

HPSC 3020 Philosophy of Physics

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The aim of this advanced (third-year) course is to explore the relationship between philosophy and physics, with a focus on selected issues in the history and philosophy of modern physics. The course is organised around two main areas. In the first part we focus on the philosophy of space and time: what is the nature of space and time? Is time real? Is our commonsense intuition that time flows always from the past to the future grounded on physics? In the second part, we focus on scientific revolutions and physical reality: what happens when a scientific revolution occurs, such as in the passage from Newtonian mechanics to Einstein's relativity theory? In what ways does quantum mechanics force us to modify our commonsense intuitions about physical reality? All these philosophical questions will be addressed by looking at some specific episodes taken from the history of modern physics: Newtonian mechanics, Einstein's relativity theory, and the Copenhagen interpretation of quantum mechanics.

Prerequisites: this advanced course requires sufficiently good background knowledge in both philosophy and physics. Students attending this course should ideally have completed the first-year HPSC1009 History of Modern Physical Science, and at least one philosophy of science course (HPSC1003 Philosophy of Science and/or HPSC2003 Topics in Philosophy of Science —indeed there is a lot of continuity between topics done in 1009 and 2003 and those covered in this course, so completion of 1009 and 2003 is highly recommended). Students that have not completed any of these courses, but have nonetheless good background knowledge in philosophy and/or physics are welcome too (please contact the course tutor for any query on prerequisites, if you are uncertain).

Lectures and Seminars (Term 2): Wednesdays 11am-1pm in Foster Court 216.

Office hour (Term 2): *Mondays and Tuesday* 13.30–14.30 in room 3.2, 22 Gordon Square. Outside office hour I receive only by appointment. Please send me an email to arrange for an appointment.

Assessment is by a written examination (50% of the final mark); one essay (2,000 words, contributing 30% of the final mark); and one written critical précis on an assigned topic for the seminar discussion that must be presented at the weekly seminar (the précis contributes 20% of the final mark). The written critical précis must be max. 1000 words and it will be on some relevant article related to the topic I cover in the lecture (see list of readings for seminar discussion in the syllabus below). The oral presentation of the précis at the seminar (15 minutes approx.) will be assessed on content, and not on the quality of the presentation per se: it is mainly functional to kick off a debate in class on the assigned topic, to critically explore and evaluate alternative philosophical views on a given subject, and hence to enhance your critical and argumentative skills as well as your communication skills (which is

an essential part of your training as third-year students preparing for the final year dissertation and for future job interviews and/or postgraduate studies). If you do the written précis but fail to give a substantive presentation of it at the seminar, 10% out of the 20% of the contributing weighting of the précis will be forfeited (in other words, the presentation is not marked, but contributes half the mark of the written précis —i.e. **with no presentation, the mark of the précis will be halved**).

Please note that you must do both the coursework and sit the exam in order to complete this course unit.

Deadlines and guidelines for essay and précis

1. **The essay is due on Wed. 14 March at noon (see suggested essay titles at the end of this syllabus). Please submit using Turn-it-In in Moodle. You must also submit a hard copy with a signed coursework cover sheet (available online at the end of the STS Student Handbook, see: http://www.ucl.ac.uk/sts/study/bsc/documents/sts_student_handbook.pdf) and be left in my p-hole. The date of your submission in Turn-it-In is the official submission date that I use to apply penalties for late submissions.**

2. **The written critical précis should be submitted the day of your oral presentation at the weekly seminar, and I expect that you will (a calendar of oral presentations will be agreed and scheduled together in class during the first week of term 1). The final and ultimate deadline for the submission of précis for everyone (after which penalties apply) is Friday 23 March at noon. As for the essay, you must submit both in Turn-it-In via Moodle and a hard copy in my p-hole.**

3. **Please note that the topic of your essay should NOT be the same as the topic of your précis.**

4. It is essential that you submit your essay on time. If, however, you do not, penalties apply for late submissions as outlined in the STS student handbook, namely:
 - Loss of 5 marks for work submitted less than 24 hours late.
 - Loss of 15 marks for work submitted between 1 and 7 days late.
 - Loss of all marks (work is graded 0) if submitted more than 7 days late.

These rules are statutory and non-negotiable.

5. All final versions of the essay and précis must be word processed. Please note that **penalties for overlength coursework apply as described in the STS Student Handbook.**

6. Please feel free to discuss your essay / précis topic with me. Suggested essay topics are at the end of this syllabus.
7. The essay *must* explore topics in greater depth than in class lectures. Consequently, *neither* class notes *nor* required readings should play a prominent role in your essay. You should focus instead on *further readings* and also feel free to use material not on the reading lists. The essay *must* have the full scholarly apparatus of footnotes and a bibliography.
8. A critical précis is a summary, a shorter version, of one article that I shall assign the whole class to read and study for discussion at the weekly seminar on a topic that I shall have explained in the previous Friday lecture. When you write your précis to present at the seminar, keep in mind the following points:
 - Read carefully the article first, and make sure that you have fully understood it. Read it more than once if necessary.
 - Try to summarise the author's position without changing or altering her/his views in your summary (try to stick as much as possible to the author's terminology, even if it involves some philosophical or physical jargon – it is a good practice to learn some of that jargon, provided that you have fully understood it).
 - Spot the key ideas and points in the text and present them in a clear, coherent, and well-structured way.
 - Identify the arguments that an author may have pro or con a given philosophical position or claim.
 - Avoid any irrelevant information in your précis – be always up to the main point that the author is making in the article.
 - Avoid trivial evaluations such as “it is an interesting position”, and focus on content instead.
 - Make sure your précis is grammatically correct.

Writing a précis involves understanding, knowledge and judgments. Different people may produce different précis on the same article as they may identify different elements as having priority. Practising précis and presentations on unfamiliar subjects is an excellent way of learning and improving your understanding and communication skills.

Reading materials: All readings are available in the UCL Science Library and/or Main Library. I have indicated in squared brackets texts which can be downloaded online from JSTOR (<http://www.jstor.org/>), available via UCL Library Online, and any other text that I shall make available for photocopy in the file cabinet near the window in the STS student common room (STS Dept., room 3.1)

SOURCES FOR BACKGROUND AND GENERAL REFERENCE

Introductory textbooks in alphabetical order

- D. Z. Albert (1992) *Quantum Mechanics and Experience* (Harvard University Press).
- D.Z. Albert (2000) *Time and Chance* (Harvard University Press).
- J. T. Cushing (1998) *Philosophical Concepts in Physics* (Cambridge: Cambridge University Press).
- P. Kosso (1998) *Appearance and reality* (Oxford University Press).
- M. Lange (2002) *An Introduction to Philosophy of Physics* (Oxford: Blackwell).
- L. Sklar (1974) *Space, time and spacetime* (Berkeley: University of California Press).
- L. Sklar (1992) *Philosophy of Physics* (Boulder: Westview Press).

More advanced and technical texts with general relevance to topics covered in this course

- H. Brown (2005) *Physical Relativity* (Oxford University Press)
- R.I.G. Hughes (1989) *The Structure and Interpretation of Quantum Mechanics* (Harvard University Press).
- M. Friedman (1983) *Foundations of Space-Time Theories. Relativistic physics and Philosophy of Science* (Princeton University Press).
- L. Sklar (1993) *Physics and Chance* (Cambridge: Cambridge University Press).
- R. Torretti (1999) *The Philosophy of Physics* (Cambridge: Cambridge University Press).

Anthologies

- J. T. Cushing and E. McMullin (eds.) (1989) *Philosophical Consequences of Quantum Theory. Reflections on Bell's theorem* (University of Notre Dame Press).
- J. Butterfield (ed.) (1999) *The Arguments of Time* (Oxford University Press).

General philosophy references

- *The Oxford Companion to Philosophy* ed. By Ted Honderich (Oxford: Oxford University Press, 1995)
- *Routledge Encyclopedia of Philosophy* ed. By Edward Craig (London: Routledge, 1998). At <http://www.rep.routledge.com/browse-articles?authstatuscode=200>
- *Stanford Encyclopaedia of Philosophy* at <http://plato.stanford.edu/>
- *A Companion to the Philosophy of Science* ed. by W. H. Newton-Smith (Blackwell Publishing).

SYLLABUS

Please note that readings assigned for seminar discussion on each Unit are an integral part of the Required Readings for that Unit.

PART 1: PHILOSOPHY OF SPACE AND TIME

Unit 1. The Leibniz–Clarke controversy on the nature of space and time (11 January)

Required readings

- L. Sklar (1974) *Space, Time and Spacetime* (University of California Press), pp. 157–181.
- A. Koyré *From the closed world to the infinite universe*, ch. X, and XI.

For seminar discussion:

- H. Alexander *The Leibniz–Clarke correspondence* (Manchester University Press), pp. 36-54 (Leibniz’s fourth paper and Clarke’s fourth reply).

Further readings

- B. Dainton (2001) *Time and Space* (Acumen), pp. 162-168.
- R. DiSalle ‘Newton’s philosophical analysis of space and time’, *Cambridge Companion to Newton*, pp. 33–56.
- D. Garber ‘Leibniz: Physics and Philosophy’, *Cambridge Companion to Leibniz*, pp. 301–309 only (see the rest of the article for a useful introduction to Leibniz).
- H. Lacey (1970) ‘The scientific intelligibility of absolute space’ *British Journal for the Philosophy of Science* **21**, pp.317-342. [download online from JSTOR]

Unit 2. From Newton to Ernst Mach and Einstein’s general relativity (18 January)

Required readings

- B. Dainton (2001) *Time and Space* (Acumen), ch. 11.
- L. Sklar (1974) *Space, Time and Spacetime* (University of California Press), pp. 182–191; 198–202; 210–221 only.

For seminar discussion:

- E. Mach ‘Newton’s views of time, space, and motion’, from *The Science of Mechanics*, extract reprinted in N. Huggett *Space from Zeno to Einstein* (MIT Press), pp. 174–180.

Further readings

- For those of you that have not taken HPSC1009 before, it may be useful to take a look at P. Kosso (1998) “The General Theory of Relativity” in *Appearance and Reality* (Oxford University Press), ch. 4.
- R. Laymon (1978) ‘Newton’s bucket experiment’, *Journal of the History of Philosophy* **16**, pp. 399–413 [photocopies in the folder in the STS common room]
- H. Stein (1977) ‘Some philosophical prehistory of general relativity’ in *Minnesota Studies in Philosophy of Science: vol. 8. Foundations of Space-Time Theories*, ed. Earman, Glymour, pp. 3–27 [photocopies available in the folder in STS common room]
- J. Norton (1995) ‘Mach’s principle before Einstein’ in J. Barbour (ed.) *Mach’s Principle: from Newton’s bucket to quantum gravity. Einstein Studies: vol. 6* (Boston), pp. 9-57 [download online from <http://www.pitt.edu/~jdnorton/papers/MachPrinciple.pdf>]
- C. Hofer (1996) ‘The metaphysics of spacetime substantivalism’, *Journal of Philosophy* **93**, pp. 5–27 [download online from JSTOR — more technical article for those of you more inclined to physics].

Unit 3. The philosophy of time: is time real? (25 January)

Required readings

- R. Le Poidevin *Travels in Four Dimensions* (Oxford University Press), ch. 8.
- B. Dainton (2001) *Time and Space* (Acumen), pp. 6-12; and entire ch. 2.

For seminar discussion:

- J. M. E. McTaggart (1908) ‘The unreality of time’ *Mind* **17** p. 457. Reprinted in R. Le Poidevin and M. MacBeath (eds.) *The Philosophy of Time* (Oxford University Press), pp. 23–34.

Further readings

- M. A. E. Dummett (1960) ‘A defence of McTaggart’s proof of the unreality of time’ *Philosophical Review* **69**, 497–505, esp. 502–503. [download online from JSTOR]

- Arthur Prior (1968) “Changes in events and changes in things” *Papers on Time and Tense*. Reprinted in R. Le Poidevin and M. MacBeath (eds.) *The Philosophy of Time* (Oxford University Press), pp. 35–46.
- D.H. Mellor (1981) “The unreality of tense” *Real Time* (CUP). Reprinted in R. Le Poidevin and M. MacBeath (eds.) *The Philosophy of Time* (Oxford University Press), pp. 47–59 [philosophically more complex article].
- C.D. Broad (1938) “McTaggart’s arguments against the reality of time” excerpt from *Examination of McTaggart’s philosophy*. Reprinted in van Inwagen and Zimmerman (1998) *Metaphysics: the big questions* (Oxford: Blackwell), pp.74-9.

Unit 4. Thermodynamics and the problem of the direction of time (1 February)

Required readings

- D.Z. Albert (2000) *Time and Chance* (Harvard University Press), ch. 1 and 2.
- H. Price “On the origins of the arrow of time: why there is still a puzzle about the low-entropy past” in C. Hitchcock (ed.) *Contemporary debates in philosophy of science* (Blackwell), pp. 219-39.

For seminar discussion:

- R. Le Poidevin *Travels in Four Dimensions* (Oxford University Press), ch. 12 only pp. 202–220 and pp. 229–233.

Further readings:

- For those of you that have not taken HPSC1009 before, it may be useful to have a look at P. M. Harman (1982) *Energy, Force, and Matter: the Conceptual Development of Nineteenth-Century Physics* (Cambridge: Cambridge University Press), chapter 3, for the history of the II law of thermodynamics.
- L. Sklar “Up and down, left and right, past and future” in R. Le Poidevin and M. MacBeath (eds.) *The Philosophy of Time* (Oxford University Press), pp. 99–116.
- L. Sklar (1974) *Space, Time and Spacetime* (University of California Press), pp.351-378.
- A. Grünbaum *Philosophical Problems of Space and Time*, pp. 209–236 only; and ch. 10.
- M. Black (1959) ‘The Direction of Time’, *Analysis* **19**, p. 54. [download online from JSTOR]

Unit 5. Immanuel Kant on space and time (8 February)

Required readings

- T. E. Wilkerson (1976) *Kant's Critique of Pure Reason. A commentary for students* (Oxford: Clarendon Press), ch. 1.
- R. DiSalle (2006) "Empiricism and a priorism from Kant to Poicare'" in DiSalle *Understanding Space-Time. The philosophical development of physics from Newton to Einstein* (Cambridge University Press), pp. 55–72.

For seminar discussion:

- I. Kant 'Transcendental ideality of space and time', extracts from the *Critique of Pure Reason*, reprinted in J. Smart *Problems of Space and Time*, pp. 104–123.

Further readings

- P. Guyer 'Introduction: the starry heavens and the moral law', in P. Guyer (ed.) *The Cambridge Companion to Kant* (CUP), pp. 1–24.
- T. E. Wilkerson (1976) *Kant's Critique of Pure Reason. A commentary for students* (Oxford: Clarendon Press), ch. 2.
- G. Hatfield 'Kant on the perception of space (and time)' in P. Guyer (ed.) *The Cambridge Companion to Kant and Modern Philosophy* (CUP), pp. 61–93.
- C. Parsons 'The Transcendental Aesthetic' in P. Guyer (ed.) *The Cambridge Companion to Kant* (CUP), pp.62–100.

READING WEEK (13–17 February): NO LECTURE AND NO SEMINAR

Unit 6. Between Kant and Thomas Kuhn: Kant's legacy for 20c. physics and the scientific revolution from Newtonian mechanics to Einstein's relativity theory (22 February)

Required readings

- Friedman, M. (2001) *The dynamics of reason. Stanford Kant Lectures* (Stanford: CSLI Publications), pp. 71–103.

For seminar discussion:

- H. Reichenbach "The Philosophical Significance of the Theory of Relativity" in S. Gimbel and A. Waltz (ed.) *Defending Einstein. Hans Reichenbach's writings on space, time and motion* (Cambridge University Press).

Further readings

- Friedman, M. (1999) *Reconsidering Logical Positivism* (Cambridge: Cambridge University Press), ch. 3.
- Friedman, M. (2000) ‘Transcendental Philosophy and A Priori Knowledge: a Neo-Kantian Perspective’, in P. Boghossian and C. Peacocke (eds.) *New Essays on the A Priori* (Oxford: Clarendon Press).
- T. Ryckman (2001) “Early Philosophical Interpretations of General Relativity” in the online *Stanford Encyclopaedia of Philosophy*: <http://plato.stanford.edu/entries/genrel-early/>

Unit 7. Physical reality: Niels Bohr and the Copenhagen Interpretation of Quantum Mechanics (29 February and 7 March)

Required readings

- L. Sklar (1992) *Philosophy of Physics* (Oxford University Press), ch. 4 pp. 157–179 only.
- P. Kosso (1998) *Appearance and reality* (Oxford University Press), ch. 6, pp. 110–133.

For seminar discussion:

- N. Bohr (1937) ‘Causality and complementarity’ *Philosophy of Science* **4**, pp. 289-98.

Further readings

- J. Cushing (1998) *Philosophical concepts in physics* (Cambridge University Press), ch. 20 [more technical chapter]
- Rae (2004, 2nd ed.) *Quantum Physics: illusion or reality?* (Cambridge University Press), ch. 1 [very good introduction to the topic—see also other chapters]
- H. Folse (1985) ‘The birth of complementarity’ in Folse *The philosophy of Niels Bohr: the framework of complementarity* (North Holland), ch. 4 [photocopies in folder in STS common room].
- C. Hooker (1994) ‘Bohr and the crisis of empirical intelligibility. An essay on the depth of Bohr’s thought and our philosophical ignorance’ in J. Faye (ed.) *Niels Bohr and contemporary philosophy* (Kluwer), pp. 155–187: Part I and III only.
- D. Murdoch (1987) *Niels Bohr’s philosophy of physics* (Cambridge University Press), ch. 3 and 4.
- G. Holton (1973) ‘The roots of complementarity’ in Holton *Thematic Origins of Scientific Thought* (Harvard University Press), ch. 4.

Unit 8. The debate on the nature physical reality: Einstein-Podolsky-Rosen (EPR) versus Bohr (21 March)

Required readings

- P. Kosso (1998) *Appearance and reality* (Oxford University Press), ch. 6, pp. 133–151 and ch. 7, pp.152–163.
- Einstein, Podolsky, Rosen ‘Can Quantum-Mechanical description of Physical Reality Be Considered Complete?’ *Physical Review* **47**, 777-780. [download online from UCL Electronic Journals: http://prola.aps.org/abstract/PR/v47/p777_1]

For seminar discussion:

- N. Bohr, ‘Can Quantum-Mechanical description of Physical Reality Be Considered Complete?’ *Physical Review* **48**, 696-702 [download online from UCL Electronic Journals: http://prola.aps.org/abstract/PR/v48/p696_1]

Further readings

- J. Cushing (1998) *Philosophical concepts in physics* (Cambridge University Press), ch. 21 [more technical chapter] V
- N. Bohr ‘Discussion with Einstein on Epistemological Problems in Atomic Physics’ in N. Bohr, *Atomic Physics and Human Knowledge*, pp. 32-66.
- H. Folse (1989) ‘Bohr on Bell’ in J. T. Cushing and E. McMullin (eds.) *Philosophical Consequences of Quantum Theory. Reflections on Bell’s theorem* (University of Notre Dame), pp. 254–271.
- A. Rae (2004, 2nd ed.) *Quantum Physics: illusion or reality?* (Cambridge University Press), ch. 3-4.
- N. David Mermin, “Quantum Mysteries for Anyone” *Journal of Philosophy* **78** (1981), pp. 397-408 [download online from JSTOR]
- Don Howard (1985) ‘Einstein on Locality and Separability’, *Studies in History and Philosophy of Science* **16**, pp. 171-201.
- D. Howard (1989) ‘Holism, separability and the metaphysical implications of the Bell experiments’ in J. T. Cushing and E. McMullin (eds.) *Philosophical Consequences of Quantum Theory. Reflections on Bell’s theorem* (University of Notre Dame), pp. 224–253.
- H. Putnam (1990) ‘Realism with a Human Face’ in *Realism with a Human Face*, ch. 1, pp. 3–11.

SUGGESTED ESSAY TITLES

1. What is the role of the principle of identity of indiscernibles in Leibniz's criticism of Newton's absolute space?

2. Why can Mach be regarded as being on the same conceptual path of Leibniz in the criticism of Newton?

3. Why is time not real, according to McTaggart?

4. What is the problem with the entropic past-future asymmetry?

5. In what ways does Kant's view of space and time differ from Leibniz's and Newton's?

6. In what sense can Kant's view of scientific knowledge still apply to 20c. physics, according to Friedman?