Evaluation Guidelines for NBA Accreditation of Undergraduate Engineering Programmes

National Board of Accreditation
New Delhi, India

June 2009

FOREWORD

National Board of Accreditation (NBA), was established in September 1994. The NBA is entrusted with the task of evolving a procedure for quality assessment in the technical education sector, and specifically to

- Articulate the criteria for assessment of quality;
- Identify parameters to quantitatively assess these criteria and assign appropriate programme-specific weights;
- Validate the procedure by well - designed test runs;
- Establish appropriate benchmarks.

The unprecedented expansion of the technical education sector in India in recent years has brought in its wake questions about the quality of education imparted, the competence of the graduates and their relevance to the current technical manpower needs of our country. The concurrent ISO standardization movement in the industrial scene has highlighted the need for accrediting programmes, especially in terms of their role as the main suppliers of technically qualified human resource.

It is heartening to note in this context that the NBA is now bringing out second edition of Manual for Accreditation of for Engineering (UG) programmes in India. It consists of four Sections, viz.,

- Accreditation Policy and Procedure
- Evaluation guidelines
- Evaluation Report
- Self Assessment Report

It is hoped that this manual will provide the students, parents, employers and the society at large, comprehensive information on all aspects of the Quality Assurance provided by the NBA to assist them in making a judicious choice among competing educational programmes.

This manual is the culmination of sustained efforts and mutually supporting interaction amongst several individuals, organizations and agencies. This manual addresses the equivalence of evaluation and accreditation processes for engineering education programs to international standards so as to ensure opportunities for global mobility of engineering graduates.

We would be failing in our duty if we do not place on record our gratitude and appreciation for the help we have received from the following people.

- The Members of the Board of the NBA and the NBA Engineering Committee for their ready and willing cooperation and the officials of NBA for their dedicated efforts.

- Committee comprising Prof. S.C. Sahasrabudhe Director, DAACT, Gandhinagar, Prof. M.U. Deshpande Former Professor, IIT – Bombay, Prof. Gopal Ranjan Former VC, IIT, Roorkee, Prof. Gautam Biswas IIT, Kanpur, Prof S Sen Gupta IIT Kharagpur, Prof. V.P. Kodali, Ex Director of E&I, DRDO, Shri Ravi Kumar, presently Principal Secretary (Technical Education), Govt of Rajasthan for their valuable contribution in drafting the initial accreditation manual.

- Prof. Ashok Saxena University of Arknas, USA and Prof K. Vedula University of Manchester, USA for their valuable guidance

- Committee comprising Prof S K Khanna Former Chairman AICTE, Prof K L Chopra, Former Director – IIT – Kharagpur, Prof S Sen Gupta, IIT – Kharagpur, Prof J P Gupta, VC – Jaypee University, Noida, Prof Rajeev Kumar, IIT Kharagpur for their contribution in refining, revising and presenting the final version of the accreditation manual.

We welcome suggestions from all the stakeholders in Engineering Education in order to bring further improvement in the effort of NBA to provide a transparent and credible System of accreditation of engineering programs in India.

Prof. P.N. Srivastava
Chairman, NBA

Criterion I: Organization and Governance, Resources, Institutional Support, Development and Planning (150)
Minimum Qualifying Points - 100

Item No.	Item Description	Points	Evaluation Guidelines
I-I.1	Campus infrastructure and facility	30	Assessment : **5 points** for each item - Land, built up area and academic infrastructure - Maintenance of academic infrastructure and facilities - Ambience, green cover, water harvesting, environment preservation etc. - Hostel (Boys and girls) - Transportation facility and canteen - Electricity, power backup, telecom, water etc.
I-I.2	Organization, governance and transparency	20	Assessment : **5 points** for each item - Governing body, administrative setup and functions of various bodies; - Defined rules, procedures, recruitment and promotional policies etc.; - Decentralization in working and grievance addressal system; - Transparency and availability of correct/unambiguous information.
I-I.3	Budget allocation and utilization	10	- Budget allocation and its utilization.
I-I.4	Library	25	Assessment : **5 points** for each item - Library space and ambience, Timings and usage; - Availability of a qualified librarian and other staff, Library automation, online access and networking; - Variety of titles and the volumes per title; - Journal subscription and internationally acclaimed titles; - Digital library.
I-I.5	Academic support units and common facilities	20	- Core laboratories (Adequacy of space, number of students per batch, quality and availability of measuring instruments, laboratory manuals, list of experiments): **10 points** - Central computing laboratory (**4 points**); Manufacturing practices laboratory (**4 points**); Language laboratory (**2 points**)
I-I.6	Internet	5	- Sufficient and effective internet access facility.
I-I.7	Co-curricular and extra curricular activities	10	Assessment : **5 points** for each item - Co-curricular and extra-curricular activities, e.g., NCC/ NSS, cultural activities etc. - Sports grounds and facilities
I-I.8	Career guidance, Training, placement and Entrepreneurship cell	15	Assessment : **5 points** for each item - Effective career guidance services including counseling for higher studies; - Training and placement facility with training-n-placement officer (TPO), industry interaction for training/internship/placement; - Entrepreneurship cell and incubation facility.
I-I.9	Safety norms and checks	5	- Effective security and safety arrangements with emergency exits and ventilation/exhausts in auditoriums and large class rooms/labs; - Checks for wiring and electrical installations for leakage and earthing; - Fire fighting equipments and training, handling of hazardous chemicals etc.
I-I.10	Emergency medical care and first-aid	10	Assessment : **5 points** for each item - Medical staff to provide first-aid and medical help in emergency; - Availability of ambulance services (response times and medical facility);

Criterion II: Evaluation and Teaching-Learning Process (175)
Minimum Qualifying Points - 115
[Based on past 3 years record]

Item No.	Item Description	Points	Evaluation Guidelines
II-I.1	Evaluation system	40	- Published schedule in academic calendar for assignments/mid-semester tests, distribution of corrected scripts : **10 points** - Maintenance of Course files – class deliveries and their closeness and mapping with PEOs : **15 points** - Quality of problems in assignments/tests/semester examinations and their closeness and mapping with Program Educational Objectives (PEOs) : **15 points**
II-I.2	Tutorial classes/ remedial classes/ mentoring	20	- Tutorial classes to address personal level doubts and queries : size of tutorial classes, hours per subject in timetable : **10 points** - Remedial classes and additional make-up tests to help academically weaker students: **5 points** - Mentoring system to help at individual levels : **5 points**
II-I.3	Teaching evaluation process : Feedback system	30	- Design of proforma and process of feedback evaluation : **5 points** - Feedback analysis and percentage of students' participation : : **5 points** - System of reward/corrective measures etc. : **10 points** - Any feedback mechanism from alumni, parents and industry : **10 points**
II-I.4	Self Learning and Learning beyond syllabus	20	- Generation of self-learning facilities and motivation : **10 points** - Availability of learning beyond syllabus contents and promotion : **10 points**
II-I.5	Faculty Ratio and qualification for First Year Common Courses	25	Assessment of Faculty Availability for first year courses in teacher-student ratio of 1: 15 : **15 points** Assessment of Qualification = (10 * x + 6 * y + 4 * z) / N Where x = No. of Faculty Members with Ph. D y = No. of Faculty Members with M. E / M. Tech. z = No. of Faculty Members with B. E / B. Tech./M.Sc./M.A N = Total No. Faculty Members For this, the faculty members to be considered are from those who teach or take tutorial for first year common courses of Science, Engineering and Humanities.
II-I.6	Academic performance in First Year Common Courses	40	Academic Performance = 40 * FYSI Where FYSI = First Year Success Index = (No. of students who have cleared all the subjects in a single attempt of their semester or year end examination) / (Total no. of students admitted in the first year)

Criterion III: Students' Entry and Outputs (150)
Minimum Qualifying Points - 100
[Based on past 3 years record]

Item No.	Item Description	Points	Evaluation Guidelines
III-P.1	Students admission	10	Assessment is based on the percentage of seats filled through Entrance Test and quality of students (rank range)
III-P.2	Success Rate	30	Success Rate = 30 * Mean of Success Index (SI) for past 3 batches SI = (No. of students who cleared the program in the minimum period of course duration) / (No. of students admitted in the first year of that batch)
III-P.3	Academic performance	30	Academic Performance = 3 * API Where API = Academic Performance Index = Mean of Cumulative Grade Point Average of all the Students on a 10 point CGPA System OR = Mean of the percentage of marks of all students / 10
III-P.4	Placement and higher studies	40	Assessment Points = 40 * (x + 1.25 * y) / 100 Where x = Percentage of students placed, and y = Percentage of students admitted for higher studies subject to Max. Assessment Points = 40.
III-P.5	Professional activities	20	Assessment : **4 points** for each item - Professional societies/ chapters and organizing engineering events, - Organization of paper contests, design contests etc. and their achievements, - Publication of technical magazines, newsletters etc., - Entrepreneurship initiatives, product designs, innovations, and - Publications and awards in inter institute events.
III-P.6	Students' Project Quality	20	- The assessment shall be made after assessment of final year students project work, their quality and mapping with the Program Educational Objectives.

Criterion IV: Faculty Contributions (150)
Minimum Qualifying Points - 100
[Based on past 3 years of the records]

Item No.	Item Description	Points	Evaluation Guidelines
IV-P.1	Faculty in position : Teacher- student ratio	20	Assessment = 20 * TSR / 15 Where TSR = Teacher Student Ratio = (x + y + z) / N subject to Max. TSR = 15; Where x = No. of students in 2nd year of the program y = No. of students in 3rd year of the program z = No. of students in 4th year of the program N = Total No. Faculty Members in the program
IV-P.2	Faculty in position : Cadre ratio	20	Assessment = 20 * CRI Where CRI = Cadre Ratio Index = 2.25 (2x + y) / N subject to Max. CRI = 1.0; Where x = No. of professors in the program y = No. of readers in the program N = Total No. Faculty Members in the program
IV-P.3	Faculty qualifications	40	Assessment = 4 * FQI Where FQI = Faculty Qualification Index = (10 * x + 6 * y + 4 * z) / N Where x = No. of Faculty Members with Ph. D in Engineering y = No. of Faculty Members with M. E / M. Tech z = No. of Faculty Members with B. E / B. Tech N = Total No. Faculty Members
IV-P.4	Faculty retention	20	Assessment = 4 * RPI / N Where RPI = Retention Point Index = Points assigned to all Faculty Where Points assigned to a faculty = 1 point for each year of experience at the Institute but not exceeding 5 points. N = Total No. of Faculty Members
IV-P.5	Research publications and IPR	20	Faculty Points in Publications and IPR (FPPR) = Assessment of Publications + Assessment of IPR Assessment of Publications = 3 * Sum of the Research points scored by each Faculty member / No. of sanctioned positions of Professors and Readers Assessment of IPR = Sum of the IPR points scored by each Faculty member / No. of sanctioned positions of Professors and Readers Note: A faculty member scores at the most 5 Research points depending upon the quality of the research papers published in the past 3 years. For this research papers considered are those (i) which can be located on Internet and/or are included in hard-copy volumes/proceedings, published by a well known publishing house, and (ii) the faculty member's affiliation, in the published paper, is the one of the same college/institute. For multiple authors, every author of the same college will earn the points. Similarly, A faculty member scores 1 point for each IPR subject to a maximum of 5 points
IV-P.6	Externally funded R & D projects and consultancy work	20	Assessment of R&D & Consultancy Projects = 4 * Sum of FPPC by each faculty / No. of sanctioned positions of

			Professors and Readers Where FPPC = Faculty Points in Projects and Consultancy Note: A faculty member gets at the most 5 points depending upon the amount of externally funded R & D project and/or consultancy work. For multiple faculty members involved in a single project, every faculty member will earn the points, depending on the funding agency as given below: 5 points for funding by National Agency, 4 points for funding by State Agency, 3 points for funding by private sector, and 2 points for funding by the sponsoring Trust/Society.
IV-P.7	Interactions of faculty members with outside world	10	Assessment of Interaction = 2 * Sum of IP by each faculty / No. of sanctioned positions of Professors and Readers Where IP = Interaction points scored by each faculty member Note: A faculty member gets at the most 5 Interaction Points depending upon the type of Institution or R&D Lab or Industry. The points earned by each faculty shall be decided as given below: 5 points for interaction with a well known Institute/University abroad, 4 points for interaction with Institute of Eminence in India or National Research Labs, 3 points for interaction with University / Industry in India and Institute/University (not covered) above 2 points for interaction with State Level Institutions, and 1 point for interaction with private affiliated Institutions.

Note :

1. Faculty cadre is 3-tier with interchangeably equivalent designations, as follows:
   A. (Professor, Associate Professor, Assistant Professor), or
   B. (Professor, Assistant Professor, Sr. Lecturer/Lecturer), or
   C. (Professor, Reader, Sr. Lecturer/Lecturer), or

2. In Item Nos. IV-P.4 to IV-P.7, no. of sanctioned positions of professors and readers (or equivalents) is considered if no. of such existing equivalent positions is lesser than the sanctioned number. Such sanctioned positions are estimated by considering a Teacher-Student Ratio of 1: 15 and the Cadre Ratio of 1:2:6.

   The Min. sanctioned positions of professors and readers is taken to be 3 for a program.

Criterion V: Facilities and Technical Support (75)

Item No.	Item Description	Points	Evaluation Guidelines
V-P.1	Class rooms	15	- Enough rooms for lectures (core/electives), seminars, tutorials, etc for the program : **10 points** - Teaching aids – black/white-board, multimedia projectors, etc. : **5 points** - Acoustics, class room size, conditions of chairs/benches, air circulation, lighting, exits, ambiance, etc.: **5 points**
V-P.2	Faculty rooms	15	- Availability of individual faculty rooms : **10 points** - Room equipped with white/black board, computer, internet, etc. : **5 points** - Usage of room for discussion/counseling with students : **5 points**
V-P.3	Laboratories including computing facility	25	- Enough labs to run all the program specific curriculum : **10 points** - Availability of computing facilities available exclusively in the department : **5 points** - Availability of labs with tech. support within and beyond working hours : **5 points** - Equipments to run experiments and their maintenance, Number of students per experimental set up, Size of the laboratories, overall ambience etc. : **5 points**
V-P.4	Technical manpower support	20	- Availability of adequate and qualified technical supporting staff for program specific labs : **10 points** - Incentives, skill-up gradation and professional advancement : **10 points**

Criterion VI: Continuous Improvements (75)

Item No.	Item Description	Points	Evaluation Guidelines
VI-P.1	Improvement in Success Index of students	10	Points are awarded in proportion to the successive improvements in computed SI (in III-P.2) over three years.
VI-P.2	Improvement in academic performance of students	10	Points are awarded in proportion to the successive improvements in computed API (in III-P.3) over three years.
VI-P.3	Enhancement of faculty qualifications and retention	15	Points are awarded in proportion to the successive improvement in computed FQI (in IV-P.3) and FRI (in IV-P.4) over three years. Full points are awarded if the FQI and FRI are converged.
VI-P.4	Improvement in Faculty activities in research publication, R & D work and consultancy, interaction	15	Points are awarded in proportion to the combined successive improvement in computed FPPR (in IV-P.5) and FPPC (IV-P.6), over three years.
VI-P.5	Continuing education	10	Points are awarded in proportion to participation in continuing education (contributing to course modules and conducting and attending short-term courses and workshops) programs to gain and/or disseminate their knowledge in their areas of expertise.
VI-P.6	New facility created	10	New facilities in terms of infrastructure/ equipment/ facilities added to augment the program.
VI-P.7	Overall improvements since last accreditation, if any, otherwise, since establishment	5	From the strengths and weaknesses mentioned in the last accreditation visit, that these were rectified or at least sincere efforts were made to rectify the shortcomings.

Note: Visiting Team MUST ENSURE THAT THE MARKS AREAWARDED BASED ON THE RATE OF IMPROVEMENT OVER THREE YEARS AND NOT ON THE ABSOLUTE VALUES IN EACH YEAR.

Points awarded are zero for negative gradient as well as for a zero gradient.

Criterion VII: Curriculum (125)

Item No.	Item Description	Points	Evaluation Guidelines
VII-P.1	Contents of basic sciences, HSS, professional core and electives, and breadth	40	Well balanced components of basic sciences, HSS, breadth subjects, professional core and elective subjects. The professional core subjects should encompass all the major areas of the program. Sufficient number of elective subjects should be actually offered from which the students can choose their field of interests.
VII-P.2	Emphasis on laboratory and project work	30	Laboratories/ project works should form the core of the curriculum in tune with the theory coverage.
VII-P.3	Curriculum updates and PEO reviews	30	- Program Educational Objectives (PEO) is defined by the institute/ their affiliating universities. The curriculum should be in tune with these objectives. - Reviews of curriculum and program educational objectives should be a regular and continuing process. At least once in five years, there should be curriculum - There should be flexibility in the academic system to introduce new elective subjects in between the revisions. - The assessment shall be made after group and individual discussions for assessment of Program Educational Objectives with final year students and alumni.
VII-P.4	Additional contents to bridge curriculum gaps	25	- Program specific contents which are added to bridge curriculum gaps in order to achieve Program/course objectives - Innovative teaching methods

Criterion VIII: Program Educational Objectives – their Compliance and Outcomes (100)

Item No.	Item Description	Points	Evaluation Guidelines
VIII-P.1	Course objective and mapping	20	Specify the program educational objectives (PEOs) and prepare a mapping between the PEO and their specified outcomes.
VIII-P.2	Assessment outcomes	20	- Effective mechanism for outcome measurements, - Indicate methodologies for outcome measurements from the stake-holders including industry, alumni, and professional bodies.
VIII-P.3	Mapping with faculty expertise	20	- Faculty expertise should be adequate to cater for all the major fields specified in the program criteria. - Assessment and mapping to what extent this is fulfilled.
VIII-P.4	Mapping with outcomes	20	- To what extent the PEOs/curriculum map with the outcomes.
VIII-P.5	Significant achievements	20	- Significant academic achievements in science & engineering teaching and research and development.

Criterion IX: General Report about the strengths, weaknesses and deficiencies, if any

Strengths:

Weaknesses:

Deficiencies, if any

Accreditation Criteria

1. The **Program** gets the status '**Accredited**' **for next 5 years** from the date of issue of the letter from NBA, if it t gets a minimum score of 750 points and scores minimum qualifying marks in the criteria specified.

2. The **Program** gets the status '**Provisionally Accredited' for next 2 years** from the date of issue of the letter from NBA, if it gets a minimum score of 600 points.

   The Institution may apply after overcoming the weaknesses to upgrade their status to "Full Accreditation" of the Program.

3. The **Program** gets the status '**Not Accredited'** if it gets the score less than 600 points.

Annexure I

Program Education Objectives and Outcomes

An engineering program must ensure that its graduates understand the basic concepts of science and mathematics, have gone through one engineering field in depth to appreciate and use its methodologies of analyses and design, and have acquired skills for life-long learning. An engineering program must therefore have a mission statement which is in conformity with the mission statement of the organization. The mission must be translated into specific program objectives and program outcomes that are expected of the educational process. The outcomes of a program must be measurable and must be assessed regularly through proper feedback for improvement of the programme. There must be a quality assurance process in place within the Institute to make use of the feedback for improvement of the programme. The curriculum must be constantly refined and updated to ensure that the defined objectives and outcomes are achieved. Students must be encouraged to comment on the objectives and outcomes and the role played by the individual courses in achieving them.

Program Educational Objectives (PEOs) : The educational objectives of a programme are the statements that describe the expected achievements of graduates within first few years of their graduation from the programme. The programme objectives, may be guided by global and local needs, vision of the Institution, long term goals etc. For defining the program objectives the faculty members of the programme must continuously work with local employers, industry and RD advisors, and the alumni. The objectives of a programme can be broadly defined on five counts :

I. **Preparation** : To prepare students to excel in postgraduate programmes or to succeed in industry / technical profession through global, rigorous education.

II. **Core Competence** : To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve engineering problems and also to pursue higher studies.

III. **Breadth** : To train students with good scientific and engineering breadth so as to comprehend, analyze, design, and create novel products and solutions for the real life problems.

IV. **Professionalism** : To inculcate in students professional and ethical attitude, effective communication skills, teamwork skills, multidisciplinary approach, and an ability to relate engineering issues to broader social context.

V. **Learning Environment** : To provide student with an academic environment aware of excellence, leadership, written ethical codes and guidelines, and the life-long learning needed for a successful professional career.

Within above five broad categories, each programme may define its own objectives appropriate for the specific discipline.

Programme Outcomes : The programme outcomes are the skills and knowledge which the students have at the time of graduation. The outcomes essentially indicate what a student can do from subject-wise knowledge acquired during the programme. The outcomes may be programme specific within broad categories given in the following. Generally, the engineering programmes must demonstrate their graduates have following capabilities*:*

(a) Graduates will demonstrate knowledge of mathematics, science and engineering.

(b) Graduates will demonstrate an ability to identify, formulate and solve engineering problems.

(c) Graduate will demonstrate an ability to design and conduct experiments, analyze and interpret data.

(d) Graduates will demonstrate an ability to design a system, component or process as per needs and specifications.

(e) Graduates will demonstrate an ability to visualize and work on laboratory and multi-disciplinary tasks.

(f) Graduate will demonstrate skills to use modern engineering tools, softwares and equipment to analyze problems.

(g) Graduates will demonstrate knowledge of professional and ethical responsibilities.

(h) Graduate will be able to communicate effectively in both verbal and written form.

(i) Graduate will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.

(j) Graduate will develop confidence for self education and ability for life-long learning.

(k) Graduate who can participate and succeed in competitive examinations.

The programme outcomes can vary slightly depending upon the discipline. However, the broad outcomes would be the same.

The outcomes of all the courses developed by the faculty members should be assessed by a committee consisting of subject experts from inside and outside the programme. The assessment process can be direct or indirect. The direct assessment will be through interim assessment by the faculty or by industry / technology experts. The indirect assessment on the other hand could be by students through course outcomes, lab evaluation, department associations, exit interviews, engineering services, GATE examination etc. Frequency of assessment can be decided and justified by the programme coordinator. A broad relation between the program objective and the outcomes is given in the following table :

Programme Objectives	**Programme Outcomes**										
	a	**b**	**c**	**d**	**e**	**f**	**g**	**h**	**i**	**j**	**k**
I	X	X									X
II	X	X	X	X		X					X
III		X	X	X	X						
IV				X			X	X	X		
V									X	X	

In the following, three sample departments and their outcomes are given using two different possible formats which have been presented. The user is free to opt for either of the formats.

Sample Assessment Plan for
Undergraduate Programme in Electrical & Electronics Engineering

Programme Outcomes :

(a) Graduates will demonstrate knowledge of differential equations, vector calculus, complex variables, matrix theory, probability theory, physics, chemistry and electrical and electronics engineering.

(b) Graduates will demonstrate an ability to identify, formulate and solve electrical engineering problems.

(c) Graduate will demonstrate an ability to design electrical and electronic circuits and conduct experiments with electrical systems, analyze and interpret data.

(d) Graduates will demonstrate an ability to design digital and analog systems and component.

(e) Graduates will demonstrate an ability to visualize and work on laboratory and multi-disciplinary tasks.

(f) Graduate will demonstrate skills to use modern engineering tools, software and equipment to analyze problems.

(g) Graduates will demonstrate knowledge of professional and ethical responsibilities.

(h) Graduate will be able to communicate effectively in both verbal and written form.

(i) Graduate will show the understanding of impact of engineering solutions on the society and also will be aware of contemporary issues.

(j) Graduate will develop confidence for self education and ability for life-long learning.

(k) Graduate who can participate and succeed in competitive examinations like GATE, GRE.

A sample list of courses offered in a typical **EEE curriculum:**

PH101 Physics I
PH102 Physics II
CH101 Chemistry
MA101 Maths I
MA102 Maths II
HS101 English
HS103 Communication skills
HS105 Economics
EEE 002 Principles of Electrical Engineering
EEE 003 Principles of Electrical Engineering Lab
EEE152 Basic Electric Circuits
EEE206 Digital Circuits
EEE207 Electronic Devices & Circuits
EEE210 Signals and Systems
EEE214 Digital Circuits Lab
EEE218 Electrical Machines
EEE219 Electronics Lab
EEE220 Electrical Machines Lab
EEE225 Network Theory
EEE301 Electromagnetic Waves
EEE302 Control Systems
EEE304 Electrical Energy Systems
EEE308 Communication Systems
EEE309 Microprocessors
EEE315 Microprocessors Lab
EEE317 Electromagnetic Waves Lab
EEE318 Electronics Design Lab I
EEE319 Analog Circuits Lab
EEE321 Power Electronics
EEE323 Analog Circuits
EEE324 Control Systems Lab
EEE326 Power Systems Lab
EEE389 Electronic Design Lab II
EEE403 Digital Signal Processing
EEE405 Communication Electronics
EEE415 Electrical Design Lab
EEE421 Communication System Theory
EEE425 VLSI Technology
EEE426 Digital Communication Systems
EEE429 Discrete Data & Digital Control
EEE432 Special Semiconductor Devices
EEE433 Electronic Instrumentation
EEE434 Industrial Instrumentation
EEE437 Analog Filters
EEE438 Control System Design
EEE450 Comp. Control & Power Systems Automation
EEE452 Microwave and Satellite Communication
EEE455 Communication Electronics Lab
EEE500 Seminar
EEE600 Project

In the following, we categorize the outcomes of the above EEE courses in the following groups:

Outcome (a)

PH101 Physics I
PH102 Physics II
CH101 Chemistry
MA101 Maths I
MA102 Maths II
EEE 002 Principles of Electrical Engineering
EEE003 Principles of Electrical Engineering Lab
EEE152 Basic Electric Circuits
EEE421 Communication System Theory

Outcome (b)

EEE318 Electronics Design Lab I
EEE319 Analog Circuits Lab
EEE321 Power Electronics
EEE323 Analog Circuits
EEE324 Control Systems Lab
EEE326 Power Systems Lab
EEE389 Electronic Design Lab II
EEE403 Digital Signal Processing
EEE415 Electrical Design Lab
EEE434 Industrial Instrumentation
EEE600 Project

Outcome (c)

EEE206 Digital Circuit
EEE207 Electronic Devices and Circuits
EEE214 Digital Circuits Lab
EEE219 Electronics Lab
EEE309 Microprocessors
EEE315 Microprocessors Lab
EEE318 Electronics Design Lab I
EEE319 Analog Circuits Lab
EEE323 Analog Circuits
EEE324 Control Systems Lab
EEE326 Power Systems Lab
EEE389 Electronic Design Lab II
EEE415 Electrical Design Lab
EEE438 Control System Design

Outcome (f)

EEE309 Microprocessors
EEE434 Industrial Instrumentation
EEE425 VLSI Technology
EEE433 Electronic Instrumentation

Outcome (d)

EEE315 Microprocessors Lab
EEE318 Electronics Design Lab I
EEE319 Analog Circuits Lab
EEE323 Analog Circuits
EEE324 Control Systems Lab
EEE326 Power Systems Lab
EEE389 Electronic Design Lab II
EEE415 Electrical Design Lab
EEE438 Control System Design

Outcome (e)

EEE214 Digital Circuits Lab
EEE219 Electronics Lab
EEE220 Electrical Machines Lab
EEE315 Microprocessors Lab
EEE317 Electromagnetic Waves Lab
EEE318 Electronics Design Lab I
EEE319 Analog Circuits Lab
EEE324 Control Systems Lab
EEE326 Power Systems Lab
EEE389 Electronic Design Lab II
EEE415 Electrical Design Lab
EEE455 Communication Electronics Lab

Outcome (g)

Elective humanities courses

Outcome (h)

HS101 English
HS103 Communication skills

Outcome (i)

HS105 Economics
Humanities courses in philosophy, psychology
EEE450 Comp. Control & Power Systems Automation
EEE452 Microwave and Satellite Communication
Advanced level elective courses

Outcome (j)

EEE500 Seminar
EEE600 Project

Outcome (k)

All electrical engineering courses

Sample Assessment Plan for Undergraduate Programme in Mechanical Engineering

Programme Educational Objectives (PEOs) :

I. To prepare students for successful careers in industry that meet the needs of Indian and multinational companies.

II. To develop the ability among students to synthesize data and technical concepts for application to product design.

III. To provide opportunity for students to work as part of teams on multidisciplinary projects.

IV. To provide students with a sound foundation in the mathematical, scientific and engineering fundamentals necessary to formulate, solve and analyze engineering problems and to prepare them for graduate studies.

V. To promote student awareness of the life-long learning and to introduce them to professional ethics and codes of professional practice.

Programme Outcomes :

(a) Graduates will demonstrate basic knowledge in mathematics, science and engineering.

(b) Graduates will demonstrate the ability to design and conduct experiments, interpret and analyze data, and report results.

(c) Graduates will demonstrate the ability to design a mechanical system or a thermal system or a process that meets desired specifications and requirements.

(d) Graduates will demonstrate the ability to function on engineering and science laboratory teams, as well as on multidisciplinary design teams.

(e) Graduates will demonstrate the ability to identify, formulate and solve mechanical engineering problems.

(f) Graduates will demonstrate an understanding of their professional and ethical responsibilities.

(g) Graduates will be able to communicate effectively in both verbal and written forms.

(h) Graduates will have the confidence to apply engineering solutions in global and societal contexts.

(i) Graduates should be capable of self-education and clearly understand the value of life-long learning.

(j) Graduates will be broadly educated and will have an understanding of the impact of engineering on society and demonstrate awareness of contemporary issues.

(k) Graduates will be familiar with modern engineering software tools and equipment to analyze mechanical engineering problems.

The Mechanical Engineering Program outcomes leading to the achievement of the objectives are summarized in the following Table.

Programme Educational Objectives	Programme Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
I	X	X		X	X						X
II		X	X								
III				X			X				
IV	X				X						
V						X		X	X	X	

In addition to defining PEOs and outcomes for a programme, the objectives and outcomes can be defined for a course and/or Group of Courses. Therefore, we consider **Engineering Mechanics,** as a subject in a Engineering Science group of courses and define the objectives and outcomes of teaching Engineering Mechanics.

Course Objectives: At the end of the course, the student should understand the basic principles of mechanics applicable to rigid bodies in equilibrium and the kinematics and kinetics of particle motion. The student should be able to apply these principles to the solution of a variety of practical problems and be able to employ their knowledge to solve more complicated problems and study the affect of problem parameters. The student should be prepared to continue the study of the dynamics of rigid bodies and the mechanics of solids and fluids.

Topics: Vector mechanics essentials, Equivalent systems of forces, Equilibrium of rigid bodies, Centroids, centers of gravity, and distributed forces, Trusses, frames, machines: two-force and multi-force members, Beams: internal forces, shear and bending moment diagrams, Dry friction, Moments of inertia, Virtual work, Kinematics of particles, Kinetics of particles: Newton's 2nd law, Energy and momentum methods, Systems of particles

Contribution to Outcomes: This course used assigned readings, lectures, and homework to enable the students to: (i) Use engineering science principles to develop algebraic relationships among key physical parameters and variable based on analysis of a specified system (ii) Understand and apply Newton's laws to problems systems consiting of rigid bodies in equilibrium and particles in motion, (iii) Use references that provide tabulated physical data that are useful to mechanical engineers (iv) Write simple programs to solve more complicated problems and to study the effect of system parameters

We consider another example **Heat and Mass Transfer,** as a departmental course, for defining course objectives and outcomes.

Course Objectives : To demonstrate basic knowledge of heat transfer by understanding: differences between conduction, convection and radiation; basic differential equations for heat transfer; thermal conductivity of materials; conduction through walls and composite walls; critical radius of insulation; heat transfer in fins; heat transfer coefficient; overall heat transfer coefficient; log-mean temperature differences; forced and natural convection correlations; Biot, Nusselt, Reynolds, Grashof, Rayleigh and Prandtl numbers; basic radiative heat transfer, basic principles of mass transfer

Outcomes : In order to assess the student's progress towards achieving the Learning Outcomes, a number of homework problems may be assigned, graded and handed back to the students. A design project involving Design of a Heat Exchangers/ Boiler/ any equipment involving principles of Heat Transfer is required from each student and graded by the instructor. Else the students may be asked use knowledge of all modes of heat transfer and write a computer program to address and analyze a design problem for different choices of design parameters

Flow Chart: The following courses form sample flow chart of the courses that a student comes across after having completed a common core programme of Mathematics, Sciences, Humanities, Engineering Sciences and Engineering Practices typically in first four semesters. The first two courses in the list are typically covered during the third and fourth semesters together with the courses of core program.

ME 211 Advanced Fluid Mechanics and Compressible Flows
ME 212 Advanced Mechanics of Solids
ME 311 Energy Systems
ME 312 Heat and Mass Transfer
ME 316 Design of Machine Elements
ME 321 Theory of Mechanisms and Machines
ME 322 Manufacturing Technologies
ME 328 Kinematics and Dynamics of Machinery
ME 338 Design and Control of Machine Tools
ME 370 Mechanical Engineering Lab I
ME 401 Thermal Turbomachines
ME 410 Computer Aided Engineering Design
ME 430 Advanced Manufacturing Processes
ME 440 Automation and Control
ME 460 Introduction to Robotics
ME 470 Mechanical Engineering Lab II

Besides the above, there are a host of departmental elective courses and open elective courses.

Sample Assessment Plan for Undergraduate Programme in Chemical Engineering

Programme Educational Objectives (PEOs) :

I. To provide the necessary background in science, particularly in chemistry and in physics and advanced mathematics.

II. To provide training to solve problems relevant to the general practice of chemical engineering and engineering design.

III. To provide students experience in conducting and in planning experiments in the modern engineering laboratory including interfacing experiments with computers as well as interpreting the significance of resulting data and properly reporting results in well written technical reports.

IV. To provide experience in the process of original chemical engineering design in the three areas of equipment design, process design, and plant design through the process of formulating a design solution to a perceived need and then executing the design and evaluating its performance including economic considerations and societal impacts if any, along with other related constraints, and culminating in both written and oral presentations of results.

V. To provide students experience with the multifaceted aspects of using computers to solve problems and present results with word processing, spreadsheet, presentation and professional level applications software used for design and analysis and to provide for obtaining and the use of information on the world wide web.

VI. To provide students a familiarity with professional issues in chemical engineering including: ethics, issues related to the global economy and to emerging technologies, and fostering of important job related skills such as improved oral and written communications and experience in working in teams at a number of levels.

Programme Outcomes :

(a) The graduates are expected to have ability to apply knowledge of mathematics, science and engineering.

(b) The graduates are expected to have ability to design and conduct experiments, as well as to analyze and interpret data.

(c) The graduates are expected to have ability to design a system, a component, or a process to meet desired needs within realistic constraints such as economic, environmental, social, ethical, health and safety, manufacturability, and sustainability.

(d) The graduates are expected to possess ability to function on multi-disciplinary teams.

(e) The graduates are expected to possess ability to identify, formulate and solve engineering problems.

(f) The graduates are expected to have understanding of professional and ethical responsibility.

(g) The graduates are expected to communicate effectively.

(h) The graduates are expected to have the broad education necessary to understand the impact of engineering solutions in a global, economic and societal context.

(i) The graduates are expected to engage themselves in life-long learning.

(j) The graduates are expected to have knowledge of contemporary issues.

(k) The graduates are expected to possess ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Table: Relation between Chemical Engineering program outcomes and program objectives

Programme Educational Objectives	Programme Outcomes										
	a	b	c	d	e	f	g	h	i	j	k
I	X				X						
II	X				X						
III	X	X			X		X				
IV	X		X	X	X	X	X	X			X
V							X				X
VI				X	X	X	X	X		X	

In addition to defining PEOs and outcomes for a programme, the objectives and outcomes can be defined for a course and/or Group of Courses. Therefore, we consider, **Thermodynamics**, as a group of courses and define course objectives and outcomes for teaching thermodynamics.

Course Objectives: The students completing this course are expected to: understand the nature and role of the thermodynamic properties of matter, internal energy, enthalpy, entropy, temperature, pressure and specific volume. They will be able to access thermodynamic property data from appropriate sources. They are expected to understand temperature-entropy or pressure-volume diagrams. They will recognize and understand the different forms of energy and restrictions imposed by the First Law of Thermodynamics on conversion from one form to the other. They will understand implications of the Second Law of Thermodynamics and limitations placed by the Second Law on the performance of thermodynamic systems. They will be able to use isentropic processes to represent the behavior of a system. They are expected to be able to quantify the behavior of power plants based on the Rankine cycle, including the effect of enhancements such as superheat, reheat and regeneration. They are expected to quantify the performance of power generation based on the Otto cycle, Diesel cycle and Brayton cycle. They will be able to quantify the performance of refrigeration and heat pump systems.

Contribution to Outcomes: The Learning Outcomes are assessed through graded homework, quizzes, mid-semester and a final exam. Since the course is a prerequisite for other courses in the curriculum, there are additional opportunities to evaluate the extent to which course objectives are achieved from the feedback of the faculty teaching professional courses. The feedback is particularly meaningful from the faculty members who teach the process-design related courses that have increased emphasis on application of basic principles, including control mass and volumes.

Next, we consider **Transfer Operations I**, as another example for defining objective and outcome of one of the departmental courses.

Course Objectives : Students are to learn the fundamentals of conservation of mass, energy and momentum as it applies to internal and external fluid flow systems. Both differential and integral techniques from a transport approach and macroscopic empirical approaches are to be learned.

Contribution to Outcomes : Through tests and homework problems, it is revealed that most of the students are able to do the following. The students are able to apply their knowledge of friction factors. They are able to perform momentum balance. They can perform control-volume based calculations involving incompressible flows; rough pipes, fittings, networks non-circular pipes. They are able to understand basic calculations of flow in Beds of Solids: Fixed beds, filtration, and fluidized beds.

Flow Chart: The following courses form sample flow chart of courses that a student comes across after having completed the common core program of Mathematics, Sciences, Humanities, Engineering Sciences and Engineering Practices during the first four semesters. The first three courses in the list are covered during the third and fourth semesters together with the courses of core program.

ChE 211 Fluid Mechanics
ChE 212 Chemical Process Calculations
ChE 221 Chemical Engineering Thermodynamics
ChE 312 Heat and Mass Transfer
ChE 314 Separation Processes
ChE 322 Chemical Reaction Engineering
ChE 328 Industrial Plants
ChE 332 Physical Metallurgy
ChE 345 ChE Laboratory I
ChE 346 ChE Laboratory II
ChE 347 Transfer Operations I
ChE 348 Transfer Operations II
ChE 349 Transfer Operations III
ChE 351 Plant Design and Economics
ChE 425 Process Dynamics and Control
ChE 434 Industrial Reaction Kinetics
ChE 436 Corrosion and Corrosion Control
ChE 448 Separations for Biotechnology

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