Approved in 38th BoA Meeting (22-01-2021)

Course Number : CE561
Course Name : The science of climate change
Credits : 3-0-0-3
Prerequisites : IC 230 (Environmental Science) or equivalent
Intended for : 3rd and 4th year B.Tech., PG
Distribution : Elective

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(1) Preamble:

While we are generally familiar with the projections of human-induced global warming and its catastrophic consequences for the world, it is desirable that we are equally aware of the basic scientific principles that define and mould this phenomenon. This is especially important given the requirement for sustainable infrastructure and societies to be necessarily climate-resilient, and therefore, the need for practitioners of science, technology and policy to be climate-conscious. This course aims to present to students the most current scientific understanding of global warming and associated climate change, charting a course from natural climatic fluctuations on geological timescales to the modern-day climate and its forcing by anthropogenic activities. It also aims to prepare students to participate in environmental decision-making by providing scientific, technological and policy perspectives on climate change.

1. Course Modules:

Module 1: Earth system concepts and early climate [5 Hours]

State of a system and couplings; negative and positive feedback loops; system response to feedbacks; stable and unstable equilibrium states; application of these concepts to the Daisyworld climate system; formation and composition of the early atmosphere, and the effect of early life; the Great Oxidation Event and the ozone shield; early climate and its evolution over time

Module 2: Basics of global climate [7 Hours]

Components of the climate system, timescales and the parameterization problem; basics of energy balance and radiative forcing; atmospheric and oceanic circulation and their role in energy redistribution; conservation of momentum, equations of state, temperature and continuity equations, moist processes, wave processes; natural climate variability – El Nino Southern Oscillation (ENSO) dynamics, ENSO teleconnection and prediction

Module 3: Long-term climate regulation and proxies [6 Hours]

The Faint Young Sun paradox – a CO_2 and CH_4-rich early atmosphere; geological indicators of paleoclimate; isotopic proxies and temperature reconstruction; long-term glacial record and evidence of past glaciations; low-latitude glaciation and the Snowball Earth; banded-iron formations and cap carbonates; Pleistocene glaciations and the Milankovitch Cycles; climate record from the Dome C and Vostok ice cores – evidence of anthropogenic influence

Module 4: The greenhouse effect and climate feedbacks [5 Hours]

Global energy balance model with a 1-layer atmosphere – IR emissions and temperature; magnitude of the greenhouse effect; global warming potential; climate feedbacks and climate sensitivity – water vapour, snow/ice, cloud, lapse rate and stratospheric cooling feedbacks; climate response time and sensitivity in transient climate change – doubling of CO_2, ocean warming

Module 5: Modern climate and human influence [7 Hours]

Climate change during the Holocene and the industrial era; the carbon, nitrogen and water cycles and their perturbations, carbon emission intensity, estimating emissions from the Kaya Identity, CO_2-equivalents; radiative forcing of other greenhouse gases (CH_4, N_2O, halocarbons) and aerosols since industrialization

Module 6: Effects of climate change in the polar regions and the Himalayas [5 Hours]

Effects of climate change on the cryosphere; temperature and precipitation trends in the poles and the Himalayas under a changing climate; aerosol deposition, snow cover change and glacier melting; effects on stream flow and water resources; the National Action Plan on Climate Change and the National Mission for Sustaining the Himalayan Ecosystem; resilience and adaptation of Himalayan communities to climate change

Module 7: Climate projections for the future and adaptation/mitigation strategies [7 Hours]

Emission paths and scenarios; globally-averaged response to warming scenarios; coupled climate models, projections and multi-model ensemble averages; mitigation strategies – climate-smart agriculture, energy efficiency, GHG accounting, renewable energy, sustainable urban systems

2. Textbooks:

i) Climate Change and Climate Modeling; 4th Edition, 2015; J. David Neelin; Cambridge University Press.

ii) The Earth System; 3rd Edition, 2010; Lee R. Kump, James F. Kasting, Robert G. Crane; Prentice Hall.

3. References:

i) Earth System Science in the Anthropocene; 1st Edition, 2005; Eckhart Ehlers, Thomas Krafft; Springer.

ii) Chemistry of the Upper and Lower Atmosphere; 2nd Edition, 2000; Barbara J. Finlayson-Pitts and James N. Pitts Jr; Academic Press.

iii) Atmosphere, Ocean and Climate Dynamics; 1st Edition, 2007; John Marshall and R. Alan Plumb; Academic Press.

iv) Relevant IPCC reports: AR5 Climate Change 2013 – The Physical Science Basis; Global Warming of 1.5°C; The Ocean and Cryosphere in a Changing Climate.

v) Research articles will be advised as required.

4. **Similarity Content Declaration with Existing Courses**

S.N.	Course Code	Similarity Content	Approx. % of Content
1	CE558 Air Pollution and its Mitigation	Global energy balance and greenhouse effect	5%

5. **Justification for new course proposal if cumulative similarity content is > 30%:** N.A.