ASSIGNMENT 3

Philosophy 167 due December 5

In August 1684, while visiting Cambridge, Edmond Halley told Newton of discussions going on between himself, Wren, and Hooke about what trajectory a body would describe under an inverse-square force directed toward a center and asked Newton whether he knew. Newton answered, an ellipse; Halley asked how he knew; Newton said he had proved it. Unable to find the proof among his papers, Newton promised that he would send it to him in London. In November Halley received a copy of a nine-page hand-written tract, *De Motu Corporum in Gyrum* (*On the Motion of Bodies in Orbit*). After reading the tract, Halley decided to take the several hour trip back to Cambridge immediately to discuss it with Newton. Thus began the sequence that culminated with the publication of Newton's *Principia* in the summer of 1687, with Halley as editor.

Though still in his twenties at the time of his initial visit to Newton, Halley was already an accomplished astronomer, and he could well have been the best informed person in the world about the state of astronomy in 1684. He had already published papers on astronomy in *Philosophical Transactions of the Royal Society* while still an undergraduate, and by 1684 was on the governing council of the Society. Upon graduating from Oxford in 1676, he had been commissioned by the King to lead a year-long expedition to St. Helena to make astronomical observations of the southern skies and a transit of Mercury, as well as other measurements. Already in close contact with Hooke, Wren, Streete, and Flamsteed, in the early 1680s Halley spent several months in Paris working with Cassini, including observations of the comet of 1680-81 and talking with other members of the Royal Academy, including Richer. Just prior to that he had spent an extended time with Hevelius (the leading authority at the time on comets) in Danzig, making observations with him, and after it he had worked with Flamsteed at Greenwich. Through his own research (including apparent familiarity with *Astronomia Nova*) and his contacts with so many of the other leading figures in astronomy at the time, Halley was thus on top of the situation in astronomy when he visited Newton in 1684.

The tract *De Motu Corporum in Gyrum*, which Halley registered with the Royal Society at its December 10 meeting, consists of four theorems and seven problems. These show that, given certain assumptions (including what we now call the principle of inertia), Kepler's ellipse, area rule, and 3/2 power rule are systematically related to motion governed by a force always directed toward a single point in space that varies in an inverse-square ratio with the distance of the body from that point. The fourth problem provides the solution for the trajectory of a projectile under such an inverse-square force toward a center and the fifth, for direct (e.g. vertical) descent toward the center in the absence of resisting media. The final two problems – as somewhat of an afterthought, some scholars have said – revisit the Galilean solutions for vertical and projectile motion, but now with resistance forces (varying linearly with velocity) included. In short, this nine-page tract ties the six "laws" that we have been considering, three from Kepler on orbital motion and two on "local" motion, plus the principle of inertia, to one another.

The natural tendency now is to consider the *De Motu* tract from the perspective of the *Principia*, focusing on how the 500-page book grew out of the embryo from which it started. We will be doing so in the next semester, for that more than anything else will help us to see the new conception of how to do science that Newton forged in the process of writing the book. Halley in November 1684, however, obviously could not have viewed the tract from this perspective, for even Newton at that time had little conception of how his continuing research might unfold. More to the point, the tract nowhere proposes that terrestrial gravity varies in an inverse-square ratio with distance to the center of the Earth, much less any hint of universal gravity among all particles of matter in the universe, or even much hint of the celestial forces countering the centrifugal *conatus* of orbiting bodies being one in kind with terrestrial gravity. Halley had expected a mathematical proof of the ellipse, and this (with qualifications) is what he got. So, why he felt compelled to make an immediate return trip to Cambridge to discuss the tract further is not transparent.

Your task is to put yourself in Halley's place, asking what contribution he saw the nine-page document *by itself* making to astronomy and the mechanics of motion at the time. Suppose, for example, that he had decided to give a ten-to-fifteen minute report of the tract to the Royal Society before he returned to Cambridge. In a brief paper (5-7 pages) *explain* what difference he would have said the purely mathematical discoveries presented in the tract made to the evidential status first of Kepler's "laws" and second of the "laws" of free-fall, projectile motion, and what we now call inertia. How, if at all, did Newton's initial mathematical discoveries, by themselves, alter the state of the evidence bearing on these "laws"? What further conclusions, if any, could "scientists" – the word had yet to be coined – as typified by Halley, have drawn at the time about these "laws" purely on the basis of this tract?