Program Profile		
Program	Program name	Synthesis and Characterization of Graphene for Semiconductor Applications
	Category	A1

Summary of Program	
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Abstract of Program	Graphene, a two-dimensional material composed of a single layer of carbon atoms arranged in a hexagonal lattice, has emerged as a promising candidate for next-generation semiconductor applications due to its exceptional electrical, thermal, and mechanical properties. In this study, graphene was synthesized using a modified chemical exfoliation method, ensuring high purity and uniformity. Graphite powder was subjected to oxidation via the Hummers' method, followed by reduction to obtain reduced graphene oxide (rGO). The synthesized graphene was characterized through various analytical techniques to confirm its structure, morphology, and electronic properties. X-ray diffraction (XRD) analysis revealed the crystalline nature of graphene with a prominent (002) peak, indicating successful exfoliation. Raman spectroscopy showed characteristic D, G, and 2D bands, confirming the formation of few-layer graphene. Fourier Transform Infrared (FTIR) spectroscopy identified the functional groups associated with oxygen-containing species and their effective removal during reduction. Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM) images exhibited thin, wrinkled sheets with a layered morphology. Additionally, electrical conductivity measurements demonstrated enhanced conductivity, making the material suitable for semiconductor device fabrication. The synthesized graphene holds significant potential for use in field-effect transistors (FETs), sensors, and other microelectronic applications due to its high carrier mobility and tunable bandgap through functionalization. This study highlights an effective route for graphene synthesis and its suitability for advanced semiconductor technologies.

Details of Program		
Planning		
Objectives	Long-term Goals	• To synthesize high-quality graphene via the modified Hummers' method. • To characterize the synthesized graphene using advanced analytical techniques.

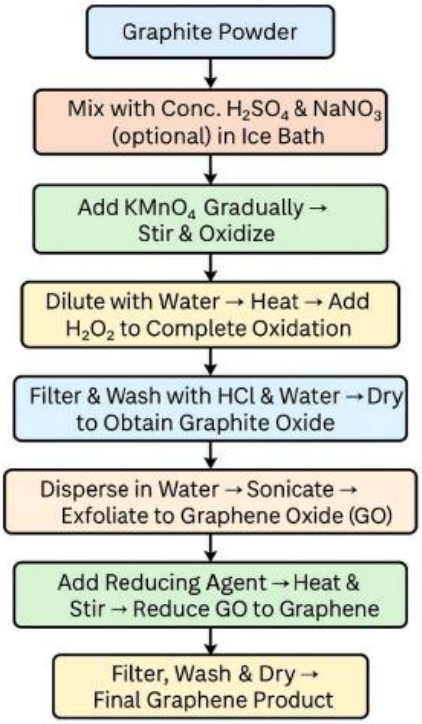
		• To evaluate the electrical properties of graphene for potential use in semiconductor devices.
	Short-term Targets	Key objectives include: • Establish a reliable synthesis process for producing graphene at the laboratory scale. • Train students and researchers in advanced materials characterization techniques. • Publish initial findings in a peer-reviewed journal to increase WUB's visibility. • Build a foundation for larger-scale graphene research projects and collaborations.
	Rationale	The semiconductor industry is continuously seeking materials that can outperform silicon in speed, efficiency, and miniaturization. Graphene, with its exceptional carrier mobility, mechanical strength, and thermal conductivity, has emerged as a promising candidate. Conducting this project will enable the development of foundational knowledge in graphene synthesis and characterization, positioning WUB as a contributor to cutting-edge research in semiconductor technology. Moreover, the project will provide training opportunities for students and foster collaborations with academic and industrial partners, aligning with global technological advancements. It will help place WUB at the center of academic innovation in Bangladesh.
Subject (Leader)	Initiator(s)	Hossain, Helal.
	Champion(s)	Hossain, Helal. (Lead Supervisor)
	Major team member(s)	
Environment	Nature/Society	This project aligns with the academic and research goals of the World University of Bangladesh (WUB) by promoting advanced material research with direct industrial and technological applications. Graphene-based research fosters innovation in semiconductor technology, which is crucial for electronics, communication, and computing industries.
	Industry/Market	The global graphene market has been growing rapidly, driven by its applications in electronics, energy storage, composites, and coatings. In the semiconductor sector, graphene is being considered for next-generation transistors, sensors, and transparent conductive films. According to recent market analyses, the graphene market is projected to reach several billion USD within the next decade. Bangladesh, with growing interest in semiconductor and electronics manufacturing, can benefit significantly from adopting graphene technologies. This project places WUB at the forefront of national and international research efforts, opening pathways for industry collaboration, technology transfer, and entrepreneurship.

Resources	Human resources	This project is going to support teaching and learning methodology of the university therefore 1 (One) teaching staff are directly involved in the project and WUB are going to get direct benefit from the project.
	Financial resources	The total financial support required to complete this project is approximately BDT 3,00,000/= (Three Lac taka only).
	Technological resources	To successfully execute this project, the following technological resources are required: • **Synthesis Facilities:** Fume hood, sonicator, hot plates, and chemical reactors for safe and effective synthesis. • **Characterization Instruments:** Access to XRD, SEM, TEM, FTIR, and Raman spectroscopy. • **Electrical Measurement Tools:** Four-point probe setup, conductivity meters, and semiconductor parameter analyzers. • **Software:** Data analysis tools such as Origin, MATLAB, or Python for structural/electrical analysis. • **Laboratory Safety Equipment:** Personal protective equipment (PPE), chemical storage, and waste disposal systems. These resources ensure that the project maintains scientific accuracy, safety, and reproducibility while offering students access to advanced technologies.
Mechanism	Strategy (Weight/Sequence)	To ensure systematic execution, the project will follow a weighted sequence of activities: 1. **Literature Review (10%)** – Understanding current graphene synthesis methods and applications. 2. **Synthesis of Graphene (30%)** – Preparation of graphene oxide and its reduction to graphene. 3. **Characterization (30%)** – Structural, morphological, and electrical testing. 4. **Data Analysis (15%)** – Interpretation of experimental results using analytical software. 5. **Reporting & Dissemination (15%)** – Preparation of reports, presentations, and publications. This weighted strategy ensures maximum focus on synthesis and characterization, while also emphasizing proper analysis and reporting.
	Organization	- The program aligns well with WUB's strategic vision of innovation in higher education. - The Mechanical Engineering Program directly oversees the project, ensuring integration with academic curricula. - Administrative support channels are available for project facilitation, media outreach, and financial oversight.

	Culture	- WUB's culture of encouraging student-led innovation supports the project strongly. - The presence of the only B.Sc. in Mechanical Engineering program in Bangladesh provides a unique platform. - Faculty mentoring culture enhances execution rather than hindering it.
Doing		
Launch date		September 2025
Responsible organization		World University of Bangladesh
Program content and process		**Program Content:** • Fundamentals of graphene and its importance in semiconductors. • Hands-on synthesis of graphene via chemical methods. • Training in advanced characterization techniques (XRD, SEM, TEM, Raman, FTIR). • Data analysis and interpretation sessions. • Reporting, presentation, and knowledge-sharing workshops. **Program Process:** 1. Orientation and literature-based training. 2. Laboratory-based synthesis experiments. 3. Characterization sessions using advanced instruments. 4. Data collection, analysis, and discussion meetings. 5. Preparation of technical reports and presentations for dissemination. This structured content and process ensure both theoretical knowledge and practical experience, equipping participants with well-rounded expertise in graphene research.
Key highlights of the content/process		• Practical exposure to **graphene synthesis and reduction methods**. • Training in **state-of-the-art characterization techniques** for nanomaterials. • Development of skills in **electrical property evaluation** for semiconductor applications. • Integration of **theoretical learning with hands-on laboratory practice**.

	• Focus on **research dissemination through reports, presentations, and publications**. • Enhancement of students' **research, technical, and analytical skills**.
Differences from traditional approaches	Before: Students had limited real-world exposure beyond classroom theory. Now: Students actively engage in design, fabrication, testing, and industry collaboration, with national media visibility.
Progress as of today	The following progress has been made until today's date: - Only laboratory setup is established
Problems in implementation	- • **Chemical Handling Risks:** Use of strong acids and oxidizers (e.g., H_2SO_4, $KMnO_4$) may pose safety hazards without proper protocols. • **Material Quality Variation:** Achieving consistent, high-quality graphene sheets may be difficult due to process sensitivity. • **Equipment Limitations:** Limited access to advanced instruments (e.g., TEM, Raman) may delay or restrict characterization. • **Cost Constraints:** High expenses for chemicals, reducing agents, and advanced analysis may exceed budget estimates. • **Time Management:** Strict timelines may be difficult to maintain due to synthesis challenges and instrument scheduling. • **Technical Expertise:** Specialized knowledge is required for synthesis and data interpretation, which may be limited among students. • **Scalability Issues:** Scaling from lab-scale synthesis to industry-level applications remains a challenge.
Approaches to solve the problems	A request has been made for financial support from the university. I am excited to collaborate and conduct research with other national and international universities as well.
Completion date, if completed	It is scheduled to be finished by Q2 of 2026.
Seeing	
Impacts on students	The project will have a significant impact on students by enhancing their technical knowledge of advanced materials like graphene, including its structure, properties, and synthesis methods. Through hands-on laboratory work, students will gain practical experience in techniques such as XRD, Raman spectroscopy, SEM, TEM, and FTIR, which will strengthen their experimental skills. The project will also develop their research and

	analytical abilities, as they learn to interpret characterization results and evaluate material performance for semiconductor applications. Additionally, students will cultivate problem-solving and innovative thinking by designing and optimizing synthesis processes. This experience will prepare them for careers in nanotechnology, electronics, materials science, and research, while also promoting interdisciplinary learning by integrating concepts from chemistry, physics, and electronics.
Impacts on professors	The academic faculty members involved in supervising the project have expressed strong satisfaction with its outcomes. They view the initiative as a practical extension of classroom learning, providing students with an opportunity to translate theoretical knowledge into real-world engineering applications. Faculty members will also benefit through increased engagement in mentoring, research, and interdisciplinary collaboration. Moreover, the project will open new possibilities for academic publications in the areas of electric mobility, lightweight design, and vehicle dynamics, further strengthening the department's academic standing.
Impacts on university administration	The university's leadership, including administrators and the Vice Chancellor, have welcomed the project as a pioneering step that reinforces WUB's unique position as the only institution in Bangladesh offering a B.Sc. in Mechanical Engineering. They recognize the initiative as a milestone that will enhance the university's profile, attract media attention, and appeal to prospective students. Leadership has acknowledged the project as not only a learning platform but also a symbol of WUB's forward-looking commitment to innovation, sustainability, and international visibility.
Responses from industry/market	Initial responses from local industry have been positive, with interest in potential collaboration and sponsorship. Industries actively researching and integrating graphene include: □ Semiconductor & Electronics □ Telecommunications □ Energy Storage (Batteries & Supercapacitors) □ Sensors & IoT Devices □ Automotive & Aerospace Semiconductor industries are focusing on graphene for: □ High-speed transistors □ Flexible and wearable electronics □ Transparent conductive films □ Photodetectors □ Radio frequency (RF) devices □ Thermal management materials
Responses from citizen/government	Given the alignment with national research policies and Smart Bangladesh initiatives, the project is likely to receive favorable attention from government stakeholders, possibly leading to grants or formal recognition
Measurable output (revenues)	N/A

Measurable input (expenses)	N/A
Cost-benefit analysis for effectiveness	N/A
Future Planning	
Where does the project go from here?	Moving forward, the project will focus on optimizing the synthesis process to produce high-quality graphene with consistent properties suitable for semiconductor applications. Further characterization will be conducted to understand how variations in synthesis parameters affect structural, chemical, and electrical properties. Once optimized, the graphene will be tested in simple semiconductor devices to evaluate its performance and potential for practical applications. Additionally, the project may explore scaling up the synthesis process and investigating hybrid materials or doping techniques to enhance the material's electronic properties. Ultimately, the insights gained will guide future research and development of graphene-based components in electronics and nanotechnology. Longer-term goals include developing autonomous capabilities, new materials, and establishing an annual innovation lab at WUB. The project is expected to evolve into a flagship program representing Bangladesh on the global stage.
Addendum	
Exhibits, pictures, diagrams, etc.	 Fig.: Experimental Process.

Reports, mimeos, monographs, books, etc.	It is expected to publish two Scopus-indexed scientific articles. In addition, a seminar will be conducted to disseminate the experimental results.
Others which may help explain the program (including website links)	A final report will be submitted to the university for record-keeping purposes. The physical prototype will be kept in the university laboratory after the competition.