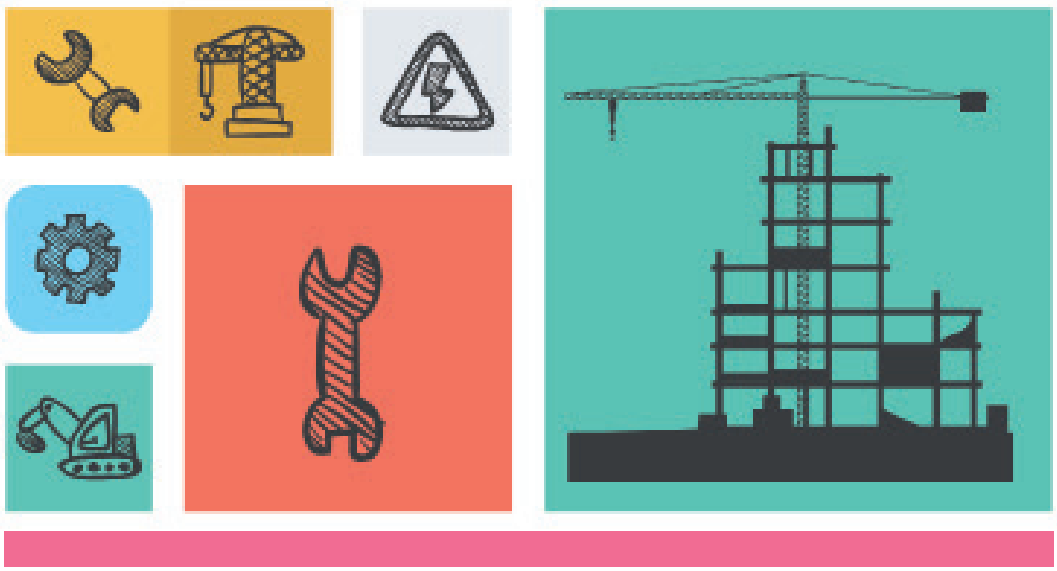
Engineering Fundamentals Exam

Mechanical 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].

Mechanical Engineering Standards

The Engineering Standards for the Mechanical Engineering Discipline are structured around eight core Topics:

1. Mechanical Design and Analysis
2. Engineering Mechanics
3. System Dynamics and Control
4. Material Processing and Manufacturing
5. Measurements and Instrumentation
6. Thermodynamics and Thermal Systems
7. Fluid Mechanics and Fluid Machinery
8. Heat Transfer

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 ME-TJ where:

- ME denotes Mechanical Engineering
- TJ denotes Topic Number J

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

Example

Topic Area:	**T8**: Heat Transfer
Strandard	**ME-T8:** Mechanical engineers should be able to differentiate and apply the basic modes of heat transfer associated with thermal systems. The following Indicators are addressed in the Test Questions on this Topic Area:
Indicator:	**ME-T8-01** Recognize the use of laws of heat transfer by conduction
Learning Level:	Applying and Analyzing (AA)

Topic T1: Mechanical Design and Analysis (16%)

ME-T1 Mechanical engineers should be able to design and analyze mechanical and thermal systems, components, products and processes to meet needs while fulfilling different types of constraints. Specifically, ME graduates should be able to apply principles and techniques of 3D surface and solid modeling as well as to design elements to achieve satisfactory level of safety including shafts, screws and fasteners, joining components, springs, gears, brakes and clutches, flexible elements, rolling element bearings, and Journal Bearings. The following *Indicators* are addressed in the *Test Questions* on this *Topic Area*:

T1-Indicators

ME-T1-01 Define, identify and apply mechanical and thermal stresses and strains

ME-T1-02 Recognize the fundamental concepts of failure, stability, fatigue and fracture theories

ME-T1-03 Identify principles and techniques of 3D surface and solid modeling and of 2D drawing from solid model database

ME-T1-04 Practice problem modeling and demonstrate analysis and rapid prototyping

ME-T1-05 Analyze mechanical behavior of deformable solid bodies subjected to various types of loading

ME-T1-06 Evaluate design alternatives based on quality and reliability principles

ME-T1-07 Identify problem formulation and formulate conceptual designs

ME-T1-08 Practice design fundamentals of mechanical elements

ME-T1-09 Apply the basic design of mechanical elements to achieve safe joining systems

ME-T1-10 Use factors of safety and code standards

T2: Engineering Mechanics (14%)

ME-T2 Mechanical engineers should be able to define, analyze and evaluate the kinematics and kinetics of particles and rigid bodies, the topological characteristics of planar mechanisms and the static and dynamic forces of machinery. ME graduates should be able to describe and analyze the kinematics and dynamics of mechanisms, cams, followers, balancing of rigid rotors, ordinary and planetary gear trains. The following Indicators are addressed in the Test Questions on this Topic Area:

T2-Indicators

ME-T2-01 Describe the fundamentals of kinematics of particles and kinematics of rigid bodies in plane motion

ME-T2-02 Define kinetics of particles using Newton's law, work and energy, impulse and momentum and impact principles

ME-T2-03 Apply static and dynamic force analysis of machinery using graphical and analytical methods

ME-T2-04 Analyze topological characteristics of planar mechanisms

ME-T2-05 Develop position, velocity and acceleration analysis of linkages

ME-T2-06 Apply kinetics of rigid bodies in plane motion including translation, fixed axis rotation, general motion, work and energy, and impulse and momentum

ME-T2-07 Apply the basic design of mechanical elements to achieve satisfactory level of power transmission

ME-T2-08 Recognize mechanical systems in real life

T3: System Dynamics and Control (15%)

ME-T3 Mechanical Engineers should be able to model physical systems (mechanical, electrical, hydraulic, pneumatic and thermal) using Laplace transformation, transfer functions and block diagrams. ME graduates should be able to define and apply the basic concepts of automatic control, dynamic system response and stability. The following Indicators are addressed in the Test Questions on this Topic Area:

T3-Indicators

ME-T3-01 Identify Laplace transformations, transfer functions, and block diagrams

ME-T3-02 Recognize the natural frequency and resonance of mechanical systems

ME-T3-03 Establish modeling of mechanical, electric, hydraulic, pneumatic and thermal systems

ME-T3-04 Design mechanical systems subjected to dynamic loads

ME-T3-05 Design system controllers (i.e., PI, PD, and PID)

ME-T3-06 Formulate the dynamic and stability response of mechanical systems in the time and frequency domains

T4: Material Processing and Manufacturing (8%)

ME-T4 Mechanical engineers should be able to distinguish the structure characteristics and mechanical properties of metals, polymers and ceramics, to define equilibrium-phase diagrams and to identify the microstructure of alloys, heat treatments of plain carbon steels and the basic manufacturing processes as well as to calculate the forces involved in manufacturing. The following Indicators are addressed in the Test Questions on this Topic Area:

T4-Indicators

ME-T4-01 Identify metallurgical properties of metals, polymers, ceramics and alloys

ME-T4-02 Describe equilibrium-phase diagrams

ME-T4-03 Define the basic manufacturing processes

ME-T4-04 Categorize the role of different thermal processing (heat treatments)

ME-T4-05 Examine and select the adequate manufacturing technique for mechanical components

ME-T4-06 Analyze the forces and power needed during manufacturing

ME-T4-07 Practice material selection for engineering design

ME-T4-08 Relate manufacturing and assembly processes to design constraints

ME-T4-09 Establish familiarity with testing and manufacturing equipment

T5: Measurements and Instrumentation (8%)

ME-T5 Mechanical engineers should be able to define the basic fundamentals of measuring concepts including uncertainty analysis, instrumentation specifications, data collection and analysis. The following Indicators are addressed in the Test Questions on this Topic Area:

T5-Indicators

ME-T5-01 Identify measurement concepts such as uncertainty analysis and instrumentation specifications

ME-T5-02 Conduct analog and digital signals analyses collected from measurements

ME-T5-03 Use signal conditioning in the operation of a mechanical system

ME-T5-04 Choose a given measurement technique based on the measurement uncertainty estimation

T6: Thermodynamics and Thermal Systems (16%)

ME-T6 Mechanical engineers should be able to recognize a thermodynamic process, apply the thermodynamic laws to analyze open and closed systems, be able to apply the different thermodynamic diagrams and use the fundamentals of combustion principles in the design of thermo-mechanical components. The following Indicators are addressed in the Test Questions on this Topic Area:

T6-Indicators

ME-T6-01 Recognize a thermodynamic process

ME-T6-02 Differentiate between heat and work transfer

ME-T6-03 Identify closed and open systems

ME-T6-04 Use the appropriate laws / tables for obtaining properties of steam, refrigerant, and air

ME-T6-05 Compute the work transfer in open systems using h-s diagrams

ME-T6-06 Apply an appropriate thermodynamic concept to analyze open and closed systems

ME-T6-07 Use the fundamentals of combustion principles in the design of thermo-mechanical components

ME-T6-08 Evaluate the possibility of using some devices through the application of the second law concept

T7: Fluid Mechanics and Fluid Machinery (16%)

ME-T7 Mechanical engineers should be able to describe the fundamentals, physical meaning and governing phenomena of fluid mechanics, including conservation of mass and balance of momentum for fluid flow situations. The following Indicators are addressed in the Test Questions on this Topic Area:

T7-Indicators

ME-T7-01 Identify the principals of fluid statics and dynamics and recognize the fundamentals of internal and external viscous flows

ME-T7-02 Recognize the type of flow using fluid mechanics concepts like Reynolds number, irrotationality, steadiness, etc.

ME-T7-03 Use proper laws to evaluate forces on bodies submerged in liquids and air

ME-T7-04 Choose the appropriate fluid mechanics principles to analyze fluid flow problems

ME-T7-05 Demonstrate the ability of using Moody's Chart for analyzing fluid flow problems in pipes

ME-T7-06 Analyze the power requirement of pumping systems used in pipeline transportation systems

ME-T7-07 Apply and use the slip factor in analyzing the power input to pumping machines

ME-T7-08 Demonstrate the use of specific speed concept in arriving at choice of a turbomachine

ME-T7-09 Obtain the major dimensions of a turbomachine using similarity concept with changes in speed

ME-T7-10 Evaluate the operating point, power requirement, and efficiency of a pumping system using pump-system characteristics

ME-T7-11 Evaluate the off design performance of turbomachines using similarity conditions

T8: Heat Transfer (10%)

ME-T8 Mechanical engineers should be able to differentiate and apply the basic modes of heat transfer associated with thermal systems. The following Indicators are addressed in the Test Questions on this Topic Area:

T8-Indicators

ME-T8-01 Recognize the use of laws of heat transfer by conduction

ME-T8-02 Recognize the use of laws of heat transfer by convection

ME-T8-03 Recognize the use of laws of heat transfer by radiation

ME-T8-04 Analyze the heat transfer through a simple composite wall using electrical analogy

ME-T8-05 Analyze simple transient heat transfer problems

ME-T8-06 Calculate the heat transfer by forced and free convection

ME-T8-07 Design a parallel flow heat exchanger for a given situation

ME-T8-08 Design a counter flow heat exchanger for a given situation

ME-T8-09 Evaluate heat exchangers performance using LMTD method

ME-T8-10 Evaluate heat exchangers performance using effectiveness method

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