



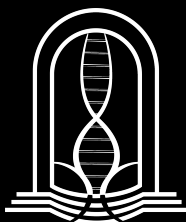
BIOENGINEERING

CATEGORY GUIDELINE



What is Bioengineering?

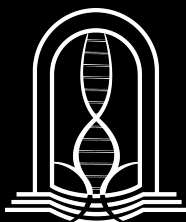
Bioengineering is a multidisciplinary field that combines principles and techniques from biology, engineering, and other related sciences to develop technologies and solutions for improving healthcare, medicine, and the overall quality of life. The primary goal of bioengineering is to apply engineering principles to biological systems, addressing challenges and developing innovations that benefit both human health and the environment.



What Do We Expect?

We expect students registering for the bioengineering category to bring a robust interdisciplinary knowledge of biology and engineering. Innovative thinking, strong problem-solving skills, and an ability to work collaboratively in multidisciplinary teams are essential. Clear communication, ethical considerations, and adaptability to dynamic challenges are key attributes. Successful participants should demonstrate effective project management, attention to detail, and a genuine passion for bioengineering. This category provides an opportunity for students to showcase their creativity and contribute to biology/healthcare with an engineering approach.

Teams can participate in the competition either with an experimental proposal or conceptual/theoretical proposal. Teams opting for experimental proposal participation or conceptual proposal participation must provide a comprehensive and detailed methodology, ensuring that their approach aligns with the competition's standards.

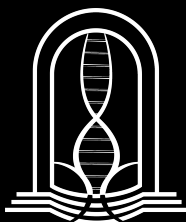


Key Aspects of This Field Include:

1) Biomechanics

The study of the mechanical aspects of living organisms, focusing on how biological structures and systems move, function, and respond to forces. It applies principles of physics and engineering to analyze the mechanics of bones, muscles, tendons, and other biological tissues. Biomechanics plays a crucial role in understanding human and animal movement. Some of the projects in this subfield may include:

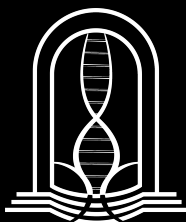
- Developing wearable sensors (technologies) to analyze and improve gait patterns in individuals recovering from injuries or surgeries.
- Developing and/or optimizing the design of orthopedic implants / prosthetic limbs.
- Design of equipment such as footwear or protective gear, based on biomechanical data.



2) Bioelectronics and Biosensors

Bioelectronics and biosensors are interdisciplinary fields that merge biology with electronics to develop devices capable of sensing and interfacing with biological systems. Biosensors are specialized devices designed to detect and quantify biological molecules or processes, often for medical, environmental, or industrial purposes. Bioelectronics involves the integration of biological components, such as enzymes or cells, with electronic systems to create devices that can convert biological signals into electrical signals or vice versa. Some of the projects in this subfield may include:

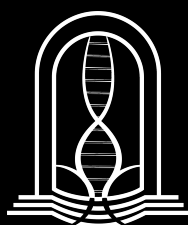
- Disease Monitoring Implants/Biosensors
- Point-of-Care Diagnostics.
- Environmental Biosensors to detect pollutants, pathogens, or specific chemicals.
- Wearable biosensors that track various physiological parameters.



3) Medical Imaging

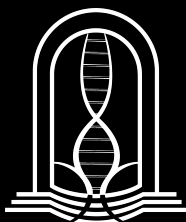
Medical imaging refers to the techniques and technologies used to create visual representations of the interior of a body for clinical analysis and medical intervention. It enables healthcare professionals to visualize the structure and function of organs, tissues, and physiological processes, aiding in the diagnosis, monitoring, and treatment of various medical conditions. Common medical imaging modalities include X-ray, computed tomography (CT), magnetic resonance imaging (MRI), ultrasound, and nuclear medicine techniques, each offering unique insights into different aspects of the body's anatomy and pathology. Some of the projects in this subfield may include:

- Artificial Intelligence for Image Analysis, Reconstruction, and Quality Enhancement
- Real-time Biomedical Image Processing
- Solutions for Inverse Problems in Medical Imaging
- 3D Printing from Medical Imaging Data



4) Biomaterials

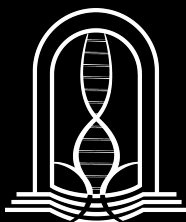
Biomaterials are substances engineered to interact with biological systems for medical or therapeutic purposes. These materials are designed to be compatible with living tissues, promoting specific biological responses while possessing physical and chemical properties suitable for various applications. Biomaterials play a crucial role in medical implants, tissue engineering, drug delivery systems, and regenerative medicine. They are selected and tailored based on their ability to integrate with the body, provide mechanical support, and, in some cases, facilitate controlled interactions for therapeutic or diagnostic purposes. Examples include biocompatible polymers, ceramics, metals, and composite materials that are utilized to create devices like artificial joints, scaffolds for tissue regeneration, and drug-eluting implants.



5) Neurotechnology

Neurotechnology is a multidisciplinary field of study that focuses on understanding the structure and function of the nervous system, which includes the brain, spinal cord, and peripheral nerves. It aims to unravel the mechanisms underlying perception, learning, memory, emotions, and various neurological disorders, contributing to technological advancements in medicine, psychology. The projects may include:

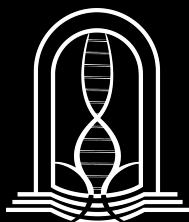
- Brain-Machine Interactions: Develop BMI technologies that allow direct communication between the brain and external devices.
- Neuroimaging Studies: Conduct functional magnetic resonance imaging (fMRI) or positron emission tomography (PET) studies to investigate brain activity patterns
- Neural Signal Processing: Create/Improve algorithms for processing and interpreting neural signals recorded from brain-computer interfaces or neuroimaging techniques
- Neuro-robotics, Neural Probes and Sensors for recording or stimulating neural activity with high precision



6) Bioreactors Design

Bioreactors are a central tool in biology and bioengineering. They are used especially for growing cells, bacteria, or microorganisms under controlled conditions. They allow precise control over factors like temperature, oxygen levels, and nutrients. They are designed by mathematical modelling, equations solved either with hand or computer software. The projects may include:

- **Cell Culture and Tissue Engineering:** Bioreactors are essential for growing cells and tissues. This has applications in developing artificial organs or tissues for medical transplants.
- **Pharmaceutical Production:** Bioreactors are used to produce pharmaceutical products, like vaccines and antibiotics. Cells or microorganisms are grown in bioreactors to produce these substances.
- **Environmental Biotechnology:** Bioreactors can be used to break down pollutants in the environment. Microorganisms in bioreactors can degrade toxic substances, helping to clean up environmental spills.
- **Food and Beverage Industry:** In the production of items like beer, wine, and cheese, bioreactors are used for fermentation processes.
- **Biofuel Production:** Bioreactors can cultivate microorganisms or algae that produce biofuels, offering a renewable energy source.



Tools for Bioengineering

These tools empower you to combine the principles of biology and engineering, fostering innovation and problem-solving in the field of bioengineering.

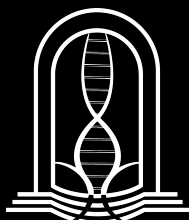
Computational Biology:

Computational Biology applies math and computer science to model and simulate biological processes, aiding in understanding complex systems like protein structures and genetic interactions.

Bioinformatics:

Bioinformatics integrates biology with informatics to manage and analyze biological data, helping students explore genetic variations, annotate genomes, and derive insights from large datasets.

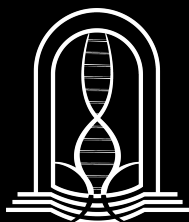
- *BLAST (Basic Local Alignment Search Tool):* A powerful tool for comparing nucleotide or protein sequences, aiding in the identification of similarities and functional relationships.
- *BioPython:* A collection of freely available tools for biological computation written in Python, providing a wide range of modules for tasks such as sequence analysis, 3D structure, and more.
- *Biopython Bioinformatics Toolkit:* An open-source collection of Python tools for computational biology, allowing students to manipulate biological data efficiently.



- *Autodesk Fusion 360*: Ideal for bioengineers engaged in CAD (Computer-Aided Design) and modeling, facilitating the creation and visualization of 3D designs.
- *COMSOL Multiphysics*: A comprehensive simulation software that integrates various physical phenomena, enabling students to simulate and optimize bioengineering systems.
- *LabVIEW (Laboratory Virtual Instrument Engineering Workbench)*: Widely used for data acquisition, instrument control, and automation, providing a flexible platform for integrating hardware and software in the lab.

Note:

The tools mentioned above are just a selection to get you started. Participants are encouraged to explore and utilize a variety of tools beyond these suggestions. There is no mandatory requirement to stick to these; feel free to choose and experiment with any tools that align with your project goals. The competition values creativity and innovation, so do not hesitate to explore a diverse set of tools to enhance your bioengineering project.



1. Choose a Current Problem:

Clearly define the problem or challenge addressed by the project and emphasize the importance of addressing the problem.

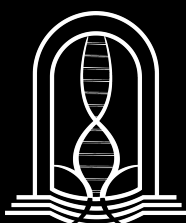
2. Literature Review and Background Research:

Demonstrate a comprehensive literature review, showcasing awareness of existing research, technologies, and advancements related to the chosen bioengineering problem.

3. Develop a Solution to Address the Problem: Propose an innovative and creative solution that goes beyond conventional methods, demonstrating a unique engineering approach to address the identified problem.

4. Future Directions:

Discuss the solution's potential for future development and improvements and its implications for biosecurity/ethics.



Evaluation Criteria:

1. Innovation and Creativity:

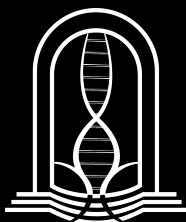
The project demonstrates a high level of innovation, showcasing creative solutions to address the bioengineering problem or challenge.

2. Cost Analysis and Budgeting:

Is the solution to the problem cost-effective and if yes, how it stands out among the traditional approaches?

3. Experimental Design

The team offered a set of experiments and hypotheses required to completely demonstrate the effectiveness of their approach. Future experiments that must be completed are listed in case the team is unable to finish all of the experiments within the competition deadline or is on the proposal track. Any hardware/software created will be evaluated.



4. Communication Skills:

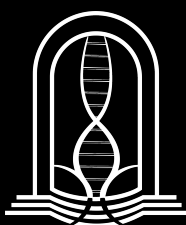
The project's details are effectively communicated through well-written reports, clear presentations, and, if applicable, engaging demonstrations. The ability to articulate complex concepts to both technical and non-technical audiences is crucial.

5. Feasibility/Reproducibility:

Assessment of the practicality and viability of translating the project from concept to real-world application. The proposed solution is technically feasible and reproducible based on current knowledge, available technology, and the state of the field. Complexity of the proposed design and any potential technical challenges are considered.

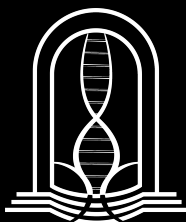
6. Ethical Considerations / Biosafety:

Ethical considerations associated with the project, including safety measures, potential risks, and the broader societal impact of the bioengineering solution.



Reminder:

Teams have the option to engage in either experimental proposal projects or conceptual projects. If a team is unable to fulfill the necessary experiments within the specified period of time, their evaluation will be conducted under the conceptual proposal category. While experimental participation is encouraged, ensured experiments are completed accordingly, teams engaging in conceptual proposal projects and experimental proposal projects are conditioned to provide an extended methodology in the project report.



Score Distribution:

