Indian Institute of Technology, Kanpur

Proposal for a new course

1. **Course No.:** KSS 6XX

2. **Course Title:** Biophysics, Ecology, and Sustainability

3. **Per Week Lectures:** 3(L), Tutorial: 0 (T), Laboratory: 0 (P), Additional Hours: 0 (A)

4. **Credits:** (3*L+0*T+P+A): 9

5. **Duration of Course:** Full Semester

6. **Proposing Department:** Kotak School of Sustainability

   Other departments that may be interested in the proposed course: Civil Engineering, Chemical Engineering, Mechanical Engineering, Earth Sciences, Environmental Science and Engineering, Physics.

7. **Proposing Instructor(s):** Prof. Praneet Prakash (KSS)

8. **Course Description:** Global warming and climate change pose direct threat to life as we know it by endangering health of living systems through extreme heat, pollution, spread of diseases, loss of biodiversity while also affecting food and water security. Tackling the climate vulnerabilities systems requires an interdisciplinary approach to ensure their continued sustainability. In this course students will learn quantitative approach to analyse microscopic phenomena and large-scale interactions that govern sustainability of living systems. The course integrates two core areas, Biophysics and Ecology into a holistic framework to address real-world case studies on Sustainability.

   A) **Objectives:**

   - Understand the interdisciplinary nature of emerging threats on living systems sustainability.
   - Develop data-driven solutions to address pressing sustainability challenges.
   - Construct ab initio dynamical models for climate vulnerabilities.
   - Deliver engineering solution to tackle emerging water pollutants such as microplastics.
   - Design experiments to explore the emerging research area of living materials.

   B) **Contents**

S. No	Broad Title	Topics	No. of Lectures
1.	Fundamentals of Microscale Dynamics	advection, active motion, diffusion	1

2.	Diffusion and Growth	linear diffusion (finite domain, infinite domain), nondimensionalization, measurements (frap), non-linear diffusion	2
3.	Reaction-Diffusion Systems	bistable systems, Fisher's equation	4
4.	Spatial Instabilities	Turing instability, activator-inhibitor dynamics, vegetation pattern	5
5.	Living Matter in Fluids	microscale swimming (motility), chemotaxis, chemoreception, transport limits, Michaelis-Menten Kinetics	3
6.	Population Dynamics	single population models, delay in population, example (Blowflies), age structures, discrete systems, logistic map, multi-species model	3
7.	Health Sustainability	epidemic models, role of vaccinations, SIR model, excitable systems	5
8.	Stochasticity in Population Dynamics	single population, extinction, multiple population, Fokker-Planck equation	5
9.	Sustainability Case Study	impact of climate change on vegetation	2
10.	Sustainability Case Study	sustainability of marine ecosystem	2
11.	Sustainability Case Study	microbial population under climate stress	2
12.	Sustainability Case Study	loss of biodiversity due to extreme climate events	2
13.	Sustainability Case Study	assessing the impact of water pollutants on ecosystem health	2
14.	Sustainability Case Study	Kelkar library fountain – Why so green?	2

C) **Pre-requisites:** Basic knowledge of Physics, Mathematics, and any engineering discipline, along with familiarity with differential equations and a programming language.

9. **Textbooks**
   a. J. D. Murray, Mathematical Biology, Volumes 1 and 2, Springer
   b. H. C. Berg, Random Walks in Biology, Princeton University Press
   c. R. May & A. McLean, Theoretical Ecology, Oxford University Press
   d. R. B. Northrop & A. N. Connor, Ecological Sustainability, CRC Press
   e. Additional references will be provided during the lectures.

**Personal copies of books are available with the instructor on request.*

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10. **Any other remarks:** Students from all engineering and science disciplines are welcome.

Dated: 29/8/25 Proposer: Pranect Prakash

Dated: 29/8/25 DUGC/DPGC Convener:

The course is approved / not approved

Chairman, SUGC/SPGC

Dated: _____