Blooms Taxonomy - Preparing CLOs and Mapping with PLOs

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Outline & outcome

Outlines

- Teaching Learning (15 mins)
  - Teaching learning materials, activities
  - Assessment tools
- Learning Outcome (75 mins)
  - Program learning outcome
  - Bloom's domain and learning taxonomy
  - Course outcome and mapping with POs
  - Writing proper CO statement - examples

Outcomes

At the end of this seminar / workshop, the participants are expected to

- understand the good practice of OBE-based Teaching, learning and assessment
- write good course outcome statement & proper matching with program outcomes
- contribute preparing SAR for BAETE accreditation

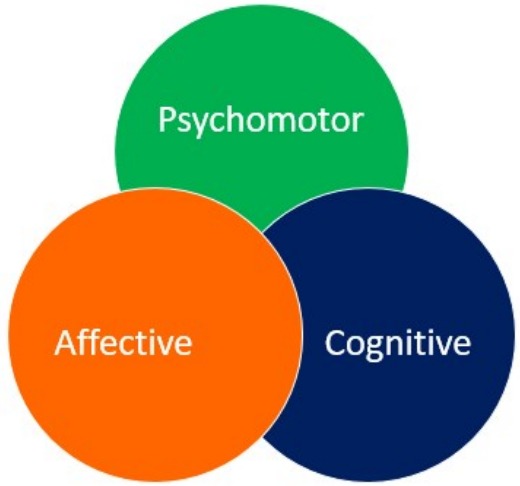
8. Program outcome (PO)

Program Outcomes	NO	Learning Taxonomy
Engineering Knowledge (K1-K4)	PO1	Cognitive
Problem Analysis (K1-K4)	PO2	Cognitive
Design/development of Solutions (K5)	PO3	Cognitive
Investigation (K8)	PO4	Cognitive, Psychomotor
Modern Tool Usage (K6)	PO5	Cognitive, Psychomotor
The Engineer and Society (K7)	PO6	Cognitive, Affective
Environment and Sustainability (K7)	PO7	Cognitive, Affective
Ethics (K7)	PO8	Cognitive, Affective
Individual Work and Teamwork	PO9	Affective
Communication	PO10	Affective
Project Management and Finance	PO11	Cognitive, Affective
Life-Long Learning	PO12	Affective

8.2 Course outcome (CO)

A *Learning Outcome (LO)* is a

- **measurable**, **observable,** and **specific** statement that clearly indicates what a student should know and **be able to do** as a **result** of learning.



Well-written LOs involve the following parts:

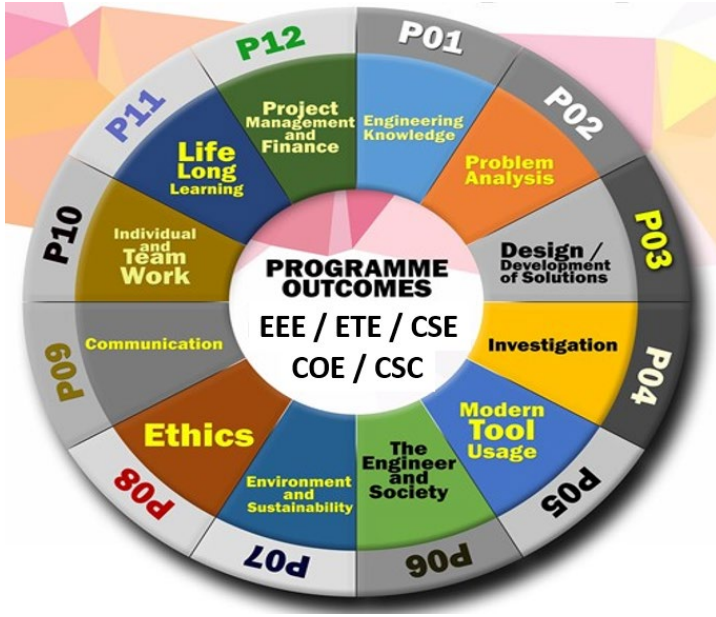
action verb → subject content → level of achievement → condition of performance *(if applicable)*

Skills or Products students are expected to learn

+

Measure of proficiency students are expected to achieve in the skill or product

→ Student Learning Outcome



8.2 CO statement – course outline template

CO No.	CO Statement	Corresponding PO	Domain & level of learning taxonomy	Delivery methods and activities	Assessment tools
CO1					
CO2					
CO3					
CO4					
CO5					

6.4 Teaching-learning activities and materials

Teaching-learning activities	
Theory	**Lab**
☑ Lecture	☑ Demonstration
☑ Tutorial	☑ Simulation
☑ Discussion	☑ Experiment
☑ Interaction, Q&A	☑ Group work
☑ Audio/Video	☑ Practice lab
☐ Others: _____	☐ Others: _____

Teaching-Learning Materials
☑ Lecture Note
☑ Handout
☑ Text & reference books
☑ Journal / conference papers
☑ Online materials
☑ Lab manual / lab sheet
☐ Others: _____

6.4 Teaching-learning and assessment (theory)

Assessment Method	Assessment Tools	Marks Distribution	%
Continuous Assessment	Class Participation / Performance	05%	50%
	Class Tests / Quiz	15%	
	Assignment / Case Studies / Field Trip	15%	
	Project / Presentation / Report / Others	15%	
Summative Assessment	Mid Term Examination	20%	50%
	Final Examination	30%	
Total		**100%**	**100%**

6.4 Teaching-learning and assessment (lab)

Assessment Method	Assessment Tools	Marks Distribution	%
Continuous Assessment	Class Participation / Performance	05%	60%
	Lab Report	40%	
	Lab Assignment	05%	
	Project / Presentation / Report / Others	10%	
Summative Assessment	Final Lab Test and Lab Report	20%	40%
	Open Ended Lab Report	20%	
Total		**100%**	**100%**

8.2.2 Relationship between COs and POs (example)

CO-PO Mapping														
Course ID	Course Title	COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
EEE 131	Electrical Circuit-I	CO1	X											
		CO2	X											
		CO3	X											
EEE 211	Electrical Circuit-II	CO1	X											
		CO2	X											
		CO3		X										
		CO4		X										
EEE 211L	Electrical Circuit Lab	CO1					X							
		CO2									X			

8.3 K-P-A

K - Knowledge Profile

P – Complex Engineering Problems

A- Complex Engineering Activities

- **K-P-A can be addressed through**
  - Complex engineering projects (course / lab)
  - Complex engineering assignments (course / lab)
  - Project labs
  - Open-ended labs
  - Final year design project (FYDP)

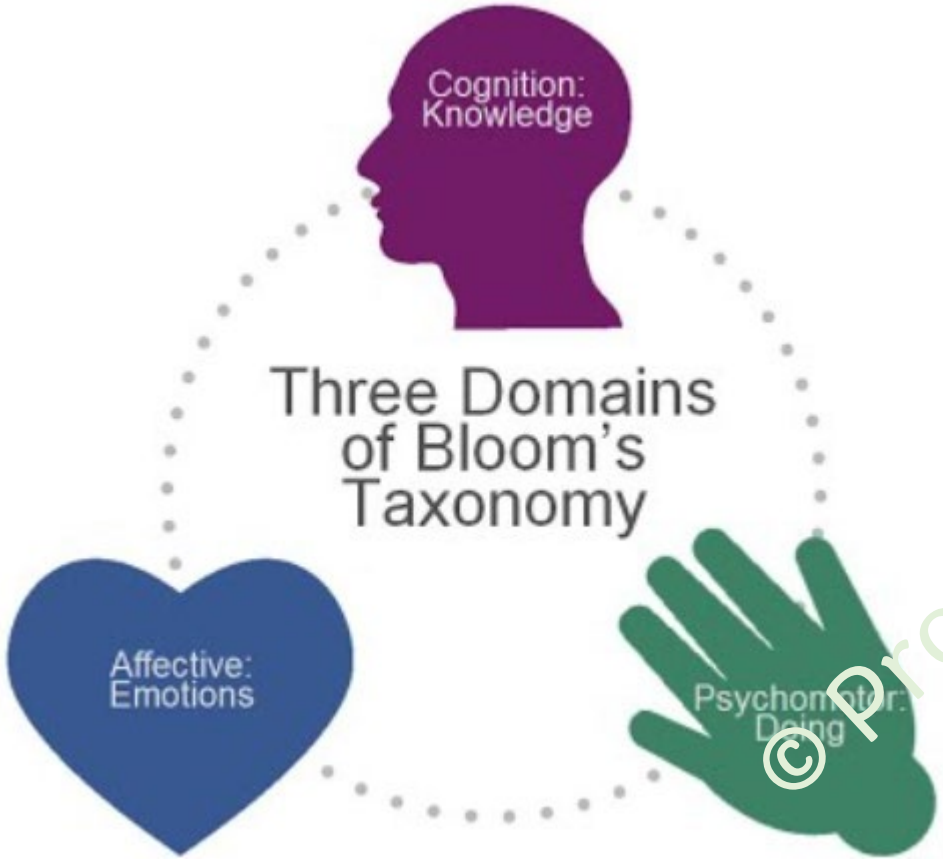
8.2.2 CO-PO-K-P-A mapping (example)

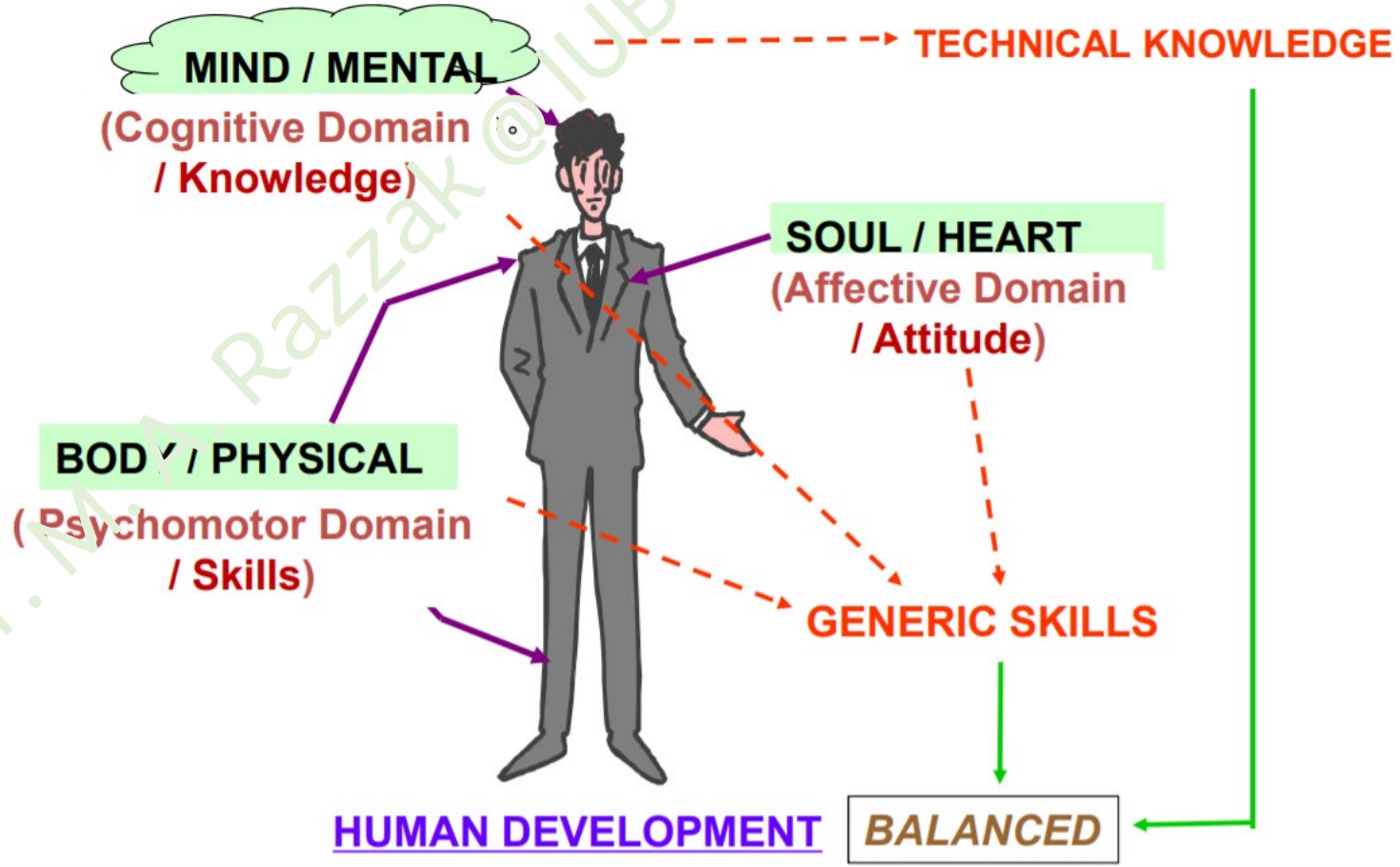
All Courses: Course ID, Course Title and Credit-Hours			Program Outcomes (POs)												Knowledge Profile								Complex Engineering Problems							Complex Engineering Activities				
			Engineering Knowledge	Problem Analysis	Design of Solution	Investigation	Modern Tools Usage	Engineer & Society	Environment & Sustainability	Ethics	Individual Work / Team Work	Communication	Project Management & Finance	Life Long Learning	PO1-PO2				PO3	PO5	PO6-PO8	PO4	PO1-PO7							PO10				
Course ID	Course Title	Cr.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	Natural Sciences	Mathematics	Engineering Fundamentals	Specialist Knowledge	Engineering Design	Engineering Practice	Comprehension	Research Literature	Depth of knowledge required (K3-K5,K8)	Range of conflicting requirements	Depth of analysis required	Familiarity of issues	Extent of Applicable Codes codes	Extent of stakeholder involvement	Interdependence	Range of resources	Level of interactions	Innovation	Consequences to society/environment	Familiarity
			K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5												
EEE131	Electrical Circuit - I	3	C4												√	√	√						√		√	√							
EEE132	Introduction to Materials and Chemistry	3	C2												√	√	√						√		√	√							
EEE211	Electrical Circuit-II	3	C3	C4											√	√	√						√		√								
EEE211L	Electrical Circuit Lab	1					P5				P3				√	√	√			√			√		√								
EEE221	Electronics - I	3	C4														√						√		√								
EEE222L	Electrical & Electronic Circuits	1					P3				A3						√		√	√			√		√	√							
EEE223	Mechanical Engineering Fundamentals	3															√																
EEE231	Signals and Systems	3	C3	C4												√	√						√		√								
EEE232	Digital Logic Design	3	C2	C3	C6											√	√	√	√				√		√	√							
EEE232L	Digital Logic Design Lab	1					P3				A3					√	√		√	√			√		√	√							
EEE233	Energy Conversion - I	3	C3	C4					C2						√	√	√						√		√								

8.3 K-P-A mapping – dominating model (example)

Selected Courses			Program Outcomes (POs)												Knowledge Profile								Complex Engineering Problems							Complex Engineering Activities				
			Engineering Knowledge	Problem Analysis	Design of Solution	Investigation	Modern Tools Usage	Engineer & Society	Environment & Sustainability	Ethics	Individual Work / Team Work	Communication	Project Management & Finance	Life Long Learning	PO1-PO2				PO3	PO5	PO6 PO8	PO4	PO1-PO7							PO10				
Course ID	Course Title	Cr.	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	K1	K2	K3	K4	K5	K6	K7	K8	P1	P2	P3	P4	P5	P6	P7	A1	A2	A3	A4	A5
															Natural Sciences	Mathematics	Engineering Fundamentals	Specialist Knowledge	Engineering Design	Engineering Practice	Comprehension	ResArch Literature	Depth of knowledge required (K3-K5,K8)	Range of conflicting requirements	Depth of analysis required	Familiarity of issues	Extent of Applicable Codes	Extent of stakeholder	Interdependence	Range of resources	Level of interactions	Innovation	Consequences to society/environmen	Familiarity
EEE 313	Electromagnetic Fields and Waves	3	C3	C4								A3			√	√	√						√		√					√			√	
EEE 315L	Electrical and Electronic Project	1		C4	C6			A3	A3	A2			C3				√		√	√	√		√		√									
EEE 316L	Engineering Drawing and Electrical	1		P3	P3		P4	P4									√	√	√	√	√	√	√		√									
EEE 321	Digital Signal Processing	3	C3	C4	C6						A3					√	√	√	√	√			√		√									
EEE 321L	Digital Signal Processing Lab	1				P4	P3											√	√	√		√	√		√									
ETE 322	Communication Engineering - II	3	C3		C6							A3		A3		√	√	√	√	√		√	√		√	√				√			√	√
ETE 322L	Communication Engineering Lab	1				P4	P3										√	√		√		√	√		√									
EEE334	Embedded Systems	3			C6	P4					A3	A3					√	√	√	√	√	√	√		√	√				√	√			√
EEE 422	Ethics, Engineering Economics and	3						C5		A3			C5			√					√		√		√									
EEE 332	Power Electronics and Drives	3		C4	C6				A3					A4		√	√	√	√	√	√	√	√		√	√								
EEE 332L	Power Electronics and Drives Lab	1				P4	P3										√	√	√	√		√	√		√									
EEE 411	Control Systems	3	C3	C6	C6							A3				√	√	√	√	√			√		√	√				√				√
EEE 411L	Control Systems Lab	1					P3				A3						√	√	√	√			√		√									
EEE 400	Final Year Design Project	6		C4	C6	P3	P3	A4	A4	A3	A4	A3	C4	A4			√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√	√

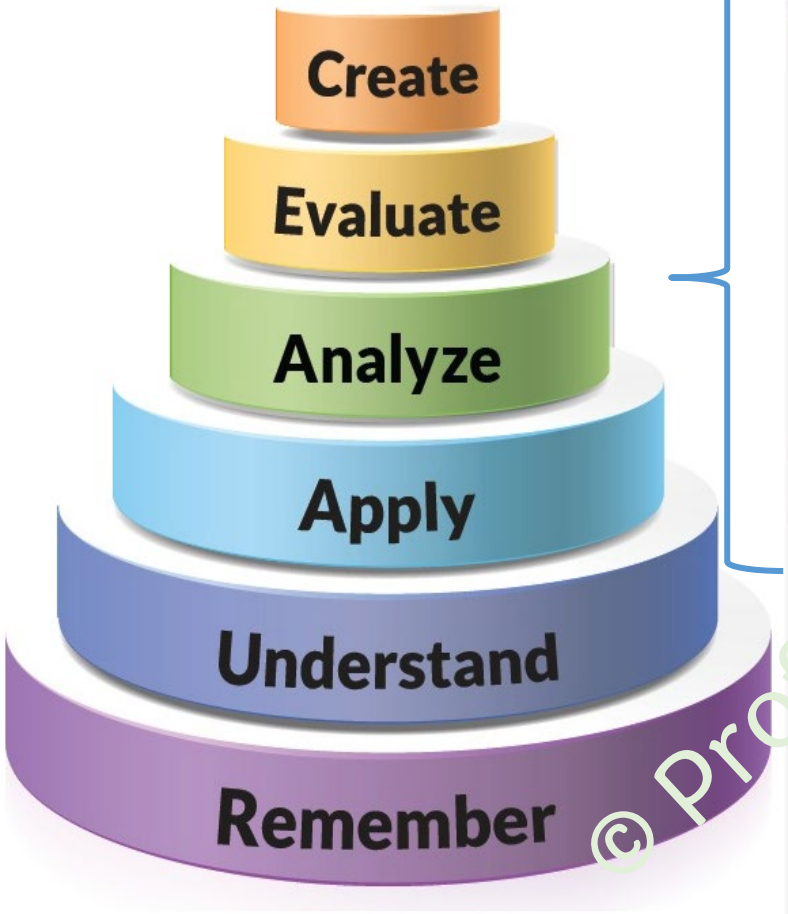
Domain of learning taxonomy for Teaching-Learning



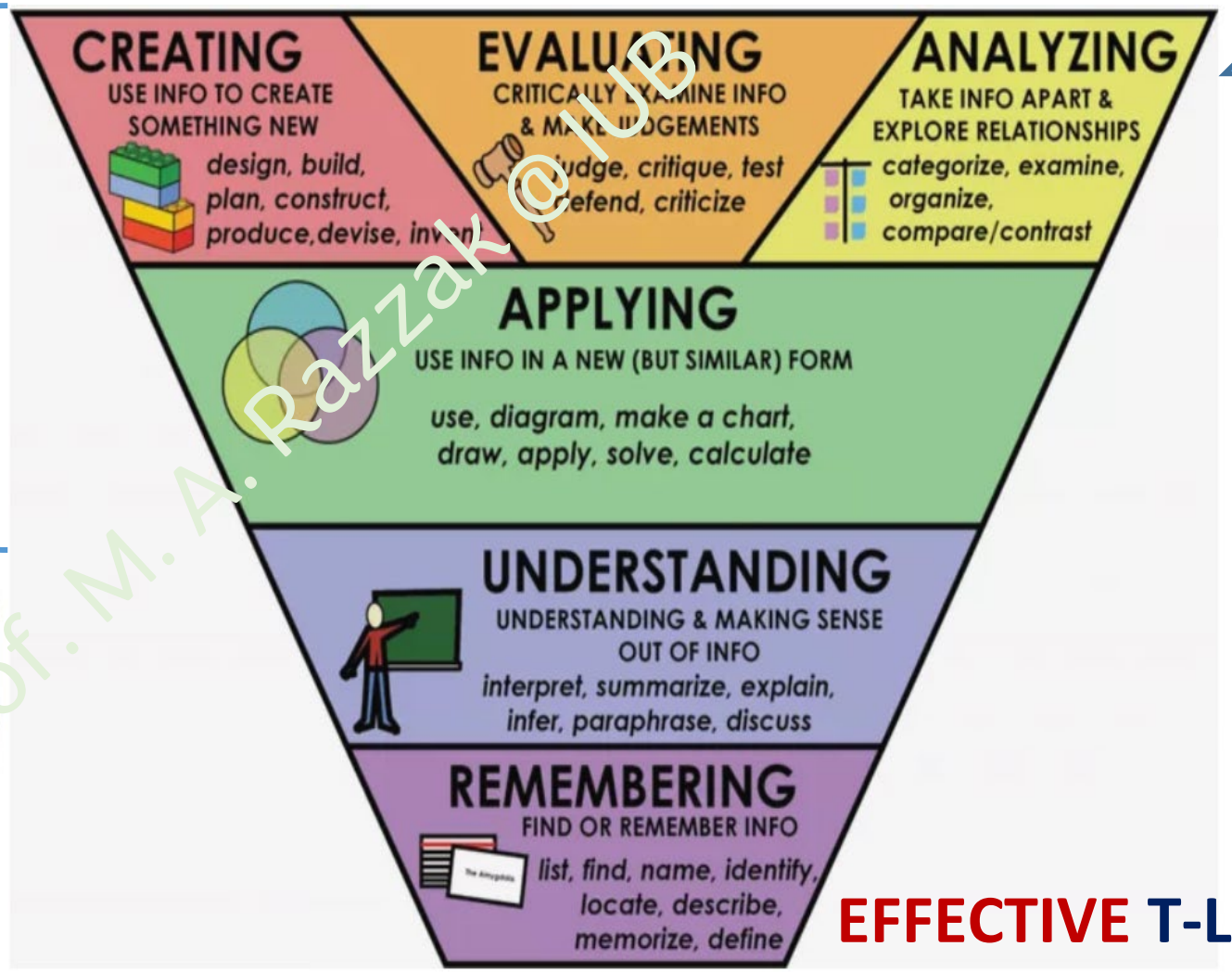


Bloom's Taxonomy - Cognitive Domain

LOWER ORDER THINKING



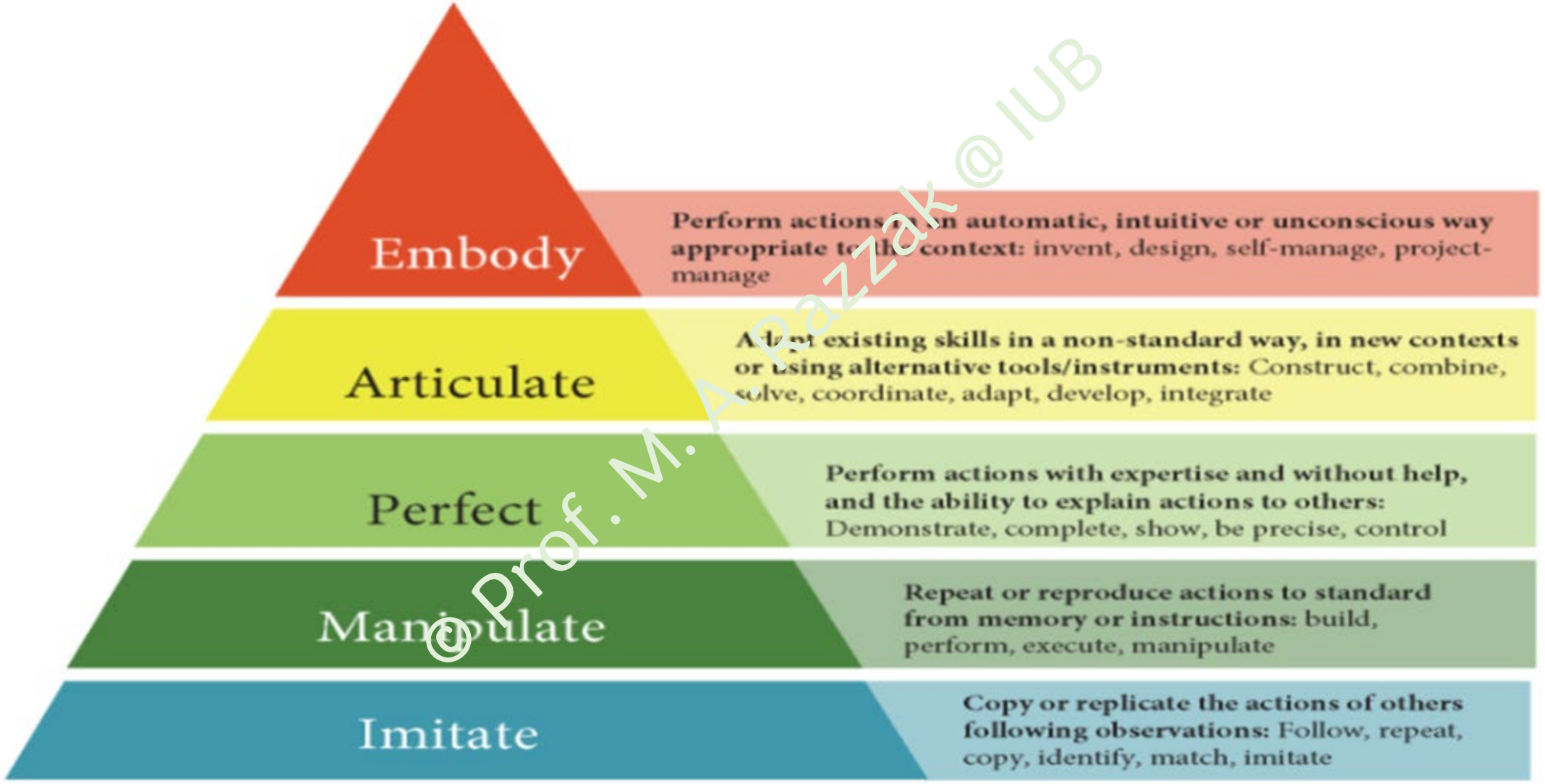
NOMINAL T-L



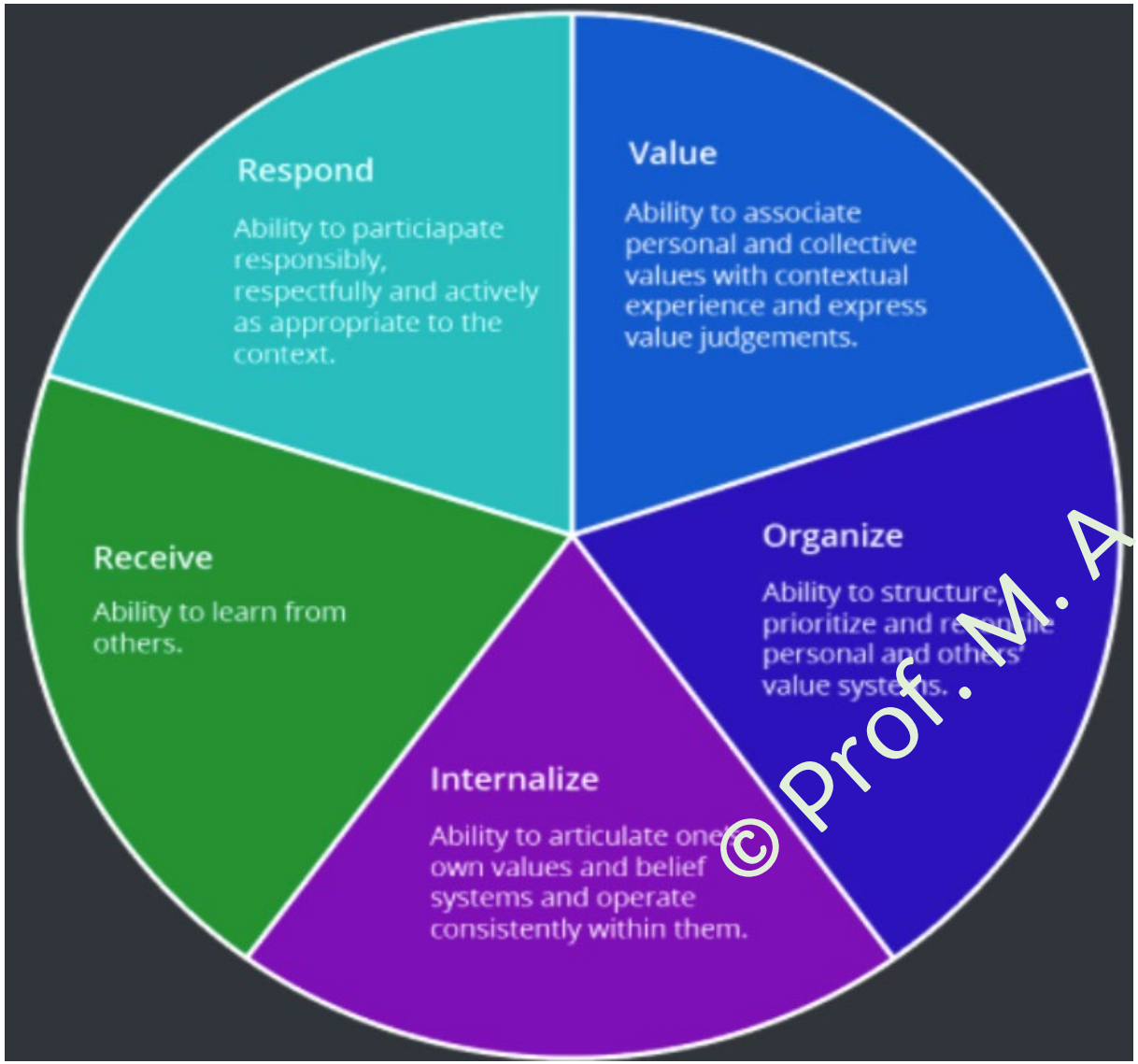
EFFECTIVE T-L

HIGHER ORDER THINKING

Bloom's Taxonomy - Psychomotor Domain

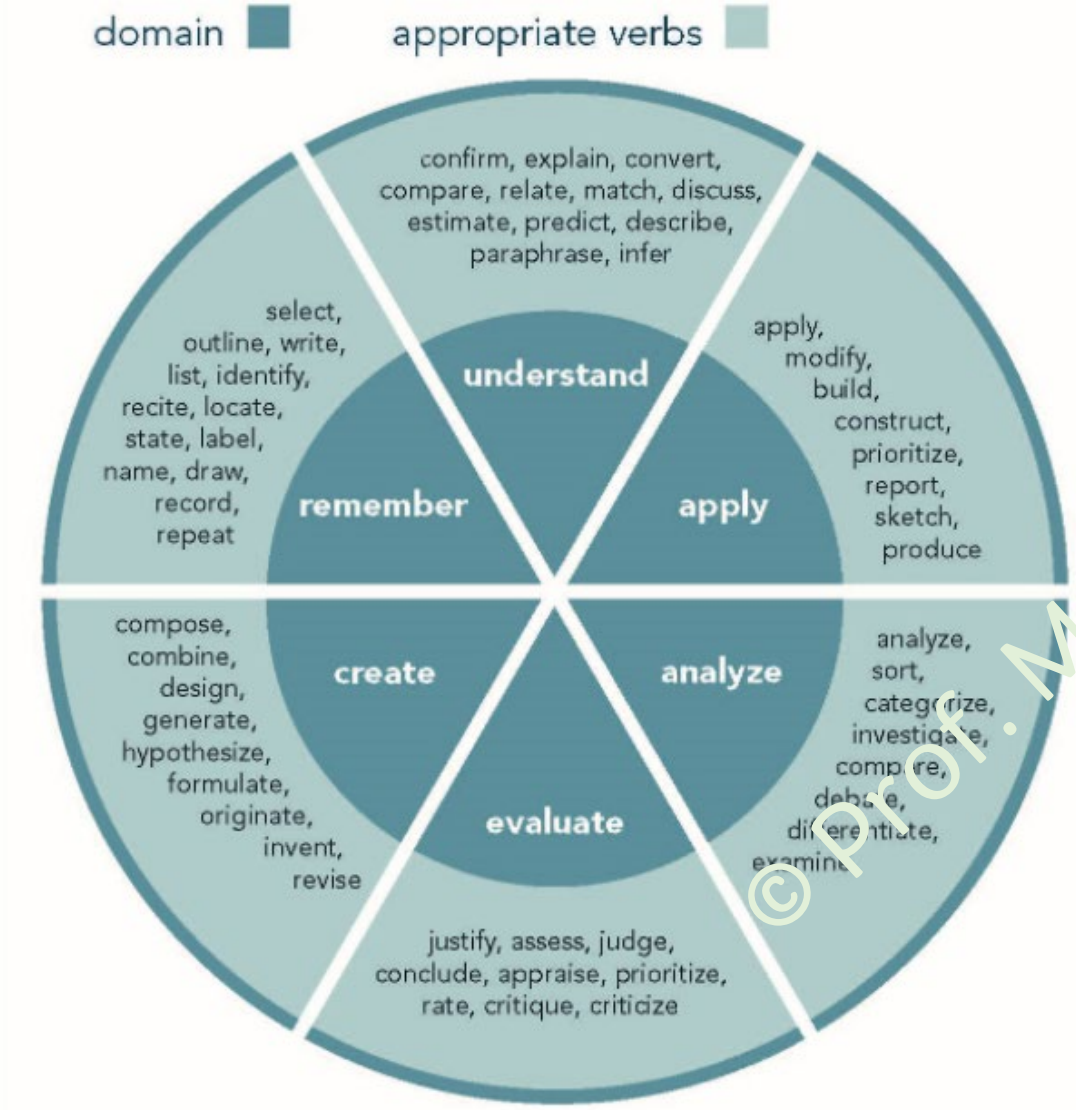


Bloom's Taxonomy - Affective Domain



Level of Taxonomy	TL Delivery - applying affective domain
Receive: willing to hear and learn with respect	• Be willing to hear and learn with respect anything that can improve delivery • Ask students if they are happy with teaching methods • Hold a class discussion on a different topic every week so that students can actively participate
Respond: react and participate actively	• Encourage students to present new ideas to address different problems
Value: attach values and express personal opinions	• Create an atmosphere in the class in which students can express their personal opinions • Explain role of a systematic problem solving approach in the class
Organization: organize internal conflicts	• Organize equal time for learning theories and applications of theories • Create more group in the lab in order to improve understanding of teamwork
Internalizing values: behave consistently with personal value set	• Create tasks in such a way that students can improve their judgment and change their behavior towards problem solving, based on new evidence

8.2 CO statement – action verb



Remembering	Understanding	Applying	Analysing	Evaluating	Creating
acquire	arrange	apply	analyse	appraise	calculate
choose	categorize	calculate	appraise	argue	change
collect	change	change	break down	assess	combine
complete	chart	choose	classify	compare	compose
copy	compile	classify	combine	conclude	constitute
define	conclude	compute	compare	consider	create
describe	convert	conduct	contrast	contrast	derive
detect	defend	construct	criticize	critique	devise
distinguish	determine	demonstrate	deduce	decide	discover
duplicate	diagram	develop	defend	describe	document
find	differentiate	discover	detect	discriminate	explain
identify	document	employ	differentiate	explain	generalize
indicate	edit	generalize	distinguish	interpret	modify
isolate	estimate	manipulate	evaluate	judge	originate
label	explain	modify	formulate	justify	plan
list	extrapolate	operate	generate	recommend	produce
mark	formulate	organize	illustrate	relate	rearrange
match	generalize	predict	infer	standardize	relate
name	give example	prepare	outline	summarize	revise
order	illustrate	produce	paraphrase	validate	signify
outline	interpret	relate	plan		specify
place	organize	restructure	relate		synthesize
recall	paraphrase	show	save		tell
recognize	predict	solve	select		write
reproduce	prepare	transfer	separate		
select	relate	use	shorten		
state	summarize		structure		
underline	update		subdivide		

Writing course outcome statement (Theory)

8. Program outcome (PO) - Recall

Program Outcomes	NO	Learning Taxonomy
Engineering Knowledge (K1-K4)	PO1	Cognitive
Problem Analysis (K1-K4)	PO2	Cognitive
Design/development of Solutions (K5)	PO3	Cognitive
Investigation (K8)	PO4	Cognitive, Psychomotor
Modern Tool Usage (K6)	PO5	Cognitive, Psychomotor
The Engineer and Society (K7)	PO6	Cognitive, Affective
Environment and Sustainability (K7)	PO7	Cognitive, Affective
Ethics (K7)	PO8	Cognitive, Affective
Individual Work and Teamwork	PO9	Affective
Communication	PO10	Affective
Project Management and Finance	PO11	Cognitive, Affective
Life-Long Learning	PO12	Affective

8.2 CO statement – example (theory)

CSE1101 – Introduction to Computer Programming

Introduction to computers and programming languages, data representation in computer, algorithms and flowchart construction for problem solving. Introduction to programming (input, output, variables, data types, operators, expressions, assignments). Conditional, control statements, and loops (if, if-else, switch, while, for etc.).

Introduction to arrays (declaring and manipulating arrays of numbers and characters, strings) and multi-dimensional arrays. Introduction to functions (definitions, prototypes, argument, header files).

Application of user defined functions. Pointers: variable declarations, operators, passing arguments to functions, pointer arithmetic and function pointers. Object oriented programming: introduction, class, object and method.

8.2 CO statement – example (theory)

CO No.	CO Statement	Corresponding PO	Domain and level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Develop** algorithms, pseudo codes, and flowcharts in a logical manner to solve problems.	PO1: Engineering Knowledge	Cognitive Level 3 (Apply)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☐ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO2	**Implement** appropriate conditionals, iteration constructs, control structures, and functions to solve programming tasks.	PO1: Engineering Knowledge	Cognitive Level 3 (Apply)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☐ Class Test ☑ Mid-Term Exam ☑ Final Exam ☑ Assignment ☐ Project (Presentation & Report)
CO3	**Apply** data structures and memory addressing techniques in programming.	PO1: Engineering Knowledge	Cognitive Level 3 (Apply)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☐ Class Test ☐ Mid-Term Exam ☑ Final Exam ☑ Assignment ☐ Project (Presentation & Report)

*Levels in Bloom's Cognitive Domain: Level 1: Remember, Level 2: Understand, Level 3: Apply, Level 4: Analyze, Level 5: Evaluate, Level 6: Create

*Levels in Bloom's Affective Domain: Level 1: Receive, Level 2: Respond, Level 3: Value, Level 4: Organize, Level 5: Internalize

8.2 Course outcome (CO) – example (theory)

CSE3224 – Computer Networks

Introduction to network and protocol. The Network Edge, Core, and Access, Networks Physical Media Delay and Loss in Packet-Switched Networks, Protocol Layers and Their Service Models, Internet Backbones, NAPs and ISPs, a Brief History of Computer Networking and the Internet.

Network Layer: The Application Layer: Principles of Application-Layer Protocols, The World Wide Web: HTTP, File Transfer: FTP, Electronic Mail in the Internet, The Internet's Directory Service: DNS, Socket Programming. The Transport Layer: Transport-Layer Services and Principles, Multiplexing and Demultiplexing Applications, Connectionless Transport: UDP, Principles of Reliable of Data Transfer, TCP case study , Principles of Congestion Control, TCP Congestion Control. The Network Layer: Introduction and Network Service Model, Routing Principles, Hierarchical Routing.

IP: The Internet Protocol, routing in the Internet, What is Inside a Router, Mobile networking. The Link Layer and Local Area Networks: The Data Link Layer: Introduction, Services, Error Detection and Correction, Multiple Access Protocols and LANs, LAN Addresses and ARP, Ethernet Hubs, Bridges and Switches, Wireless LANs: IEEE 802.11, PPP: the Point-to-Point Protocol, ATM.

Security in Computer Networks: What is Network Security, Principles of **Cryptography** Authentication, Integrity, Key Distribution and Certification, Firewalls, Attacks and Countermeasures Protocols

8.2 Course outcome (CO) – example (theory)

CO No.	CO Statement	Corresponding PO	Domain and level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Understand** the basic architectures of computer networks and OSI reference model.	PO1: Engineering Knowledge	Cognitive Level 2 (Understand)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☑ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO2	**Analyze** the requirements for a given organizational structure and **select** the most appropriate networking architecture and technologies.	PO2: Problem Analysis	Cognitive Level 4 (Analyze)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☑ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO3	**Understand** the basic use of cryptography and network security.	PO1: Engineering Knowledge	Cognitive Level 2 (Understand)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☑ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO4	**Identify** limitations of existing network protocols through literature review and propose new solutions for specific needs and requirements.	PO12: Life-long learning	Affective Level 3 (Value)	☑ Lecture ☐ Tutorial ☑ Discussion ☐ Interaction ☑ Audio/Video	☐ Class Test ☐ Mid-Term Exam ☐ Final Exam ☑ Assignment ☑ Project (Presentation & Report)

*Levels in Bloom's Cognitive Domain: Level 1: Remember, Level 2: Understand, Level 3: Apply, Level 4: Analyze, Level 5: Evaluate, Level 6: Create

*Levels in Bloom's Affective Domain: Level 1: Receive, Level 2: Respond, Level 3: Value, Level 4: Organize, Level 5: Internalize

8.2 Course outcome (CO) – example (theory)

EEE1101 – Electrical Circuit-I

DC circuit variables and elements: Charge & current, Voltage, power& energy, voltage source, current source, independent and dependent sources, types of resistors, color coding and standard resistor values, conductance, thermistors, photoconductive cell, varistors.

Basic laws: Ohm's law, nodes, branches and loops. **Series DC circuits:** series resistors, series circuits, power distribution in a series circuit, voltage sources in series, Kirchhoff's voltage law. Voltage division in a series circuit, voltage regulation and the internal resistance of voltage source. **Parallel DC circuits:** parallel resistors, parallel circuits, power distribution in a parallel circuit, Kirchhoff's current law, current divider rule, voltage sources in parallel, open and short circuits. Series-Parallel networks, current sources in parallel and in series.

Method of analysis: branch-current analysis, nodal analysis, mesh analysis including super node and super mesh. Wye-Delta and Delta-Wye transformation. **Circuit theorems**: Thevenin's, Norton's and Superposition theorems, maximum power transfer theorem, Millman's theorem, Substitution theorem and reciprocity theorem, linearity property, source transformation.

Transient analysis:
RC transient: charging and discharging phase, initial conditions, instantaneous values, Thevenin Equivalent: time constant=$R_{th}C$, capacitors in series and in parallel, energy stored by a capacitor, stray capacitance. **RL transient:** Magnetic Field, inductance, induced voltage, the storage phase and the release phase, Thevenin equivalent: time constant=L/R_{th}, inductors in series and in parallel, steady state conditions, energy stored by an inductor.

8.2 Course outcome (CO) – example (theory)

CLO No.	CLO Statement	Corresponding PLO	Domain & level of learning taxonomy
CLO1	**Explain** the concepts of circuit elements, DC sources, circuit laws and analysis techniques.	PO1: Engineering Knowledge	Cognitive Level 2 (Understand)
CLO2	**Solve** DC circuits using various network theorems.	PO1: Engineering Knowledge	Cognitive Level 3 (Apply)
CLO3	**Analyze** step response of 1st order RL and RC circuits.	PO1: Engineering Knowledge	Cognitive Level 4 (Analyze)
CLO4	**Apply** the concepts of magnetic flux density, magnetization curve, hysteresis, Ampere's circuital law to solve DC magnetic circuits.	PO1: Engineering Knowledge	Cognitive Level 3 (Apply)

8.2 Course outcome (CO) – example (theory)

EEE3222 – Power Electronics & Drives

Power semiconductor devices: power diodes, power transistors, thyristors (GTOs) – steady state and switching characteristics. **Power diodes:** general purpose diode, fast recovery diode, Schottky diodes. **Power transistors:** MOSFET, IGBT, SIT. **Thyristors:** SCR, GTO.

AC-DC converters / Diode rectifiers / Uncontrolled rectifiers: Design & Applications of single and three converters.
DC-DC converters: Buck, Boost, Buck-Boost and Cuk regulators, multistage topologies, Design & Applications of DC-DC converters: Power factor correction, EV chargers.
DC-AC converters (Inverters): Gate drives Circuits. Various PWM techniques, Single-phase and three-phase inverters (180-degree and 127-degree conduction), PWM inverters, Design of inverters, Design of various filters for inverter circuits, Applications of inverters, Voltage and current source inverters, Resonant pulse inverter, Multilevel inverter.

SCR/ Controlled rectifiers: Controlled rectifiers using thyristors. **Motor drives:** DC motor drives, Induction and Synchronous motor drives.

Industrial applications of power electronics: Solid State Transformer (SST), Induction heater, VFD.

8.2 Course outcome (CO) – example (theory)

CO No.	CO Statement	Corresponding PO	Domain and level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Identify** the characteristics of various types of dc-dc converters, rectifiers (AC-DC converters) and inverters (DC-AC converters).	PO2: Problem Analysis	Cognitive Level 4 (Analyze)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☐ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO2	**Design** power converters (ac-dc, dc-dc, dc-ac) with specific requirements and need.	PO3: Design/ Development of Solution	Cognitive Level 6 (Create)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☑ Final Exam ☑ Assignment ☐ Project (Presentation & Report)
CO3	**Develop** applications using the designed power converters for sustainable development and analyze its environmental impact.	PO7: Environment and Sustainability	Affective Level 3 (Value)	☑ Lecture ☐ Tutorial ☑ Discussion ☐ Interaction ☑ Audio/Video	☐ Class Test ☐ Mid-Term Exam ☐ Final Exam ☑ Assignment ☑ Project (Presentation & Report)
CO4	**Identify** a contemporary problem through literature review whose solution will be designed, developed and verified using power electronics and drives.	PO12: Life-long learning	Affective Level 4 (Organize)	☑ Lecture ☐ Tutorial ☑ Discussion ☐ Interaction ☑ Audio/Video	☐ Class Test ☐ Mid-Term Exam ☐ Final Exam ☑ Assignment ☑ Project (Presentation & Report)

*Levels in Bloom's Cognitive Domain: Level 1: Remember, Level 2: Understand, Level 3: Apply, Level 4: Analyze, Level 5: Evaluate, Level 6: Create

*Levels in Bloom's Affective Domain: Level 1: Receive, Level 2: Respond, Level 3: Value, Level 4: Organize, Level 5: Internalize

8.2 Course outcome (CO) – example (theory)

EEE4122 – Control Systems

Introduction to control system. Open loop and closed loop or feedback control systems, transient responses to the delta, step and ramp functions and their graphical interpretations. ***Electrical systems***. First, second, and higher order. Under-damped, over damped and critically damped R-L-C circuits, Op-amp circuits for PID controllers. ***Mechanical systems***. Translational and rotational systems with mass, springs and dampers, mechanical systems with gear, **electromechanical system**, mechanical–electrical analogies. **Mathematical modeling.** *Block diagrams, signal flow graph, Mason's gain formula.* ***Stability***. Transient & steady state error, steady state error, second, third, and higher order systems, poles & zeros, Routh's criterion, Root locus. ***PI, PD, PID controller***. Ziegler-Nichols method for determination of constants. ***Programmable logic controllers***. Construction, applications, ladder logic and programming. **Modern control theory**. *Multivariable systems, state variables and state equations* for electrical and mechanical systems, applications of eigenvalues, observability, and controllability, linear control system design by state feedback. **Simulation.** Modeling and simulation of control system using software e.g. MATLAB / Simulink.

8.2 Course outcome (CO) – example (theory)

CO No.	CO Statement	Corresponding PO	Domain and level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Construct** mathematical of electrical, electronic and mechanical (translational & rotational) systems both in time and frequency domain.	PO1: Engineering Knowledge	Cognitive Level 3 (Apply)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☐ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO2	**Identify** the characteristics of electrical, mechanical & electromechanical control systems by both classical and state-space representation.	PO2: Problem Analysis	Cognitive Level 4 (Analyze)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☐ Mid-Term Exam ☑ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO3	**Design** a control system using required specifications addressing the complex engineering problems.	PO2: Problem Analysis	Cognitive Level 6 (Create)	☑ Lecture ☐ Tutorial ☑ Discussion ☐ Interaction ☑ Audio/Video	☐ Class Test ☐ Mid-Term Exam ☑ Final Exam ☑ Assignment ☐ Project (Presentation & Report)
CO4	**Explain** effectively both in oral and written form the design of a control system that meets the specific need and requirements addressing complex engineering activities.	PO10: Communication	Affective Level 4 (Organize)	☑ Lecture ☐ Tutorial ☑ Discussion ☐ Interaction ☑ Audio/Video	☐ Class Test ☐ Mid-Term Exam ☐ Final Exam ☐ Assignment ☑ Project (Presentation & Report)

*Levels in Bloom's Cognitive Domain: Level 1: Remember, Level 2: Understand, Level 3: Apply, Level 4: Analyze, Level 5: Evaluate, Level 6: Create

*Levels in Bloom's Affective Domain: Level 1: Receive, Level 2: Respond, Level 3: Value, Level 4: Organize, Level 5: Internalize

8.2 Course outcome (CO) – example (theory)

EEE2121 – Mechanical Engineering Fundamentals

Thermal energy: Comparison and conversion with other sources such as mechanical and electrical energy. Sources of thermal energy, such as oil, gas, coal, nuclear power plant, solar energy harvested thermodynamically.

Gases and thermodynamic processes: The P-V plane and work done, entropy, the T-S plane and heat transferred. Isothermal, isochoric, isobaric, isentropic, and isenthalpic processes. Reversibility and irreversibility.

Carnot cycles: Carnot cycle, it's thermal efficiency, and second law, two-phase Carnot cycle. Reversed Carnot cycle, operating mediums of air, steam, Freon, etc.

Practical Cycles: Otto cycle and diesel cycle.

Four stroke and two stroke engines. Crankshaft and camshaft. Cooling, lubrication, and ignition systems.

Gas turbines, Brayton cycle and modifications.

Reheat and regenerative cycles. **Steam turbine cycle** and modifications, combined cycle.

Boilers: Classification, fire-tube, water-tube, horizontal, vertical, etc.

Refrigeration cycle: Principles, stages, and components, Concerns with Freon and alternative fluids.

8.2 Course outcome (CO) – example (theory)

CO No.	CO Statement	Corresponding PO	Domain and level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Explain** fundamental characteristics of fluid mechanics, reversible & irreversible processes, and working principle of heat engines, refrigerators, boilers and heat pumps.	PO1: Engineering Knowledge	Cognitive Level 2 (Understand)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☐ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO2	**Analyze** various thermodynamic cycles used in power plants for power generation.	PO2: Problem Analysis	Cognitive Level 4 (Analyze)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☑ Audio/Video	☐ Class Test ☑ Mid-Term Exam ☑ Final Exam ☑ Assignment ☐ Project (Presentation & Report)

*Levels in Bloom's Cognitive Domain: Level 1: Remember, Level 2: Understand, Level 3: Apply, Level 4: Analyze, Level 5: Evaluate, Level 6: Create

8.2 Course outcome (CO) – example (theory)

EEE 432 – Power Plant Engineering

Power plant fundamentals: general layout and principles,

Selection of location: Technical, economic and environmental factors.

Thermal power plants: diesel power plant, steam turbine power plant, gas turbine power plant, combined cycle gas turbine power plant and nuclear power plant.

Non-thermal power plants: Hydro, solar, wind and tidal power plant.

Power plant instrumentation, Load forecasting, Generation scheduling: deterministic and probabilistic. Electricity tariff: formulation and types.

8.2 Course outcome (CO) – example (theory)

CO No.	CO Statement	Corresponding PO	Domain and level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Explain** the fundamentals, general layout, thermodynamic cycles,, and working principle of heat engines, boilers and heat pumps used in power plants.	PO1: Engineering Knowledge	Cognitive Level 2 (Understand)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☑ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO2	**Analyze** the technical and economic aspects of installation, operation and control of various thermal and non-thermal power plants.	PO2: Problem Analysis	Cognitive Level 4 (Analyze)	☑ Lecture ☑ Tutorial ☑ Discussion ☑ Interaction ☐ Audio/Video	☑ Class Test ☑ Mid-Term Exam ☑ Final Exam ☐ Assignment ☐ Project (Presentation & Report)
CO3	**Assess** social, health, safety, legal and cultural issues and the consequent responsibilities of Engineers on the development of new power plants.	PO6: The Engineer and Society	Affective Level 3 (Value)	☑ Lecture ☐ Tutorial ☑ Discussion ☐ Interaction ☑ Audio/Video	☐ Class Test ☐ Mid-Term Exam ☐ Final Exam ☑ Assignment ☑ Project (Presentation & Report)
CO4	**Analyze** the sustainability of different power plants by evaluating technical, economic, social and environmental factors.	PO7: Environment and Sustainability	Affective Level 3 (Value)	☑ Lecture ☐ Tutorial ☑ Discussion ☐ Interaction ☑ Audio/Video	☐ Class Test ☐ Mid-Term Exam ☐ Final Exam ☑ Assignment ☑ Project (Presentation & Report)

*Levels in Bloom's Cognitive Domain: Level 1: Remember, Level 2: Understand, Level 3: Apply, Level 4: Analyze, Level 5: Evaluate, Level 6: Create

*Levels in Bloom's Affective Domain: Level 1: Receive, Level 2: Respond, Level 3: Value, Level 4: Organize, Level 5: Internalize

8.2 Course outcome (CO) – example (theory)

MSE1225 Fundamentals of Properties of Materials

Fundamentals of Chemistry: Atomic structure and atomic number; bonding types in solids; kinetic molecular theory; thermal fluctuations and noise, the crystalline state - types of crystals; crystal directions and planes; allotropy and carbon; solid solutions and two-phase solids, the hydrogen molecule – molecular orbital theory of bonding; band theory of solids; density of states in energy bands; quantum theory of metals; Fermi energy significance; thermionic emission and vacuum tube devices; phonons; photons; the electron as a wave; Heisenberg's Uncertainty Principle, tunneling phenomenon – quantum leak; potential box – three quantum numbers; the hydrogen atom, the helium atom and the periodic table; stimulated emission and lasers.

Properties of Semiconductor Materials: Intrinsic semiconductors, doping, extrinsic semiconductors; temperature dependence of conductivity; direct and indirect recombination; minority carrier lifetime; diffusion and conduction equations and random motion; optical absorption; direct and indirect bandgap semiconductors; indirect recombination.

Dielectric Properties of Materials and Insulation: Matter polarization and relative permittivity; polarization mechanisms; frequency dependence: dielectric constant and dielectric loss; Gauss's Law and boundary conditions; capacitor dielectric materials.

Magnetic Properties and Superconductivity: Magnetization of matter; magnetic material classifications; ferromagnetism origin and the exchange interaction; magnetic domains; ferromagnetic materials; soft and hard magnetic materials; energy band diagrams and magnetism; magnetic recording materials; Superconductivity - zero resistance and the Meissner effect; Type I and Type II superconductors; critical current density; superconductivity origin and principles.

8.2 Course outcome (CO) – example (theory)

CO No.	CO Statement	Corresponding PO	Domain / level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Understand** the chemistry of atoms, ions, molecules, crystal structure of solids and the structure and molecular bonding involved in materials used in electronic devices.	PO1: Engineering Knowledge	Cognitive domain – level 2 (understand)	• Lecture • Tutorial • Discussion	• Class Test • Mid Term • Assignment
CO2	**Understand** the quantum mechanical model of the atom, Fermi energy levels; band theory of solids and the tunneling phenomenon.	PO1: Engineering Knowledge	Cognitive domain – level 2 (understand)	• Lecture • Tutorial • Discussion	• Class Test • Mid Term • Assignment
CO3	**Understand** the physical and chemical properties of different kinds of semiconductor materials.	PO1: Engineering Knowledge	Cognitive domain – level 2 (understand)	• Lecture • Tutorial • Discussion	• Class Test • Final Exam • Assignment
CO4	**Understand** the dielectric and magnetic properties of materials used in electronic devices and insulation.	PO1: Engineering Knowledge	Cognitive domain – level 2 (understand)	• Lecture • Tutorial • Discussion	• Class Test • Final Exam • Assignment

*Levels in Bloom's Cognitive Domain: Level 1: Remember, Level 2: Understand, Level 3: Apply, Level 4: Analyze, Level 5: Evaluate, Level 6: Create

Writing course outcome Statement (Lab)

8.2 CO statement – Example (Computer Programming Lab)

CO No.	CO Statement	Corresponding PO	Domain and level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Write** and **debug** computer programs to solve practical problems using known programming language studied in the theory course.	PO5: Modern Tools Usage	Psychomotor Level 4 (Articulate)	☑ Programming ☑ Experiment ☐ Open Ended Lab ☑ Demonstration ☑ Practice Lab	☑ Lab Performance ☑ Lab Test ☑ Lab Report ☐ Open-ended Lab Report ☐ Project (Presentation & Report)
CO2	**Write** report individually and/or in a group by designing an open ended lab for solving practical problems with specific needs and requirements.	PO9: Individual Work and Teamwork	Affective Level 4 (Organize)	☐ Programming ☐ Experiment ☑ Open Ended Lab ☑ Practice Lab ☐ Demonstration	☐ Lab Performance ☑ Lab Test ☐ Lab Report ☑ Open-ended Lab Report ☐ Project (Presentation & Report)

*Levels in Bloom's Cognitive Domain: Level 1: Remember, Level 2: Understand, Level 3: Apply, Level 4: Analyze, Level 5: Evaluate, Level 6: Create

*Level of Bloom's Psychomotor Domain: Level 1 - Imitate, Level 2 – Manipulate, Level 3 – Perfect, Level 4 – Articulate, Level 5 - Embody

8.2 CO statement – Example (Circuit Lab)

CO No.	CO Statement	Corresponding PO	Domain and level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Build** basic electrical circuits and **operate** fundamental circuit lab instrument & equipment.	PO5: Modern Tools Usage	Psychomotor Level 3 (Precise)	☐ Simulation ☑ Experiment ☐ Demonstration ☑ Practice Lab ☐ Tutorial	☑ Lab Performance ☑ Lab Test ☑ Lab Report ☑ Open-ended Lab ☐ Project (Presentation & Report)
CO2	**Use** PSPICE / PSIM / computer aided design (CAD) tool to simulate DC circuits.	PO5: Modern Tools Usage	Psychomotor Level 3 (Precise)	☑ Simulation ☐ Experiment ☐ Demonstration ☑ Practice Lab ☐ Tutorial	☑ Lab Performance ☑ Lab Test ☑ Lab Report ☑ Open-ended Lab ☐ Project (Presentation & Report)

*Level of Bloom's Psychomotor Domain: Level 1 - Imitate, Level 2 – Manipulate, Level 3 – Perfect, Level 4 – Articulate, Level 5 - Embody

8.2 CO statement – Example (Power Electronics Lab)

CO No.	CO Statement	Corresponding PO	Domain and level of learning taxonomy*	Delivery methods and activities	Assessment tools
CO1	**Measure** the performance of power converters (ac-dc, dc-dc & dc-ac) using experiments / simulation software (MATLAB/ PSIM / PROTEOUS).	PO5: Modern Tools Usage	Psychomotor Level 4 (Articulate)	☑ Simulation ☑ Experiment ☐ Demonstration ☑ Practice Lab ☐ Tutorial	☑ Lab Performance ☑ Lab Test ☑ Lab Report ☐ Open-ended Lab Report ☐ Project (Presentation & Report)
CO2	**Investigate** the performance of a power converter with specific requirements and needs by designing an open ended experiment.	PO4: Investigation	Psychomotor Level 4 (Articulate)	☑ Simulation ☑ Experiment ☐ Demonstration ☑ Practice Lab ☐ Tutorial	☐ Lab Performance ☐ Lab Test ☐ Lab Report ☑ Open-ended Lab Report ☑ Project (Presentation & Report)

*Level of Bloom's Psychomotor Domain: Level 1 - Imitate, Level 2 – Manipulate, Level 3 – Perfect, Level 4 – Articulate, Level 5 - Embody

Any questions or comments?