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John Buridan, *Questions on the Four Books on the Heavens and the World of Aristotle**

1. BOOK II, QUESTION 12. Whether natural motion ought to be swifter in the end than the beginning .... With respect to this question it ought to be said that it is a conclusion not to be doubted factually *(quia est)*, for, as it has been said, all people perceive that the motion of a heavy body downward is continually accelerated *(magis ac magis velocitatur)*, it having been posited that it falls through a uniform medium. For everybody perceives that by the amount that a stone descends over a greater distance and falls on a man, by that amount does it more seriously injure him.

2. But the great difficulty *(dubitatio)* in this question is why this [acceleration] is so. Concerning this matter there have been many different opinions. The Commentator (Averroës) in the second book [of his commentary on the *De caelo*] ventures some obscure statements on it, declaring that a heavy body approaching the end is moved more swiftly because of a great desire for the end and because of the heating action *(calefactionem)* of its motion. From these statements two opinions have sprouted.

3. The first opinion was that motion produces heat, as it is said in the second book of this [work, the *De caelo*], and, therefore, a heavy body descending swiftly through the air makes that air hot, and consequently it (the air) becomes rarefied. The air, thus rarefied, is more easily divisible and less resistant. Now, if the resistance is diminished, it is reasonable that the movement becomes swifter.

But this argument is insufficient. In the first place, because the air in the summer is noticeably hotter than in the winter, and yet the same stone falling an equal distance in the summer and in the winter is not moved with appreciably greater speed in the summer than in the winter; nor does it strike harder. Furthermore, the air does not become hot through move-

* Translated from the Latin edition of E. A. Moody, (Cambridge, Mass., 1942), pp. 176–81.

ment unless it is previously moved and divided. Therefore, since the air resists before there has been movement or division, the resistance is not diminished by its heating. Furthermore, a man moves his hand just as swiftly as a stone falls toward the beginning of its movement. This is apparent, because striking another person hurts him more than the falling stone, even if the stone is harder. And yet a man so moving his hand does not heat the air sensibly, since he would perceive that heating. Therefore, in the same way the stone, at least from the beginning of the case, does not thus sensibly heat the air to the extent that it ought to produce so manifest an acceleration *(velocitatio)* as is apparent at the end of the movement.

4. The other opinion which originated from the statements of the Commentator is this: Place is related to the thing placed as a final cause, as Aristotle implies and the Commentator explains in the fourth book of the *Physics*. And some say, in addition to this, that place is the cause moving the heavy body by a method of attraction, just as a magnet attracts iron. By whichever of these methods it takes place, it seems reasonable that the heavy body is moved more swiftly by the same amount that it is nearer to its natural place. This is because, if place is the moving cause, then it can move that body more strongly when the body is nearer to it, for an agent acts more strongly on something near to it than on something far away from it. And if place were nothing but the final cause which the heavy body seeks naturally and for the attainment of which the body is moved, then it seems reasonable that that natural appetite *(appetitus)* for that end is increased more from it as that end is nearer. And so it seems in every way reasonable that a heavy body is moved more swiftly by the amount that it is nearer to [its] downward place. But in descending continually it ought to be moved more and more swiftly.

But this opinion cannot stand up. In the first place, it is against Aristotle and against the Commentator in the first book of the *De caelo*, where they assert that, if there were several worlds, the earth of the other world would be moved to the middle of this world . . . .

Furthermore, this opinion is against manifest experience, for you can lift the same stone near the earth just as easily as you can in a high place if that stone were there, for example, at the top of a tower. This would not be so if it had a stronger inclination toward the downward place when it was low than when it was high. It is responded that actually there is a greater inclination when the stone is low than when it is high, but it is not great enough for the senses to perceive. This response is not valid, because if that stone falls continually from the top of the tower to the

earth, a double or triple velocity and a double or triple injury would be sensed near the earth than would be sensed higher up near the beginning of the movement. Hence, there is a double or triple cause of the velocity. And so it follows that that inclination which you posit not to be sensible or notable is not the cause of such an increase of velocity.

Again, let a stone begin to fall from a high place to the earth and another similar stone begin to fall from a low place to the earth. Then these stones, when they should be at a distance of one foot from the earth, ought to be moved equally fast and one ought not be swifter than the other if the greater velocity should arise only from nearness to [their] natural place, because they should be equally near to [their] natural place. Yet it is manifest to the senses that the body which should fall from the high point would be moved much more quickly than that which should fall from the low point, and it would kill a man while the other stone [falling from the low point] would not hurt him.

Again, if a stone falls from an exceedingly high place through a space of ten feet and then encountering there an obstacle comes to rest, and if a similar stone descends from a low point to the earth, also through a distance of ten feet, neither of these movements will appear to be any swifter than the other, even though one is nearer to the natural place of earth than the other.

I conclude, therefore, that the accelerated natural movements of heavy and light bodies do not arise from greater proximity to [their] natural place, but from something else that is either near or far, but which is varied by reason of the length of the motion *(ratione longitudinis motus)*. Nor is the case of the magnet and the iron similar, because if the iron is nearer to the magnet, it immediately will begin to be moved more swiftly than if it were farther away. But such is not the case with a heavy body in relation to its natural place.

5. The third opinion was that the more the heavy body descends, by so much less is there air beneath it, and the less air then can resist less. And if the resistance is decreased and the moving gravity remains the same, it follows that the heavy body ought to be moved more swiftly.

But this opinion falls into the same inconsistency as the preceding one, because, as was said before, if two bodies similar throughout begin to fall, one from an exceedingly high place and the other from a low place such as a distance of ten feet from the earth, those bodies in the beginning of their motion are moved equally fast, notwithstanding the fact that one of them has a great deal of air beneath it and the other has only a little.

Hence, throughout, the greater velocity does not arise from greater proximity to the earth or because the body has less air beneath it, but from the fact that that moving body is moved from a longer distance and through a longer space.

Again, it is not true that the less air in the aforementioned case resists less. This is because, when a stone is near the earth, there is still just as much air laterally as if it were farther from the earth. Hence, it is just as difficult for the divided air to give way and flee laterally [near the earth] as it was when the stone was farther from the earth. And, in addition, it is equally difficult or more difficult, when the stone is nearer the earth, for the air underneath to give way in a straight line, because the earth, which is more resistant than the air, is in the way. Hence, the imagined solution *(imaginatio)* is not valid.

6. With the [foregoing] methods of solving this question set aside, there remains, it seems to me, one necessary solution *(imaginatio)*. It is my supposition that the natural gravity of this stone remains always the same and similar before the movement, after the movement, and during the movement. Hence the stone is found to be equally heavy after the movement as it was before it. I suppose also that the resistance which arises from the medium remains the same or is similar, since, as I have said, it does not appear to me that the air lower and near to the earth should be less resistant than the superior air. Rather the superior air perhaps ought to be less resistant because it is more subtle. Third, I suppose that if the moving body is the same, the total mover is the same, and the resistance also is the same or similar, the movement will remain equally swift, since the proportion of mover to moving body and to the resistance will remain [the same]. Then I add that in the movement downward of the heavy body the movement does not remain equally fast but continually becomes swifter.

From these [suppositions] it is concluded that another moving force *(movens)* concurs in that movement beyond the natural gravity which was moving [the body] from the beginning and which remains always the same. Then finally I say that this other mover is not the place which attracts the heavy body as the magnet does the iron; nor is it some force *(virtus)* existing in the place and arising either from the heavens or from something else, because it would immediately follow that the same heavy body would begin to be moved more swiftly from a low place than from a high one, and we experience the contrary of this conclusion . . . .

From these [reasons] it follows that one must imagine that a heavy body

not only acquires motion unto itself from its principal mover, i.e., its gravity, but that it also acquires unto itself a certain impetus with that motion. This impetus has the power of moving the heavy body in conjunction with the permanent natural gravity. And because that impetus is acquired in common with motion, hence the swifter the motion is, the greater and stronger the impetus is. So, therefore, from the beginning the heavy body is moved by its natural gravity only; hence it is moved slowly. Afterwards it is moved by that same gravity and by the impetus acquired at the same time; consequently, it is moved more swiftly. And because the movement becomes swifter, therefore the impetus also becomes greater and stronger, and thus the heavy body is moved by its natural gravity and by that greater impetus simultaneously, and so it will again be moved faster; and thus it will always and continually be accelerated to the end. And just as the impetus is acquired in common with motion, so it is decreased or becomes deficient in common with the decrease and deficiency of the motion.

And you have an experiment [to support this position]: If you cause a large and very heavy smith's mill [i.e., a wheel] to rotate and you then cease to move it, it will still move a while longer by this impetus it has acquired. Nay, you cannot immediately bring it to rest, but on account of the resistance from the gravity of the mill, the impetus would be continually diminished until the mill would cease to move. And if the mill would last forever without some diminution or alteration of it, and there were no resistance corrupting the impetus, perhaps the mill would be moved perpetually by that impetus.

7. And thus one could imagine that it is unnecessary to posit intelligences as the movers of celestial bodies since the Holy Scriptures do not inform us that intelligences must be posited. For it could be said that when God created the celestial spheres, He began to move each of them as He wished, and they are still moved by the impetus which He gave to them because, there being no resistance, the impetus is neither corrupted nor diminished.

You should note that some people have called that impetus "accidental gravity" and they do so aptly, because names are for felicity of expression. Whence this [name] appears to be harmonious with Aristotle and the Commentator in the first [book] of this [work, the *De caelo*], where they say that gravity would be infinite if a heavy body were moved infinitely, because by the amount that it is moved more, by that same amount is it moved more swiftly; and by the amount that it is moved more swiftly,

by that amount is the gravity greater. If this is true, therefore, it is necessary that a heavy body in moving acquires continually more gravity, and that gravity is not of the same constitution *(ratio)* or nature as the first natural gravity, because the first gravity remains always, even with the movement stopped, while the acquired gravity does not remain. All of these statements will appear more to be true and necessary when the violent movements of projectiles and other things are investigated . . . .

COMMENTARY

This selection (passages 3–5) tells us of three common explanations of the cause of the acceleration of falling bodies in addition to the fourth, the impetus explanation which Buridan is supporting: (1) a heating of the medium which decreases its resistance and thus increases the velocity; (2) proximity to natural place which acts by some virtue or other (like that of the magnet) as a moving cause, this virtue being increased as the body comes closer (see the discussion of Simplicius and Aristotle in the introductory remarks of this chapter); (3) as the body falls there is continually less air beneath it acting as resistance; hence the velocity increases (see the discussion of Simplicius above);[22] (4) the impetus explanation, i.e., gravity continually introduces an impetus which acting as a supplementary increasing cause of movement, and acting with the gravity, produces the acceleration. Among the other explanations not mentioned by Buridan were two which centered around the supplementary action of the medium: (5) one which held that air stirred up by the movement is able to get behind the falling body and give it supplementary pushes (a theory taken over from Aristotle's explanation of the continuance of projectile motion, see Chapter 8);[23] and (6) the falling body not only draws the air behind, but in pushing the air beneath it, it sets it in motion, and this air sets other air in motion, and the drawing action of the air makes it less resistant and helps the gravity of the body (a theory found in the *Liber*

[22] Something of this sort is understood by the author of the *De sex inconvenientibus* (see footnote 15 and cf. Maier, *An der Grenze*, pp. 190–91). A somewhat different view was held by Durandus de St. Porciano, who held that "by the amount that the air is closer to the earth, by that amount is it less light and exerts itself less against the motion of the heavy body" ("motus naturalis sit intensior in fine quam in principio: causa est minor resistentia medii, supposita eadem inclinatione mobilis, quanto enim aer est terrae propinquior, tanto est minus levis et minus nititur contra motum gravis"). *Sent.*, Bk. II, dist. 14, quest. 1, quoted through Maier, *An der Grenze*, p. 190.

[23] It is this theory that is referred to by "pulsus medii" by the author of the *De sex inconvenientibus*, *edit. cit.* in footnote 15.