Assignments for preparing the lectures and the exam
Philosophy of Engineering: Science

The questions cover what you need to understand and/or know for the exam as to these materials:

Assignment 2:

- Ladyman Chapter 3 with focus on 3.1-3.4.
- Handout on Truth & empirical adequacy (see Course materials).
- Slides on Falsificationism & Truth [Lecture 4].

Important note: Sometimes it is helpful to browse the internet in order to find additional information on a topic, or nice examples etc. However, be careful. Only use sources from a philosophical background. Wikipedia articles oriented at philosophical topics often are OK. Another, more thorough source is the Stanford Encyclopedia of Philosophy and other internet encyclopedias on philosophy. Through the UT library, you can get access to the Routledge encyclopedia of philosophy[1] (however, this CDROM does not always function properly). If you are interested in original sources Google books can be used. When using other sources, check whether it is an academic or educational philosophy (of science) entry. You can see this, for instance, by checking whether the www address contains **.edu**.

Note 2. Related to the former note: In this class you will learn some so-called 'technical terms.' These are terms in the philosophy of science that have a specific meaning that may differ from its ordinary meaning in all day life or its specific meaning in other scientific fields. By the way, the use of technical terms that have different meanings in

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different fields is not specific for philosophy – think for instance of the term 'operator', which has different meanings in mathematics, chemical engineering and telecom. Examples of terms with a specific meaning in the philosophy of science are: induction (which has a different meaning in mathematics), logic, truth, and realism.

Note 3. The assignments are exercises that aim to prepare you for the lectures and for the final exam. When doing these assignments (1, 2, 3), you will find that not all answers can be found in Ladyman or study materials provided so far – they will be addressed in the lecture after your submission. In some cases, you aim to think about the question yourself and formulate an answer; otherwise, you just write: '<u>not in book</u>'. It is recommended to bring your own answers to the lectures and develop them further during or right after class – in that manner, you will be well prepared for the final exam.

Note 4. Please copy the questions and numbering in your assignments. Try to be concise and adequate in your answers. Several questions overlap. This is because the questions aim to have a didactical structure that guides you in <u>thinking through</u> the materials. At the exam, less background information will be provided.

Assignment 2. Scientific Methodology: Falsification, Truth and Empirical Adequacy.

1) Karl Popper aimed at distinguishing ('demarcating') between science and pseudo-science (such as, in his view, astrology and psychology of his days; e.g. a horoscope usually is so general that it is hard to see the claims can be disproven, that is, it is hard to *falsify* claims made by astrology). Popper argued that the accepted empiricist theory of scientific method (which involves the inductive method) could not rule out what was regarded as pseudo-science.
   a. Explain why Popper finds pseudo-scientific theories troubling (e.g. by using the example of how the psychologist Alfred Adler, by means of one and the same psychological theory, explains why a man tries to drown a child, as well as why a man tries to save a child at the risk of his own life). Suggestion: summarize Popper's worries in a few keywords, which you briefly explain.
   b. Confirmation is fundamental to the inductive method. Explain why.
   c. According to Popper, confirmation must be replaced by falsification. Explain what is meant here. Suggestion: summarize Popper's theory of scientific method in a few keywords, which you briefly explain.
   d. Explain how Popper solved the problem of induction. First briefly summarize what the problem is (suggestion: also use a logical schema!), then, present Popper's solution. Also explain why *falsificationism* is logically valid according to Popper (use a logical schema).

e. Give your own (not from the book) example of a statement or theory that is not falsifiable and explain why it cannot be falsified. Also give an example of a falsifiable statement or theory, and explain how it could be falsified.

f. Note that Popper (1969) is not a skeptic: he believes that this scientific method will bring us nearer to the truth! However, as we cannot confirm the truth of theories, what then, in his view, is the status of theories (p.70-71)?

g. Describe in your own words Popper's theory of scientific method (falsificationism). Suggestion, imagine that you have to teach this method to someone who wants to apply it in his scientific research; maybe also contrast it with a naive inductive method, and with a deductive method.

2) Some (e.g., Popper and many other philosophers of science) claim that scientific knowledge is *scientific* because a scientific methodology is applied.

a. Explain why a scientific methodology is needed anyway, e.g., by explaining the difference between 'scientific' knowledge and 'ordinary' knowledge.

b. Popper distinguishes between science and pseudo-science. Are his examples of pseudo-science also examples of 'ordinary' knowledge? Why/not?

3) 'Truth' is a very important but also very difficult notion. Alfred Tarski regarded 'truth' as a semantic notion, and from that starting-point proposed a semantic definition of truth.

a. Explain what is meant by "truth is a semantic notion" (be very precise and brief!).

b. Explain Tarski's semantic definition of truth. (be very precise and brief!)

c. A *definition* of truth does not automatically provide a *criterion* of how to decide whether a sentence is true. Bas Van Fraassen is a modern empiricist who proposed a truth criterion that adds to Tarski's definition. What, according to Van Fraassen, is a proper explication of what we mean when saying "a theory is true"? (by which he aims to show that from an empiricists point of view, 'true theories' is a weird and confusing notion.)

d. Apply this definition and criterion to scientific laws such as Newton and Maxwell (e.g., Newton's laws are true iff ....).

e. Van Fraassen proposed *empirical adequacy* of theories as an alternative to *truth* of theories, in order to grasp what we aim to say when we say that a theory is true. Explain how this works out for scientific laws (or theories).

f. In a common understanding of 'truth' (especially Truth with a capital T), confusion often arises when *truth* is taken as synonymous with *existence*: a true theory means that it literally tells us what the world is like, i.e., what really exists 'out there'. How do the semantic notion of truth

combined with Van Fraassen's notion of empirical adequacy solve this confusion (e.g., it presents us with a better understanding of where and how to apply 'truth')?

4) Empirical adequacy has been proposed as an alternative to the idea of the truth of theoretical knowledge.
    a. Analyze the meaning and use of truth (i.e., first, its role in accepting knowledge; next, how by starting from a semantic conception of truth this notion can be defined; and finally, how attribution of this notion to … is justified).
    b. Explain why truth is a problematic notion when it comes to the idea of 'true theoretical knowledge'.
    c. Explain why (or to what extent) empirical adequacy circumvents (or solves) this problem.
    d. Explain in your own words what has been achieved by this so-called 'philosophical analysis' of truth? In other words, which problem has been solved, and how -- why is it a solution. [Note that this is not the only possible way to 'explain' truth; other accounts are possible as well.]

5) Scientific knowledge can be defined as being about the world 'behind' the phenomena', rather than about the observable (or perceivable) world. As scientific claims cannot be proven or checked by direct, straightforward observation, we need a methodology that justifies the acceptance of knowledge, that is, we need a methodology that justifies the attribution of the epistemological property – such as truth, or empirical adequacy – to scientific claims [Note that this passage is part of the answer to 7a.].
    a. Explain the so-called Hypothetico-deductive method.
    b. Explain by means of logical analysis why this method is problematic from a logical point of view.
    c. Explain Popper's method of falsification [partly repetition of former question].
    d. Explain by means of logical analysis why this method solves the logical problem of H-D.
    e. Explain why falsification is not very satisfactory either. It does not account very well for how scientists reason when they find a result that disagrees with the hypothesis. What do they do? Do they really reject the hypothesis? [refers to Quine-Duhem].
    f. Induction as a scientific method didn't work either. Why not, from a logical point of view?
    g. And how about deduction? So the problem of the deductive method is not a logical problem. Is deduction the final solution?
    h. Explain the difference in character of the hypothesis in case of inductive reasoning versus abductive (or "inference to the best explanation") reasoning (see examples Boyle, Hooke, versus Bohr, on slides).

       i.   Do you find that Boyle's (or Hooke's) law is an <u>explanation</u> of the behavior of gasses? (explain this). And how about Bohr's model of the atom?

6) Theories (or models) are not only supposed to be true (or empirically adequate), they also must be explanatory.
    a. Explain what is meant by the 'explanatory power' of a theory.
    b. Explain why having explanatory power still does not bring us closer to the truth of a theory (or model).