a. An earlier notebook -- "The Waste Book" -- and a brief manuscript -- the "Vellum" manuscript -- contain precursors of some of the papers assigned for tonight, as noted below

b. The only other work was a brief, unsuccessful foray into projectile motion under air resistance -- this following publication of James Gregory's work on this topic and pendulums (1673)

D. Newton's Work in Mathematics: 1664-1680

1. Newton seems to have begun educating himself in mathematics in 1663, from an elementary text on arithmetic and algebra by Oughtred (1631) and a more advanced text by van Schooten (1646)
   a. The work that appears to have brought him to the then-current forefront of the field was van Schooten's second Latin edition (1659) of Descartes' *Géométrie*
   b. From there he turned to numerous sources, including Wallis's work on indivisibles and infinite series and Barrow's works and (presumably) lectures at Cambridge
2. He discovered the fundamentals of what we now call the calculus over a two-year period from 1664 to 1666 (see chart in Appendix), culminating in his first tract, "To resolve problems by motion"
   a. General algorithms for solving problems concerning infinite sums, maxima and minima, tangents (see Appendix), quadratures, being worked on by Fermat, Pascal, and Huygens (among others) in France and by Wallis, Barrow, and Gregory (among others) in England
   b. Employing a Barrow device of a curve described by a moving point, and taking what we would now call derivatives with respect to time, which Newton called "fluxions" of "fluents"
3. This was followed by a tract in Latin, "De Analysi per Aequationes Infinitas," in 1669, which Barrow circulated, gaining Newton recognition as the leading figure in mathematics in England, and then a full-fledged treatise, *De Methodis Serium et Fluxionum*, in 1671, for which Newton was unable to find a publisher; in all of these he continued with fluents unfolding over "time"
   a. The range of the problems addressed in the latter is spectacular (see Appendix, where examples on curvature and a table of integrals are included as well): Newton had full control of the algorithmic methods that came to be known as the calculus by 1671
   b. The history of mathematics would have been quite different if that book had been published then (rather than finally in two different English editions during the 1730s)
   c. Leibniz's initial work on the calculus began in the mid-1670's and came to fruition in the mid-1680's, but unlike Newton's it was published in the leading journals and led to a tradition of research involving the Bernoullis, l'Hôpital, Varignon, and later Euler and several others
4. One shortcoming of Newton's early work on the calculus was a lack of perspicuous notation; only after the *Principia* in 1687 did he invent the dot notation that came to be associated with him
   a. For example, in the early work he often used lower-case letters to represent the fluxions (time-derivatives) of fluents represented by the corresponding upper-case letters
   b. By contrast Leibniz had a more perspicuous notation from the outset
   c. So even if Newton's early works had been published, they might not have caught on quickly

5. Over the next decade Newton studied classic geometry in more detail than he had before and in lectures rigorously developed foundations of algebra, later published as *Arithmetica Universalis*
    a. These efforts appear to have convinced him that limits could never be done with proper rigor in symbolic methods, but only by extending geometry to incorporate them
    b. That view is reflected in the mathematical method used throughout most of his *Principia*, and subsequently in his unfinished treatise *Geometria*, intended to carry out that project on limits
6. Newton's first publication of work in the calculus was as an appendix to the 1704 first edition of his *Opticks*, and comparatively little more made it into print until posthumously
    a. In 1710 the priority controversy over the calculus began, growing into something that then colored all publication of his work in mathematics after that (see Hall, *Philosophers at War*)
    b. Meanwhile, calculus as we know it continued to be developed in the tradition stemming from Leibniz, with a real explosion in the hands of Euler from 1730 to 1780
    c. View now is that they discovered the calculus indepedently, but calculus as we know it, including the word itself and much of the notation, derives from Leibniz

E. Newton's Work in Optics: 1665-1680

1. Much of Newton's initial work on optics and the theory of light occurred during this period, undoubtedly stimulated by Descartes' *Optics* and *Principia*, as well as by Barrow's lectures in geometric optics
    a. Extraordinary experiments showing that white light is composed of light of different colors, along with a theory of refraction explaining chromatic aberration as a consequence of differing refraction indices of different color light -- Lucasian lectures, 1670-72
    b. Papers in the form of letters published by the Royal Society in 1671 and 1672 on this work and the reflecting telescope (and then in reply to objections until 1675) made Newton famous and respected throughout the scientific world
2. The controversy they initiated -- in particular, the insistence by Hooke and others that the experiments were predicated on a particle theory of light -- then led Newton to shun further publication
    a. One source of this insistence was Newton treating rays of light in the abstract, concluding that rays of different color are differently refrangible, and then suggesting that rays are the paths of light particles without in any way using this (see his reply to Pardies in Appendix)
    b. To some extent the controversy also stemmed from the difficulty of replicating his experiments -- though Hooke managed to do so; for, as the key pages (see Appendix) describing his so-called *experimentum crucis* make clear, the experiments were elaborate and required great care
3. But it stemmed even more from differing conceptions of science, where Newton was outspokenly negative toward the "method of hypotheses," especially those concerning underlying processes
    a. Newton already insistent on a strict distinction between experimentally established theoretical claims, on the one hand, and hypothetical conjectures, on the other