## 7.0 DESIRED ATTRIBUTES OF ENGINEERING GRADUATES

### 7.1 Program Outcomes

A list of generic attributes for engineering graduates in Indonesia was complied and presented in Table 3-3. They were assembled from various sources such as overseas accreditation bodies and have been confirmed by feedback given to the consultants in industry visits. The list presented in Table 7-1 is very similar to that generic list. They may be altered or added to as the process of curriculum development evolves.

| | PROGRAM ATTRIBUTES (OUTCOMES) |
|---|---|
| 1 | An ability to apply knowledge of basic sciences, mathematics and engineering principles |
| 2 | An ability to design and conduct experiments, and to analyse, interpret and present data |
| 3 | An ability to design systems, processes or components to meet desired needs |
| 4 | An ability to work effectively not only as an individual, but also in multi disciplinary and multi-cultural teams, with the capacity to be a leader or manager as well as a team member |
| 5 | An ability to identify, formulate and solve problems (especially defining the scope of the problems) in complex process systems |
| 6 | An understanding of and commitment to professional and ethical responsibilities |
| 7 | An ability to communicate effectively, both orally and in writing, with other engineers, with managers and with the community at large |
| 8 | Fluency, written (especially for technical reporting) and spoken, in the English language |
| 9 | An awareness of the necessity for safe design and operation, and of the environmental responsibilities of engineers, including the principles of sustainable development and an understanding of the impact of engineering solutions in their social, cultural and global contexts |
| 10 | An understanding of business operations, business relationships, entrepreneurship and the process of innovation, and of the contribution of the engineer to these functions |
| 11 | A knowledge of contemporary issues |
| 12 | A recognition of the need to maintain competencies and a willingness to undertake lifelong learning |
| 13 | An ability to use the techniques, skills and modern engineering tools necessary for engineering practice |
| 14 | In-depth technical competence in at least one specific area of engineering |
| 15 | An awareness of information technology and the ability to acquire data as required from a range of sources |

**Table 7-1: Attributes of Graduates from Engineering Programs**

Some desired skills highlighted by industrialists during the course of the visits to industry and which support the above list were:

- A positive attitude to work in the organisation;
- An ability to become a contributor to the company's operations in a short time and with minimum training;
- Self-confidence, knowing that he/she can perform the tasks and provide correct solutions;
- Willingness to admit mistakes and to recognise mistakes as a learning event;
- A working knowledge of real plant equipment (pumps, piping, heat exchangers and so on);
- Willingness to adopt a "hands-on" approach, to "get dirty";

### 9.2.3 *Basic Science In Electrical Engineering*

*Objective of Basic Science*

The objective of the studies in basic sciences is to acquire fundamental knowledge about nature and its phenomena, including quantitative expression. These studies must include both general chemistry and calculus-based general physics at appropriate levels, with at least a two-semester (or equivalent) sequence of study in either area.[3]

*Use of Computers in Basic Science*

The students should be introduced to the use of computers in Chemistry and Physics, particularly in the use of Spreadsheets for data manipulation, numerical calculations and graphing.

Computer-Aided Instruction (CAI) should be introduced where possible, particularly in the more conceptual topics.

*Topics Included in Basic Science*

| Topic | Sub-Topic |
|---|---|
| **CHEMISTRY** | |
| Inorganic Chemistry: | Atomic Structure and Periodic Trends of Properties;<br>Models of Bonding;<br>Solubility & Acid-base Equilibrium in Aqueous Solution;<br>Electro-chemistry;<br>Changes of Enthalpy, Entropy & Free-Energy During Reactions; Properties of Solutions;<br>Structures of Molecules and Crystals; |
| Organic Chemistry | Properties, Preparation, Reactions and Uses of various classes of Organic Compounds |
| **BASIC PHYSICS** | |
| Waves and Optics | Harmonic Oscillations, the Wave Equation;<br>Mechanical Waves: Sound Waves, Light Waves;<br>Light and Matter, Interference, Diffraction. |
| Electricity and Magnetism | Flux & Gauss's Law, Electric Field & potential, Potential Energy, Capacitance, Dielectrics, Energy Density, Electric Current (not Circuit Theory),<br>Magnetic Field, Lorentz Force, Magnetic Moment, Torque on a Dipole, Biot-Savart Law, Ampere's Law, Field of Wires and Solenoids, Induction,<br>Induction, Stored Energy, Electromagnetic waves. |
| Heat & Properties of Matter | Temperature, Heat, Work & First Law of Thermodynamics, Entropy & the Second Law, Low Temperatures & the Third Law<br>Kinetic Theory of gases, Elastic Moduli, Hydrostatics, Fluid Dynamics. |
| Quantum Mechanics | Quantum Phenomena;<br>Atomic Spectra;<br>The Wave Function;<br>Instruments & Techniques;<br>Solid-state Materials |
| Electrical Engineering Materials | Band Theory of Semiconductors, Effect of Impurities, Fermi Level, Diffusion & Recombination, Diodes and Rectifiers, Junction Width & Capacitance, Transistor Mechanisms, Hall Effect, Photodiodes, Solar Cells;<br>Electrical properties of materials |

**Table 9-7: Basic Science in Electrical Engineering**

### 9.1.3 *Mathematics in Electrical Engineering*

*Objective of Mathematics*

The mathematics category provides the underpinning mathematical knowledge for a student entering into electrical engineering studies.

The emphasis of the studies of mathematics must emphasise concepts and principles rather than computation.

*Use of Computers in Mathematics*

The students should be introduced to the use of computers as tools in mathematics, basically seen as an extension of the calculator, currently in common use.

Students should become competent:

- In the use of Spreadsheets, e.g. Microsoft EXCEL to an advanced level, i.e. use of functions, user-defined functions using Visual Basic, looping and decision making etc.;
- In the more advanced mathematics software packages, eg. MatLab and many of its toolboxes for higher level usage.
- Computer Assisted Learning (CAL) should be introduced where possible, particularly in the more conceptual topics.

*Topics Included in Mathematics*

| Topic | Sub-Topic |
|---|---|
| Differential and Integral Calculus | Differential calculus; mathematical induction, Rolle's and Mean Value theorem, curve sketching, maxima and minima; Integration: numerical approximation of integrals, integrals over infinite intervals, techniques of integration; inverse functions, indeterminate forms |
| Differential Equations | Differential equations, use of Laplace transforms, solutions by series; partial differential equations and their solution for selected physical problems, use of Fourier Series |
| Probability & Statistics | Basic probability, random variables and their distributions, expectations, joint distributions, limit theorems, statistical estimation, standard errors, sampling distributions, hypothesis testing and discrimination |
| Linear Algebra | Inner products, orthonormal vectors and Gram-Schmidt process; symmetric and positive definite matrices, quadratic forms; complex vector spaces; orthogonal expansion |
| Complex Variables | Elementary properties of analytic functions of a complex variable; differential and integral calculus for analytic functions |
| Discrete Mathematics | Role of proof in mathematics: logical reasoning and implication; different types of proof; Sets: algebra of sets, operations on sets; Mathematical logic: truth tables, syntax, induction; Graphs and directed graphs, basic graph algorithms; Counting, combinational identities, binomial and multinomial theorems; Binary operations and their properties, groups and semi-groups, ordered structures; Recursion relations; Application to network theory, assignment problems and population growth. |

**Table 9-3: Mathematics in Electrical Engineering**

## 1.1 ELECTRICAL ENGINEERING

The typical curriculum of an undergraduate electrical engineering student includes the subjects listed in Table 1.1. Although the distinction between some of these subjects is not always clear-cut, the table is sufficiently representative to serve our purposes. Figure 1.1 illustrates a possible interconnection between the disciplines of Table 1.1. The aim of this book is to introduce the non–electrical engineering student to those aspects of electrical engineering that are likely to be most relevant to his or her professional career. Virtually all of the topics of Table 1.1 will be touched on in the book,

Table 1.1 Electrical engineering disciplines

| |
|---|
| Circuit analysis |
| Electromagnetics |
| Solid-state electronics |
| Electric machines |
| Electric power systems |
| Digital logic circuits |
| Computer systems |
| Communication systems |
| Electro-optics |
| Instrumentation |
| Control systems |

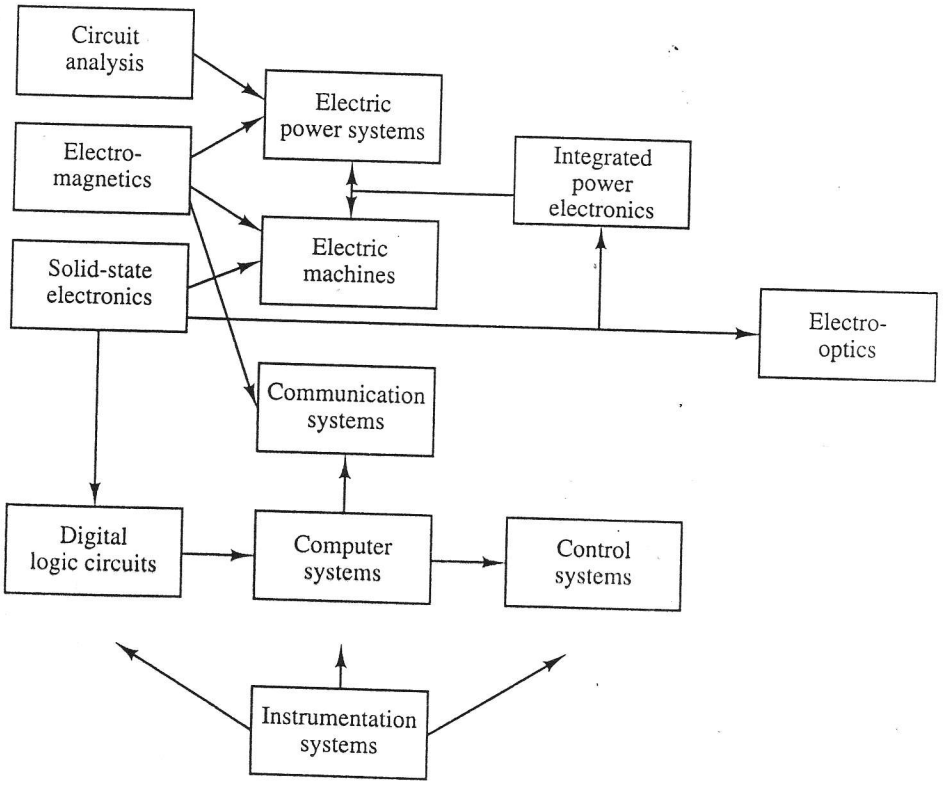


Figure 1.1 Electrical engineering disciplines

Rizzoni, Giorgio, [1993], "Principles and Applications of Electrical Engineering", IRWIN, Sydney, Australia

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**Table 1.1** Electrical engineering disciplines

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| Electromagnetics |
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| Electric power systems |
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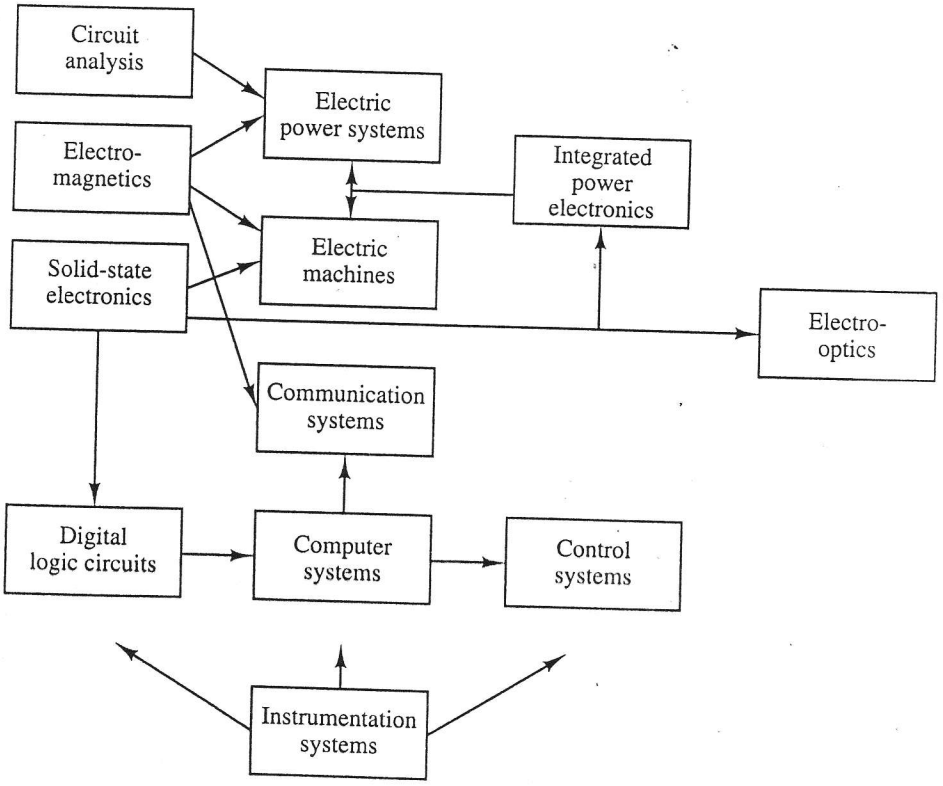


**Figure 1.1** Electrical engineering disciplines

### 9.4.3 *Electrical Engineering Specialisation*

*Objective of Electrical Engineering Discipline Specialisation*

While *Electrical Engineering Principles* provide the underpinning knowledge required to be a practising professional engineer, depth is required in one area of electrical engineering.

The specialisation area builds on the electrical engineering principles and provides the additional depth required in a student's primary electrical engineering education. It extends the knowledge gained into creative application in the specific electrical engineering specialisation.

*Use of Computers in Electrical Engineering Discipline Specialisation*

Students should be exposed to, and become proficient in the use of computers for:

- Hardware and software design of electrical and electronic systems;
- The use of application packages for design and production;
- The design, development of modification of application packages in engineering;

*Topics Included in Electrical Engineering Discipline Specialisation*

| Topic | Sub-Topic |
|---|---|
| ELECTRIC POWER | |
| Power Systems | Power System Analysis; Power System Protection; Stability, Dynamics and Control; Distribution System Planning and Operation; Optimisation of Thermal, Hydro and Geo-thermal Power Systems; Electromagnetic Transient Analysis; Static VAR Compensation; Power System Planning and Control; Load Management Control; Renewable Energy Sources Photovoltaic Systems; Remote Area Supply; Harmonic; Flexible AC Transmission Systems. |
| Electrical Power Equipment and Utilisation | High Voltage and high Current Phenomena; Insulating Material Application; Voltage Disturbances in LV and MV Systems; Electrical Measurements and Data Acquisition; Electrical Machine Drives; Arcing Fault Characteristics; Partial Discharge Detection and Location; Gaseous Discharges and Insulation; Equipment for hazardous Atmospheres; Synthetic Loading of Machines; Electrical Machine Modelling; Electrical Safety; Vector Control of Induction and Synchronous Motor Drive. |
| Power Electronics | DC/DC Converters; High Frequency Power Transformers; Inverters for Machine Drives; Microprocessor Control of Power Electronics; Variable Speed Drives; Dynamics of Drives, Speed Observer Techniques; Power Electronic Simulation Studies; Electronic Commutation; Remote Area Supplies. |
| COMMUNICATIONS | |
| Optical Communications | Optical Communications; Optical Fibres and Integrated Optics; Electro-Optic Devices; Sensors; Non-linear Optical switching; |
| Microwaves and Antennae: | Microwave Circuits and Devices; Microwave Measurement and Electronics; Antennas and Phased arrays; |
| Signal Processing | Signal Processing and Analysis; Active and Adaptive Filtering; Digital Filters; Digital Signal Processor Chip; Acoustic And Seismic Signal Processing; Speech Processing and Coding; Digital Image Processing and Video Signal Processing; Signal Processing and Analysis; Active and Adaptive Filtering; |

| Topic | Sub-Topic |
|---|---|
| Digital Communications | Digital Communications; Digital Radio And Modulation Methods |
| Communication Networks | Computer Communications and Local Area Networks; New Architectures for Local Area; Network Reliability and Service Availability; ISDN, ATM Protocols |
| Communication Systems | Radar And Navigational Aids;<br>Land & Satellite Mobile Communications; Mobile Satellite Communications |
| Electronics | Semiconductor Device Physics; Novel Semiconductor Devices;<br>Integrated Circuit Design; Integrated Circuit Technology;<br>Optical And Infra-red Detector Arrays;<br>Microelectronic Sensors;<br>Photovoltaic Solar Energy Conversion; Silicon Solar Cells;<br>Computer-Aided IC Design;<br>Plasma Processing; Integrated Circuits For Advanced Signal Processing; Photovoltaic Module Design; Micro-structured Devices; GaAs Devices |
| Control Systems | Multi-variable Control, Simulation, Modelling,<br>Expert Systems In Control Design, Advanced Control Of Power Plant, Computer Aided Design and Optimal Control.<br>Cybernetic Engineering and Advanced Robotics: Signal, Pattern, Image and Scene, Analysis and Processing, Brain Modelling, Neural Computing and Learning Machines, Vision Robotics and Assembly, Adaptive Control. Hierarchical Control, Formal Systems and Functional Representation.<br>Robust Control, Computation Issues In Control, Adaptive Control.<br>Adaptive and Multi-variable Systems, Multi-rate Control, Robust Digital Control, Robust Digital Control, Motion Control Systems.<br>Digital and Adaptive Control, Real-Time Computing, Multi-variable Control<br>Biomedical Engineering, Biological Signal Analysis, Physiological Systems Modelling and Analysis, Computer Hardware and Software, Data Acquisition, Signal Processing Ecg Analysis.<br>Control and Simulation, Digital System and Digital Signal Processing, Physiological System Modelling, Biological Signal Processing, Computer Modelling Of Information Processing, Neural Computing and Learning Machines, Adaptive Control.<br>Robust Adaptive Control Theory and Applications, Robot Control, Fuzzy Control Systems, Neural Networks For Identification and Control, Multirate Digital Control Systems, Adaptive Noise Cancellation, Process Control Systems.<br>On-Line Measurement Systems; Systems Analysis, Identification and Control: Digital Image Processing In Measurements and Control: Computer Simulations Of Power Generation and Industrial Processes, their Optimisation and Control; Computer Simulations in Education |
| COMPUTER SYSTEMS | |
| Computer Structures | Architectural philosophies- RISC and CISC; Processor performance measurement and analysis; Processor organisations;<br>Instruction set - register file interactions; Pipelining, scheduling; Memory management; Concurrent processing. |
| Real Time Systems | Overview of tasking concepts; Real-time scheduling; - rate monotonic algorithm;<br>Real-time kernels; Real-time case studies – cruise control, robotics, elevator control, distributed process control; SCADA systems |
| Networking | Network organisational issues: Topologies latency hiding techniques, routing;<br>Queuing theory and performance modelling of data networks. |
| Other Topics | Parallel computing structures; Pattern recognition;<br>Database machines; Machine vision; |