Homi Bhabha Center for Science Education
Tata Institute of Fundamental Research, Mumbai

Course Title: Colours and Human Knowledge

Course Number: SCE702.2

Credits: Four

Duration: Jan 05 to April 25, 2026

Contact Hours: 4 hours per week (preferably Mon, Wed afternoons)

Instructor: Ankush Gupta

Course Objectives

- To appreciate that origin of colour is deeply related to the structure and nature of matter and the nature of light.
- To understand that coloured substances and coloured light(s) do not mix in same manner
- To explore technologies which produced new colours, and technologies which evolved with colours.
- To understand how two human beings perceive the same colour differently, due to physiological differences as well differences in cognition
- To reflect on how colour markets have changed, and have impacted society in terms of economy, human health, and environment
- To reflect on how human engagement with colours have influenced the domain of science teaching and learning

About the Course

Today, it is possible to change colour(s) (with a large variety to choose from) of our digital screens, clothes, walls, hair, birthday cakes, vehicles, often by a click. However, each of these colour choices for each material uniquely affects a large supply chain of resources and persons in the world, along with significant impacts on our environments and on us. Interestingly, every individual perceives a given colour differently from another, because of biological differences in our eyes, as well as numerous factors affecting human perception. Yet, human society has evolved systems of coding/identifying colours (for example, colour charts for hardware paints, and calibration scales for digital and print media), presenting an example of how knowledge gets standardized in human society. A major scientific and technological domain involving standardization of colours is the domain of spectroscopy or light-matter interactions, which requires us to understand both light and matter.

Colours also have symbolic meanings in different social contexts. Plus, they are also known to affect humans psychologically playing a defining role in the world of art and aesthetics. In many situations, colours also act as a non-verbal language modifying expressions of knowledge. Apart from spoken/written language and symbolic forms of knowledge, colours can be considered as the third major channel of human communication.

Use of diverse kinds of colours is also constantly increasing in human society, with significant impacts on economies, environment, as well as what we (and our children) learn.

This course will explore scientific and technological evolution of colours in the human world. Course participants will also conduct some basic experiments and activities related to colours. We will discuss various technologies that have developed in human society based on these concepts of colours. Subsequently, we will try to understand some epistemological aspects of science and its practice through the idea(s) of colours. The course can help students appreciate some aspects of the nature of science as well as its pedagogy useful from primary grade to higher education levels.

The rough progressions of content in the course would be as follows:

1. Colours in natural world; natural paints, pigments and dyes
2. Nature of colour (property of electromagnetic waves interacting with matter or additions to a white or colourless substance); primary colours (additive and subtractive)
3. Vision and perception of colours in humans and animals; mixing of coloured lights vs mixing of coloured substances
4. Chemical origin of colours (unsaturated molecules and the molecules bound to heavy metals); industrial evolution of synthetic colours
5. Coloured materials made of (micro-structured) colourless substances. Eg soils, butterfly wings, oil films, crystals
6. Psychological and physiological effects of colours; effect of background on perception of a colour; non-image forming visual pathways
7. Coloured substances as bioactive compounds (e.g., uses as antiseptics); environmental impact of coloured substances; changes in optical and thermal balances due to extensive use of colours; colours in food, pharma and art
8. Colours as elements of a non-symbolic (embodied) language; and colours as words with literal meaning in human communications; social meanings of colours (does AI understand colours?)
9. Techniques developed with colours: titrations, spectroscopic techniques; and colourimetric markers of properties of substances
10. Colours in education: (physical) prevalence of colours in educational materials; vs conceptual understanding of the world of colours—how far we have come.

Experiments and activities planned for this course:

Making paint from a pigment, dyeing a fabric; studying dispersion of light by prisms; making a synthetic dye, observing changes in colour through particle size change (through grinding process); observing CMYK prints, RGB colour panels, coloured fabric, soil, micro-structured materials under a lens/microscope;

Key readings:

The course would include readings from

1. Mary Virginia Orna (2015). The Chemical History of Color. Springer Berlin, Heidelberg. https://link.springer.com/book/10.1007/978-3-642-32642-4

2. Sean F Johnston (2001). A History of Light and Colour Measurement: Science in the Shadows. Institute of Physics Publishing, Bristol and Philadelphia.

3. Michael Mark Woolfson (2016). Colour: How we see it and how we use it? World Scientific, Singapore.

4. Vien Cheung (2021). Colour: its influence and impact on the way we live", https://spotlight.leeds.ac.uk/world-changers/colour/

5. A Annam Renita, Tejal K Gajaria, S Sathish, J Aravind Kumar, D Shanthana Lakshmi, Joanna Kujawa, Wojciech Kujawski (2023). Progress and Prospective of the Industrial Development and Applications of Eco-Friendly Colorants: An Insight into Environmental Impact and Sustainability Issues. Foods, 12(7):1521. doi: 10.3390/foods12071521

6. Varela FJ, Thompson E, and Rosch E (1991). The Embodied Mind: Cognitive Science and Human Experience, MIT press, Cambridge, Ch 8. https://monoskop.org/images/2/21/Varela_Thompson_Rosch_The_Embodied_Mind_Cognitive_Science_and_Human_Experience_1991.pdf

Evaluation

Course evaluation would be based on:

1) A mid-semester (in-class) exam (20% weightage)

2) An end-semester term paper (40% weightage)

3) 4 short assignments (10% weightage each)

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