SCHOOL OF ENGINEERING & TECHNOLOGY

COURSE FILE

Program: cse
Course Code: PHY4706
Course Title: Quantum Matter & Technologies (QM&T)
Module Semester: 7th
Session: 2024

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1. Course Details

- Course Code: PHY4706
- Course Title: Quantum Matter & Technologies (QM&T)
- **Module/Semester: 7th**
- Session: 2024

2. Vision, Mission of the University

Vision

BML Munjal University seeks to nurture ethical leaders who are skilled, knowledgeable and have the life skills required for leading their organizations to success. The university shall seek the advancement and dissemination of practically oriented knowledge benchmarked with the best global standards.

Mission

BML Munjal University aims to be a leading university for the quality and impact of its teaching, research and linkages with major stakeholders. The focus of the university is to find creative solutions to problems through application of knowledge. The university aims to create a talented community of students and faculty who excel in teaching, learning and research, in a creative and stimulating environment. The university will collaborate with other institutions for development of science, technology and arts in the global context.

3. Graduate Attributes

- Acquire and apply practical understanding of discipline knowledge.
- Demonstrate a sense of ethics and display excellence in both personal and professional life.
- Exhibit problem solving, critical thinking skills and investigative capability to address real world problems.
- Manifest leadership qualities and work effectively in teams across globally diverse environments.
- Be a lifelong learner with an entrepreneurial mindset to innovate in the constantly changing global scenario.
- Possess a strong sense of inquiry and design innovative solutions for positive societal impact.
- Be effective communicators and possess an empathetic outlook.

4. Vision, Mission of the School

Vision of School:

To be amongst the leading engineering schools of the country recognized globally for excellence in teaching and research with focus on experiential learning, innovation and entrepreneurship.

Mission of School:

* Providing high-quality learning experience to our students, preparing them to be global leaders, and contributing to the development of society through research, innovation, and entrepreneurship.
* Creating an inclusive and diverse learning environment that fosters creativity, critical thinking, and ethical values.

* Collaborating with industry, government, and other institutions to address complex societal challenges and promote sustainable development.

5. PEOs and POs & PSOs of the Program

Program Educational Objectives (PEO):

a) PEO 1: Identify real-life problems and develop creative and innovative hardware/software-based solutions.
b) PEO 2: Achieve professional development through self-learning to adapt to the technological changes in the ever changing field of computing.
c) PEO 3: Engage in life-long learning of computer engineering technologies, critical thinking and continuous ingenuity and apply them in real-life applications.
d) PEO 4: Accomplish leadership roles by imbibing ethics and professionalism with emphasis on sustainable development of the society.

Program Outcomes (PO):

e) PO1: Apply the foundational concepts of mathematics, science and computer engineering to find novel solutions for complex real-life engineering problems.
f) PO2: Identify, formulate, review literature and analyze complex computer engineering problems reaching substantiated conclusions and derive a coherent logic that can be implemented by computers.
g) PO3: Design analytical and computational models for solving complex engineering problems giving due consideration to issues related to public health and safety, cultural and societal constraints, and environmental concerns.
h) PO4: Use research-based knowledge, methods, tools and techniques for data collection, designing digital computing systems, analyzing and interpreting the results to provide substantiated conclusions.
i) PO5: Use appropriate tools to model complex computer engineering problems through identification of the limitations and creating solutions to predict the real-world phenomena.
j) PO6: Use appropriate contextual knowledge of computer engineering to review and assess societal, health, legal, cultural, safety and contemporary issues and rationalize the ensuing responsibilities towards the society.
k) PO7: Adopt computer engineering practices in congruence with societal need, understand the working practices and its impact on natural resources for sustainable development.
l) PO8: Use ethical principles to pursue excellence in developing computer engineering systems and behave appropriately to develop a reliable and trustworthy relationship with others.
m) PO9: Function effectively as a reliable and responsible individual, and as a member or leader in diverse computer engineering teams, and in multidisciplinary settings, thereby placing team goals ahead of individual interests.
n) PO10: Communicate effectively by capturing the desirable computer system requirements for preparation of specification documents, write clear and concise report such as laboratory files, research papers, thesis, and presentation materials.
o) PO11: Demonstrate knowledge of computer engineering and management principles for the completion of individual or group projects in multidisciplinary environments.
p) PO12: Recognize the evolving technological changes and engage as an independent and life-long learner in both computing and non-computing fields.

Program Specific Outcomes (PSO):

q) PSO1: Identify applicable tools and techniques related to data science practice such as data

collection, cleaning, analysis, modelling, evaluation and result interpretation and apply them for deriving hidden and meaningful patterns for appropriate actionable insights.

r) PSO2: Develop intelligent systems for various real-life domains like healthcare, transportation, finance etc. using Artificial Intelligence methodologies.

s) PSO3: Understand the foundational concepts and techniques to protect computing systems against constantly evolving cybersecurity threats and analyze security breaches and violations of cyber systems and networks to provide appropriate solutions.

t) PSO4: Design effective security systems to mitigate risks, threats and vulnerabilities for protecting the organizations against cyber threats.

6. Course Description and its objectives

Recently, many advances in quantum technologies (based on some interesting concepts of quantum physics and matter) have emerged where big companies like Google, Microsoft, IBM and Facebook are taking interest due to the impact of these technologies beyond the imagination of a layman. In quantum physics, it is quite evident that whether it makes sense or not, but it “works”. Some concepts still look far sighted now where the quantum physics proposes that it is possible to have a communication far beyond using conventional technologies (in a very robust manner without losing the information) or the state can’t be just defined as 0 and 1 (used in current computation) but the infinite states between 0 and 1 (giving extremely fast and accurate calculations). However, all these discoveries will depend on the progress made in the manipulation and development of quantum matter at atomic scales. In this course, I will take this journey from this fascinating physics to some serious applications in quantum information processing devices and computing. As the course is UG, there will be less use to rigorous mathematics and wherever it appears it will be explained at simpler level. Many activities such programming a real quantum computer through remote IBM Quantum Experience (https://quantum-computing.ibm.com/) and experiments will be performed in class itself. The difficult concepts will be explained with help of videos and animations. The practice and focus on problems will be done through take-home assignments (which will be major component of internal marks).

7. Course Outcomes and CO-PO Mapping

Course Outcomes:

CO1: Understand the principles of quantum mechanics, quantum matter and get familiar with the new research areas in the field of quantum computing

CO2: Apply these concepts in solving the problems in quantum information and quantum computation.

CO3: Analyze and compare the results and data of different quantum materials and device technologies

8. Course Syllabus

Sr. No.	Content	CO	Sessions
1	Fundamentals of Quantum Mechanics Particles and Waves, Uncertainty Principle, Wavefunctions, Superposition Principle, Schrodinger Equation, Quantum Tunneling, Quantum Entanglement	1	2
2	Quantum Matter, Devices and Measurement Technologies Quantum Dots, Nanostructures, 2-D Materials, Quantum Hall Effect, Superconductors, Tunneling Devices (Josephson junctions, STM, SQUID etc.) Ion-traps	1	2
3	Quantum Information Processing and Computing Technologies Qubits, Bloch Sphere, Quatum Logic Gates (X, Y, Z, H, CNOTetc), Basic architecture of quantum computing and examples of Quantum Algorithms (Bernstein–Vazirani, Shor's Algorithm etc)	2	2
4	Programming a Quantum Computer, Lab Projects	2	2

9. Learning Resources

Text Books:

✓ David J. Griffiths, Introduction to Quantum Mechanics, Cambridge University Press, 2017

✓ Eleanor G. Rieffel and Wolfgang H. Polak, Quantum Computing: A Gentle Introduction, Cambridge, Mass.: The MIT Press

✓ Jack D. Hidary, Quantum Computing: An Applied Approach, Springer

✓ Richard Phillips Feynman, The Feynman Lectures on Physics (Volume 3), Pearson P T R; 1st Edition

✓ Chris Bernhardt, Quantum Computing for Everyone, Cambridge, Mass.: The MIT Press

✓ Michael A. Nielsen &Isaac L. Chuang, Quantum Computation and Quantum Information, Cambridge University Press

Reference Links:

- https://www.coursera.org/learn/physical-basis-quantum-computing
- https://www.coursera.org/learn/quantum-computing-algorithms
- https://www.edx.org/course/applications-of-quantum-mechanics
- https://www.edx.org/course/hardware-of-quantum-computer

10. Weekly Timetable

Time	Monday	Tuesday	Wednesday	Thursday	Friday
9:15-10:10	Quantum Matter & Technologies (QM&T) (PHY4706)				
10:15-11:10		Quantum Matter & Technologies (QM&T) (PHY4706)			
11:15-12:10			Quantum Matter & Technologies (QM&T) (PHY4706)		
12:15-13:10				Quantum Matter & Technologies (QM&T) (PHY4706)	
13:15-14:10					Quantum Matter & Technologies (QM&T) (PHY4706)
14:15-15:10	Quantum Matter & Technologies (QM&T) (PHY4706)				
15:15-16:10		Quantum Matter & Technologies (QM&T) (PHY4706)			
16:15-17:10			Quantum Matter & Technologies (QM&T) (PHY4706)		
17:15-18:10				Quantum Matter & Technologies (QM&T) (PHY4706)	

11. Student List

uniqueId	studentName
210C2030002	Aayush Dubey
210C2030004	Pelleti Sujith Reddy
210C2030007	Malladi Sai Prabhas
210C2030010	Subhransh Behura
210C2030014	Abhimanyu Gulati

12. Internal Assessment Data

Component	Duration	Weightage	Evaluationweek	Remarks	Evaluation
Assignment I	Week 10	23		23 Aug 2024	c
Assignment II	Week 20	20		20 Sept 2024	
Assignment III	Week 20	20		11 Oct 2024	
Quiz/Viva-Voce	One	10		15 Nov 2024 Close Book	
Make Up Internal Exam	Throughout the course	20		5 Dec 2024	
End term presentation	Throughout the course			9 Dec 2024	
End term project report	Throughout the course	30			

13. Weak Students Data

uniqueId	studentName	totalMarks	grade
210C2030002	Aayush Dubey	83	A+
210C2030007	Malladi Sai Prabhas	81.5	B+

14. Actions taken for weak students

- lmafo
- ggs

15. Marks Details

uniqueId	studentName	totalMarks	grade
210C2030002	Aayush Dubey	83	A+
210C2030004	Pelleti Sujith Reddy	78.5	B
210C2030007	Malladi Sai Prabhas	81.5	B+
210C2030010	Subhransh Behura	87	A+
210C2030014	Abhimanyu Gulati	47	R

17. Attendance Report

uniqueId	studentName	attendance
210C2030002	Aayush Dubey	88
210C2030004	Pelleti Sujith Reddy	90
210C2030007	Malladi Sai Prabhas	78
210C2030010	Subhransh Behura	82
210C2030014	Abhimanyu Gulati	68