

Warm up philosophical questions

1. What does it really mean to say something like “that is a circle on the chalkboard”? Under what conditions is such a claim true? How would one go about testing such a claim? (You might want also to think about other geometric objects such as lines, triangles, etc.) The point here is that lines, triangles, circles are *abstract* objects, whereas things written on a chalkboard are *concrete objects*. So what does it mean to say that a concrete object (e.g. “that on the chalkboard”) is the same as an abstract object (e.g. “a circle”).
 - (a) Is the “is” in “ x is a circle” (where x is a physical object) an assertion of identity or of predication? For example, when I say “my shirt is red” then I am not asserting an identity “shirt = red”, but that “my shirt” falls under the predicate “is red”. In contrast, when I say that Superman is Clark Kent, I am asserting an identity “Superman = Clark Kent”.
2. Physicists today have no problem saying things like “our universe is a curved four-dimensional manifold”. What do they mean by that? Is their claim justified? Why or why not?
3. What problems might there be with taking the truths of geometry to be purely analytic, i.e. true by definition?
4. What problems might there be with taking a neo-empiricist stance about the axioms of geometry? (A neo-empiricist stance might say that we accept a certain geometry because it is part of the best overall explanation of the things we experience.)
5. What problems might there be with saying that reality is actually made out of geometrical objects, and that our (or physics’) goal is to say true things about them?
6. (Euthyphro meets physics) Does light follow a line because it is straight, or is a line straight because light follows it?

On the Factual Foundations of Geometry

1. (p 47) What dilemma does Helmholtz start the article with? (For deeper reflection: How does this dilemma relate to the traditional dichotomy between analytic and synthetic propositions?)
2. (p 47) What does Helmholtz think is the problem with trying to “test rigid bodies for the invariance of their form”?
3. (p 47) What advantage does Helmholtz think that analytic geometry has?
4. (p 50) What must be presupposed in order for us to be able to use geometry to make meaningful statements about the world?

On the Origin and Meaning of Geometrical Axioms

1. (p 54) What does Helmholtz think is the main difficulty for figuring out what justifies the geometric axioms?
2. (p 54) What does Helmholtz think is actually happening (in our minds) when we assume that certain geometric objects can be constructed?
3. (p 59) What does Helmholtz think is an advantage of Riemann's approach to geometry?
4. (p 63, top) What does Helmholtz say about the claim that we know a priori that space is Euclidean? (What argument does he give?)
5. (p 63, bottom) What, according to Helmholtz, must be assumed in order to compare magnitudes of physical objects?
6. (p 64) What does Helmholtz think it would feel like if suddenly everything were doubled in size?
7. (p 66) What does Helmholtz think about the idea that human beings are physiologically pre-wired to perceive space in a Euclidean fashion?
8. (p 67) Why can geometry alone not really tell us if two physical bodies are congruent with each other?
9. (p 67) What does Helmholtz mean by "taking the notion of rigidity as a mere ideal"? Do you think he is endorsing this notion or not?
10. (p 67) What examples of "propositions relating to the mechanical properties of natural bodies" does Helmholtz give?
11. (p 68) Does Helmholtz think that we have a priori knowledge of the axioms of geometry, in the sense of Kant's "transcendental form given before experience?"
12. (p 68) What else is needed in order for the axioms of geometry to represent relations of real (i.e. physical) things? (For further reflection: what would Helmholtz say about the idea that an axiom of geometry has been falsified by experience?)
13. (p 68) Harder question: Does Helmholtz think that the axioms of geometry can be confirmed or disconfirmed by empirical observations?
14. Explain in a few sentences what Helmholtz means by the title of this essay.