00184

The Open University of Sri Lanka
Faculty of Engineering Technology
Department of Mathematics & Philosophy Of Engineering

Study Programme	: Bachelor of Technology Honours in Engineering
Name of the Examination	: Final Examination
Course Code and Title	**: MHJ5343 Nature of Science**
Academic Year	: 2020/21
Date	:15th February 2022
Time	: 14:00- 18:00 hrs
Duration	: **4 hours**

General Instructions

1. Read all instructions carefully before answering the questions.
2. This question paper consists of **Eight (8)** questions in **Seven (6)** pages.
3. Answer any **Six (6)** questions only. All questions carry equal marks.
4. Answer for each question should commence from a new page.
5. **This is an Open Book Test (OBT).**
6. Answers should be in clear hand writing.
7. Do not use Red colour pen.

01 (i). State the Galilean Transformation equations.

(ii). What did Einstein postulate regarding the laws of physics?

(iii). What was the problem with Maxwell's laws of electromagnetism with regards to Galilean Transformation?

(iv). What did Lorentz notice with Maxwell's laws of electromagnetism and the new transformation he introduced, namely Lorentz Transformation?

(v). What was the bold decision that Einstein took with regards to Maxwell's laws of electromagnetism and Newton's laws of mechanics?

(vi). Why it took such a long time (nearly 200 years) to replace Newtonian Mechanics by Einstein's Relativistic Mechanics?

(vii). The two inertial frames of reference S and S' are such that S' moves with uniform velocity V along the x-axis relative to frame S. the space-time coordinates of the two events as measured by frame S are

$x_1 = 6 \times 10^4 m,\ y_1 = z_1 = 0,\ t_1 = 1 \times 10^{-4} S$

$x_2 = 12 \times 10^4 m, y_2 = z_2 = 0,\ t_2 = 2 \times 10^{-4} S$

What must be the velocity of S', with respect to S, if an observer in S' measures the two events occur simultaneously?

02 (i). State the Relativistic Velocity addition formula (all three components along x, y and z axes)

(ii). F_1, F_2 and F_3 are three inertial frames. The mapping $F_1 \rightarrow F_2$ and $F_2 \rightarrow F_3$ are special Lorentz Transformations in x and y directions respectively such that the velocities for F_2 relative to F_1 and F_3 relative to F_2 are (v, 0, 0) and (0, v', 0) respectively.

Show that the velocity of F_3 relative to F_1 is $\left[v, v'\sqrt{1-\frac{v^2}{c^2}},\ 0\right]$

(iii). Twin brothers T_1, T_2 are each 20 years old on earth (E), when T_2 sets off on a journey to a distant star S. T_2n moves with an uniform speed V for most of the journey and returns to earth E, by the same route with the uniform speed V. When T_2 arrives on earth, T_1 is 61 years old and T_2 is 29 years old.

(a). Find $^v/_c$ and the distance to the star from earth in light years.

(b). How long will T_2 live after the death of his twin brother T_1 assuming that the span of life is 70 years.

03. (i). Compare and contrast the views of Empiricists and Rationalists regarding knowledge?

(ii). Compare and contrast the views of the two schools of philosophy of science namely 'Inductivism' and 'Hypothetico-Deductivism' regarding the following

(a). Method of science

(b). Their claims on scientific knowledge

(c). Theoretical terms

(iii). Briefly explain the method of induction advocated by Francis Bacon

(iv). What was the critique of David Hume regarding the principle of induction?

04. (i). Why did Karl Popper reject ad-hoc modifications to theories?

(ii). Briefly explain how Karl Popper applies his concept 'Verisimilitude' to describe the 'Progress of Science'

(iii). What is the main draw-back of Popper's method of falsification?

05. Briefly explain the following relationships based on Thomas Kuhn's philosophy of science.

(i). Normal Science, Paradigm and Scientific community

(ii). Revolutions in science, Paradigms, Anomalies and Scientific Community

(iii). Uniqueness of science, Paradigms and Schools of science

(iv). Progress of science, Paradigms and Puzzle solving

(v). Incommensurability and Paradigms.

06. (i) . Explain briefly the views of Francis Bacon regarding 'Nature'

(ii). Explain briefly the views of Francis Bacon regarding 'Knowledge' and 'Power'

(iii). It is argued by many philosophers of science that western science is basically reductionist. Explain briefly the basic assumptions of this reductionism in western science.

07. The following passage is taken from an article by Vandana Shiva, a physicist by training, a philosopher of science and a leading environmentalist.

Thomas Kuhn, Paul Feyerabend, Michael Polanyi and others have convincingly argued that modern science does not proceed according to a well-defined and stable scientific method. All that can be granted to reductionist science is that it is an approach, a way of looking, a mode of thought. Considering its predatory treatment of nature, attested to by the ecological crisis, it is indeed a very unreliable way.

Controlled experiment in the laboratory is a central element of the methodology of reductionist science. The object of study is arbitrarily isolated from its natural surroundings, from its relationship with other objects and observer(s). The context (the value framework) so provided determines what properties are perceived in nature, and leads to a particular set of beliefs about nature.

There is threefold exclusion in this methodology: (i). ontological, in that other properties are not taken note of; (ii). epistemological, in that other ways of perceiving and knowing are not recognized; and (iii). sociological, in that the non-expert is deprived of the right both of access to knowledge and of judging the claims of knowledge.

Science claims that since scientific truths are verifiable, they are justified beliefs and therefore universal, regardless of the social context. The verificationist model of science was forcefully presented by positivism. It claimed that verification was direct observation of the 'facts' of nature, free from the proclivities of the observer. This was, however, challenged by post-positivist philosophers. Kuhn, for example, showed that facts and data in science are determined by the theoretical commitment of scientists. In other words, scientific facts are determined by the social world of scientists, not by the natural world.

While the Kuhnian model challenged the neutrality of scientific facts, it failed to provide an adequate epistemological framework for handling the violence of reductionist science. By insisting that 'nature fits into the realistic boxes of paradigms', Kuhn rendered his model of science materially and politically vacuous. Moreover, he failed to take into account the value system of the larger society that determines the choice of scientific research. Value-determination in the Kuhnian model is done by scientific paradigms, not by social, political, economic interests. By restricting itself to the social world of scientists, the Kuhnian model is unable to deal with the more significant value-determination of scientific facts by the demands made on the science system by economic interests. Moreover, by restricting himself to the material world of the lab, Kuhn was unable to deal with those ecological situations in which reductionist claims are falsified by nature, as symbolized by ecological crises.

(i). Explain briefly the methodology and the salient factures of a controlled experiment according to the above passage.

(ii). What are the main drawbacks of the controlled experiment according to the above passage.

(iii). Compare and contrast the views of Verificationists (Positivists) and Thomas Kuhn regarding 'facts and data' in science, according to the above passage.

(iv). Explain briefly the drawbacks and limitations of the Kuhnian model by Vandana Shiva, according to the above passage.

08. Read the following passages and answer the questions given below

Descartes created the conceptual framework for seventeenth-century science, but his view of nature as a perfect machine, governed by exact mathematical laws, had to remain a vision during his lifetime. He could not do more than sketch the outlines of his theory of natural phenomena. The man who realized the Cartesian dream and completed the Scientific Revolution was Isaac Newton, born in England in 1642, the year of Galileo's death. Newton developed a complete mathematical formulation of the mechanistic view of nature, and thus accomplished a grand synthesis of the works of Copernicus, Kepler, Bacon, Galileo, and Descartes.

Newtonian physics, the crowning achievement of the seventeenth-century science, provided a consistent mathematical theory of the world that remained the solid foundation of scientific thought well into the twentieth century. Newton's grasp of mathematics was far more powerful then that of his contemporaries. He invented a completely new method, known today as Differential Calculus, to describe the motion of solid bodies; a method that went far beyond the mathematical techniques of Galileo and Descartes. The Newtonian universe was indeed one huge mechanical system, operating according to exact mathematical laws.

Before Newton there had been two opposing trends in seventeenth-century science; the empirical, inductive method represented by Bacon and the rational, deductive method represented by Descartes, Newton, in his Principia, introduced the proper mixture of both methods, emphasizing that neither experiments without systematic interpretation nor deduction from first principles without experimental evidence will lead to a reliable theory. Going beyond Bacon in his systematic experimentation and beyond Descartes in his mathematical analysis, Newton unified the two trends and developed the methodology upon which natural science has been based ever since.

In Newtonian mechanics all physical phenomena are reduced to the motion of material particles, caused by their mutual attraction, that is, by the force of gravity. The effect of this force on a particle or any other material object is described mathematically by Newton's equations of motion, which form the basis of classical mechanics. These

were considered fixed laws according to which material objects moved and were thought to account for all changes observed in the physical world. In the Newtonian view, God created in the beginning the material particles, the forces between them, and the fundamental laws of motion. In this way the whole universe was set in motion, and it has continued to run every since, like a machine, governed by immutable laws. The mechanistic view of nature is thus closely related to a rigorous determinism, with the giant cosmic machine completely causal and determinate. All that happened had a definite cause and gave rise to a definite effect, and the future of any part of the system could-in principle – be predicted with absolute certainty if its state at any time was known in all details.

At the same time, new discoveries and new ways of thinking made the limitations of the Newtonian model apparent and prepared the way for the scientific revolutions of the twentieth century. One of these nineteenth-century developments was the discovery and investigation of electric and magnetic phenomena that involved a new type of force and could not be described appropriately by the mechanistic model. The important step was taken by Michael Faraday and completed by Clerk Maxwell – the first one of the great experimenters in the history of science, the second a brilliant theorist. Faraday and Maxwell not only studied the effects of the electric and magnetic forces but made the forces themselves the primary object of their investigation. By replacing the concept of a force with the much subtler concept of a force with the much subtler concept of a force field they were the first to go beyond Newtonian physics, showing that the fields had their own reality and could be studied without any reference to material bodies.

(i). Explain briefly the main features of Newtonian physics which is considered to be the crowning achievement of the 17th century science that dominated well into the 20th century.

(ii). Explain briefly how Newton unified the two opposing trends in the 17th century science and developed the methodology of upon which science has been based ever since.

(iii). Explain briefly the main features of the mechanistic view of nature propagated by Isaac Newton.

(iv). What were the new discoveries and new ways of thinking that highlighted the limitations of the Newtonian model and prepared the way for the scientific revolution of the 20th century?