Study Questions for Hunt (1991) *The Maxwellians*.

Chapter 1

1. What characterized the mathematical reform in the early 1800s at universities like Trinity College in Dublin, and Cambridge in England?
2. What characterized MacCullagh's optical ether?
3. Why sorts of criticism did Cambridge researchers like Stokes and Thomson have about MaCullagh's ether?
4. How did Faraday's account of electromagnetic phenomena differ from action-at-a-distance theories in terms of electric particles?
5. What was the Faraday Effect? How did Thomson explain it?
6. What were Maxwell's two new ideas of great importance in his extension of Thomson's model?
7. According to Hunt, what was Maxwell's *Treatise* intended to be? How did this impact key ideas like the concept of a displacement current?
8. Did Maxwell's original account say anything about how electromagnetic waves are generated? Did it give an account of optical phenomena like reflection and refraction?
9. How can the Faraday Effect be explained in terms of the double refraction of light waves?
10. What is the Kerr Effect?
11. What was the basis of the analogy FitzGerald proposed between MacCullagh's ether and Maxwell's theory? What role did this play for the treatment of reflection and refraction in Maxwell's theory?
12. How did Maxwell's treatment of magnetism differ from FitzGerald's treatment (under his analogy involving MacCullagh's ether)?
13. What is the Hall Effect? Why was it significant in the development of FitzGerald's analogy between MacCullagh's ether and Maxwell's theory?
14. According to Hunt, what are two ways in which FitzGerald's work on MacCullagh's ether strengthened Maxwell's theory?
15. What does Hunt mean when he says: "...if Maxwell's theory were to survive, it had to be cut loose from reliance on an elastic solid ether and given a fundamentally new basis."

Chapter 2.

1. Why does Hunt think Maxwell never tried to produce electromagnetic waves?
2. Does the claim that light waves are electromagnetic waves entail that light waves are *generated* electromagnetically?
3. What was Lodge's cogwheel model of electromagnetism?
4. Why is the fact that Lodge was seeking to generate *light* waves significant in his attempts to produce electromagnetic waves?
5. According to Lodge, how might a discharging condenser produce light waves?
6. What were FitzGerald's two lines of reasoning against the possibility of generating electromagnetic waves?
7. What was the basic problem that FitzGerald saw for generating electromagnetic waves?
8. How did Rayleigh's theory of sound solve the problem in #7 for FitzGerald?
9. How did FitzGerald use an analogy with a bubble in jelly to explain how an oscillating electric current could radiate energy in the form of electromagnetic waves?
10. What are "retarded potentials"?
11. What was one consequence that FitzGerald drew from his formula for the energy radiated by an oscillating current?
12. How did FitzGerald propose to detect the high frequency/long wavelength radiation his formula predicted should be produced by an oscillating current?

Chapter 3.

1. How did Heaviside get his first job as a telegrapher in Newcastle?
2. When was the first submarine telegraph cable between Dover and Calais built? When was the first trans-Atlantic cable built?
3. What were some of the ways that the technology of telegraph cables interacted with the development of Maxwell's theory?
4. Why did William Henry Preece and his followers want to "pot Oliver"?
5. What were some of the problems associated with distortion in submarine telegraph cables?
6. What was Faraday's explanation of distortion in telegraph cables? How did this differ from action-at-a-distance theories?
7. What was Thomson's Law of Squares? What series of events confirmed his theory of distortion over that of E. O. Whitehouse?
8. What property of telegraph cables did Heaviside think Thomson's Law of Squares ignored?
9. Describe one way in which Heaviside's equation for telegraph cables is conceptually significant.
10. What was Heaviside's salary as a writer for the journal *The Electrician*?

Chapter 4.

1. In what sense was physics an intensely vivid and tactile pursuit for Maxwell?
2. What was FitzGerald's distinction between *analogy* and *likeness*? Was Maxwell's vortex model intended as an analogy or a likeness?
3. What was FitzGerald's wheel and rubber-band model intended to explain?
4. How did FitzGerald's wheel and rubber-band model represent electric and magnetic fields? How did it represent self-inductance?
5. How did FitzGerald's model represent the charging of a condenser?
6. How did FitzGerald's model represent the discharging of a condenser? What is a conducting current in this model? How does it represent Poynting's account of electromagnetic energy?
7. How are electromagnetic waves represented in FitzGerald's model?
8. What moral about electric displacement did FitzGerald draw from his model?
9. What was the basis of Thomson's rejection of Maxwell's theory in 1885? What moral did FitzGerald draw from Thomson's argument?
10. What was Duhem's criticism of Lodge's string and beads model?
11. How did Lodge's string and beads model represent a dielectric?
12. How did Lodge's cogwheel model represent electric current and electric displacement? How did it represent a conductor?
13. Why did FitzGerald object to Lodge's use of positive and negative wheels?
14. What was Poynting's objection to Lodge's cogwheel model?
15. What was FitzGerald's vortex sponge model? How did it differ in the way it was intended from FitzGerald's earlier wheels and rubber-band model?
16. What was Thomson's criticism of the vortex sponge model?
17. What are some reasons why mechanical models of electromagnetism and the ether fell out of favor in the late 1800s?
18. In what sense was Heaviside's development of vector analysis a focus on mathematical models, as opposed to mechanical models?