

Newton by Kneller (1689)



Hooke by Greer (2004)

# A body falling through the Earth: Newton vs. Hooke

Todd Timberlake – Berry College (GA)  
Christopher Graney – Jefferson Community  
& Technical College (KY)

# The Debate

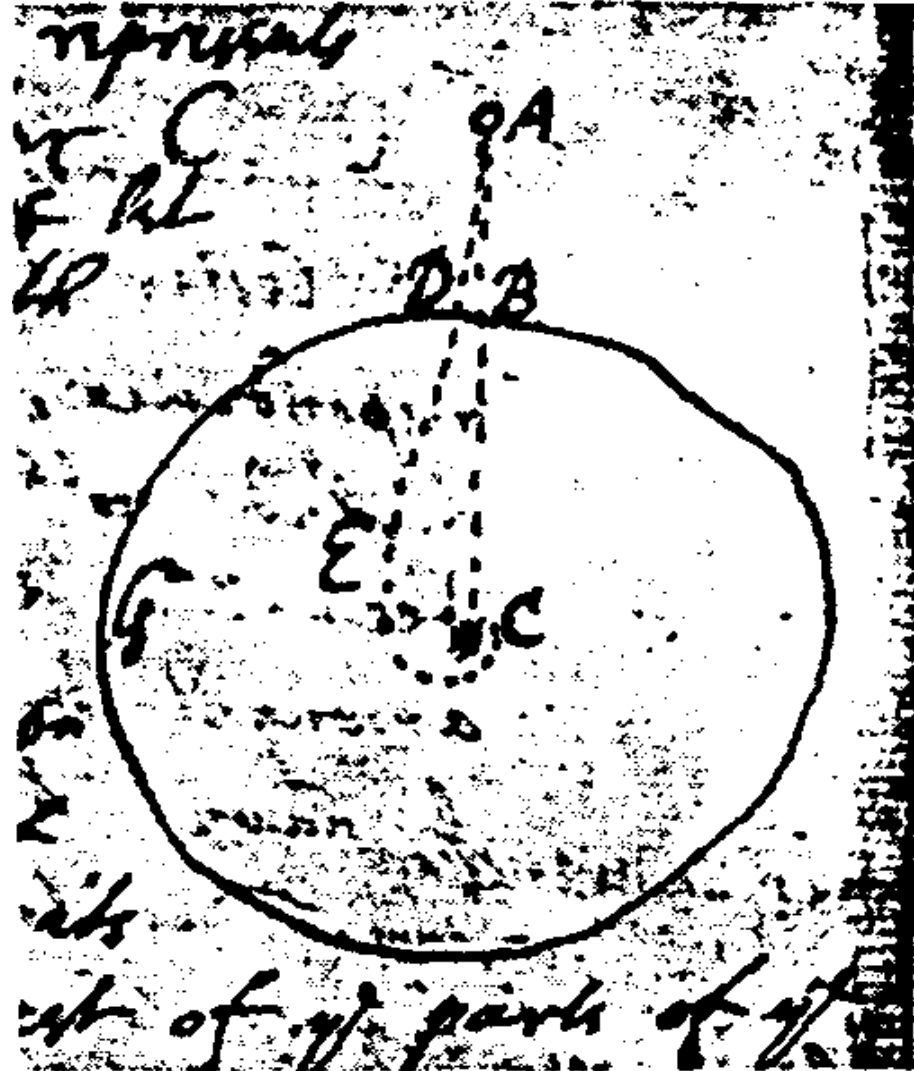
- From late 1679 to early 1680, Isaac Newton and Robert Hooke exchanged letters about the motion of a body falling through the rotating Earth.
- Each man presented multiple conjectures about this motion, each conjecture based on different implicit assumptions about the forces acting on the body as it travels through the Earth.
- We have constructed computer simulations to illustrate each conjecture.

# Newton Conjecture 1

- Newton wrote to Hooke suggesting an object dropped from a tall tower would fall slightly to the East, because the object is initially moving eastward (due to Earth's rotation) faster than the point on Earth directly below it.
- Implicit assumptions: object at Equator, no significant forces other than gravity, object released from rest in rotating Earth frame

# Newton's Sketch

- Newton included a sketch showing the motion of the body to, and *through*, the Earth.
- More on this later.

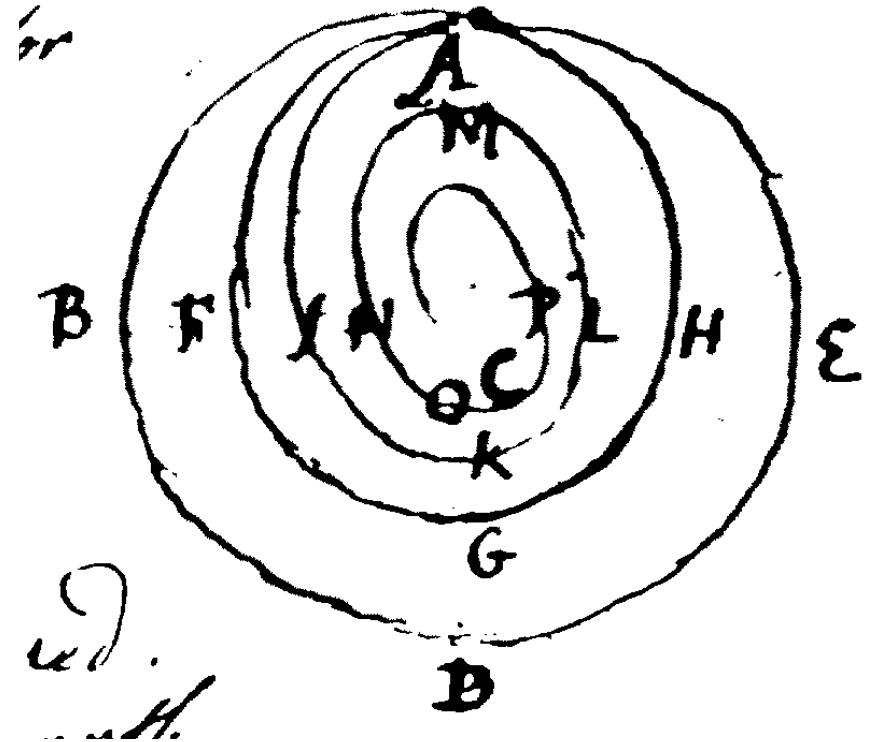


# Hooke Conjecture 1

- Hooke agreed that the body would fall east, but disagreed with the part of Newton's sketch inside Earth.
- He stated that the path would “resemble an Elleipse” if the “gravitation to the former Center remained as before.”
- Implicit assumptions: object at Equator, inverse square gravitational force, no resistance, released from rest in rotating frame, path described in inertial frame

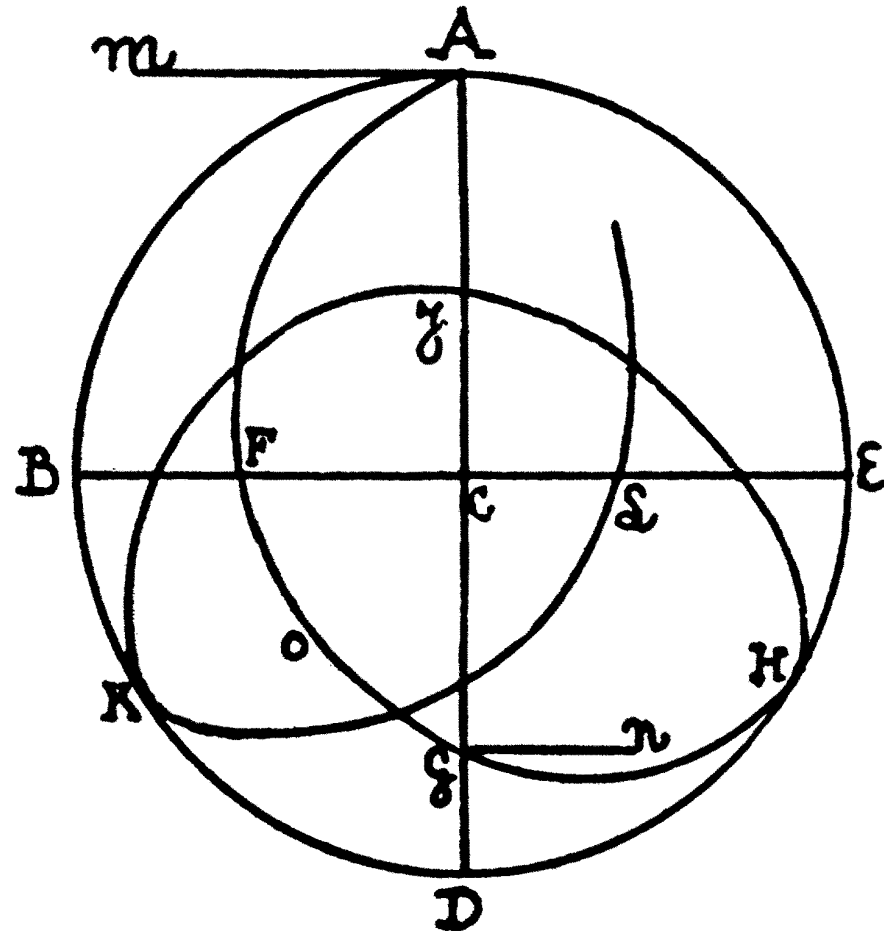
# Hooke Conjecture 2

- Hooke noted that if one assumes a resistance to motion within the Earth, then the path will be an elliptispiral (as shown in Hooke's sketch).
- Implicit assumptions: as before but with very slight resistive force



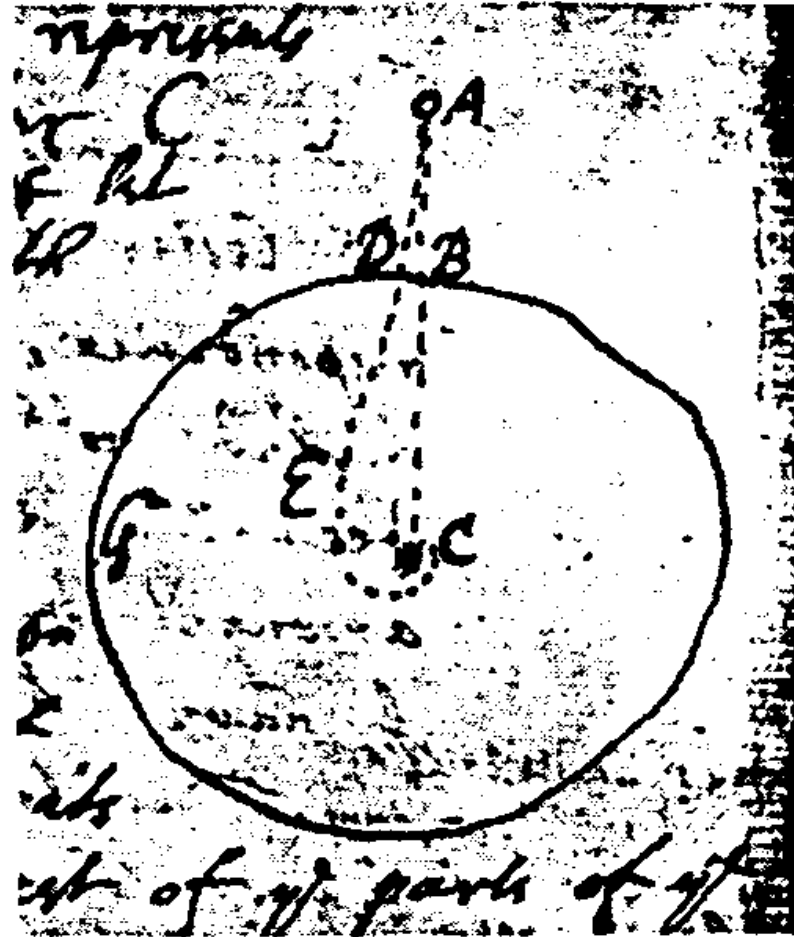
# Newton Conjecture 2

- Newton thinks Hooke is saying that the gravitational force inside Earth has constant magnitude. He supplies his own sketch of what this path should look like.
- Implicit assumptions: object released from Equator, constant magnitude force toward Earth's center, no resistance, released from rest in rotating frame, path shown in inertial frame



# Hooke Conjecture 3

- Hooke says he didn't mean constant magnitude, he meant inverse square. But he really thinks the force would get smaller toward the center "possibly somewhat like the gravitation on a pendulum ..."
- A uniform density Earth does give a linear Hooke's law force. If we include a moderate resistive force, the result is a path very much like Newton's original sketch if we view it in the rotating Earth frame.





# Lessons

- Scientists always make assumptions when modeling a physical system. Sometimes these assumptions are left unstated.
- Things are much less confusing when we identify, and clearly state, the assumptions that are involved in our modeling. (Building computer simulations forces you to do this!)
- To understand a sketch depicting motion, we must know which reference frame is being used.
- In this debate, Newton's original sketch was probably the most realistic, but Hooke clearly had sophisticated ideas about gravity before the publication of the *Principia*.

# Resources

- Stand-alone simulation (FallingBodyOnRotatingEarth2D) available in the Open Source Physics collection:  
[www.compadre.org/osp/](http://www.compadre.org/osp/).
- Launcher package available at  
[facultyweb.berry.edu/ttimberlake/newtonhooke/](http://facultyweb.berry.edu/ttimberlake/newtonhooke/).