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Course Outcomes (COs), Intended Learning Outcomes (ILOs) and Learning Outcome representation table using Bloom's Taxonomy for Engineering Physics Sikkim Institute of Science & Technology, Chisopani, South Sikkim, Sikkim University

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Abstract

This research paper deals with course objectives, course outcomes (COs) and intended learning outcomes (ILOs) of Bachelor of Technology (B. Tech.) Programme in Sikkim Institute of Science and Technology (SIST), South Sikkim. This paper adopts a systematic approach for encourage the learners to get their final goal through the Bloom Taxonomy tables based on the Factual knowledge, Conceptual knowledge, Procedural knowledge, and Metacognitive knowledge by remembering, understanding, applying, analyzing, evaluating and creating. The fundamental concepts and applications of the laws of physics through real life applications are embodied in the B. Tech. Programme. This research suggested that the intended learning outcomes are never been explicit resulting in inconsistent assessment in physics.

1. Introduction

The ILOs can be used to guide learning and assessment of the COs for education providers, clinical educators and supervisors, and students [1]. This study has identified agreed learning outcomes for B. Tech. students undertaking COs. The consensus agreement of experts reinforced the learning model enables the development of student-centred practice that is underpinned by accountability, advocacy, and autonomy. Purposeful learning outcomes for Engineering Physics been developed, informing how the Taxonomy Tables can be embedded in curriculum, guide student learning and assessment to standardize the pedagogy of the model [2] to prepare future Engineering students. However, changing care through integration facilitated by digitalisation has proven difficult. Much prior development has operated within local institutional remits. Coordinating system development and service collaboration between disparate settings poses complex technological and socio-organisational challenges [3]. In addition, strategic transformation efforts are frequently framed as individual change projects as opposed to long-term transformative change programmes, hampering advancements towards an integrated vision. As a result, the vision of technological systems to support integrated care haveemerged in advance of the establishment of institutional operating and governance models based on Bloom's Taxonomy. The academic institutions and programs, therefore, develop institutional and Program's Learning Outcomes (PLOs), aiming to produce professionals who possess the required skills and professional competencies demanded in the job market. Keeping in view the prime importance of humans and their safety, these PLOs are considered more seriously in engineering program. The curriculum provides detailed information about the learning outcomes, teaching strategies and assessment methods of the programs; as well as about the courses to achieve those learning outcomes. Hence, these curriculums serve as the building blocks for the educational programs [4] like B. Tech. This study adopted a five Bloom Taxonomy Tables, these five tables indicates the mapping between Cos and ILOs of Engineering Physics at SIST, south Sikkim, India.

1.1. Course: Engineering Physics

1.2.Code: BTEG-UG-C104

1.3. Course objectives

1.3.1. The course limelight at developing the basic milieu in Physics that will be required by an

Engineering student to pursue their B.Tech.Programme through Factual knowledge, Conceptual knowledge, Procedural knowledge, and Metacognitive knowledge. The fundamental concepts and applications of the laws of physics through real life applications are embodied in the programme.

1.3.2. The course start with a brief overview on oscillations and waves, then gives thorough the ideas about damped and forced oscillations, wave equation, wave optics, and fibre optics required in different branches of Engineering programme.

1.3.3. The fundamental concept to the Quantum Mechanics is given so that the students can understand its applications in their advanced courses in higher semesters.

1.3.4. The physics of band theory of solid is introduced which forms the backbone of electronics.

1.3.5. Generally, the course aims for use of an integrated system of remembering, understanding, applying, analyzing, evaluating, and creating. Then, mathematical and scientific skills such as measuring, predicting, formulating explanations, drawing conclusions, and solving problems that are used in technology and its development. Scientific information will be made with real life examples and related laboratory experiments where possible.

1.4. COURSE OUTCOMES (COs)

After completion of the course, students will be able to

CO1: Differentiate oscillation and waves in perspective of Engineering applications.

CO2: Develop the phenomenon of formation of interference and diffraction of light waves and their mathematical derivation.

CO3: Interpret the fundamentals importance of Quantum Mechanics and uses.

CO4: Derive the slope & intercept of Einstein's photoelectric equation.

CO5: Provide the derivation of time independent Schrödinger's wave equation.

CO6: Analyze the difference between the conductor, semiconductor & insulator based upon band gaps.

CO7: Extrapolate the Band Theory of Solid is back bone of Electronics.

Table 1: Bloom's Taxonomy for Cos

Cognitive knowledge Dimensions	Cognitive process dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual knowledge						
Conceptual knowledge		CO1,CO3, CO7		CO6		
Procedural knowledge			CO2		CO4, CO5	
Metacognitive knowledge						

Result or explanation of Table 1

CO1: This objective involves understanding how waves and oscillation formed, which requires acquisitive the conceptual knowledge related to the formation of waves and vibration through output plots and their differences.

CO2: This objective involves applying knowledge of interference and diffraction, and it requires procedural knowledge about how to form, and step by step calculation for generating mathematical expression. This course outcome is instructional models such as analyse, design, develop, implement and evaluate. Then, provide a systematic approach to organise appropriate educational scenarios through learning theories to achieve instructional goals through behavioural approach that focuses on achieving specific learning outcomes and behavioural change by considering the different learning theories [5].

CO3: This objective involves describing the fundamental of Quantum Mechanics and usage and evaluating potential solutions. It requires Conceptual knowledge about how to convert classical mechanics to Quantum mechanics.

CO4: This objective emphasizes the importance of students not only evaluating the subject matter but also developing a procedural knowledge for calculating slope and intercept of Einstein's equation. This approach promotes higher-order thinking skills and encourages students to apply their knowledge in step by step on various contexts beyond rote memorization.

CO5: This objective involves both creating and evaluating Schrodinger's time dependant wave equation. It requires procedural knowledge about how to generate solution and assess their suitability as replacements for exact solution as shown in table 1.

CO6: This objective emphasizes the importance of students not only evaluating the subject matter but also developing a Conceptual knowledge for conductor, semiconductor and insulator. This approach promotes higher-order thinking skills and to apply their knowledge on various contexts beyond rote memorization.

CO7: This objective involves describing the band theory of solid and usage and evaluating potential solutions and backbone of Electronics. It requires conceptual knowledge about how band theory is backbone of Electronics.

1.5. Intended Learning Outcomes (ILOs) for Cos

1.5.1. CO1: Distinguish between oscillations and waves in perspective of Engineering applications.

ILO1: Define wave & oscillation.

ILO2: Distinguish wave & oscillation, group & phase velocities.

ILO3: Derive wave equation.

ILO4: Identify the output plots of wave & oscillation.

ILO5: Justify the forced and damped vibrations are free from natural vibration.

Table 2: Bloom's Taxonomy for CO1

Cognitive knowledge Dimensions	Cognitive process dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual knowledge	ILO1					
Conceptual knowledge		ILO2, ILO4			ILO5	
Procedural knowledge					ILO3	
Metacognitive knowledge						

Result or explanation of Table 2

ILO1: This outcome involves recalling and stating the basic definition of wave & vibration. It requires remembering factual information about what wave & vibration are.

ILO2: This outcome requires understanding the differences between wave & vibration and group & phase velocities. It involves categorizing based on their properties or plots, which falls under the conceptual knowledge category.

ILO3: This outcome involves evaluating the step by step solution of wave equation and it requires grasping the procedural knowledge as shown in Table 2.

ILO4: This outcome requires understanding the differences between wave & vibration and their output diagrams. It involves categorizing based on their properties or plots, which falls under the conceptual knowledge category.

ILO5: This outcome involves evaluating the force and damped vibrations, and both are free from natural vibration. It requires procedural knowledge about how to forms both the vibrations and formation of resonance.

1.5.2. CO2: Evaluate the phenomenon of formation of interference and diffraction of light waves and their mathematical derivation.

ILO1: Define interference & diffraction.

ILO2: Distinguish between Fresnel & Fraunhofer class of diffractions.

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ILO3: Derive fringe width of Young's single & double slits experiments.
ILO4: Relate the numerical aperture and acceptance angle.
ILO5: Conclude the interference is free from diffraction.

Table 3: Bloom's Taxonomy for CO2

Cognitive knowledge Dimensions	Cognitive process dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual knowledge	ILO1					
Conceptual knowledge		ILO2, ILO4			ILO5	
Procedural knowledge					ILO3	
Metacognitive knowledge						

Result or explanation of Table 3

ILO1: This outcome involves recalling and stating the basic definition of wave & vibration. It requires remembering factual information about what wave & vibration are.
ILO2: This outcome requires understanding the differences between wave & vibration and group & phase velocities. It involves categorizing based on their properties or plots, which falls under the conceptual knowledge category as shown in Table 3.
ILO3: This outcome involves evaluating the step by step solution of wave equation and it requires grasping the procedural knowledge.
ILO4: This outcome requires understanding the differences between wave & vibration and their output diagrams. It involves categorizing based on their properties or plots, which falls under the conceptual knowledge category.
ILO5: This outcome involves evaluating the force and damped vibrations, and both are free from natural vibration. It requires procedural knowledge about how to forms both the
1.5.3. CO3: Interpret the fundamentals importance of Quantum Mechanics and uses.
1.5.4. CO4: Derive the slope & intercept of Einstein's photoelectric equation.
1.5.5. CO5: Provide the derivation of time independent Schrödinger's wave equation.
ILO1: Define black body radiation, wave function, potential well & photoelectric effect.
ILO2: Distinguish between wave & particle nature of radiation.
ILO3: Derive and interpret one dimensional time independent Schrodinger's wave equation & slope and intercept of photoelectric equation.
ILO4: Categorize the inadequacy of classical mechanics.
ILO5: Interpret the physical significance of wave function.

Table 4: Bloom's Taxonomy for CO3, CO4 and CO5

Cognitive knowledge Dimensions	Cognitive process dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual knowledge	ILO1					
Conceptual knowledge		ILO2, ILO4			ILO5	
Procedural knowledge					ILO3	
Metacognitive knowledge						

Result or explanation Table 4

ILO1: This outcome involves recalling and shaping the definition of black body radiation, wave function, potential well & photoelectric effect. It requires remembering and chooses the factual information about the recall and recognizes the basic of what they are.
ILO2: This outcome requires understanding the differences between wave & particle nature

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of light. It involves summarizing based on their properties and examples, which falls under the group of conceptual knowledge.

ILO3: This outcome involves evaluating the step by step solution of Schrodinger's wave equation. Assess to solving the standard solutions for slope and intercept of photoelectric equation. It recommend for validate the solution using procedural knowledge.

ILO4: This outcome requires understanding the inadequacy of Classical Mechanics. It involves categorizing based on their laws and their shortcoming; formulate all the laws of Physics using quantum mechanics which falls under the category of conceptual knowledge.

ILO5: This outcome involves physical significance of wave function, and concluding the application of wave function. It requires interpreting and comparing the procedural knowledge for normalization and orthogonalization of wave function as shown in Table 4.

1.5.6. CO6: Analyze the difference between the conductor, semiconductor & insulator based upon band gaps.

1.5.7. CO7: Extrapolate the Band Theory of Solid is back bone of Electronics.

ILO1: Define conductor, semiconductor and insulator based on their band gap diagram.

ILO2: Distinguish between Fermi, acceptor and donor levels based on their types.

ILO3: Derive Fermi-Dirac distribution free electron theory.

ILO4: Identify the output plots of p-n junction diode.

ILO5: Justify Band Theory of Solid is back bone of Electronics.

Table 5: Bloom's Taxonomy for CO6, CO7

Cognitive knowledge Dimensions	Cognitive process dimension					
	Remember	Understand	Apply	Analyze	Evaluate	Create
Factual knowledge	ILO1					
Conceptual knowledge		ILO2, ILO4			ILO5	
Procedural knowledge					ILO3	
Metacognitive knowledge						

Result or explanation Table 5

ILO1: This outcome involves recalling and stating the basic definition of conductor, semiconductor and insulator based on their band gap diagram. It requires remembering factual information about what they are as shown in Table 5.

ILO2: This outcome requires understanding the differences between Fermi, acceptor and donor levels based on intrinsic and extrinsic semiconductors. It involves categorizing based on their properties and diagrams, which falls under the conceptual knowledge category.

ILO3: This outcome involves evaluating the step by step solution of Fermi-Dirac distribution free electron theory and it requires grasping the procedural knowledge.

ILO4: This outcome requires understanding the output plots of p-n junction diode. It involves categorizing based on their properties or plots, which falls under the conceptual knowledge category.

ILO5: This outcome involves evaluating the Band Theory of Solid is back bone of Electronics. It requires procedural knowledge about how Band Theory of Solid is back bone of Electronics.

Conclusion

The results of this study demonstrate that standardised ILOs for each Cos through Bloom Taxonomy tables. This is the first study to correlate and mapping of COs and ILOs for B. Tech. Program in SIST Sikkim. Both the COs and ILOs are achievable through this teaching plan. The national board of accreditation (NBA) standardized and articulate the COs should support the student to establish, maintain, and conclude a professional relationship while experiencing continuity with individual learners through Factual knowledge, Conceptual knowledge, Procedural knowledge, and Metacognitive knowledge by remembering, understanding, applying, analyzing, evaluating and creating. This can be realised through recognition of the Cos and ILOs to inform how the ILOs is integrated in the students learning and assessment. Further research evaluating the application of the ILOs for curriculum design, and the usability against a measure of student assessment is needed.

Conflict of interest

The authors declare that no conflict of interest.

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