Indian Institute of Technology, Kanpur

Proposal for a New Course

1. Course No: **BSE6xx** 665
2. Course Title: **Electronics and Signal Processing for Biologists**
3. Per Week Lectures: **2.5**(L), Tutorial: **0** (T), Laboratory: **1.5** (P), Additional Hours [0-2]: **0** (A)
   - Credits (3*L+2*T+P+A): **9**
   - Duration of Course: **Full Semester**
4. Proposing Department/IDP: **Biological Sciences & Bioengineering**
   - Other Departments/IDPs which may be interested in the proposed course: **Cognitive Science, Design**
   - Other faculty members interested in teaching the proposed course: **Prof. K. S. Venkatesh (EE)**
5. Proposing Instructor(s): **Prof. Nikunj Bhagat**
6. **Course Description:**

   An introductory course on basic electronics and signal processing techniques for students in Biological Sciences, Bioengineering, and related disciplines. The course will teach fundamental topics in passive and active electronic systems, as well as time and frequency domain analysis for signals and systems typically encountered in a biomedical or neuroscience laboratory. Practical hands-on training on electronic circuit design, signal measurements and analysis, will be provided through laboratory experiments, demonstrations, and MATLAB programming. There are no prerequisites for this course and students from both engineering and non-engineering backgrounds will gain practical insights in electronics and signal processing through real-world applications.

   A. Objectives:

   - Introduce fundamental concepts in electronics and signal processing.
   - Provide practical training through lab experiments and demonstrations.
   - Familiarize with MATLAB programming for biosignal processing.

   B. Contents:

S. No.	Title	Topics	No. of Lectures
1.	Introduction to electrical circuits & networks	• Basic concepts: voltage, current, R, L, C • Kirchoff's laws, Ohm's law, Superposition • Circuit Analysis – Mesh & Nodal Analysis • Lab practical on R-C circuits*	4
2.	Semiconductor electronics	• Semiconductor basics, diodes, rectifiers • BJT transistors, inverters, CE amplifiers • Lab practical on diode and transistor circuits*	5

3.	Operational Amplifiers (Op-Amp)	• Differential Amplifiers • Input & output impedance, CMRR, feedback. • Inverting & non-inverting amplifiers • Lab practical on basic op-amp circuits*	5
4.	Op-Amp Applications	• Active filters, multiple-feedback filters • Instrumentation amplifiers • Lab practical and hands-on demonstration on recording ECG, EMG, and EEG signals*.	6
		Mid-Semester	
5.	Introduction to Signals & Systems	• Biological Systems & Biosignals • Examples of electrical, mechanical, thermal biosignals • Continuous & discrete-time signals • Sampling frequency, bandwidth, Nyquist Rate and SNR measurements	4
6.	Basic Signal Processing	• Measurement of signal properties: mean, variance, power, ensemble averaging. • Correlation & Covariance • Programming in MATLAB	4
7.	Frequency Analysis of Signals	• Discrete Fourier Transform (DFT), FFT • Power Spectrum estimation • MATLAB-based examples	4
8.	Discrete-Time Systems & Digital Filters	• Discrete-time systems & its types • Analysis of LTI systems using Convolution • Transfer function, magnitude & phase response. • Introduction to filtering, filter types & characteristics • Design of Digital Filters using MATLAB	8
		Total	**40**

*(*Prefabricated circuits on breadboards/PCBs will be provided to students in order to reduce the time required for laboratory experiments. Demonstrations will be conducted using off-the-shelf/commercial systems)*

C. Pre-requisites: None

D. Short Summary:

This course aims to impart knowledge on fundamental topics in electronics and signal processing and familiarize students will real-world applications. The course content is relevant for students interested in pursuing a career in interdisciplinary fields such as Biomedical Engineering, Neuroscience and Neural Engineering, as well as Rehabilitation Engineering.

7. **Recommended Books: Textbooks, Reference books**

- *Electronics for Biologists* by Timothy Gawne, Ballacourage Books

- *Hands-On Electronics: A Practical Introduction to Analog and Digital Circuits* by Daniel Kaplan and Christopher White, Cambridge University Press
- *Electronic Principles 9th Edition* by Albert Malvino, David Bates, Patrick Hoppe, McGraw Hill
- *Biosignal and Medical Image Processing 3rd Edition* by John Semmlow and Benjamin Griffel, CRC Press
- *Signal Processing for Neuroscientists* by Wim van Drongelen, Academic Press
- *Digital Signal Processing: principles, algorithms, and applications 4th Edition* by John Proakis and Dimitris Manolakis, Pearson Education

Dated: **20-02-2024**

Proposer: **Nikunj Bhagat**

Dated: _____

DPGC Convener: _____

The course is approved/not approved.

3/4/24

Chair, SPGC

Dated: _____