results of calculations.

[1] A Collection of opinions through the SEFI National Representatives Network, www.sefi.be, September 2002, Edited by T. Hedberg, SEFI Task Force on the Bologna Declaration, Special Issue in occasion of SEFI 30th Annual Conference on: "The Renaissance Engineer of Tomorrow", Firenze, Italy, 8-11 Sept. 2002 (printed by the Organising Committee of SEFIrenze2002)