the problem of the path under an inverse-square center-directed force:

> "It now remaines to know the proprietys of a curve Line (not circular nor concentricall) made by a centrall attractive power which makes the velocitys of Descent from the tangent Line or equall straight motion at all Distances in a Duplicate proportion to the Distances Reciprocally taken. I doubt not but that by your excellent method you will easily find out what that Curve must be, and its proprietys, and suggest a physicall Reason of this proportion."

a. Method to which Hooke refers surely the calculus -- that is, Newton's method of fluxions

b. Well known in science circles that Newton had made a breakthrough in mathematics

C. The Comet(s) of 1680-81

1. Exactly what Newton discovered in 1679-80 in conjunction with this correspondence with Hooke we do not know, for no document remains

   a. Some have speculated that a paper he wrote for Locke after the *Principia* appeared that gives a more simplistic approach to ellipses and the inverse-square represents what he found earlier

   b. But there is no evidence for this, and Newton himself never gave any indication after the dispute with Hooke over credit for the inverse-square emerged in 1686

2. Newton's sole interest in mechanics in the period from 1679 to 1684 for which we have any documents involves an intense episode starting in mid-December 1681 and extending at least to April 1682 in which he was trying to work out the trajectory of the comet (or comets) observed in November 1680 and then December through February 1681

   a. Flamsteed, Newton learned, was proposing, on the basis of symmetry, that this seemingly pair of comets was one comet, seen initially moving from north to south and then from south to north

   b. This proposal initially included a claim that magnetic repulsion as it had approached the sun had caused the comet to be deflected through a large hairpin angle

   c. Included in Newton's letters to Flamsteed in response to this proposal is a denial that (1) that the magnetism of the sun could do this (heat cancels magnetic effects) and (2) that such a hairpin angle could happen through repulsion

   d. In its place Newton offers Flamsteed the alternative that the comet button-hooked around the sun, with the attraction of the latter producing the hairpin angle

3. This supporting proposal notwithstanding, Newton's own efforts on the comet of December centered on a straight line trajectory at uniform speed, with at most slight curvature either from the sun or the "vortex" around it

   a. In particular, the late James Ruffner's (2013) detailed analysis of Newton's recorded observations and calculations from 1681 show him struggling, with less than reliable data, to fit a straight line trajectory of the sort Wren had proposed in 1664 (see Notes, Class 11)

   b. So, while Newton offered suggestions to help Flamsteed with his proposal, he was throughout their correspondence at this time working on an approach expressly denying one instead of two comets

c. So, whatever Newton had concluded about planetary motion in conjunction with his 1679-80 correspondence with Hooke, it did not include universal gravity, or even solar attraction acting on comets in the same way as on planets

d. And he was still clearly wedded to the presence of an aetherial vortex around the sun

4. Newton breaks off the correspondence with Flamsteed insisting on two separate comets, partly because he had concluded from the observations available to him, after much effort, that the requisite high curvature is not consistent with them

a. Ruffner has shown that during this period Newton initiated a review of comets, turning first to Riccioli's *New Almagest* and then to Hevelius's review from the 1660s

b. This review led to his concluding,"this sways most with me that to make ye Comets of November and December but one is to make that one paradoxical. Did it go in such a bent line other comets would do ye like & yet no such thing was ever observed in them but rather the contrary"

c. In short, therefore, his position on comets in the 1679-1684 period seems close to Hooke's and not at all what subsequently emerged

5. There is one further single sheet document that on comets from somewhere between 1681 and 1685 in which Newton returns to the comet(s) of 1680-81

a. Ruffner (2000) originally dated this before Halley's visit in 1684, but subsequently (Ruffner, 2013) backed off this, allowing it to post-date Halley's visit

b. This document (ULC Add. 3965,14, fol. 613r and 613v) still has a fluid vortex around the sun, but allows for trajectories "oval" and "nearly hyperbola" in response to inverse-square gravitation toward the sun and each of the planets (see Ruffner, 2000 for details)

D. The Renewal of Interest in 1684 -- Halley

1. Newton's life forever changes as a consequence of a visit by Halley in August 1684 (see Halley letter in Appendix; but Newton years later said earlier) in which he informed Newton of the intense interest in London in inverse-square center-directed forces and the path a body will follow under them

a. Halley had himself noticed the inverse-square force implied by Kepler's 3/2 power "law" and Huygens's centrifugal force, and had entered into intense, somewhat contentious discussions with Wren and Hooke

b. Newton said the path is an ellipse, and when Halley asked how he knew, he said he had calculated it

c. He looked for the proof, said he was unable to find it, promised to send it to Halley forthwith

2. (Though Halley was still in his late 20s at this time, he may well have had a more complete overview of what was and was not known about orbital motion at the time than anyone else in England

a. He had himself worked in astronomy ever since his student days at Oxford, including efforts assisting Flamsteed from time to time