Graduate Attributes and Indicators

Detailed/Program Specific Descriptions

Glossary

Complex Engineering Problems: In 2012, the CEAB adopted the definition of "complex problem" used in the Washington Accord (WA) exemplar of graduate attributes. A defining characteristic of the engineering profession is the ability to work with complexity and uncertainty given that all real engineering projects are different from one another. Accordingly, the notion of complex engineering problems and the solving of complex problem are central to the definition of certain attributes.

According to the CEAB, a complex engineering problem is defined by the following characteristics:

1. It must require the application of in-depth knowledge
2. It must satisfy at least one of the following additional characteristics:
    - involves wide-ranging or conflicting issues
    - has no obvious solution such that originality is required
    - involves infrequently encountered issues
    - is outside accepted standards and codes
    - involves diverse stakeholders and needs
    - is posed at a high-level with many components or sub-problems

In–Depth Knowledge: In-depth knowledge means knowledge gained from courses/learning activities beyond the introductory instructional level.

First Principles: First principles are the fundamental concepts or assumptions on which a theory, system, or method is based. In engineering, first principles start directly at the level of established laws of chemistry, physics and mathematics and do not argue by analogy or make use of any empirical formulae or assumptions.

Research: Primary research involves experiments, investigations, or tests carried out to acquire data first-hand. Research in the context of this guide is used more broadly to include data gathered from appropriate technical and non-technical sources, including but not restricted to the peer-reviewed engineering literature, specifications, standards, codes, and reports.

KB - Knowledge base for engineering

Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

Indicators	Indicator Descriptions
KB.1 - Recalls and defines information and concepts in *mathematics* **KB.3** - Recalls and defines information, first principles and concepts in *natural sciences* **KB.5** - Recalls and defines information, first principles and concepts in *fundamental engineering sciences* **KB.7** - Recalls and defines information, first principles and concepts in *specialized engineering sciences*	• Defines terminology and facts related to university level mathematics • Defines terminology and facts related to university level natural sciences • Defines terminology and facts related to engineering fundamentals such as: (to be completed for each program) • Defines terminology and facts related to specialized engineering knowledge appropriate to the program such as: (to be completed by each departments discipline) • States first principles and theories in university level mathematics • States first principles and theories in university level natural sciences • States first principles and theories in engineering fundamentals such as: (to be completed for each program) • States first principles and theories in specialized engineering knowledge appropriate to the program such as: (to be completed for each departments discipline) • Identifies rules and methodologies • Reproduces solutions to problems, Uses correct equations, Calculates parameters
KB.2 - Comprehends information and applies concepts in *mathematics* **KB.4** - Comprehends information and applies concepts in *natural sciences* **KB.6** - Comprehends information and applies concepts in *fundamental engineering sciences* **KB.8** - Comprehends information and applies concepts in *specialized engineering sciences*	• Shows an in-depth understanding of key ideas and concepts related to university level mathematics e.g. by explaining, translating mathematical concepts into engineering applications • Shows an in-depth understanding of key ideas and concepts related to university level natural sciences e.g. by explaining engineering concepts using natural sciences • Shows an in-depth understanding of key ideas and concepts related to engineering fundamentals (to be completed for each departments discipline) , e.g. by explaining • Shows an in-depth understanding of key ideas and concepts related to specialized engineering knowledge appropriate to the program (to be completed for each departments discipline) , e.g. by explaining • Appropriately interprets mathematical terms • Applies theories to simple problems • Shows appropriate engineering interpretation of scientific terms • Uses fundamental engineering science to explain real world phenomena

PA - Problem analysis

An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

Indicators	Indicator Descriptions
PA.1 - Identifies and formulates complex engineering problems	• Determines type of problem to be solved i.e. complex engineering problem, Open-ended problem • Identifies first principles, relevant information as well as uncertainty and biases in problems • Interprets auxiliary information • Adjusts from known problems to different situations • Derives familiar problems from infrequently encountered problems by simplifying problems, reducing number of variables, and applying assumptions • Formulates solutions, procedures, and methods • Uses order-of-magnitude estimates to obtain fundamental insights into complex engineering problems • Researches for development of solution
PA.2 - Develops models from first principles to analyze complex engineering problems	• Develops solution/model from first principles • Selects and applies appropriate computational procedures • Formulates models and identifies their limitations • Validates credibility of models with first principle analysis
PA.3 - Analyzes and solves complex engineering problems	• Extracts conclusions from calculations • Evaluates validity of the answers and results • Provides comments to questions posed • Provides recommendation • Demonstrates creative synthesis of solution and creates new alternatives by combining knowledge and information • Predicts the performance of engineering systems • Predicts and justifies problem outcomes
PA.4 - Critically evaluates the validity and accuracy of solution	• Researches alternative existing solutions • Identifies solution methods limitation(s) • Identifies sources of error in the solution process • Evaluates the validity of a proposed solution

IN – Investigation

An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data and synthesis of information in order to reach valid conclusions.

Indicators	Indicator Descriptions
IN.1 - Conducts planned activities (literature review, experiments, measurements, laboratories, etc.) and analyzes data	• Researches information for the activity • Measures and controls variables necessary to solve problem or understand system • Uses valid methods, conducts methods well and with sufficient accuracy • Objectively documents all data and information. • Analyzes the data • Troubleshoots
IN.2 - Interprets results and reaches valid conclusions regarding complex engineering problems	• Interprets results using appropriate theory • Plots data as a function of correct variables • Shows awareness of major interrelations and trends in the data • Relates physics of the system to results • Uses caution in interpretations • Acknowledges limitations of data and measurement error • Reaches valid conclusions justified by the data • Compares results and conclusions with previous works
IN.3 - Formulates hypotheses and designs suitable investigative approaches and/or research methodologies	• Constructs hypotheses and recommends further investigations • Applies the principles of experimental design • Formulates an investigative plan of data gathering to attain stated objective (develops correlation, tests a model, ascertains performance of equipment, etc.) • Develops and implements logical investigative procedures
IN.4 - Understands and/or demonstrates appropriate safety protocols	• Obtains WHMIS Certification • Observes laboratory safety procedures

DE – Design

The ability to perform engineering design. Engineering design is a process of making informed decisions to creatively devise products, systems, components, or processes to meet specified goals based on engineering analysis and judgement. The process is often characterized as complex, open-ended, iterative, and multidisciplinary. Solutions incorporate natural sciences, mathematics, and engineering science, using systematic and current best practices to satisfy defined objectives within identified requirements, criteria and constraints. Constraints to be considered may include (but are not limited to): health and safety, sustainability, environmental, ethical, security, economic, aesthetics and human factors, feasibility and compliance with regulatory aspects, along with universal design issues such as societal, cultural and diversification facets.

Indicators	Indicator Descriptions
DE.1 - Understands the problem and defines objectives and constraints	• Understands the nature of the complex/open-ended engineering problems • Defines the functions and objectives • Identifies technical constraints as well as constraints set by factors such as health, safety, engineering standards, etc.
DE.2 - Develops a design process considering health and safety risks, applicable standards, economic, environmental, cultural and societal considerations.	• Develops a process to design systems, components and/or processes to solve complex/open-ended engineering problems • Breaks down the complex problem into sub-problems and recombining to form the whole. • Is capable of conceiving and inventing a plan specifications considering health and safety risks • Is capable of conceiving and inventing a plan specifications considering engineering standards and codes • Is capable of conceiving and inventing a plan specifications considering economic, environmental, cultural and societal issues in design
DE.3 - Researches and develops possible solutions to a complex engineering problem and recommends a final design	• Conceives alternative design solutions that meet most of the desired functions and objectives • Systematically identifies and justifies an appropriate design that satisfies all requirements (functions, objectives, and constraints) and considers implementation issues. • Performs Design calculations
DE.4 - Implements and evaluates a final design	• Validates the design against the problem specifications • Transforms conceptual design to a detailed design • Integrates engineering, computer, and mathematical principles to resolve all the constraints involved in the design process to take into account economic, health, safety, social and environmental factors, engineering codes of practice and applicable laws

ET - Use of engineering tools

An ability to create, select, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

Indicators	Indicator Descriptions
ET.1 - Selects and uses tools	• Selects appropriate techniques, modern engineering tools and resources such as: short list of tools that are important and specific to the discipline grouped by software, Modern engineering tools • Demonstrates correct use of modern techniques, testing apparatus, databases, models such as: short list of tools that are important and specific to the discipline grouped by software, Modern engineering tools • Applies modern engineering tools in complex engineering activities
ET.2 - Evaluates tools and identifies their limitations	• Evaluates tools to identify their limitations in specific engineering activities • Understands the limitation of tools • Validates the limitations of engineering tools with empirical measurements
ET.3 - Adapts, integrates and/or creates tools	• Understands the adaptability of tools • Combines tools and techniques • Integrates software with physical hardware, • Creates simple tools, e.g. measurement modules, codes

The term “Tools” refers to any equipment, software or resources used in each engineering discipline. A few examples are:

• Equipment: Modern engineering tools, prototypes, simplified physical models, laboratory materials

• Software: Programming language interfaces, models and/or simulation of systems, measurement and monitoring software and instruments

• Resources: Scientific references

IT - Individual and teamwork

An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

Indicators	Indicator Descriptions
IT.1 - Participates actively in a uni- and/or multi-disciplinary team	• Participates and shows interest in discussions and activities • Participate in group decision making • Demonstrates initiative • Functions well in multi-disciplinary teams
IT.2 - Shares workload	• Contributes an appropriate share of the group's work • Completes assigned tasks on time • Collaborates with other team members
IT.3 - Displays good interpersonal skills	• Treats team members respectfully • Listens to other team members • Gives and receives constructive feedback • Maintains composure in difficult situations • Contributes to the group's effectiveness
IT.4 - Develops leadership skills in a uni- and/or multi-disciplinary team	• Provides direction and facilitates achievement of the team's goals • Evaluates team effectiveness and plans for improvement • Gets the most from resources • Motivates team members

CS - Communication skills

An ability to communicate complex engineering concepts within the profession and with society at large. Such abilities include reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

Indicators	Indicator Descriptions
CS.1 - Understands, interprets and/or assesses oral, written, graphical or visual communications	• Understands and processes engineering documents • Understands complex engineering concepts
CS.2 - Produces written research papers, engineering reports and design documentation	• Produces acceptable level of technical communication with clarity in presentation of complex engineering ideas • Articulates ideas clearly and concisely • Uses graphs, tables, and diagrams to support points to explain, interpret, and assess information • Provides citations and references • Follows proper structure in writing
CS.3 - Demonstrates competency in the oral communication of complex engineering concepts	• Adjusts presentation of ideas depending on the audience (professional and technical vs. public and non-technical) • Delivers a fluid oral presentation • Listens carefully and responds to questions appropriately • Explains and interprets results for various audiences and purposes (professional and technical vs. Public and non-technical) • Communicates complex engineering concepts clearly
CS.4 - Demonstrates an ability to give and/or effectively respond to clear instructions	• Organizes instructions in a logical sequence to enhance the reader's comprehension • Understands and follows verbal or written instructions • Overcomes minor deficiencies in instruction with good engineering intuition

PR – Professionalism

An understanding of the roles and responsibilities of the Professional Engineer in society, especially the primary role of protection of the public and the public interest.

Indicators	Indicator Descriptions
PR.1 - Understands the role of the engineering profession in society	• Shows awareness of professional/technical associations in engineering • Understands the role of Professional Engineer • Understands the duty of engineers in society, i.e. safeguard life, health, property, economic interests, public welfare or the environment where engineering is concerned
PR.2 - Understands the responsibility of Professional Engineer in protection of the public and its interest	• Understands the responsibility of Professional Engineer • Demonstrates an understanding of the protection of the public and its interest in decision making • Understands Professional Engineers are licensed to be accountable to the public for their work • Discusses engineering failures
PR.3 - Knows pertinent codes, laws and regulations	• Demonstrates awareness of engineering as a regulated profession, including reference to relevant engineering codes, laws and regulations • Applies engineering standards to engineering problems • Understands the legal liability of engineers • Discusses integrity issues for engineers

IE - Impact of engineering on society and the environment

An ability to analyze social and environmental aspects of engineering activities. Such abilities include an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society; the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.

Indicators	Indicator Descriptions
IE.1 - Understands the social, environmental, economic, health, safety, legal and/or cultural aspects of engineering activities	• Understands global, regional and local societal values applicable to engineering activities • Understands the importance of achieving a balance between environmental, social, cultural, legal and economic factors while contributing to healthy and safe surroundings in both the built and natural environment • Understands the interaction of engineering with ▪ Economic issues ▪ Legal issues ▪ Cultural and societal issues ▪ Health and safety issues
IE.2 - Understands and/or is able to analyze the uncertainties in the prediction of interactions between the different aspects of engineering activities	• Understands the uncertainties in the prediction of the interaction of engineering with environmental, social, cultural, legal and economic factors • Analyzes the uncertainties in the prediction of interaction of engineering with environmental, social, cultural, legal and economic factors • Uses precautionary, risk assessment, processes to recommend actions to protect, restore & improve the environment • Identifies and analyzes uncertainties in scientific data or incomplete evidence of adverse impacts
IE.3 - Conducts social and/or environmental impact analyses	• Shows awareness of and the ability to follow the principle steps of Environmental and Social Impact Assessment (ESIA) • Recognizes the importance of Environmental Management Systems (EMS) • Identifies environmental impacts and knows different methods to estimate environmental impacts of engineering designs in their branch of engineering. • Uses a diversity of approaches to "measure" the sustainability of designs (e.g., life cycle analysis, multi-criteria analysis, or monetary valuation).
IE.4 - Understands and/or applies the concepts of environmental stewardship, sustainable design and sustainable development	• Understands the concept of sustainable design and development • Understands the three dimensions of sustainable development (social justice, environmental preservation, economic growth), as well as the trade-offs between them and knows how they affect engineering design/implementation. • Recognizes the extent that engineering activities affect the environment and sustainability • Understands that environmental issues and sustainability are interdisciplinary in nature • Uses methods to measure uncertainty and knows how they apply in the context of sustainability

EE - Ethics and equity

An ability to apply professional ethics, accountability, and equity.

Indicators	Indicator Descriptions
EE.1 - Appreciates and articulates issues and dilemmas related to equity	• Exhibits awareness of the equity-related implications of their work
EE.2 - Demonstrates knowledge of ethical standards (i.e. Code of Ethics)	• Knows the codes of ethics • Analyzes a case by applying the codes of ethics • Applies a code of ethics in an engineering activity
EE.3 - Understands and/or resolves ethical issues	• Generates and understands approaches for resolving ethical dilemmas and issues of equity in relation to both professional and substantive ethics • Can discuss and/or apply principles of equity in workplace
EE.4 - Demonstrates individual accountability	• Understands accountability and personal responsibility • Recommends actions that are accountable • Can discuss and/or apply principles of professional accountability

EP - Economics and project management

An ability to appropriately incorporate economics and business practices including project, risk and change management into the practice of engineering, and to understand their limitations.

Indicators	Indicator Descriptions
EP.1 - Understands economic concept in engineering context	• Understands concepts required for the economic assessment of engineering projects, evaluates the economic viability of defined cases e.g. the short-term cost vs. the long-term value of a project • Understands the limitation of economic analysis in an engineering context • Understands the effect of the national/global economy on engineering projects
EP.2 - Understands project management life cycle and its limitations	• Understands the 5 levels of the project management phases, i.e. initiating, planning, executing, monitoring and controlling, and closing the project and can define the necessary tasks for each. • Understands project constraints, i.e. cost, time and resources • Understands risk management principles in an engineering context • Understands change management principles in an engineering context • Understands the limitation of engineering management techniques
EP.3 - Applies business tools and economics principles in managing engineering projects (or the engineering practice)	• Applies engineering economic principles and business tools as appropriate in project management • Analyzes the economic viability of engineering projects by applying economic tools and principles • Identifies, selects, and uses the appropriate project management tools understands the limitations of the different tools • Identifies the requirements, assumptions, risks and constraints • Creates measurable objectives • Plans the project within the project constraints, creates a schedule, performs risk analysis, considers plans to manage changes • Evaluates cost of alternative approaches, assesses purchases and creates procurement document, reports on project progress, produces deliverables • Applies risk management principles in an engineering project • Applies change management principles in an engineering project

LL - Life-long learning

An ability to identify and to address their own educational needs in a changing world, sufficiently to maintain their competence and contribute to the advancement of knowledge.

Indicators	Indicator Descriptions
LL.1 - Sets goals	• Aims to achieve • Has goals for extra-curricular engagement • Has career goals
LL.2 - Applies appropriate knowledge and skills to learning activities	• Manages own learning in changing conditions • Is unsatisfied with superficial explanations or understanding • Questions assumptions and identifies personal limitations
LL.3 - Engages in self-direction and self-evaluation	• Engages in self-study on topics of interest • Keeps updated with knowledge of current events in the engineering discipline and in society • Reviews and reflects on and make improvements on own skills and educational needs • Engages in reflection on issues of local, national and global changes
LL.4 - Locates required information	• Finds appropriate information from various sources and checks relevant references • Assesses credibility of information, refers to course or recommended textbook(s) for details.
LL.5 - Adapts learning strategies to new conditions	• Recognizes parallels, analogies or similarities of new situations to more familiar situations • Adapts from known approach • Generates new tactics as needed • Researches engineering topics outside of the scope of formal coursework • Understands how information is applied in practice

References

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