THE FUNDAMENTALS OF ENGINEERING (FE) EXAMINATION: THE FIRST STEP FOR THE PROFESSIONAL LICENSING

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ABSTRACT

Engineering licensure is considered as a measure of competence, dedication, and credibility to practice the profession. The trend is growing worldwide towards making professional licensure a major requirement for practicing the profession if not a must. As a first step for professional licensure of the engineers, the Fundamental of Engineering examination (FE), which is administrated by the National Council of Examiners for Engineering and Surveying (NCEES), is widely used in the United States. The exam, which must be passed, is normally taken by recent graduates or by student in their last year before graduation. Typically, after a minimum of four years of professional experience, the second exam can be taken. It is called the Principles and Practice of Engineering (PE) or Land Surveying (PLS), as applicable, and the candidate can be designated as P.E. or P.L.S. when passing this exam. In this paper, an introduction about the contents and process of the (FE) examination is presented. The steps for adopting or establishing a similar exam in Saudi Arabia are proposed.

KEYWORDS

Professional Licensure, Certification, Fundamental of Engineering Examination, Principles and Practice of Engineering Examination

INTRODUCTION

What is a Professional or licensed engineer?

Professional engineers (PEs), or licensed engineers, are those who have fulfilled the education and experience requirements and passed the rigorous exams that, under licensure laws, permit them to offer engineering services directly to the public. PEs take legal responsibility for their engineering designs and are bound by a code of ethics to protect the public health and safety.

Engineering licensure is a prestigious step in professional growth and development. It certifies the engineer as a duly licensed member of the engineering profession. It's a legal acknowledgment by a competent body that he has a specified degree of competence and has demonstrated the qualifications necessary to practice as a professional engineer. In exchange for taking on an obligation to the public and to the profession, the licensed engineer is granted certain rights and privileges (www.nspe.org).

Why become a Professional or licensed engineer?

There are many advantages for becoming a licensed engineer. Licensure demonstrates the commitment to the engineering profession, allows an engineer's judgment to carry greater weight, and helps him to gain the deserved recognition. From the employer side, licensure is considered as an important factor in the evaluation, promotion, and advancement of the engineer, and in assigning him for more responsible work. Also, employers acknowledge that licensed employees can enhance the reputation and status of the employer.

In summary, licensure in a strong indicator of professional ability, dedication to integrity, experience, hard working, creativity, character, and assurance of passing a minimum screen of competence. Moreover, it gives the individual more opportunity and flexibility the career path and choices.

In the United States, there are many important considerations that make licensure to become a necessity. As described by the National Society of Professional Engineers (NSPE), these include the following (www.nspe.org):

- Only a licensed engineer may prepare, sign and seal, and submit engineering plans and drawings to a public authority for approval, or seal engineering work for public and private clients.
- For a consulting engineer or a private practitioner, licensure is a legal requirement for those who are in responsible charge of work.
- In government, many federal, state, and municipal agencies require that certain governmental engineering positions, particularly those considered higher level and responsible positions, be filled only by licensed professional engineers.
- For those considering a career in education, many states have been increasingly requiring that those individuals teaching engineering must be licensed. Licensure helps educators prepare students for their future in engineering.
- With the growing advancement of modern construction processes and techniques, the engineer in construction must readily be able to communicate and exchange ideas and views with other licensed design engineers.
- For those pursuing careers in industry, licensure has recently taken on increased meaning with heightened public attention concerning product safety, environmental issues, and design defects.
- Engineers in the military must have the credentials to stay with the service in the face of downsizing or to make the transition to the private sector.
- The scope of engineering practice is constantly changing, and engineering activities that may be exempt today may eventually shift into a practice area that one day requires a license.

• State engineering boards are increasingly seeking and obtaining the authority to impose civil penalties against unlicensed individuals who unlawfully engage in the practice of engineering.
• Engineers must adapt to a rapidly changing workplace-restructuring, downsizing, outsourcing, privatization, and re-engineering.

The Pillars of Licensure

Education, experience, and examination are the three basic requirements for engineering licensing; McClure (1997). The education requirement is fulfilled if the individual has completed the engineering degree in a program that is reviewed and accredited by the Accreditation Board for Engineering and Technology (ABET). The degree acknowledges that the individual is a graduate of an ABET accredited program and does not guarantee the desired level of competency. Thus, it does not license him as a professional engineer. The experience part of licensure requires the individual to practice the engineering profession for at least four years after graduation.

The third pillar of licensure is the examinations. Two examinations are required to be passed in order to become a professional licensed engineer. The first one is the Fundamental of Engineering examination (FE), which is administrated by the National Council of Examiners for Engineering and Surveying (NCEES). The exam is normally taken by recent graduates or by student in their last year before graduation. Typically, after four years of professional experience he can take the second exam - the Principles and Practice of Engineering (PE) or Land Surveying (PLS), as applicable, to be designated as P.E. or P.L.S. when passing this exam. Fig. 1. shows the overall licensing process. This is the process followed in the United States for Engineers to be licensed in their respective states. Since the (FE) is considered as the first step towards obtaining licensure and due to its direct relationship to the academic programs, it will be presented in this paper.

THE FUNDAMENTAL OF ENGINEERING EXAMINATION (FE),

The licensing process in the United States has been standardized in all the fifty states, which includes passing the (FE) as the first requirement for licensing. In this section, an introduction about this exam is outlined and other related issues are described.

The (FE) examination, sometimes called the Engineer-In-Training (EIT) exam, is prepared and scored by the NCEES. This exam is used as the first step in the professional licensing of engineers and was developed to measure minimum technical competence. It is a pass/fail exam that is taken by approximately 50,000 people a year, most of whom are recent college graduates or seniors within one year of graduating; Lefevre et al. (2000).

The Format

The format of the (FE) examination is as follows; Lefevre et al. (2000), and (www.ncees.org):

- It is administered in two 4-hour sessions, a morning and afternoon sessions.
- The morning session is common to all disciplines.

- The afternoon session is administered in the following five disciplines: Chemical, Civil, Electrical, Industrial, and Mechanical with a General Engineering section for all remaining disciplines.
- There are 120 multiple-choice questions in the morning session and 60 multiple-choice questions in the afternoon session.
- Every question in the examination is a multiple-choice format consisting of a problem description, requirement, and a set of four responses. There is only one correct answer that may be selected.
- The exam is closed book. A reference handbook containing information that examinees are not expected to commit to memory is provided.
- Examinees will work all questions in the morning session and all questions in the afternoon section they have chosen according to their specialization.

The Content

The (FE) examination assesses the candidate's knowledge obtained during the academic education. As mentioned above, it consists of two parts: the morning (AM) and afternoon (PM) sessions. The first session assesses the understanding of engineering principles common to all engineering disciplines, while the second is designed for the specific discipline of the candidate such as Chemical, Civil, Electrical, Industrial, Mechanical, or General Engineering for all remaining disciplines.

The contents of the (FE) examination were decided on by surveying the ABET accredited engineering programs in the US; McClure (1997). Tables 1 and 2 show the contents, and percentage of questions for each subject covered in the two examinations; Lefevre et al. (2000) and (www.ncees.org).

Score Reporting

The (FE) examination is a measure of the candidate's minimum competence in his field of study, as determined by the NCEES requirement. The scoring of the is done according to the following (www.ncees.org):

- The 120 morning questions are each worth one point.
- The 60 afternoon questions are each worth two points.
- A summation of the points for correct answers yields what is called the raw score. Since the final passing score is a combination of the AM and PM examinations, a candidate who has some weaknesses in one section can compensate that in the other.
- The raw scores are converted to a common scale on which the passing score is 70. This is referred to as the scaled score or converted score. This permits comparison of scores from examinees who took different administrations of the exam.
- The passing score for each administration of the exam is determined by a panel of experts, using statistical techniques to ensure that the likelihood of passing is independent of the difficulty of the exam or the quality of candidates.
- Results are sent to the state board offices typically within 6 weeks following the administration of the exam.

- The passing scores are recommended to the licensing boards of each state by the NCEES. Each board can set its own passing score, but normally they adopt the NCEES recommended scores.

A sample of the pass rate (%) comparison for the (FE) examinations that was released in October 2001 is shown in Table 3.

SUGGESTIONS FOR ADOPTING THE (FE) EXAMINATION

As mentioned in the introduction, the (FE) examination is considered as the first step in the engineering licensing process. It must be followed by the (PE) examination, which should be taken after a minimum of four years experience to get licensed. Having discussed the details of the (FE) examination, some steps toward adopting this exam in the Saudi Arabia is proposed here:

1- There should be a full awareness about the advantages of professional licensing from all the partners involved, i.e., the students, engineers, educators, professional societies, public, and government.
2- Setting a plan for the phases of establishing a licensing system that gradually grow from optional to required licensure.
3- Encourage all engineering programs to become accredited by ABET to guarantee the quality required for licensure.
4- Encourage the universities to conduct the (FE) examination as soon as possible in order to assess the outcomes of their academic programs and become ready for the licensing requirements.
5- Explore the possibility of adopting international licensure in cooperation with the NCEES and the United States Council for International Engineering Practice (USCIEP); Townsend (2002).
6- The establishment of a national commission or center for licensure that has similar function as the NCEES, administers the (FE) and (PE) examinations, and awards the certification to professional engineers.

CONCLUSION

Professional engineering licensure or certification is becoming a global issue that may have an impact on the status of the engineers everywhere. In this paper, the (FE) examination is highlighted since it is the first step for engineers to be licensed. The other required examination, the (PE), is as important and should also be emphasized. The (FE) examination is based on the education gained by the candidate and the (PE) examination on the practical experience after graduation. Since the (FE) examination is directly related to the contents and quality of the academic programs, it was solely discussed here. The engineering programs should be strong enough to ensure that their outcomes are capable of passing the (FE) examination before or while getting involved in the process of licensure. As a measure for assessing the programs, the exam can be planned to be conducted soon, as proposed in this paper.

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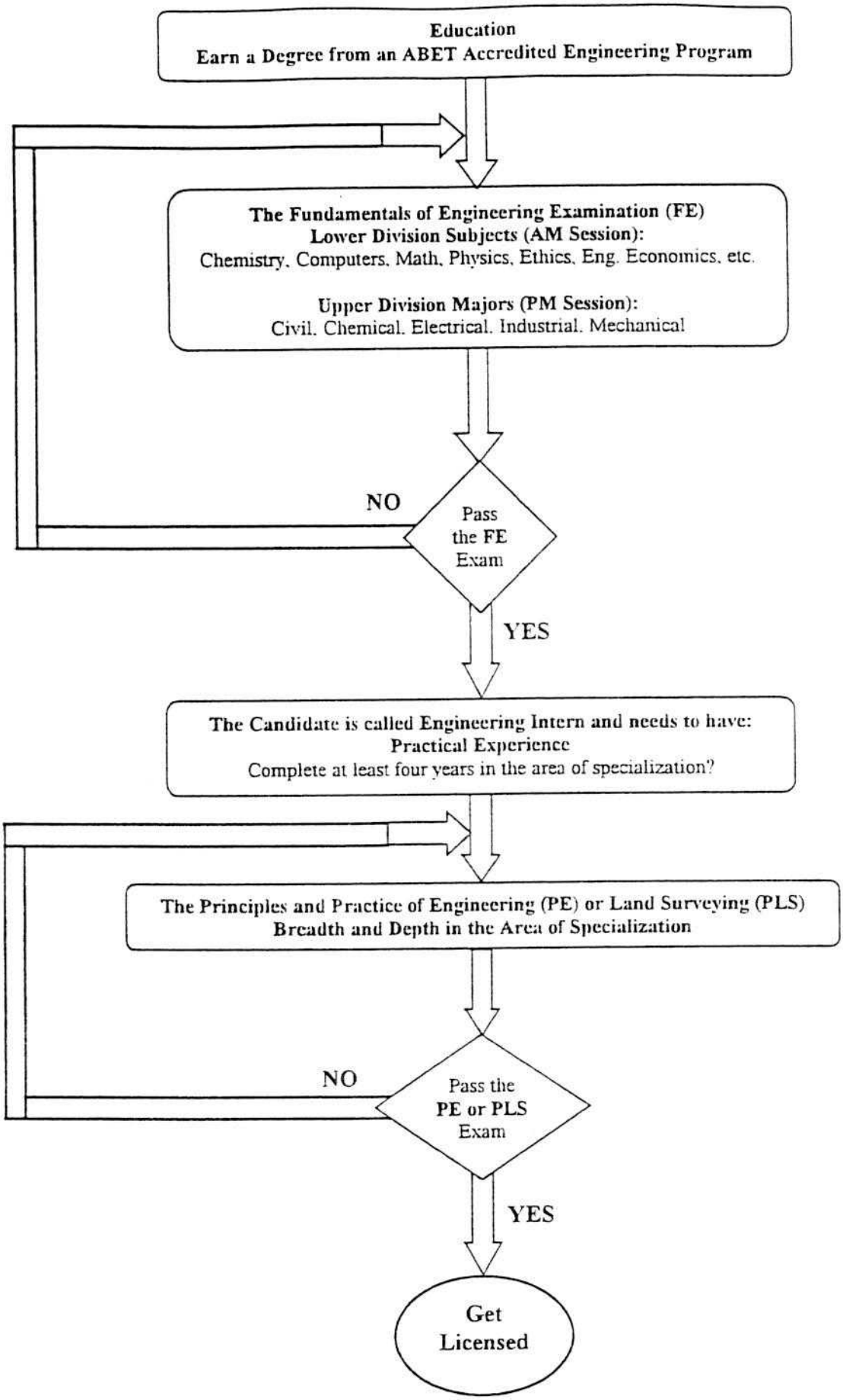

Fig. 1. The overall engineering licensing process followed in the United States

Table 1. NCEES fundamental of engineering (FE) examination
Morning (AM) session contents

SUBJECT	CONTENTS	%Q
CHEMISTRY	Acids & Bases, Equilibrium, Equations, Electrochemistry, Inorganic Chemistry, Kinetics, Metals and Nonmetals, Nomenclature, Organic Chemistry, Oxidations & Reduction, Periodicity, States of Matter, Solutions, Stoichiometry	9
COMPUTERS	Algorithm Flowchart, Spreadsheets, Psuedocode, Data Transmission & Storage	6
DYNAMICS	Force, Mass, & Acceleration, Friction, Impulse & Momentum, Kinematics, Vibrations, Work & Energy	7
ELECTRIC CIRCUITS	AC Circuits, Diode Applications, DC Circuits, Electric & Magnetic Fields, Capacitance & Inductance, Ideal Transformers, Fourier & Laplace Transforms, Operational Amplifiers (Ideal)	10
ENGINEERING ECONOMICS	Annual Cost, Breakeven Analysis, Benefit-Cost Analysis, Future Worth or Value, Present Worth, Valuation & Depreciation	4
ETHICS	Relations with Clients, Relations with Peers, Relations with Public	4
FLUID MECHANICS	Flow Measurement, Fluid Properties, Fluid Statics, Impulse & Momentum, Pipe & Other Internal Flow, Similitude & Dimensional Analysis	7
MATERIAL SCIENCE / STRUCTURE OF MATTER	Atomic Structure, Crystallography, Corrosion, Diffusion, Materials, Binary Phase Diagrams, Properties, Processing & Testing	7
MATHEMATICS	Analytic Geometry, Differential Equations, Differential Calculus, Difference Equations, Integral Calculus, Linear Algebra, Laplace Transforms, Probability & Statistics, Roots of Equations, Vector Analysis	20
MECHANICS OF MATERIALS	Beams, Bending, Columns, Combined Stresses, Shear, Stress & Strain, Tension & Compression, Torsion	7
STATICS	2-Dimensional Equilibrium, 3-Dimensional Equilibrium, Centroid of Area, Concurrent Force Systems, Friction, Moment of Inertia, Vector Forces	10
THERMODYNAMICS	1st Law, 2nd Law, Availability-Reversibility, Cycles, Energy, Heat & Work, Ideal Gases, Mixture of Gases, Phase Changes, Properties: Enthalpy, Entropy, Free Energy, Thermodynamic Processes	9

%Q is the percentage of Questions

Table 2. NCEES fundamental of engineering (FE) examination
Afternoon (PM) session contents

CHEMICAL	%Q	GENERAL	%Q
Chemical Reaction Engineering	10	Chemistry	7.5
Chemical Thermodynamics	10	Computers	5
Computer & Numerical Methods	5	Dynamics	7.5
Heat Transfer	10	Electrical Circuits	10
Mass Transfer	10	Engineering Economics	5
Material/Energy Balances	15	Ethics	5
Pollution Prevention	5	Fluid Mechanics	7.5
Process Control	5	Material Science/Structure of Matter	5
Process Design & Economics Evaluation	10	Mathematics	20
Process Equipment Design	5	Mechanics of Materials	7.5
Process Safety	5	Statics	10
Transport Phenomena	10	Thermodynamics	10
CIVIL	**%Q**	**ELECTRICAL**	**%Q**
Computers & Numerical Methods	10	Analog Electronic Circuits	10
Construction Management	5	Communications Theory	10
Environmental Engineering	10	Computer & Numerical Methods	5
Hydraulics & Hydrologic Systems	10	Computer Hardware Engineering	5
Legal & Professional Aspects	5	Computer Software Engineering	5
Soil Mechanics & Foundations	10	Control Systems Theory & Analysis	10
Structural Analysis	10	Digital Systems	10
Structural Design	10	Electromagnetic Theory & Applications	10
Surveying	10	Instrumentation	5
Transportation Facilities	10	Network Analysis	10
Water Purification & Treatment	10	Power Systems	5
		Signal Processing	5
		Solid State Electronics & Devices	10
INDUSTRIAL	**%Q**	**MECHANICAL**	**%Q**
Computer Computations & Modeling	5	Automatic Controls	5
Design of Industrial Experiments	5	Computer	5
Engineering Economics	5	Dynamic Systems	10
Engineering Statistics	5	Energy Conversion & Power Plants	5
Facility Design & Location	5	Fans, Pumps, & Compressors	5
Industrial Cost Analysis	5	Fluid Mechanics	10
Industrial Ergonomics	5	Heat Transfer	10
Industrial Management	5	Material Behavior/Processing	5
Information System Design	5	Measurement & Instrumentation	10
Manufacturing Processes	5	Mechanical Design	10
Manufacturing Systems Design	5	Refrigeration & HVAC	5
Material Handling System Design	5	Stress Analysis	10
Mathematical Optimization & Modeling	5	Thermodynamics	10
Production Planning & Scheduling	5		
Productivity Measurement & Management	5		
Queuing Theory & Modeling	5		
Simulation	5		
Statistical Quality Control	5		
Total Quality Management	5		
Work Performance & Methods	5		

%Q is the Percentage of questions

Table 3. Pass Rate (%) comparison for the (FE) examinations (October 2001)
Breakdown by Module

Examination Module	EAC/ABET* 1st Time Takers	EAC/ABET* Repeat Takers
Chemical	86	53
Civil	80	41
Electrical	75	25
Industrial	70	43
Mechanical	84	37
General	75	29

* *EAC is the Engineering Accreditation Commission of ABET.*

Source: www.ncees.org