Development Engineering

A course proposal

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Preamble.

Higher education is one of the foremost mechanisms by which a society may change and improve itself. This it does through a careful accumulation and analysis of practices within a society, to create new professions through this analysis, to undertake research and to transmit this through its graduates, and finally to prepare employees for its state and private sector entities. The engineering profession is even more privileged for it seeks to change the material conditions of the society from within. Thus, it involves the manufacture of rockets and shampoos, of basic engineering services such water supply and roads, the capital intensive sectors of railways or steel, and also the logistics and planning sectors of public transport or irrigation.

Engineering education must therefore be embedded into a framework which (i) describes the material conditions of a society, (ii) the analysis of desirable and undesirable changes, (iii) the design of interventions, and (iv) the processes of implementation. The disciplinary nature of engineering comes only after the inter-disciplinary analysis of the material conditions has been achieved and its decomposition into disciplinary problems has been accomplished. This inter-disciplinary framework is essential for the modern engineer since he/she must face the challenges of tomorrow, such as climate change, planning under scarcity, global vs. local manufacturing, and socio-economic and cultural desirables such as gainful employment for all, and designing for sustainability.

This course aims to introduce the basic principles of engineering for a developing society such as India. It aims to teach students how to study society and its engineering systems, the generation of value, the use of natural resources and the various agents who are involved in this. It also supplements this with basic skills of field-work and of data.

The course is based on the extensive experience of CTARA over the last 30 years of forming a bridge between engineers and society, of development of case-studies as a way of documenting and transmitting practices. It is this body of inter-disciplinary knowledge and methods which has been found useful by us, that we wish to collect together as a course.

The course is aimed at under-graduate students who have just started in their disciplinary work and who will face the question of design-design what and for whom, with what outcomes. Thus, we expect that students will take it in their 4^{th} or 5^{th} semester of study. It is also expected that the course is customized by each institute and department depending on the practices that the department has studied.

Description.

Development Engineering may be defined as the

(A) **inter-disciplinary study** of
(i) engineering and science of the provision of basic engineering services such as drinking water or electricity and resources such as firewood,
(ii) the issues and problems of household and small enterprises
(iii) principles of value-creation and social outcomes

(B) the **methods** of

(i) applied social science, field-work, problem formulation, analysis, engagement and reporting,
(iii) the use of a planning framework for the above, i.e., the supply, demand and allocation of resources and services, the underlying socio-economic, governance and technical issues.

(C) the **values**
(i) of equity, efficiency and sustainability
(ii) and recognition of the role of community and culture.

Objectives.

The objective of the course is to prepare an engineering student for professional work in the development sectors, i.e., to work as a development engineer. This requires a
(i) basic understanding of society and development and the data-sets that surround it,
(ii) the role of agents, professions and value-creation, and
(iii) the ability to formulate problems, analyse them into its constituent disciplinary parts, solve and report them for stakeholders, and
(iv) the ability to design, conduct and report field-work, and finally
(v) a particular discipline of engineering and how it contributes to development.

It may be offered for UG students in their 4th or 5th semester and who have some exposure to their own disciplines. The course should be followed up by a Development Project course whereby the student may use the skills and knowledge acquired into executing a case-study. See for example, the TDSL course at CTARA (http://www.ctara.iitb.ac.in/tdsl).

Customization. The course allows room for each institution and within that, each department, to customize the course to suit their needs and expertise. Thus, while we have chosen ***Water for Irrigation*** as the sector to illustrate the connection between engineering and development, other departments may choose other sectors, e.g., housing, rural electricity, small enterprises and so on. This should be dictated by the areas in which the department has expertise, a significant number of case-studies and engagements with regional agencies.

The course is divided into several modules whereby the student develops the skills of analysing societal systems as explained in the table below.

Structure of Development Engineering Curriculum		
Module	**CTARA**	**Guidance for other institutions**
Module 0	The Engineer as a change agent. Introduction.	Core
Module 1,2,4	Basic Development Engineering	Core
Module 3	Sector as a development service	Choice of department and institution
Module 5	How to do fieldwork.	Training using past case-studies.
Module 6	Preparing for a project (separate semester).	New case-study

The course begins by analysing various notions of development and the datasets which may be used to measure development. It also presents simple tools for analysing data and developing relationships between various attributes. The second module develops an elementary structure of society, viz., the human structures of the state, the market and the civil society and the natural

world, i.e., the environment. It explains the role of assets and institutions and the creation of value through agents and practices. The next module explains an engineering system in its full complexity, i.e., the geographical extent, the multitude of players, the supply and the demand side and the allocation processes. It also familiarizes the students with certain key data-sets and socio-technical procedures within the sector used by the government. The GIS as a tool is introduced. Next, we explain how a village may be studied as a composite social, cultural and environmental system. Finally, we help the student in designing her/her own project.

Lecture Plan.

What follows here is a possible lecture plan and a list of topics from which to choose. It is not expected that all topics will be covered. Each lecture is assumed to be roughly of 1 hour and the whole course to be of 40 hours with 2-3 days of field exposure with, ideally, an overnight stay.

Module 0. The Engineer as a change agent.	
Lecture 1	The method of Science. The method of engineering. Delivering value by solving societal problems. Interdisciplinarity. The need for design and synthesis. The case-study and the skills required. Organization of the course. *Resource:* https://www.youtube.com/watch?v=G71maumVZ1A
Module 1. The Household and the development agenda	
Lecture 1	The household as the basic unit. The needs of the household. Cultural, biological needs. The notion of development as a life of less drudgery, more certainty and more culture. Environmental needs and the development engineering sectors. *Activity:* Listing household consumption. Time-lines of various members. activities and engagements.
Lecture 2	Development Indices. HDI and OECD indices. The data needed to compute these. Core values of equity, efficiency and sustainability. Paradigms of development.
Lecture 3	Introduction to the village-level census data. Engineering content in various amenities indices. *Dataset:* District census data XL-sheet (see https://www.cse.iitb.ac.in/~sohoni/TD603/ for Thane data-sets) http://www.cse.iitb.ac.in/~sohoni/taluka1.pdf also taluka2.pdf
Census Data 1	Manipulating census data. Identifying best-case and worst-case villages. Comparison plots and correlation plots.
Lecture 4	Agents and Value. How is value created in a household. The peasant and the artisan. Resources and amenities. The employee. The teacher. Various modes of payments. Seasons and history of accounting. Knowledge of agents. *Activity:* Listing activities of a *lohar* or an enterprise such as a *chakki*.
Module 2. The Society and its Organization	
Lecture 1	The basic divisions - State, Market and Civil Society. The environment. Assets and institutions.

	The environment -land, air, water. Attributes-cultural and as a resource. Pollution. Demands of people and other members of the biosphere. Pollution and sustainability.
Lecture 2	The structure of the State. The center and the state. The District Collector and the district planning committee. The district and sub-district hierarchy. Various departments. The hierarchy of elected representatives. *Activity:* Reading a suitable GR.
Lecture 3	Production. The factory and its history. Factors of production-capital, labour and technology. Operations-energy, depreciation, rents, regulation, market access. The small producer and the ecosystem. The corporation. The 5-fold layering of engineering as development engineering, informal India, Make by India, Make for India and finally the global Make in India. Matching cultural and manpower layers. Appropriate technology. http://www.cse.iitb.ac.in/~sohoni/ATreport1.pdf, also ATreport2 and ATreport3.pdf
Lecture 4	The Market. The notion of money. Loans and repayments and the role of capital. Money transaction vs. seasonal transactions and others based on trust. The anonymity and instanteity of money. Wholesale vs. Retail markets. Weekly markets, APMC. Market making. The supply chain and costs. Market transactions across various sectors such as the household, state and corporates. *Activity:* Understanding the activities of an APMC. Reading the price-data for an APMC.
Lecture 5	The Civil society. Trust, kin-ship and culture. Other attributes of civil interactions. Reputations and role-models. Various institutions such as the religious institution, the NGO, the school, the university, the panchayat. *Activity:* Understanding how *Amul* and how *Anandvan* work.
Lecture 6	Knowledge and Practice. Types of knowledge-science and technology, practices, institutional knowledge. The role of knowledge in sustainability, equity and efficiency.
Lecture 7	Tying it all up. Institutes as agents and Value revisited. The competition between various divisions, e.g., between the state and the market, and others. How does an engineer intervene. The role of new knowledge and practices.
Module 3. A Sectoral Engineering System. Example: Irrigation Water.	
Lecture 1	The geography of *Sinnar* taluka and its irrigation systems. Listing stakeholders, i.e., villages-farmers, people with and without land, local industrial workers, agriculture-cash crops and traditional crops, irrigation department and the market. Description of the engineering assets. *Resource:* https://www.cse.iitb.ac.in/~sohoni/TD603/
Lecture 2	Key environmental and scientific variables such as crop data, reservoirs and

	irrigation schedules, soils and rainfall. Agents and their interactions and key decisions on rotations, cropping pattern. Key transactions and decisions. The PMKSY framework and development objectives.
Lecture 3	The planning framework and its representation. Stocks and flows. Measuring supply parameters, demand parameters and allocations. Key infrastructure and institutions and their role. Allocation regimes and the connection with development paradigms. *Resource:* https://www.cse.iitb.ac.in/~sohoni/TD603/YMAug2016Draft2.pdf
Lecture 4	History of irrigation for the region. Beale's report and design objectives. Protective vs. command irrigation and its consequences. Reading the Jal Yukta Shivar GR. Developing a methodology for assessment. An example of a design document.
Lecture 5	Socio-Technical challenges-increasing irrigated area, drip irrigation and better fram practices. Groundwater regulation. Collective vs. Individual solutions.
Field Visit 1.	To an irrigation system. Meeting with an NGO, farmers, a state officer and an elected representative.
Module 4. GIS	
GIS 1	Loading QGIS and a district data-set. Using a given data-set. Writing queries and manipulating appearances. *Resource:* http://www.ctara.iitb.ac.in/water/tools.html
GIS 2	Types of objects and manipulating objects. Linking Census data to GIS. Basic analysis and representation.
GIS 3	Introduction to a case-study. Basics of spatial planning queries such as computing net supply and net demand.
Module 5. Fieldwork. The Village via a CTARA Village Report and Case-Study	
Lecture 1	Reading the CTARA Village Report. The sectors and its indices. The methodology. The reporting. *Resource:* http://www.ctara.iitb.ac.in/tdsc/uma/VillageReports.html
Lecture 2	The basics of PRA-1. The Demand Side. Household-surveys. Focus group discussions. Drinking water and irrigation water. Community vs. Farmers.The issue ranking. Non water issues and issue ranking.
Lecture 3	The basics of PRA-2. The supply side. Resource map. Assets, institutions and allocation documents. Time-line. Changes in crops and in welfare.
Lecture 4	The basics of PRA-3. The allocations. Questions of equity, efficiency and sustainability. Regional vs. Household balance.
Invited Lecture	What should an engineer know about Caste, Class and Gender.
Lecture 5	Preparing for the village meeting. Census data. Key contacts. What to look for.
Field Visit 2.	2 days and 2 nights at the village. Village meeting, household meeting. Resources.
Module 6. The Capstone Project via a Case -Study	

Lecture 1	Framing the project. Understanding the demand. What needs to be achieved. Studying the options available. Measurement of social and economic parameters as inputs. *Resource:* https://www.cse.iitb.ac.in/~sohoni/water/
Lecture 2.	The activities and the analysis. The reporting. Picking your case-study.
Finally. What has been achieved.	

Resources.

1. Village level Census Data 2011-Part I and II (i.e., amenities) and the metadata.
2. MRSAC. Various maps and data-sets. Revenue map, GIS layers obtained from MRSAC. Village, taluka and district boundaries, watershed boundaries, roads, drainage, water bodies.
3. Agriculture. Village and taluka agricultural data. Soil maps and other watershed maps.
4. Irrigation. Salient features of tanks and projects. Irrigation rounds and canal network. Command area maps and cropping patterns.
5. This course is based on the TD603 Water course taught at CTARA and also the TD609 and TD604 courses. See http://www.cse.iitb.ac.in/~sohoni/TD603
6. http://www.ctara.iitb.ac.in/tdsc/uma/Development_engineering.html