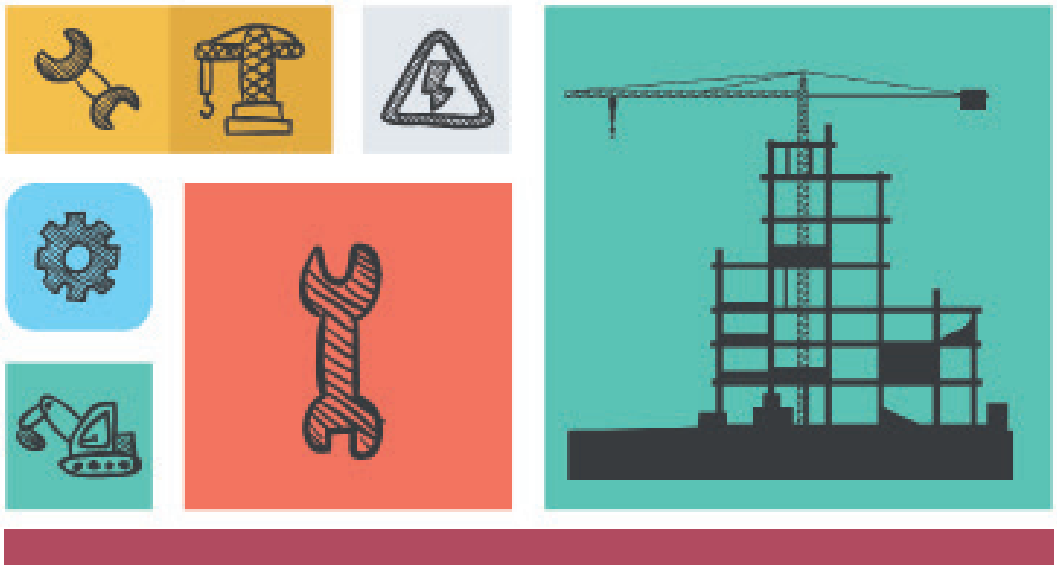
Engineering Fundamentals Exam

General Engineering Standards



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Introduction

Engineering standards are the set of knowledge, abilities, and professional attributes necessary to practice the engineering profession [3-5]. Every Engineering Standard is linked to a number of indicators. These indicators can be viewed as instruments that measure the examinee fulfillment of the corresponding standard. In other words, a Standard is a broad statement about a specific topic, whereas, the Indicators are specific requirements extracted from the Standard and directly linked to the exam question.

Some of these first level standards are drawn from the completion of a Bachelor of Engineering degree from an accredited engineering college. An accredited engineering degree program usually has the breadth of understanding of a wide range of technologies and applications. It also usually has sufficient depth in at least one specific area of practice to develop competence in handling technically complex problems [6].

The knowledge part of the first level standards include, generally, knowledge of science and engineering fundamentals, in-depth technical competence in an engineering discipline, knowledge of theoretical and experimental techniques, knowledge of basic business and project management practices, and broad general knowledge.

The ability part of the first level standards include, generally, the ability to identify, formulate, and solve problems, ability to understand environmental and social issues, ability to deal with ambiguity and complex problems, ability to perform engineering design, and an ability to interpret and visualize data [3-5].

The professional Attributes part of the first level standards are the sets of skills often sought by employers for hiring engineers either fresh graduates or experienced. They are sometimes called “soft” or “general” skills. They include capacity for effective communication [7] with the engineering team and costumers, capacity for effective work within multidisciplinary and multicultural teams, capacity for lifelong learning and professional development, self-drive and motivation, creativity and innovation, leadership, and capacity to maintain a professional image in all circumstances [3-5].

General Engineering Standards

The Engineering Standards for the General Engineering are structured around thirteen core Topics in addition to General Skills.

1. Mathematics
2. Probability and Statistics
3. Computer Literacy
4. Statics and Dynamics
5. Chemistry
6. Thermodynamics
7. Fluid Mechanics
8. Materials Science and Engineering
9. Electricity and Magnetism
10. Engineering Drawing
11. Engineering Economics
12. Project Management
13. Ethics and Professionalism
14. General skills

Each Indicator is projected onto three Learning Levels (obtained by combining every two consecutive levels in the revised Bloom's taxonomy into one level)

1. Remembering and Understanding
2. Applying and Analyzing
3. Evaluating and Creating)

Standards are coded GE-TJ where:

- GE denotes General Engineering
- TJ denotes Topic Number J

Indicators are coded GE-TJ-K (where K denotes the Indicator number).

Topic T1: Mathematics (10%)

Standard GE-T1: Engineers are expected to demonstrate knowledge in differential and integral calculus, in matrix and vector analysis and in the fundamentals of analytical geometry. Engineers should also be able to analytically solve elementary initial and boundary value problems. Furthermore, engineers are expected to demonstrate knowledge of some numerical techniques for solving single or system of algebraic equations, single initial value problem, and single variable optimization problem. Examinees will demonstrate this knowledge by carrying out hand iterations. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T1-Indicators

GE-T1-01 Recognize and apply principles of differential calculus (e.g., derivative rules, tangents, inflection points, finding minimum or maximum)

GE-T1-02 Recognize and apply principles of integral calculus (e.g., integration formulas, area under curve)

GE-T1-03 Solve analytically initial value problem (single equation)

GE-T1-04 Solve analytically boundary value problem (single equation)

GE-T1-05 Apply the principles of analytical geometry (e.g., line, plane, circle)

GE-T1-06 Apply matrix algebra (e.g., matrix operations, determinant)

GE-T1-07 Apply vector analysis (e.g., dot product, cross product)

GE-T1-08 Perform iterations to numerically solve nonlinear algebraic equations (using Bisection and Newton methods)

GE-T1-09 Perform iterations to numerically solve initial value problems (using Euler and Second Order Runge-Kutta methods)

GE-T1-10 Perform iterations to numerically solve one dimensional optimization problem (using Newton and Golden section methods)

T2: Probability and Statistics (4%)

GE-T2 Engineers are expected to demonstrate knowledge in fundamentals of engineering probability and statistics. These include the knowledge of key measures of central tendency and dispersion, the application of conditional probability rules, the familiarity with probability functions (discrete and continuous), the estimation (e.g., point and confidence intervals), hypothesis testing and linear regression. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T2-Indicators

GE-T2-01 Recognize the concept of mean, mode, standard deviation

GE-T2-02 Apply conditional probabilities

GE-T2-03 Apply probability distributions (discrete, continuous, normal, binomial)

GE-T2-04 Conduct point and interval estimation

GE-T2-05 Apply hypothesis testing (One sample test of mean and population proportions)

GE-T2-06 Calculate the expected value in decision-making

GE-T2-07 Perform linear regression

T3: Computer Literacy (7%)

GE-T3 Engineers should have essential computer skills. These include familiarity with computer and internet concepts, ability to understand the different number systems, logic gates and circuits as well as the ability to analyze a computer program written in pseudo code or flowchart forms. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T3-Indicators

GE-T3-01 Recognize the building blocks of a computer and internet terminologies

GE-T3-02 Recognize the number systems (binary, octal, and hexadecimal)

GE-T3-03 Explain the principles of spreadsheets

GE-T3-04 Identify logic gates and circuits

GE-T3-05 Analyze algorithms in flowchart or pseudo code formats.

T4: Statics and Dynamics (7%)

GE-T4 Engineers should have knowledge of essential concepts of statics and dynamics. These include static equilibrium of particles and rigid bodies, friction, linear and angular motion of particles, Newton's second law, impulse and momentum, and work and energy concepts. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T4-Indicators

GE-T4-01 Apply static equilibrium to particle and rigid body

GE-T4-02 Apply concepts of friction

GE-T4-03 Apply kinematics of particles (linear and angular motion)

GE-T4-04 Use Newton's second law of motion

GE-T4-05 Apply Impulse and momentum to problems involving particle and rigid body

GE-T4-06 Apply work and energy principles to particle and rigid body

T5: Chemistry (7%)

GE-T5 Engineers should be familiar with some fundamental concepts in chemistry. These include the basic concepts in atomic structure and different bounds, the concepts of concentration and molarity, be able to complete and balance chemical reactions, be familiar with chemical equilibrium and the factors affecting it, and be able to solve problems involving acid dissociation. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T5-Indicators

GE-T5-01 Recognize chemical nomenclature

GE-T5-02 Recognize metals and nonmetals in the periodic table

GE-T5-03 Complete and balance chemical reaction equations

GE-T5-04 Recognize the concepts of concentration and molarity

GE-T5-05 Recognize and apply the principles of chemical equilibrium

GE-T5-06 Recognize the basic concepts of atomic structure and bonds

GE-T5-07 Calculate pH and acid concentration constant

T6: Thermodynamics (3%)

GE-T6 Engineers should have an understanding of the concepts of heat, work, internal energy, enthalpy, and entropy. They should be able to apply first and second laws of thermodynamics, particularly with ideal gas law and be able to analyze basic power and refrigeration cycles. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T6-Indicators

GE-T6-01 Apply the ideal gas law

GE-T6-02 Use thermodynamics tables (saturated and superheated steam tables)

GE-T6-03 Determine the properties of mixture of gases

GE-T6-04 Calculate energy, heat, and work in thermodynamic processes

GE-T6-05 Apply thermodynamics laws (first and second laws)

GE-T6-06 Analyze the efficiency of power and refrigeration processes

GE-T6-07 Apply the third law and use entropy/enthalpy considerations.

T7: Fluid Mechanics (3%)

GE-T7 Engineers should have a knowledge of fluid statics, fluid dynamics, flow through pipes, around submerged bodies, and through porous media, be able to quantify friction losses and be able to apply dimensionless analysis in fluid mechanics problems. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T7-Indicators

GE-T7-01 Be familiar with fluid measurement devices

GE-T7-02 Apply fluid statics (pressure and its relationship with height)

GE-T7-03 Apply fluid kinematics and dynamics (Euler, Bernoulli, and Manning equations)

GE-T7-04 Analyze flow through pipes

GE-T7-05 Use dimensional analysis in fluid mechanics problems

T8: Materials Science and Engineering (7%)

GE-T8 This topic area combines materials properties and elements of strength of materials. Engineers should be able to recognize the various properties of the different materials, be familiar with general characterization techniques for materials, recognize types of crystal structure and calculate atomic packing factor and recognize corrosion mechanisms and ways to control them. Engineers should also have a knowledge of essentials of strength of materials. These include the determination of size of materials under loads, the understanding of types of deformation, the calculation of stresses and the solution of torsion problems. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T8-Indicators

GE-T8-01 Recognize different material properties (mechanical, electrical, physical, etc.)

GE-T8-02 Select appropriate materials based on specific application

GE-T8-03 Identify general material characterization techniques (mechanical, electrical, chemical, optical, etc.)

GE-T8-04 Recognize types of crystal structure and calculate atomic packing factor

GE-T8-05 Recognize types of corrosion and their control

GE-T8-06 Calculate stresses due to normal loads, shear load, bending and torsion

GE-T8-07 Differentiate between plastic and elastic deformation

GE-T8-08 Determine the type of material and calculate its size under the application of a load

GE-T8-09 Solve torsion problems of circular shafts as solid or hollow bars

T9: Electricity and Magnetism (3%)

GE-T9 Engineers should have knowledge of basic concepts of electric and magnetic quantities, be able to apply the Ohm and Kirchhoff circuit laws, be able to perform complex algebra and apply fundamentals of AC circuits. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T9-Indicators

GE-T9-01 Recognize and interpret the basic concepts of electrical and magnetic quantities (e.g., charge, energy, current, voltage, power)

GE-T9-02 Write expressions and evaluate the forces between electric charges

GE-T9-03 Express and apply current and voltage laws (Kirchhoff, Ohm) for simple electrical circuits

GE-T9-04 Write circuit relationships and solve simple equivalent circuits (series, parallel)

GE-T9-05 Perform algebra of complex numbers

GE-T9-06 Recognize and express units of AC quantities and apply fundamentals of AC circuits

T10: Engineering Drawing (4%)

GE-T10 Engineers should have knowledge of basic terminologies used in engineering drawing, the concepts of AUTOCAD, and be able to analyze views and projections. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T10-Indicators

GE-T10-01 Recognize the concepts and terminologies used in engineering drawing

GE-T10-02 Recognize the concepts of computerized drafting software

GE-T10-03 Interpret engineering drawings

T11: Engineering Economics (7%)

GE-T11 Engineers should have knowledge of basic terminologies used in engineering economics, understand the time value of money, prepare cash flow diagrams, calculate the worth of cash flow series and be able to evaluate the profitability of a project using a variety of criteria. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T11-Indicators

GE-T11-01 Recognize financial statements

GE-T11-02 Recognize Cost (e.g., incremental, average, sunk, estimating)

GE-T11-03 Prepare and interpret a cash flow diagram

GE-T11-04 Recognize the concept of the time value of money and calculate worth (present, annual equivalent, and future) of a cash flow time series

GE-T11-05 Analyze and evaluate alternatives (present-worth, annual equivalent-worth, rate-of-return, payback period and benefit-cost ratio)

T12: Project Management (7%)

GE-T12 Engineers should have an understanding of key issues related to the project organization, contract and liability. They should also be able to apply the fundamentals of project management (work breakdown structure, scheduling techniques, monitoring of project progress). The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T12-Indicators

GE-T12-01 Recognize the fundamentals of project management

GE-T12-02 Apply basic principles to establish a work breakdown structure

GE-T12-03 Apply critical path method technique to distinguish critical and slack activities

GE-T12-04 Monitor project progress in terms of cost and time

T13: Ethics and Professionalism (7%)

GE-T13 Engineers should be familiar with codes of ethics in the engineering profession, recognize the difference between what is legal and what is ethical, be able to observe standards, safety and ethical issues while making decisions. and be able to understand intellectual property issues. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T13-Indicators

GE-T13-01 Recognize and interpret codes of ethics in the engineering profession

GE-T13-02 Recognize conflict of interest and whistle blowing

GE-T13-03 Make decisions while observing standards, safety and ethical implications

GE-T13-04 Recognize intellectual property, agreements and contracts.

T14: General Skills (24%)

GE-T14 General Skills refer to some soft (i.e. transferable) skills that engineers ought to possess. These include essentially analytical skills, communication skills, team work, time management, continuous improvement, decision making, ability to analyze and interpret data, and select optimum solution from alternative ones. The following Engineering Indicators are addressed in the Test Questions on this Topic Area:

T14-Indicators

GE-T14-01 Use analytical thinking (logical deductions, statements and assumptions, cause and effect, verbal reasoning, analyzing arguments, statements and conclusions, break a complex problem into smaller problems and solve them)

GE-T14-02 Use effective communication in writing, orally, and graphically

GE-T14-03 Work cooperatively with other team members to deliver the required outcomes

GE-T14-04 Set goals and ways for personal development

GE-T14-05 Strive for ways to resolve conflicts while being sensitive to others opinions

GE-T14-06 Be able to use time and available resources in an efficient way

GE-T14-07 Recognize and interpret environmental, social, cultural, political and safety considerations in engineering solutions.

GE-T14-08 Recognize decision making process

GE-T14-09 Recognize major engineering concepts outside the discipline.

GE-T14-10 Interpret uncertainties in measurements and calculations

GE-T14-11 Analyze and interpret data

GE-T14-12 Apply evaluation criteria and contemporary knowledge to select the optimum design from alternative solutions

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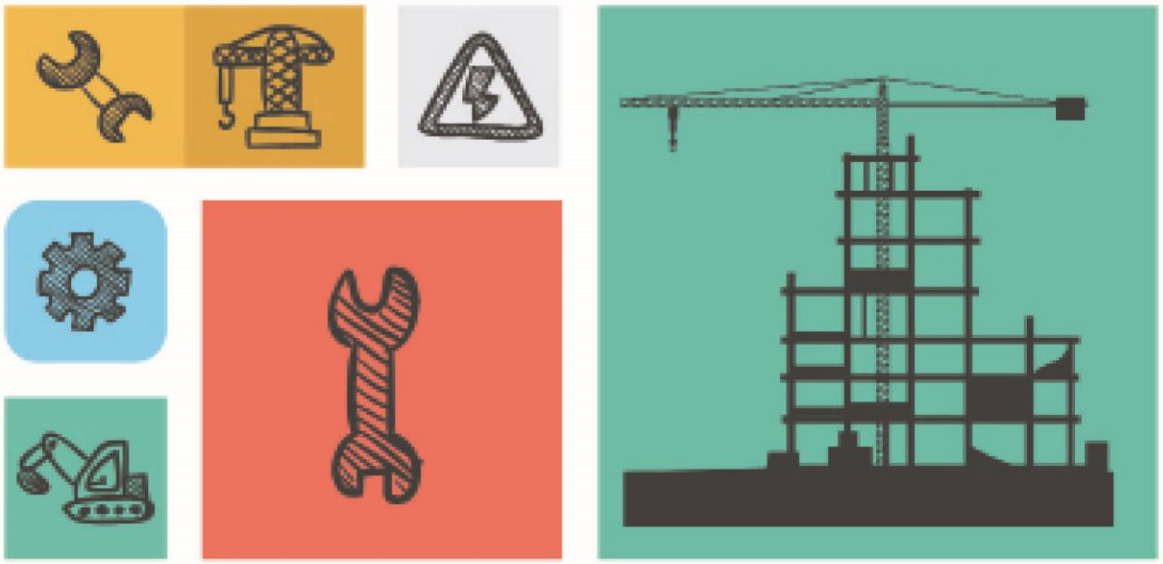

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