NPTEL Syllabus Template

Course Title	Diffusion in Solids
Discipline	Metallurgy, Materials Science and Engineering
Duration of course 4/8/12 weeks (10/20/30 hours @2.5 hrs/week)	8 weeks
Number of times you have taught this course totally and in the last 5 years (2-3 times is preferable, if not more)	5
Is this course syllabus approved by AICTE or by Senate in your/any institute? If yes, please give the course name and institute under which this is approved.	Yes, the course is approved by the Senate of IIT Hyderabad: MS2290 – Diffusion in Solids
The time frame of when you would want to offer the course: (Jan 2024/July 2024)	July 2024
Will it map to any course in the AICTE model curriculum? LINK to AICTE Curriculum LINK 1 LINK 2 LINK 3 LINK 4	PCC-MM203 (Module 2 and 3) PCC-MM204 (Module 5)
Will it map onto any of the NPTEL domain? LINK to Domain page: https://nptel.ac.in/noc/Domain/	Metallurgical & Materials Engineering – Minor in Metallurgy

Name of the Instructor(s)	Dr. Mayur Vaidya	
Department	Materials Science and Metallurgical Engineering	
Institute	IIT Hyderabad	
Email ID	vaidyam@msme.iith.ac.in	
Mobile Phone Number	7879916780	
Website of Instructor	https://msme.iith.ac.in/assets/docs/profiles/MV_CV.pdf	

Intended audience	Undergraduate students and First year PG students
Is it a core/elective course?	Core
Is it a UG/PG/PhD level course?	UG (Relevant for PG and PhD as well)
Is this course relevant for GATE exam preparation?	Yes
Which degrees would it apply to? (BE/ME/MS/BSc/MSc/PhD etc)	BE/ME/MS
What are the next set of courses that can be taken by students who complete this?	Interdiffusion in Solids, Phase Transformations
Pre-requisites in terms of educational qualification of participants, or if any other courses should be done before this course can be taken	None
Industry recognition of this course – List of companies/industry that will recognize/value this online course	Tata Steel, JSW, General Electric, Eaton, Kennametal India, TCS Engineering, Hindalco, MIDHANI, Sandvik. In general, all Materials and Manufacturing Industries that engage in materials processing and design, and the government labs like DMRL, ISRO, BARC, IGCAR
Will the final certification exam be– paper/pen type or computer based - both are proctored	Computer Based
Will the course require use of any software such as MATLAB or any programming language, etc. or any other tool? If yes, does it have a Linux based compiler available or if licensed, can we get the educational license for the same?	The course will use Thermo-Calc Student's edition (available for free for students and teachers) for CALPHAD-based calculations of diffusion profiles using DICTRA module. Sci lab (available for free) to generate solutions to diffusion equations
Names of 2 reviewers for the course (can be from other institutes – will be used if we need any additional inputs on the course) – Name, Dept, email id, Institute	Name : Prof. G. Phanikumar Dept. : MME Institute : IIT Madras Email : gphani@iitm.ac.in Name : Prof. Kaustubh Kulkarni Dept. : MSE Institute : IIT Kanpur Email : kkaustub@iitk.ac.in
List of reference materials/books	1. Mehrer, Helmut. *Diffusion in solids: fundamentals, methods, materials, diffusion-controlled processes*. Vol. 155. Springer Science & Business Media, 2007. 2. Paul, Aloke, Tomi Laurila, Vesa Vuorinen, and Sergiy V. Divinski. *Thermodynamics, diffusion and the Kirkendall effect in solids*. Cham: Springer International Publishing, 2014.

FOR GETTING THE INTRODUCTORY COURSE PAGE READY – TO OPEN FOR ENROLLMENTS

1. Introduce the course in about 4-5 lines

This course introduces the fundamental concepts of diffusion in solids to the students of materials science and metallurgical engineering. Diffusion is a key phenomenon controlling several thermally activated processes in materials. The course offers unique blend of in-depth fundamental diffusion concepts applied to several class of materials such as metallic alloys, semiconductors, ionic solids and nanocrystalline systems. The students will learn to solve diffusion equations following a continuum approach as well as gain understanding of atomic mechanisms of diffusion. The course will also include a DICTRA module where students will learn basics of computational tools for diffusion and get a hands on experience on the same. Techniques to measure the diffusion coefficients are also a part of the course.

2. Photograph of instructor(s)

3. About the instructor(s)

Dr. Mayur Vaidya is currently an Assistant Professor at the Department of Materials Science and Metallurgical Engineering, IIT Hyderabad. Dr. Vaidya's PhD, from IIT Madras, was on diffusion behaviour in high entropy alloys and he has since then expanded his research field to understanding diffusion in variety of materials. His pioneering work on tracer diffusion in high entropy alloys formed the basis of his selection for prestigious Young Scientist award by Indian National Science Academy. Dr. Vaidya has 25 research publications in peer-reviewed journals, with over 1300 citations and h-index of 16. Earlier, Dr. Vaidya did his B. Tech and M. Tech at IIT Madras, during which he received Institute Silver Medal for excellent academic performance. At IIT Hyderabad Dr. Vaidya has taught UG core course on Diffusion in Solids, PG core courses on Advanced Thermodynamics of Materials and Advanced Physical Metallurgy, PG electives on Interdiffusion in solids, high entropy materials and phase transformations. He was awarded Teaching Excellence award – 2023 by IIT Hyderabad.

4. An introductory video about the course (2-5 minutes' duration)

Weekly Course Plan			
Weeks		**Lecture Names**	**Assignments**
Week 1	:	Lec 1: Diffusion in materials world Lec 2: Ficks Laws of Diffusion Lec 3: Solutions to Diffusion equations - 1 Lec 4: Solutions to Diffusion equations - 2 Lec 5: Demo of Scilab – 1 (generating graphs for diffusion equation solutions, hands on experience)	Online
Week 2	:	Lec 6: Demo of Scilab – 1 (generating graphs for diffusion equation solutions, hands on experience) Lec 7: Diffusion Mechanisms - Interstitial, Vacancy Lec 8: Diffusion Mechanisms - (Divacancy, Interstitialcy, Dissociative) Lec 9: Random Walk and Correlation Factor Lec 10: Tutorial 1	Online
Week 3	:	Lec 11: Basics of Interdiffusion Lec 12: Phase formation in interdiffusion zone Lec 13: Practical examples of interdiffusion zone development - 1 Lec 14: Practical examples of interdiffusion zone development - 2 Lec 15: Tutorial 2	Online
Week 4	:	Lec 16: Kirkendall Effect Lec 17: Introduction to Thermo-Calc and Dictra software Lec 18: Thermodynamic and kinetic databases Lec 19: Homogenization, moving boundary problems Lec 20: Tutorial - 3	Online
Week 5	:	Lec 21: Radiotracer diffusion Lec 22: SIMS and EPMA	Online

		Lec 23: Mechanical spectroscopy Lec 24: Nuclear & Electrical methods Lec 25: Tutorial-4	
Week 6	:	Lec 26: Grain boundary structure and fisher model Lec 27: Kinetic regime of grain boundary diffusion Lec 28: Dislocation pipe diffusion Lec 29: Diffusion in nanocrystalline materials Lec 30: Tutorial-5	Online
Week 7	:	Lec 31: Diffusion in metallic alloys-1 Lec 32: Diffusion in metallic alloys-2 Lec 33: Diffusion in Intermetallics Lec 34: Diffusion in semiconductors-1 Lec 35: Tutorial - 6	Online
Week 8	:	Lec 36: Diffusion in semiconductors-2 Lec 37: Diffusion in ionic solids-1 Lec 38: Diffusion in ionic solids-2 Lec 39: Diffusion in glasses-1 Lec 40: Tutorial - 7	Online

TA Details			
	:	Teaching Assistant 1	Teaching Assistant 2
Name	:	Ms. Bhawna Yadav	
Department	:	MSME	
Email ID	:	ms21resch01002@iith.ac.in	
Mobile Number	:	9424401710	
Currently pursuing degree	:	PhD	

Novelty of the proposed Course

Although there is one related course (NOC: Diffusion in multicomponent solids) available on NPTEL, the proposed course has several unique topics, which makes it qualify as a separate course. These are listed below:

a) Kinetic simulations: **Lecs 17-19** are dedicated to using Thermocalc and DICTRA and using them to perform basic kinetic simulations. This is not only a unique topic of this course, but the live demonstrations of the software for problem solving will lend an active

learning component to the students as they will be able to perform calculations while they listen to the content.

b) Diffusion measurement techniques: **Lecs 21 - 24** – This novel aspect of the course aims to teach students the basis of techniques used to determine the diffusion coefficients. The experience of the instructor in using several of the techniques mentioned will enhance the learning experience of the students.

c) High diffusivity paths: **Lecs 26 - 29**– It will introduce the concept of Grain boundary diffusion, dislocation diffusion and their application to understand the diffusivity in nanocrystalline materials.

d) Diffusion in important class of materials: **Lecs 31 – 34, 36 - 39** – Diffusion plays a very important role not only in metallic systems, but in several other materials such as semiconductors, ionic solids, and glasses. Over a span of two weeks, this course would give students key concepts in understanding diffusion behaviour of these important classes of materials.

e) Use of Scilab: Students will be shown to plot some of the solutions to diffusion equations **(Lecs 5 and 6)** using open-source software Scilab. I believe, such hands-on experience will make the learning more active and interesting, and students will be able to grasp the concepts easily.