UNIVERSITI SAINS MALAYSIA

SCHOOL OF MECHANICAL ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEO)

(Career and professional accomplishment that program is preparing graduates to achieve)

Our graduates are expected to achieve the following PEOs within five years of graduation from our program:

1. Excel in engineering practices in various industries with a focus on creative, innovative and sustainable solution
2. Establish themselves as leaders in their professional careers
3. Earn an advanced degree or professional certification

UNIVERSITI SAINS MALAYSIA

SCHOOL OF MECHANICAL ENGINEERING

PROGRAM OUTCOMES (PO)

Bachelor of Manufacturing Engineering with Management with Honours

PO1 Engineering Knowledge:
Apply knowledge of mathematics, natural science, computing and engineering fundamentals, and an engineering specialization as specified in WK1 to WK4 respectively to develop solutions to complex engineering problems particularly in manufacturing engineering

PO2 Problem Analysis:
Identify, formulate, research literature and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences with holistic considerations for sustainable development (WK1 to WK4)

PO3 Design/development of solutions:
Design creative solutions for complex engineering problems and design systems, components or processes to meet identified needs relevant to manufacturing engineering with appropriate consideration for public health and safety, whole-life cost, net zero carbon as well as resource, cultural, societal, and environmental considerations as required (WK5)

PO4 Investigation:
Conduct investigation of complex manufacturing engineering problems using research methods including research-based knowledge, including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions (WK8)

PO5 Tool Usage:
Create, select and apply, and recognize limitation of appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering problems, (WK2 and WK6)

PO6 The Engineer and the World:
Analyze and evaluate sustainable development impacts to: society, the economy, sustainability, health and safety, legal frameworks, and the environment, in solving complex engineering problems (WK1, WK5, and WK7)

PO7 Ethics:
Apply ethical principles and commit to professional ethics and norms of engineering practice and adhere to relevant national and international laws. Demonstrate an understanding of the need for diversity and inclusion (WK9)

PO8 Individual and Collaborative Team work:
Function effectively as an individual, and as a member or leader in diverse and inclusive teams and in multidisciplinary, face-to-face, remote and distributed settings (WK9)

PO9 Communication:
Communicate effectively and inclusively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, taking into account cultural, language, and learning differences

PO10 Project Management and Finance:
Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects in multidisciplinary environments

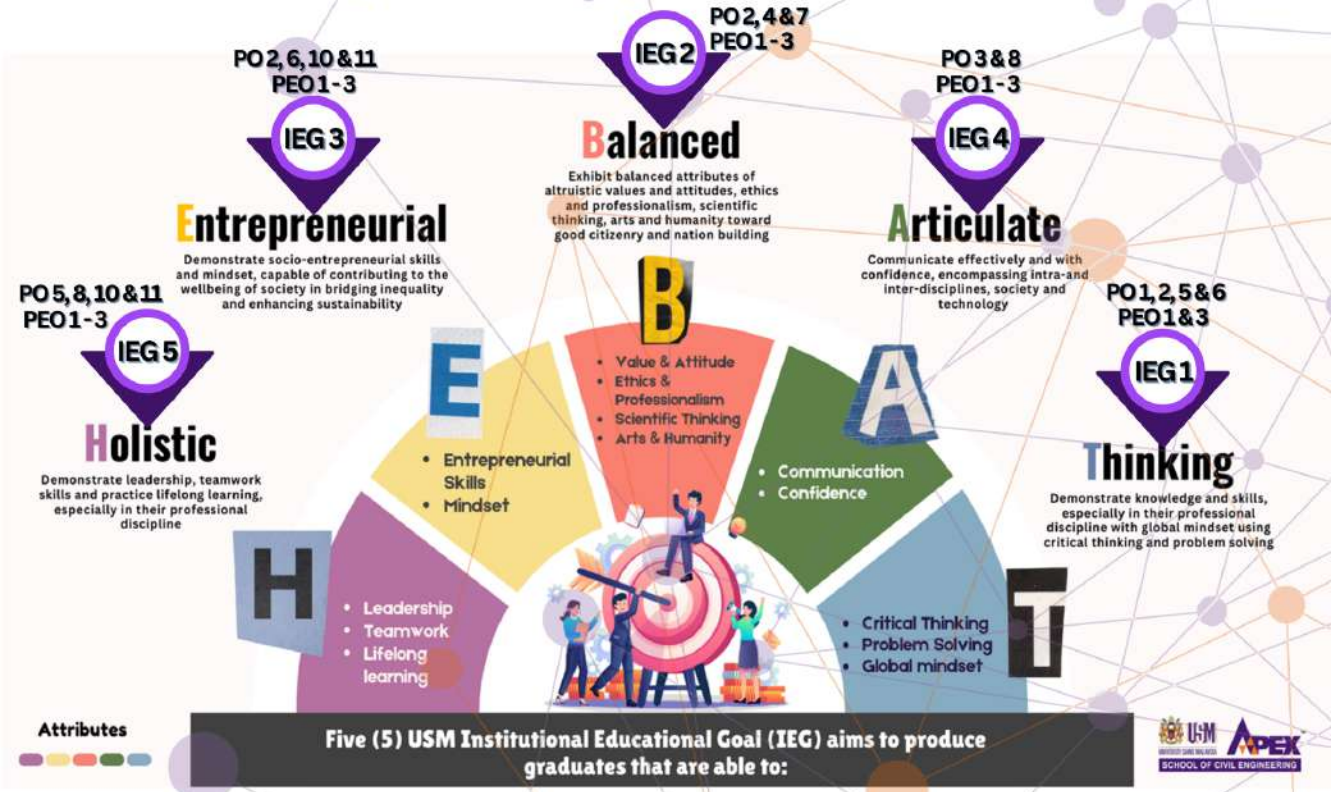
PO11 Lifelong learning:
Recognise the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change (WK8)

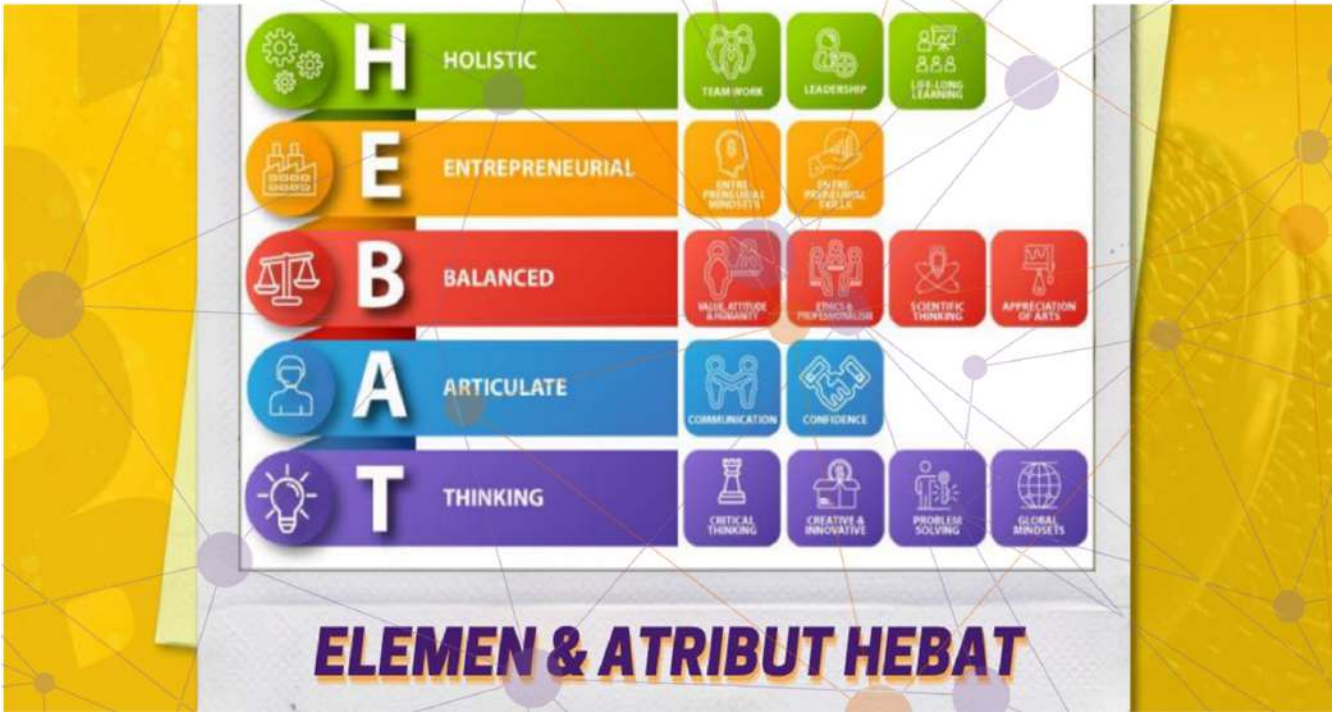
-BASED ON EAC STANDARD 2024-

UNIVERSITI SAINS MALAYSIA
SCHOOL OF MECHANICAL ENGINEERING

INSTITUTIONAL EDUCATIONAL GOAL (IEG)

is based on its HEBAT Agenda that aims to produce holistic, entrepreneurial mindset, balanced, articulate and thinking graduates to contribute to the wellbeing of the society, as well as meeting national and global needs.





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CLUSTER DIVISION OF PLO BASED ON THE MQF 2.0 DOCUMENT

The set of USM Programme Learning Outcomes (PLOs) based on MQF 2.0 is used for both undergraduate and postgraduate programmes, as both are accredited under the Malaysian Qualifications Agency (MQA).

However, for undergraduate programmes, the USM PLOs are used only for the Borang Penawaran Kursus (BPK), since the programmes are also accredited by another body — the Engineering Accreditation Council (EAC). For all Outcome-Based Education (OBE) management activities, including the development of teaching plans and mapping in OCADS, the EAC PPKM Programme Outcomes (POs) are used in accordance with the EAC Standard 2024.

EAC Program Outcomes (PO) - for OBE Management in PPKM		USM PLO (MQF 2.0) new mapping to EAC Standard 2024 (update on 10 Oct 2024)										
		Knowledge & understanding	Cognitive Skills	Practical Skills	Interpersonal Skills	Communication Skills	Digital Skills	Numeracy Skills	Leadership, Autonomy & Responsibility	Personal Skills	Entrepreneurial Skills	Ethics and Professionalism
		PLO1	PLO2	PLO3	PLO4	PLO5	PLO6	PLO7	PLO8	PLO9	PLO10	PLO11
PO1	Engineering knowledge	✓										
PO2	Problem Analysis		✓					✓				
PO3	Design / Development of Solutions		✓									
PO4	Investigation		✓									
PO5	Tool Usage			✓			✓					
PO6	The Engineer and the World											✓
PO7	Ethics											✓
PO8	Individual and Collaborative Team Work				✓				✓			
PO9	Communication					✓						
PO10	Project Management and Finance										✓	
PO11	Lifelong Learning									✓		

MQF2.0 Level	Summary of Learner's Profile	CLUSTER 1	CLUSTER 2	CLUSTER 3: FUNCTIONAL WORK SKILLS				CLUSTER 4	CLUSTER 5
		Knowledge & understanding	Cognitive Skills	Practical Skills	Interpersonal & Communication Skills	Digital & Numeracy Skills	Leadership, Autonomy & Responsibility	Personal & Entrepreneurial Skills	Ethics and Professionalism
LEVEL 6 BACHELOR GRADUATE CERTIFICATE / DIPLOMA	Learners will demonstrate a thorough comprehension of broad based and coherent body of knowledge and skills for para and full professional work embedding research, innovation and creativity in specialized areas. Demonstrate professionalism, resilience commitment to an ethical work culture, sustainability issues and an awareness of global citizenship in alignment with national aspirations.	Describe advanced and comprehensive, theoretical and technical knowledge and demonstrate relevant skills in a specialized field, or of a multidisciplinary nature related to the field of study, work and/or practice.	Demonstrate intellectual independence in the application of knowledge within specific field(s) by applying critical, analytical and evaluation skills in the field of study/work/practice. Manage, resolve complex applications and handle unpredictable issues with creative and innovative solution(s). Apply skill/ knowledge to a range of approaches in the field of study/work/practice.	Apply a range of essential methods and procedures to solving a broad range of complex problems. Review, make adjustments and supervise related practices and processes concerning field of specialization.	Convey ideas both in written or oral forms using appropriate and different forms of presentation, confidently, accurately and coherently in appropriate context in a well-structured manner to a diversity of audiences. Work together with different people in diverse learning and working communities as well as other groups locally and internationally.	Use a broad range of information, media and technology applications to support study and/or work. Use and combine numerical and graphical/visual data for study/work.	Work autonomously, and show leadership and professionalism in managing responsibilities within broad organizational parameters. Undertake significant levels of work related responsibilities of others as well as self. Demonstrate decision making capacities and professionalism by working towards pre-determined goals and outcomes. Demonstrate accountabilities, especially in professional fields.	Engage effectively in self-directed lifelong learning and professional pathways. Demonstrate entrepreneurial competency with selected project(s). Demonstrate an appreciation of broader socio-political, economic and cultural issues at local/national and regional level.	Demonstrate adherence, and ability to identify ethical issues, make decision ethically, and act professionally within the varied social and professional environment and practice. Demonstrate a deep familiarity and knowledge of local and global issues relating to science, technology, business, social and environmental issues.

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MAPPING GUIDELINE FOR PO-WK-WP/EA-PLO-LEARNING DOMAIN-SOFT SKILLS

This mapping guideline was developed by the OBE Committee of the School of Mechanical Engineering (PPKM), Universiti Sains Malaysia, and endorsed by the PPKM Council Meeting on 1st October 2024. It serves as an official reference for PPKM lecturers in preparing the Borang Penawaran Kursus (BPK) and teaching plans in accordance with OBE requirements.

EAC Program Outcomes (PO) (Standard 2024) *PO for CO/PO attainment		WK - Knowledge Profile	WP - Complex Problem EA - Engineering Activity	Updated Program learning Outcome (PLO) by USM (29th Sept 2024) *PLO for BPK documentation*	Learning Domain (LD) of MechE/MfrgE USM	Learning Domain (LD) NOBLe 2021 by KPT	Soft Skills or Kemahiran Insaniah (KI)
		WK	WP / EA	PLO USM	LD PPKM	LD KPT	Soft Skills
PO1	Engineering knowledge	WK1-WK4	WP	PLO1 - Knowledge & Understanding	C	C	-
PO2	Problem Analysis	WK1-WK4	WP	PLO2 - Cognitive Skills	C	C	CTPS
				PLO7 - Numeracy Skills	C	C	CTPS
PO3	Design / Development of Solutions	WK5	WP	PLO2 - Cognitive Skills	C	C	CTPS
PO4	Investigation	WK8	WP	PLO2 - Cognitive Skills	C	C	CTPS
PO5	Tool Usage	WK2, WK6	WP	PLO3 - Practical Skills	P/C	P	-
				PLO6 - Digital Skills	P/C	C/P/A	CTPS
PO6	The Engineer and the World	WK1, WK5, WK7	WP	PLO11 - Ethics & Professionalism	A/C	A	EM
PO7	Ethics	WK9	-	PLO11 - Ethics & Professionalism	A/C	A	EM
PO8	Individual and Collaborative Team Work	WK9	-	PLO4 - Interpersonal Skills	A	A	TS
				PLO8 - Leadership, Autonomy & Responsibility Skills	A	A	LS
PO9	Communication	-	EA	PLO5 - Communication Skills	A	A	CS
PO10	Project Management and Finance	-	-	PLO10 - Entrepreneurial Skills	A/C	A	KK
PO11	Lifelong Learning	WK8	-	PLO9 - Personal Skills	A/C	A	LL

ABBR. DESCRIPTION

LD — LEARNING DOMAIN
- C — Cognitive
- P — Psychomotor
- A — Affective

WK — KNOWLEDGE PROFILE (ACCORDING TO WASHINGTON ACCORD)
- WK1 — Theory-based understanding of natural and social sciences.
- WK2 — Mathematics, data analysis, statistics, and computing for modeling.
- WK3 — Theory-based engineering fundamentals.
- WK4 — Specialist knowledge driving current engineering practices.
- WK5 — Knowledge of sustainability, cost, and resource use in design.
- WK6 — Knowledge of engineering technology in practice.
- WK7 — Understanding engineering's role in society, safety, and sustainability.
- WK8 — Engage with research, critical thinking, and emerging issues.
- WK9 — Knowledge of ethics, responsibilities, and inclusivity.

WP — COMPLEX ENGINEERING PROBLEM
- WP1 — Requires advanced engineering knowledge (WP3+)
- WP2 — Involves conflicting technical and non-technical issues, with future considerations.
- WP3 — Requires abstract thinking, creativity, and original analysis to develop solutions.
- WP4 — Involve infrequently encountered issues or novel problems.
- WP5 — Addresses problems outside established engineering standards and codes.
- WP6 — Involves cross-disciplinary collaboration with diverse stakeholders.
- WP7 — Solves complex problems with many parts, often needing a systems approach.

EA — COMPLEX ENGINEERING ACTIVITIES
- EA1 — Involves using diverse resources—people, data, materials, finances, and tech.
- EA2 — Requires resolving conflicting technical, non-technical, and engineering issues.
- EA3 — Involves creative engineering, innovation, and research.
- EA4 — Have significant, unpredictable consequences across various contexts.
- EA5 — Can go beyond past experience using principles.

Note:

KIM — Kemahiran Insaniah Mesti @ Compulsory Soft Skills

KIT — Kemahiran Insaniah Tambahan @ Additional Soft Skills

- Kemahiran Insaniah (KI) dikategorikan kepada KIM dan KIT
- Pemilihan ciri KI bagi setiap CO boleh dipilih daripada salah satu pilihan yang disenaraikan MQA bersesuaian dengan perlaksanaan kursus.
- Sekiranya ciri KI yang dipilih berada pada bahagian KIT, ini bermakna kesemua ciri KIM akan dipenuhi/diperlukan bersama dengan ciri KIT yang dipilih.

KI - KEMAHIRAN INSANIAH/SOFTSKILLS (CS, CTPS, TS, LL, KK, EM, LS)

CS — COMMUNICATION SKILLS
- CS1 — Communicates clearly, orally and in writing.
- CS2 — Listens actively and gives feedback.
- CS3 — Delivers confident, audience-appropriate presentations.
- CS4 — Uses technology in presentations.
- CS5 — Negotiates and agrees.
- CS6 — Communicates across cultures.
- CS7 — Develops communication skills.
- CS8 — Uses non-verbal skills.

CTPS — CRITICAL THINKING AND PROBLEM SOLVING SKILLS
- CTPS1 — Identifies and analyzes complex problems.
- CTPS2 — Improves analysis and evaluation skills.
- CTPS3 — Finds ideas and solutions.
- CTPS4 — Thinks beyond boundaries.
- CTPS5 — Makes decisions based on evidence.
- CTPS6 — Handles and focuses on responsibilities.
- CTPS7 — Adapts to new cultures and environments.

TS — TEAMWORK SKILLS
- TS1 — Build relationships, collaborate, and work towards shared goals.
- TS2 — Understand and take on roles as a leader and team member.
- TS3 — Recognize and respect others' attitudes, beliefs, and viewpoints.
- TS4 — Contribute to group planning and tasks.
- TS5 — Take responsibility in group decision-making.

LL — LIFELONG LEARNING AND INFORMATION MANAGEMENT SKILLS
- LL1 — Search and manage information from various sources.
- LL2 — Accept new ideas and learn independently.
- LL3 — Cultivate a curious and knowledge-seeking mindset.

KK — ENTREPRENEURIAL SKILLS
- KK1 — Identify business opportunities.
- KK2 — Plan business strategies
- KK3 — Build, explore, and seize business and career opportunities.
- KK4 — Work independently.

EM — ETHICS AND PROFESSIONAL MORAL
- EM1 — Understand the impacts of economics, environment, and culture on work.
- EM2 — Analyze and make decisions to solve ethical problems.
- EM3 — Practice ethics and be responsible to society.

LS — LEADERSHIP SKILLS
- LS1 — Master knowledge of basic leadership theories.
- LS2 — Lead projects.
- LS3 — Understand and take on roles as a leader and team member.
- LS4 — Supervise team members.

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KNOWLEDGE PROFILE (WK)

The list of WK define indicated volume of learning and attributes against which graduates must be able to perform. The list is used to extend and clarify the definition of the Graduate Attributes (see the PO list above). The curriculum shall encompass the knowledge and attitude profile as summarised in the table below:

WK	CATEGORY	DESCRIPTION	RELATED PO EAC
WK1	**Natural Sciences**	A systematic, theory-based understanding of the **natural sciences** applicable to the discipline and awareness of relevant **social sciences**	**PO1, PO2, PO6**
WK2	**Mathematics**	Conceptually-based **mathematics**, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline	**PO1, PO2, PO5**
WK3	**Engineering Fundamentals**	A systematic, theory-based formulation of **engineering fundamentals** required in the engineering discipline.	**PO1, PO2**
WK4	**Specialist Knowledge**	Engineering **specialist knowledge** that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.	**PO1, PO2**
WK5	**Engineering Design**	Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports **engineering design and operations** in a practice area	**PO3, PO6**
WK6	**Engineering Practice**	Knowledge of **engineering practice** (technology) in the practice areas in the engineering discipline.	**PO5**
WK7	**Societal Roles**	**Knowledge** of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.	**PO6**
WK8	**Research Literature**	Engagement with selected knowledge in the current **research literature** of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues	**PO4, PO11**
WK9	**Ethics, inclusive behavior and conduct**	**Ethics, inclusive behavior and conduct.** Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes	**PO7, PO8**

Reference: EAC Standard 2024

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RANGE OF COMPLEX ENGINEERING PROBLEM (WP)

The list of WP clarifies the definition of Complex Engineering Problem by establishing seven range, or attributes of problem solving. Based on this list of WP, the attributes of a Complex Engineering Problem is that it must have WP1 and some or all of WP2 to WP7:

WP	ATTRIBUTE	DESCRIPTION
WP1	Depth of Knowledge Required	Cannot be resolved without in-depth engineering knowledge at the level of one or more of WK3, WK4, WK5, WK6 or WK8 which allows a fundamental-based, first principles analytical approach.
WP2	Range of conflicting requirements	Involve wide-ranging and/or conflicting technical, nontechnical issues (such as ethical, sustainability, legal, political, economic, societal) and consideration of future requirements
WP3	Depth of analysis required	Have no obvious solution and require abstract thinking, creativity and originality in analysis to formulate suitable models
WP4	Familiarity of issues	Involve infrequently encountered issues or novel problems
WP5	Extent of applicable codes	Address problems not encompassed by standards and codes of practice for professional engineering
WP6	Extent of stakeholder involvement and conflicting requirements	Involve collaboration across engineering disciplines, other fields, and/or diverse groups of stakeholders with widely varying needs
WP7	Interdependence	Address high level problems with many components or sub-problems that may require a systems approach

RANGE OF COMPLEX ENGINEERING ACTIVITIES (EA)

There are five attributes of activities student can be involved in when solving Complex Engineering Problem. A Complex Engineering Activity or Project is that which has some or all of the following attributes:

EA	ATTRIBUTE	DESCRIPTION
EA1	Range of resources	Involve the use of diverse resources including people, data and information, natural, financial and physical resources and appropriate technologies including analytical and/or design software
EA2	Level of interactions	Require optimal resolution of interactions between wide-ranging and/or conflicting technical, nontechnical, and engineering issues
EA3	Innovation	Involve creative use of engineering principles, innovative solutions for a conscious purpose, and research-based knowledge
EA4	Consequences to society and the environment	Have significant consequences in a range of contexts, characterised by difficulty of prediction and mitigation.
EA5	Familiarity	Can extend beyond previous experiences by applying principle-based approaches.

Reference: EAC Standard 2024

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LEARNING DOMAIN

The LD are based on the three learning domains, i.e., cognitive (C), affective (A), and psychomotor (P), and their levels of learning are listed below:

Six levels of the Cognitive (C) Domain (Anderson and Krathwohl's Taxonomy 2001):

BLOOM'S LEVEL	LEVEL OF LEARNING	CHARACTERISTICS OF LEARNING	BLOOM'S ACTION VERBS (EXAMPLE)
C1	Remembering	Recognizing and recalling relevant knowledge from long term memory.	List, Identify, Outline, Define, Arrange, Select, State, Match, Name, Recognise, Label, Know, Recall, Reproduce
C2	Understanding	Constructing meaning from oral, written and graphic messages through interpreting, classifying, summarizing, inferring, comparing and explaining.	Explain, Describe, Interpret, Distinguish, Summarize, Paraphrase, Illustrate, Convert, Discuss, Estimate, Classify, Rephrase, Translate, Show, Relate, Comprehend, Defend, Extend, Generalize, Gives an example, Infer, Rewrite
C3	Applying	Carrying out or using a procedure through executing or implementing.	Apply, Calculate, Solve, Use, Compute, Demonstrate, Construct, Sketch, Write, Discover, Manipulate, Modify, Operate, Prepare, Produce, Run
C4	Analyzing	Breaking Material into constituent parts, determining how the parts relate to one another and to an overall structure or purpose through differentiating, organizing and attributing.	Analyze, Analyse, Compare, Derive, Categorize, Contrast, Assume, Conclusion, Examine, Simplify, Break down, Diagram, Deconstruct, Differentiate, Discriminate, Separate
C5	Evaluating	Making judgments based on criteria and standards through checking and critiquing.	Determine, Optimize, Evaluate, Agree, Appraise, Assess, Choose, Criticize, Decide, Influence, Judge, Justify, Measure, Opinion, Recommend, Prove
C6	Creating	Putting elements together to form a coherent or function whole; recognizing elements into a new pattern or structure through generating, planning or producing.	Formulate, Design, Create, Adapt, Build, Change, Combine, Compile, Develop, Propose, Predict, Conclude

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Five levels of the Affective (A) Domain (Krathwohl, Bloom, Masia 1973):

BLOOM'S LEVEL	LEVEL OF LEARNING	CHARACTERISTICS OF LEARNING	BLOOM'S ACTION VERBS (EXAMPLE)
A1	Receiving Phenomena	Awareness, willingness to hear, selected attention.	Ask, choose, describe, follow, identify, locate, name, select, reply, use, acknowledge, attentive, courteous, dutiful, gives, listens, understands
A2	Responds to Phenomena	Active participation, interaction or response to new information or experiences.	Answer, assist, aid, compile, conform, discuss, help, label, perform, practice, present, read, recite, report, select, tell, write
A3	Valuing	Value or worth a person attaches to particular object, phenomenon or behavior. This ranges from simple acceptance to more complex state of commitment.	Complete, demonstrate, differentiate, explain, follow, form, initiate, join, justify, propose, read, share, study, work, appreciates, cherish, treasure, invites, respect
A4	Organization	Incorporating new information or experiences to existing system	Adhere, alter, arrange, combine, compare, complete, defend, formulate, generalize, identify, integrate, modify, order, organize, prepare, relate, synthesize
A5	Internalizes Values (Characterization)	Value system that controls their behavior. The behavior is pervasive, consistent, predictable and most importantly, characteristic of the learner	Act, discriminate, display, influence, listen, modify, perform, practice, propose, qualify, question, revise, serve, solve, verify, use

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Seven levels of the Psychomotor (P) Domain (Simpson, 1972):

BLOOM'S LEVEL	LEVEL OF LEARNING	CHARACTERISTICS OF LEARNING	BLOOM'S ACTION VERBS (EXAMPLE)
P1	Perception (awareness)	Uses senses organs to obtain cues to guide action: ranges from awareness of stimulus to translating cue perception into action.	Choose, describe, detect, differentiate, distinguish, identify, isolate, relate, select, separate
P2	Set	Readiness to take action: includes mental, physical and emotional set.	Begin, display, explain, move, proceed, react, respond, how, start, volunteer
P3	Guided Response	Knowledge of the steps required to perform a task: includes imitation and trial and error.	Copies, traces, follows, react, reproduce, responds
P4	Mechanism (basic proficiency)	Perform tasks in a habitual manner: with a degree of confidence and proficiency.	Assembles, calibrates, constructs, dismantles, displays, fastens, fixes, grinds, heats, manipulates, measures, mends, mixes, organizes, sketches
P5	Complex Overt Response (Expert)	Skill performance of motor acts involving complex patterns of movement.	Assembles, builds, calibrates, constructs, dismantles, displays, fastens, fixes, grinds, heats, manipulates, measures, mends, mixes, organizes, sketches Note: The examples are the same as Mechanism, but will have adverbs or adjectives that indicate that the performance is quicker, better, more, accurate, etc.
P6	Adaptation	Modifies movement patterns to account for problematic or new situations.	Adapt, alter, chance, rearrange, reorganize, revise, vary
P7	Origination	Creating new movement patterns to account for problematic or new situations; creates new tasks that incorporate learned ones.	Arranges, builds, combines, composes, constructs, creates, designs, initiate, makes, originates