

Lecture 26

Galileo on Natural and Uniform Acceleration

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Galileo's claim

- Galileo calls the motion of falling bodies “naturally accelerated motion” (160).
- He gives the following **definition**: *A motion is said to be uniformly accelerated, when starting from rest, it acquires, during equal time-intervals, equal increments of speed.* (162)
- He **claims** that naturally accelerated motion is uniformly accelerated.
- *Sagredo: Although I can offer no rational objection to this or indeed to any other definition, devised by any author whomsoever, since all definitions are arbitrary, I may nevertheless without offense be allowed to doubt whether such a definition as the above, established in an abstract manner, corresponds to and describes that kind of accelerated motion which we meet in nature in the case of freely falling bodies.*
(162)

Reasons to believe the claim

Agreement with experiment

Galileo demonstrates that uniform acceleration has certain properties. (This is just mathematical deduction from the definition of uniform acceleration.) The reason to believe the claim is that experiment shows that naturally accelerated motion has the same properties.

- *In this belief we are confirmed mainly by the consideration that experimental results are seen to agree with and exactly correspond with those properties which have been, one after another, demonstrated by us. (160)*
- *If we find the properties which will be demonstrated later are realized in freely falling and accelerated bodies, we may conclude that the assumed definition includes such a motion of falling bodies and that their speed goes on increasing as the time and the duration of the motion. (167)*

Simplicity

Finally, in the investigation of naturally accelerated motion we were led, by hand as it were, in following the habit and custom of nature herself, in all her various other processes, to employ only those means which are most common, simple and easy.

For I think no one believes that swimming or flying can be accomplished in a manner simpler or easier than that instinctively employed by fishes and birds.

When, therefore, I observe a stone initially at rest falling from an elevated position and continually acquiring new increments of speed, why should I not believe that such increases take place in a manner which is exceedingly simple and rather obvious to everybody? If now we examine the matter carefully we find no addition or increment more simple than that which repeats itself always in the same manner. (160–161)

The most important reason is agreement with experiment

- Galileo said so:

*In this belief we are confirmed **mainly** by the consideration that experimental results are seen to agree with and exactly correspond with those properties which have been, one after another, demonstrated by us. (160)*

- He later repeated the argument from experimental agreement but not the argument from simplicity:

If we find the properties which will be demonstrated later are realized in freely falling and accelerated bodies, we may conclude that the assumed definition includes such a motion of falling bodies and that their speed goes on increasing as the time and the duration of the motion. (167)

Comparison with Copernicus

Copernicus's reasons to believe his theory:

- The consequences deduced from the theory agree with the phenomena that are observed. Galileo said the same.
- The theory is simple and nature acts in simple ways.

We should rather heed the wisdom of nature. Just as it especially avoids producing anything superfluous or useless, so it frequently prefers to endow a single thing with many effects. [20.43]

Galileo made a similar point.

- The theory is symmetric and harmonious. This doesn't apply to Galileo's topic.

Both men used the method of hypothesis.

The cause of natural acceleration

Introduction

Galileo presented this topic as a discussion by the three characters who are reading his treatise. The characters are:

- **Salviati:** An expert follower and friend of Galileo. What he says can be taken as Galileo's view.
- **Sagredo:** Sympathetic to Galileo but not an expert. What he says is not necessarily Galileo's view.
- **Simplicio:** An Aristotelian. What he says is almost never Galileo's view.

Sagredo's theory (165–166)

- Sagredo proposes that the cause of natural acceleration is this: Gravity by itself would produce a constant velocity downwards. When a body is thrown upwards, it is given an impetus upwards that exceeds the downwards velocity from gravity. But the impetus gradually diminishes and the result is acceleration downwards.
- Simplicio objects that this only works for bodies that are thrown upwards, not for those that are held at rest and then released.
- Sagredo responds that a body held at rest is given impetus upwards that is just sufficient to cancel out the velocity of gravity. When the body is released, that impetus decays away, producing acceleration downwards.

Salviati's response

The present does not seem to be the proper time to investigate the cause of the acceleration of natural motion concerning which various opinions have been expressed by various philosophers, some explaining it by attraction to the center, others to repulsion between the very small parts of the body, while still others attribute it to a certain stress in the surrounding medium which closes in behind the falling body and drives it from one of its positions to another. Now, all these fantasies, and others too, ought to be examined; but it is not really worth while. At present it is the purpose of our Author merely to investigate and to demonstrate some of the properties of accelerated motion (whatever the cause of this acceleration may be). (166–167)

- 1 What did Galileo mean by “naturally accelerated motion” and “uniformly accelerated motion”?
- 2 What two reasons did Galileo give for thinking that naturally accelerated motion is uniformly accelerated? Which reason did he regard as the most important?
- 3 Did Galileo demonstrate that freely falling bodies are uniformly accelerated? Explain.
- 4 Was Galileo trying to find the cause of naturally accelerated motion? Justify your answer.



Galileo Galilei.

Dialogues Concerning Two New Sciences.

Macmillan, 1914.

Translated by Henry Crew and Alfonso de Salvio.

Online in [facsimile pdf](#) (16MB) and [html](#).

Numbers in parentheses are page numbers of this edition.