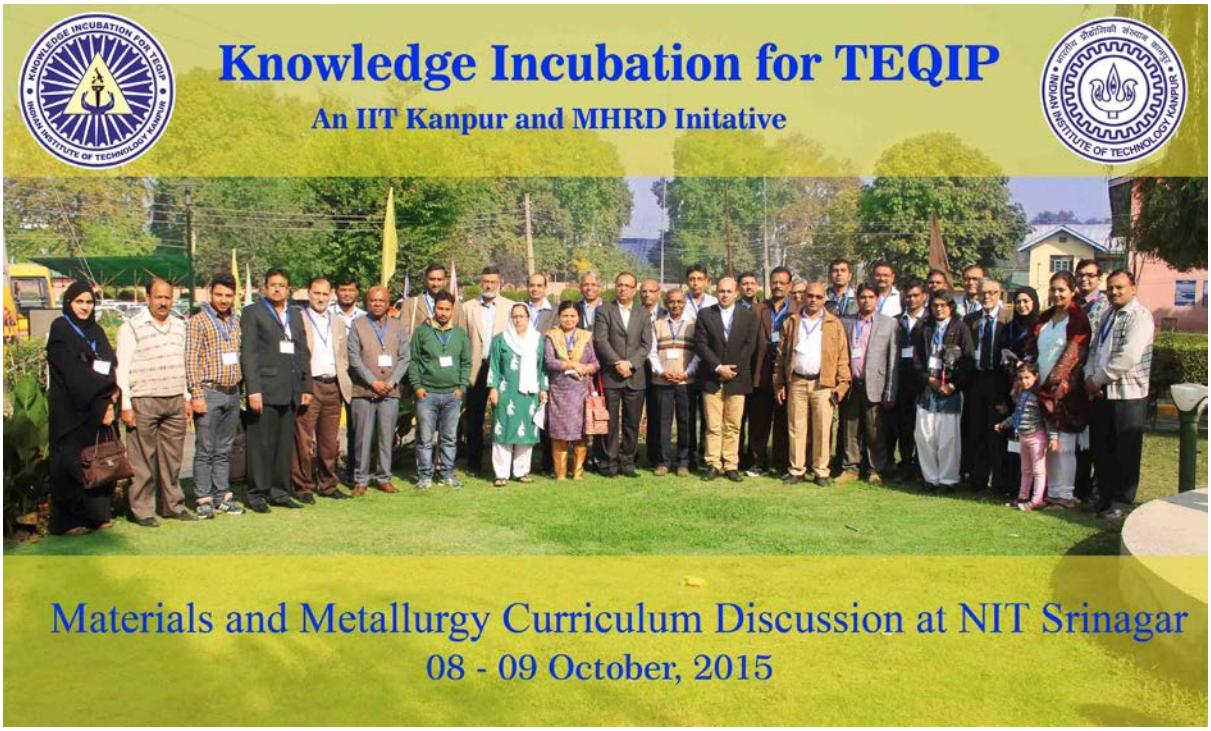
KNOWLEDGE INCUBATION FOR TEQIP, IIT KANPUR

TEQIP Workshop on Materials & Metallurgy Curriculum Discussion

October 08-09, 2015



The two day workshop on **Materials and Metallurgy Curriculum Discussion was held at NIT Srinagar.** The need for organizing such a workshop arose from the changing face of Metallurgy and Materials Science all over the world and India not being an isolated case either. To prepare the students for national needs in industry, research as well as academia, the curriculum must evolve in such a fashion that departments are able to engage the students both depth as well breadth wise whilst not sacrificing on the core concepts. The primary aim of the workshop was to discuss the undergraduate curriculum of Materials and Metallurgical Engineering and similar disciplines. The emphasis was to understand the structure of curriculum in various institutes and then to have meaningful discussions to evolve a basic structure of the curriculum, which can be recommended to each institute for further implementation.

The workshop also included discussion on how one can make effective use of online resources such as NPTEL to augment or support the teaching strengths of the institutions which can also help in designing the curriculum.

TOPICS DISCUSSED

- Philosophy behind teaching of Materials and Metallurgical Engineering UG and PG Programs
- Objectives and evolution with changing times
- Existing courses and lab component
- How to balance theoretical concepts and hands-on skills of the students as well as core and elective courses
- Relevance to the industry as well as higher education and research
- Discussions to evolve a model curricula which should be able to motivate the students with the framework of existing strengths of the participating institutions.

PARTICIPATING INSTITUTES

Institute	Number of Participant
NIT Rourkela	1
NIT Raipur	2
NIT Jamshedpur	2
PEC Chandigarh	2
MNIT Jaipur	2
VNIT Nagpur	2
MANIT Bhopal	1
IIEST Shibpur	1
NIT Surathkal	1
IIT Madras	1
IIT Bombay	2
IIT Kanpur	5
IIT Kharagpur	1
IISc Bangalore	1
Jadavpur university	1
Total	**25**

WORKSHOP SCHEDULE

Day 1(08th October, 2015)

Time	Event
8:45 – 9:00 AM	***Registration***
9:00 – 9:10 AM	**Introductory remarks (Organizers)**
9:10 – 9:30 AM	**Inauguration** (Director, NIT Srinagar) Director's remarks
9:30 – 9:45 AM	**Remarks from TEQIP Coordinator, IIT Kanpur and the Organizers**
9:45 – 10:30 AM	***High Tea***

10:30 – 1:00PM	Presentations by Institutional Representatives (15 minutes each) on their UG and PG curriculum of their departments focussing on the structure or template, strengths and possible changes that are desired) IISc Bangalore ● PEC University, Chandigarh ● NIT Jaipur ● BESU Shibpur ● NIT Bhopal ● NIT Jamshedpur ● NIT Srinagar ● NIT Rourkela ● IIT Kharagpur ● VNIT Nagpur
1:00 – 2:00 PM	***Lunch Break***
2:00 – 3:30 PM	● NIT Raipur ● IIT Madras ● IIT Kharagpur ● IIT Bombay ● IIT Kanpur
3:30 – 3:45 PM	***Tea Break***
3:45 – 5:15 PM	● Discussions (***Moderator: Prof. A.S. Gandhi***) ○ Critical observations of existing curriculum. ○ What are the key strengths and weaknesses? ○ How are students and faculty perspectives served? ● Summary and agenda for the next day (***Prof. A. Garg***)

Day 2 (09th October, 2015)

Time	Event
9:00 – 9:30 AM	**Views from Prof. Indranil Manna, Director, IIT Kanpur**
9:30 – 10:30 AM	**Basic structure Defining key components of Materials and*Metallurgy UG curriculum*** ***Moderators*:*Prof. T.A. Abinandanan and Prof. M.K. Agarwa***l
10:30 – 11:00 AM	***Tea Break***
	Discussions (UG Curriculum)
11:00 – 11:30 AM	**UG Curriculum: Core Component (Institute Courses)** ● Engineering ● Science and Mathematics ● Humanities courses ● Scientific, research and communications Skills ***Moderator: Prof. Rajiv Shekhar and Prof. Anindya Bose***
11:30 – 12:45 PM	**Curriculum: Departmental and Elective Components** ● Departmental Core and Elective Courses ● Laboratories ● Non-departmental electives and humanities ● Project

	● Industrial visit ***Moderator: Prof. A.S. Gandhi and Prof. Upender Patel***
12:45 – 1:00 PM	● Final template of four years UG Programme (AG)
1:00 – 2:00 PM	***Lunch Break***
2:00 – 3:00 PM	**Pedagogical issues and new concepts** ● How to excite the students, particularly at the UG level ● Scope of Dual Degree, Double Major & MinorProgrammes ● Use of online resources such as NPTEL in designing the curriculum ***Moderator: Prof. N.N. Viswanathan and Prof. D.R. Peshwe***
3:00 – 3:15 PM	***Tea Break***
3:15 – 4:15 PM	**M.E./M.Tech. Curriculum** ● Course-work structure for M.Tech. ● M.Tech. Project ● Research and communications skills ***Moderator: Prof. ShashankShekhar and Prof. Uma Batra***
4:15 – 4:45 PM	**Discussion and Summary** (***Moderator: Prof. AshishGarg)*** ● UG Program (***Presented by Prof. A.S. Gandhi and Prof. A. Garg)*** ●PG Program including dual degree(**Prof. ShashankShekhar**)
4:45 – 5:00 PM	Concluding remarks (***Director, NIT Srinagar and Organizers***)
5:00 PM	Vote of Thanks (***Prof. AtikurRahman***)
	High Tea

Summary of Faculty Feedback

Workshop

Questions	***Excellent***	***Good***	***Ordinary***
Effectiveness of discussions		5	
Duration of workshop	13	19	
	Definitely	***Maybe***	***No***
Would you like to have more such sessions?	25	7	
Would you like e-lectures by experts on special	25	4	2

Suggest specific topic that you would like additional expert lectures on	➢ Computational Approach in Metallurgy ➢ Deformation behaviour of alloy ➢ Advance Materials ➢ Iron & Steel making/ Mechanical Metallurgy ➢ Compositional analysis, Spectoscopy, Image analysis ➢ Functional Materials ➢ Teaching and Learning Methods ➢ Functionally graded materials ➢ Thermodynamics, Computational Techniques in metallurgy, Extraction processes ➢ Technologically important materials ➢ Entrepreunuship in materials Engg. ➢ Science and Engineering design ➢ Super alloys and their fabrication
Additional Suggestions	➢ Hands-on training on characterization equipment at IIT Kanpur ➢ Invite stake holders like Alumni/Industry/ Students ➢ Hold a joint workshop for common courses for UG ➢ Some courses partly or fully taught by other departments, course contents to be regulated by metallurgy department ➢ Homogenerating the courses ➢ More institutiona should be encourage to participate ➢ Aspects of Materials Engineering

Teaching

Which subjects do you teach?	➢ Material models and simulation, Phase transformation. ➢ Principles of extraction and refining, Transport phenomena, Met. Kinetics, Electrochemistry. ➢ Materials process, Grain boundaries, Dislocation and Plasticity. ➢ Physical science, Heat Treatment. ➢ Iron Making, Computational Methods, Process Modelling Kinetics. ➢ Solidification of Metals and Alloys, Continuous casting of steels. ➢ Powder Metallurgy, Eorrosion Engineers. ➢ Manufacturing and Metallurgy. ➢ Electrometallurgy and Nanomaterials process application. ➢ Electronics Engineering Materials. ➢ Physical Metallurgy and Corrosion. ➢ Metal Forming Technology and Metal Processing technology. ➢ X-RD, Mech. behaviour of materials, Crystallography, Extractive Metallurgy. ➢ Physics of Materials and Joining of Metals. ➢ Machine Design, Tribology, Condition monitoring. ➢ Mineral processing and foundry. ➢ FFR and Principles of Meta extraction.	
What is average student to teacherratio in your institute?	➢ 1:20 ➢ 1:30 ➢ 1:15 ➢ 1:65 ➢ 1:75 ➢ 1:25 ➢ 1:5 ➢ 1:45 ➢ 1:60	
Questions	***YES***	***NO***

Do you have additional support forteaching (tutors, graders, teachingAssistants, etc)?	20		13	
Do you have this subject as a full course in your Institute in the UD curriculum?	31		2	
Do you have this subject as a full course in your Institute in in the PG curriculum?	18		11	
Do you think this subject is important for all engineering branches?	19		12	
Is a lab associated with the subject in your institute?	26		6	
Do you give class projects for UGclasses?	21		10	
Do you give class projects for PGclasses?	23		8	
Do you have sufficient resources forlaboratory courses?	28		5	
	Sufficient		***Inadequate***	
Is the library/journal/e-connectionsupport adequate?	17		10	
	Definitely	***May* be**	***No***	
Would you like to have common(TEQIP) repository of coursematerial?	25	6	1	
Would you like to visit IITK toparticipate in and develop coursematerial (existing or new)	27	6		
Would you like to participate increation of the repository material(course files/lab. Manuals/questionbank/etc)	23	10		
	e-courses	***Workshops***	***Content***	***none***
How can IITK effectively help youprepare for	21	23	8	2
How can TEQIP help improve yourteaching?	19	22	5	1
Suggestions				

Name the engineering branches for which you consider this subject to be a necessary part of curriculum.	➢ Metallurgy and Materials Engineering. ➢ Electrical Engineering, Electronic Engineering, Civil Engineering, Mechanical Engineering ➢ Chemical Engineering ➢ Production Engineering, Ceramics Engineering ➢ Heat Treatments, Mechanical Design ➢ Aerospace Engineering ➢ FEM- Mechanical, Chemical, Metallurgy & Civil Engg. ➢ Fatigue & Fracture- Mechanical & Metallurgical Engg.
Give suggestions for changes in the curriculum to make the subject useful across engineering branches	➢ Firstyear courses need to have more emphasis on engineering mathematics. ➢ Introduction to lab and tutorials. ➢ Introduction to project assignment and technical paper/research paper discussion in class. ➢ More elective papers should be included in course structure. ➢ Focus on scientific concepts and quantitative approach. ➢ Cannot have a universal course on materials. It has to be branch specific. ➢ As discussed during workshop Materials science as a course should be taught to all branches and the curriculum should be prepared according to the branch concerned. ➢ More session on syllabus design and teaching materials design. ➢ Advanced materials should be included apart from regular extraction courses. ➢ These courses do not act across other engg. branches. ➢ Further meeting may be required for content of individual subjects. ➢ The subject of Tribology in multi disciplinary in nature. ➢ Chemical/chemistry , Materials engg. specifically need an introductory course in this subject must be adversed.

Any other suggestions.	➢ Reinforcement of faculty through new recruitments. ➢ Advanced materials and their applications may be introduced at 11th and 12thstd to introduce about materials. ➢ Separate groups should be formed to make syllabus and course contents. ➢ Long duration program on the similar area. ➢ More interactive sessions should be included. ➢ Invite regular lectures from top faculties. ➢ Member from industry should also be a part of such kind of exercise. ➢ Other departments should discuss the application in metallurgy/materials engineering. ➢ There needs to be a balance between teaching and research. ➢ Expert from physics, chemistry and mathematics to be invited in future to correlate the corresponding subjects with materials engineering. ➢ A committee of eminent metallurgists should be set up to ask the G.O.I as to what is their future plan regarding metallurgical industry and how should we change ourselves in order to meet their requirements. ➢ Regarding the course of Mech. Metallurgy and joining of metals courses 6th and 7th semester there must be work practice instead of lab work of above said courses. Because students does not get enough equipments/tools in labs and not able to do practice of such courses practically.

Research

Questions	***Definite***	***Maybe***	***No***

Would you like to visit an IIT for a visiting-faculty/ post-doctoral fellow, if offered(via-TEQIP)?	21	8	1
Would you like to share/use research infra-structure at IITK, if made available?	26	4	1
Would you like to conduct collaborative research with IITK?	27	3	1
Would you like lectures by experts (Indianand international) on niche researchareas/topics?	25	4	
Do you want special-topic conferences?	24	7	

How can TEQIP help improve your research?	➢ Through discussion with different experts of the country in diverse area of research interest. ➢ Our institute lack some infrastructure since presently we are not a part of TEQIP program we may avail the infrastructure from TEQIP institute. ➢ This can improve research activities by collaborations among IIT's and NIT's. ➢ By organizing more such events. ➢ Helping with research facilities. ➢ Interaction with peer resources for the students. ➢ Through sharing of equipments facility. ➢ Academia-Academics as well as Academia-Industry interactions.Development of special lab facility. ➢ Faculty development program. ➢ TEQIP funds are always helpful for organizing research with the help of funds available. ➢ The department facilities for doing research need to be upgraded at MANIT, Bhopal. ➢ We still are lacking in some facilities for metallographic specimen preparation . Also we would be provided training on characterization equipment. ➢ Funding for research and organizing workshop and conferences. ➢ Procurement of laboratory equipments. ➢ By providing e-tenders and avail facilities in other colleges. ➢ Interaction with pioneers from top institutes in their respective fields their lectures.

OBSERVER'S COMMENTS

This was a unique workshop which aimed to discuss the overall curriculum of a discipline with the involvement of most institutions which offers degree in that discipline with the aim of developing a model curriculum which can be adopted at all these institutions. With this view, an observer was appointed to oversee the proceedings and see whether the same experiment can be replicated for other disciplines as well. Based on the discussions that took place over these two days, the observer definitely felt that more such workshops in other disciplines should be planned such that we at least get the various institutions start discussing the idea of resource sharing. The following points have been felt by the observer which if incorporated can improve the outcome of such workshops.

a) Almost all the institutes follow a credit system now. However, the system used for calculating the credits earned by a student for doing a course with a certain number of lecture/tutorial/lab hours per week followed by the various institutes is different. Even after normalising the credit system of each institute, it was observed that the required number of credits for graduation varied significantly from one institution to other with some institutions requiring almost 25% more credits than the others. This aspect is not specific to this discipline but will continue to hold across all disciplines in these institutes. Hence, there is a need to discuss this issue at a larger forum, maybe a joint meeting of the heads of various CFTIs and decide on a reasonable range of the required credits for graduation which can be followed at each institute.
b) There was no representative from industry in this workshop. Since the objective was to propose a model curriculum for this discipline which will prepare the students of the various programs being run in this discipline with a certain set of skills, inputs from the industries which will ultimately hire these students could have been very useful. This would have ensured that the aims and objectives of the various programs would be aligned with the aims and aspirations of majority of the students who would like to get a decent job on graduation.
c) It was felt that an online forum can be created on the TEQIP webpage for the various disciplines with some key persons from these disciplines as the lead who will moderate the forum. Faculty from that discipline of the various TEQIP institutes as well as CFTIs can be allowed access to this forum and the entire exercise of initiating, discussing and finalising a model curriculum for the various programs can be done through this forum. As a start, a "materials forum" can be created using which further refinement of the UG curriculum of materials and metallurgy discipline (if felt necessary by the various participants) and discussions on the PG curriculum be undertaken. KIT at IIT Kanpur is requested to initiate this forum.

OUTCOME

Participants from fifteen institutions in India having UG or dual degree and PG programs in the discipline of metallurgy and materials attended the workshop and worked out a model basic structure of the curriculum. This model curriculum has a core component which is uniform across all institutes ensuring opportunities for sharing of resources among these institutes. However, enough flexibility has been given through a higher number of electives to cater to the specialised needs of the various institutions based on their location (local industries). The detailed curriculum can be found in the attached report of the organisers.

ORGANISER'S REPORT

The primary aim of the workshop was to discuss the undergraduate curriculum of Materials and Metallurgical Engineering and similar disciplines. The emphasis was to understand the structure of curriculum in various institutes and then to have meaningful discussions to evolve a basic structure of the curriculum, which can be recommended to each institute for further implementation. The purpose was evolve a structure which can be uniformly applied across various institutes whilst ensuring sufficient flexibility in the design of courses and content yet retaining core philosophy similar across the institute which will assist in student rotation sharing of resources as well as in ensuring a basic minimum standard of materials and metallurgy education. Details on the need for such as workshop and the program can be seen in the attached document.

This workshop was organized by TEQIP programme at IIT Kanpur. It was also supported by the Knowledge Incubation Under TEQIP (TEQIP-KITE) at IIT Bombay. Participants from fifteen institutions in India, including NITs, IITs, IISc, IISET Shibpur and PEC Chandigarh having four year UG or dual degree programs in this discipline attended the workshop, held over two days.Various participants presented the curriculum structure of their respective departments. This was followed by a discussion on evolving the common observations and lacunae of present curriculum across various institutions. Subsequently, session wise discussions took place to evolve a model curriculum for the discipline across various institutions with an emphasis on developing a basic template, which can be adopted to bring a synergy between various institutions, which will help faculty as well as student in imparting the knowledge effectively and efficiently.

1. General Observations

- The procedure for calculating credits is not uniform across the Institutes; it ranges from 131 to 254.
- Most institutions have 27 contact hours/week with the exception of NIT Raipur where contact hours per week are between 30-40 hours.
- A few NITs such as NIT Bhopal and NIT Srinagar face severe faculty crunch and have to depend on other academic institutes and R&D organizations for teaching courses and conducting laboratories. **This requires immediate attention to ensure that the programmes run smoothly**.
- Since, most current PhD students prefer to do their research on modern materials, very few metallurgical/materials engineering graduates are pursuing PhD in traditional areas. Hence, a possible lack of faculty members who can teach fundamental courses such as Thermodynamics, Kinetics, and Transport Phenomena is a matter of serious concern.
- It was strongly felt that attempts should be made to ensure a balance and synergy between the career aspirations of students and the faculty, former in terms of jobs, and latter in terms of research and career advancement.

2. Content related observations:

- Departmental course content exceeds 50% of the total number of credits in most institutions, particularly the NITs. In a majority of the institutions, there are insufficient electives.
- The rationale for assigning core engineering and science courses through the four years requires introspection and on many occasions, has not kept pace with the changing requirements of research and industry.

- Humanities content across various institutions is small.
- The sequencing of courses merits greater attention to ensure delivery of topics at appropriate times allowing one to appreciate the linkages between various courses.
- The departmental course curriculum does not provide opportunities to the students to use and sharpen their mathematical and computational skills for tackling analytical challenges and problem solving.

3. Name of the Department/Discipline:

There were intense discussions on the name of the department on whether it should be "Metallurgical Engineering" or "Materials and Metallurgical Engineering" or "Materials Engineering" or "Materials Science and Engineering". A few others felt that Metallurgy and Materials should be two different departments. However, most participants countered the idea of having two separate departments, as it was felt that if the fundamentals for the two departments are same, then there is no point in having two departments with different names but similar content. The general view was that time is ripe to incorporate the word "materials" in the department name. Each institute, however, should evolve their own time-frame for this transition.

4. Design of a Model Materials and Metallurgical Engineering Curriculum

Pre-requisites:

- A uniform template for core and department compulsory courses should be developed. This will ensure a basic level of synergy across various institutes helping students pursuing higher degrees.
- Each institute should design electives by also considering the research interests and expertise of its faculty.
- Sharing of courses, for example manufacturing processes and mechanical properties, across departments should be promoted to enhance inter-disciplinarity and increase the time available to faculty members for research.
- Faculty members may be encouraged to become tutors in core science and engineering science courses offered by other departments.
- The total contact hours should be approximately 24-28 hrs per week. For a 3-lecture course total contact hours in a semester should be 35-40 hours.

What should govern the curriculum?

- The compulsory department curriculum should adopt a **unified approach** towards materials. Fundamental concepts related to structure, properties and processing for different types of materials should be consolidated and taught together, and not as separate courses. For example, structure of materials can be taught together for both metals, ceramics, and semiconductors.
- Courses should be quantitative, wherever possible. Emphasis on quantitative correlations between structure, property and process should be encouraged. Excessive memorizing should be discouraged. In fact, concepts should be through quantitative projects and assignments.
- In manufacturing and extractive metallurgy courses, a unit operations based generalized approach is recommended. This may also minimize the number of courses without sacrificing the content.
- Balancing of lectures, tutorials, and experiments is critical.
- Computational and mathematical skills acquired during the core courses should be utilized in making the departmental courses more analytical.

- There should be adequate emphasis on process design in all areas of materials and metallurgy. This implies that students should also have a good understanding of transport phenomena and solid mechanics.
- Teaching methodology should keep pace with changing times. Innovative ideas are necessary to sustain students' interest in courses, for example, by incorporating small projects in the courses wherever possible.
- The concept of modular courses may be thought of. Here, courses can consist of topics around a theme that may be taught by multiple instructors.

Key points:

a) Mathematical component and quantitative analysis need to be increased in teaching of Materials and Metallurgy.
b) Innovative ideas have to be implemented while teaching some "theoretical and seemingly abstract concepts."
c) Faculty resources may be utilized effectively by having a unified course template to the maximum possible extent.
d) Institutes should collaborate in designing syllabus and specifying a road map for teaching of courses.

5. Basic Curriculum Template

Following is the curriculum template with basic division between two components: Institute courses and Departmental courses. The number of lectures, tutorials and labs are only notional and can be changed by each institute as per their infrastructure, faculty strength and any other factors.

(A) Institute Core Courses

These are the list of basic courses which are to be spaced out in eight semesters with most of them being taught in first two years.

A1: Mathematics related courses (5-6)

1. Numerical Methods	(2L+1T)
2. Probability & Statistics	(2L+1T)
3. Linear Algebra	(3L)
4. Ordinary and Partial differential equations.	(3L)
5. Vector Calculus	(3L)

It is critical that the above courses should be spaced out over four years and are complemented with appropriate exercises in the departmental courses so that the concepts are retained.

A2: Physics related courses (3)

1. Physics I: Engineering Mechanics	(3L)
2. Physics II: Electricity/ Magnetism/ Quantum Mechanics	(3L+1P)

A3: Chemistry related courses (2)

1. Physical Chemistry	(3L)
2. Analytical Chemistry/ Inorganic Chemistry/ Metallurgical Analysis	(2L+1P)

A4: Biology and Life Sciences (1)

1. Basic Biology	(2L)

(B) Other Institute Core courses/topics related to Science and Engineering (10-12)

1. Engineering Drawing and Design (3L+1T)
2. Programming and Computational Skills (2L+1T/P)
3. Manufacturing Process (2L+1P)
4. Solid Mechanics and Rigid Body Mechanics (Statics and Dynamics) (3L)
5. Fluid Mechanics/ Transport Phenomena (2L+1T)
6. Basic electrical engineering, electronics, andinstrumentation (2L+1P)
7. Introduction to Materials (2L)
8. Humanities and Social Sciences (**2 to 4 courses**) (3L)
9. Ethical and Environmental issues (2L)

(C) Departmental Courses (40-50%)

It was proposed that departmental core courses can be listed in terms of topics and various Institutes can decide on the weightage to be given to various topics, depending on their strengths. The overall department course content is divided into four broad categories. The numbers of lectures, tutorials and labs are only suggestive.

C1: Departmental Core Courses (11)

Course or topic	Lectures	Tutorial	Laboratory/Project
1. Materials Thermodynamics and Phase Equilibrium	3L	1 T	--
2. Reaction kinetics, Diffusion and Phase Transformations	3L	1 T	--
3. Structure and Characterization of Materials	3L		1 P
4. Mechanical Properties and Processing of Materials	3L		1 P
5. Functional Properties of Materials	3L		1 P
6. Chemical Processing of Materials	2L		1P
7. Thermal Processing of Materials	3L		1P
8. Electrochemical Processing and Materials degradation	2L		
9. Design and selection of Materials	2L		1-2 mini projects
10. Iron and Steel Making (Can be offered as Departmental soft core)	3L		

Brief guideline of the departmental core courses is as follows:

1. Materials Thermodynamics and Phase Equilibria.
2. Reaction kinetics, Diffusion and Phase Transformations.
3. Structure of Materials
    - Bonding, Crystalline and non-crystalline solids, Defects, Microstructure and basic characterization such as XRD, OM and SEM
4. Unified Course on Mechanical Properties and Processing
    - Mechanical behavior of materials (elasticity, plasticity, tensile, creep, fracture)
    - Deformation processing and particulate processing of various types of materials
5. Unified Course on Functional Properties
    - Functional properties (electrical, dielectric, magnetic, and optical) and biomaterials
6. Chemical Processing of Materials
    - Unit operations for the extraction, purification, and recycling of materials.
    - Iron and Steel Making can be moved as a departmental soft core.

7. Thermal Processing of Materials
    - Heat treatment and phase transformations, Solidification, Casting, Joining.
8. Electrochemical processing and Material Degradation
    - Electrodeposition, corrosion, oxidation, fatigue, wear
9. Design and selection of Materials
    - Coupled with a mini project.

C2: Laboratories (5)

1. Structure and Characterization of Materials
2. Mechanical Processing of Materials
3. Functional Properties of Materials
4. Thermal Processing of Materials
5. Chemical Processing of Materials

C3: Mini-Projects (minimum 2)

1. Design and selection of materials
2. Structure-property-process correlations

Whenever possible, other courses may also incorporate a mini-project component.

C4: Departmental Electives

The elective course list can be further modified and augmented depending on faculty strength and their research interests. Following is a suggestive template in which courses are classified into a few categories:

Physical and Mechanical Metallurgy	**Modeling and Simulation**	**Extractive and Process Metallurgy**	**Advanced Functional Materials**	**Processing and Manufacturing**
Dislocation theory	Computational methods in materials engineering	Nonferrous extraction	Smart materials	Welding and joining
Microstructural engineering	Modeling and simulation (FEM/FDM/CV)	Secondary steel making	Thin films and device fabrications	Powder metallurgy
Advanced phase transformation	Numerical analysis for metallurgical problems	Electro and hydro metallurgy	Electrical, optical and magnetic ceramics	Solidification processing
Diffusion in materials	Mechatronics	Plant design and economics	Nuclear metallurgy	Surface engineering
Alloy design	Computational materials science		Biomaterials	Nondestructive testing
Advanced metal forming			Polymers and composites	Environmental issues of materials
Interfaces in materials			Advanced ceramics and composites	
Advanced Materials Characterization				

C5: Institute Open Electives

To be determined by availability in the institute and relevance

C6: UG Project

It was felt that the issues of evaluation and plagiarism were quite important in the UG project. While it is an important exercise, it should be conducted in such as manner so that its purpose is achieved. It was felt that it can be made optional if the departments desire so.

One model can be to replace the UG project with 2-3 elective courses. Another model can be to make students do two or more mini-projects focusing on various aspects of materials which could be more relevant and interesting such as one on design and selection of material, another or structure property correlations in materials and so on.

C7: Industrial visit/training

The institute should facilitate this activity so that students compulsorily spend a month in summer or winter at an industry. PEC Chandigarh has taken a unique initiative in this direction where students are expected to spend 16 week (a semester) in an industry. For this, a professional training and placement department should be created. Faculty should be freed from this responsibility.

6. Summary over eight semesters

Institute core and HSS courses	18-20 Courses
Departmental Core	10-12 Courses
Departmental and Open Electives	6-8 Courses
Laboratories	6 (Department) 3-4 (Institute)
Mini Projects	2+

7. Notes on curriculum challenges:

- A few participants suggested that course on “Numerical Methods” needs to be taught by the department instead of being taught by Mathematics faculty in order to give a more application based problems to the students. It was also suggested that theory part of this course needs to be condensed. Others suggested that this course needs to be replaced by “Modeling & Simulation” which deals with finite-element, finite-volume calculations and then these can be used for solving various problems in linear algebra, partial differential equations etc.
- The role of contents of analytical chemistry was also extensively discussed while some believed it should be called “Metallurgical/Materials Analysis”. One point everyone seemed to agree on is that the number of courses in Chemistry needs to be reduced.
- Fluid Mechanics and Transport Phenomenon: It was again pointed out that this course can be followed in 2L +2T mode where lectures are taken by one department for students from various streams like Materials Engineering, Mechanical Engineering, Chemical Engineering. While tutorials can be taken by specific departments so that relevant examples can be provided to students)

8. How to excite the undergraduate students

It was felt that one of the biggest challenges in materials and metallurgy education is the how to motivate and excite the young undergraduate students over the course of four years. There were various suggestions such as:

- Faculty can use technological tools to update the students along with live or virtual demonstrations.

- Students should be provided help to improve job opportunities in the core sector and departments should make efforts to excite them about it. Reviving industrial training can play an important role in this.
- Facilities (labs and softwares) can be shared with the UG students to improve their motivation. IITs must share facility with students from NITs and other institutions offering materials/metallurgical engineering.
- Industry leaders should be invited periodically to motivate the students.
- More hands-on and project related approach can enthuse the students
- Technical festivals can be utilized to showcase his/her skills.
- Sharing of course material, question banks and online resources can be done between IITs and NIT and other institutions offering materials/metallurgical engineering.

9. Summary

In the end, it is important for materials and metallurgy as a discipline to innovate in the design and delivery of curriculum to ensure a balance between the motivation of the students and faculty. Challenges lie in maintaining a balance between traditional metallurgical engineering subjects and modern materials and methods and in Indian scenario, both are critical. Also, It is vital to determine between a science or an engineering related approach. It was felt that Materials and Metallurgy discipline can become attractive for the students by designing it to be more analytical by significantly employing mathematical, modeling and computational tools and by blending it effectively with the experiments.