

CONCERNING THE THIRD AND
FOURTH DEFINITIONS AND THE
FIRST LAW IN NEWTON'S *PRINCIPIA*

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AT the very beginning of the *Principia*, Newton speaks of the "state of moving" and the "state of rest" indifferently. Many have remarked the strangeness of his language here, and have pondered the philosophical difficulties which such language raises. It is strange indeed to take a word which at root means "standing" or "staying" and apply it to movement, which is the contrary of standing or staying. Newton does not, of course, speak of a "state of change," nor does he describe every movement as a state, but only uniform motion in a straight line. There is evident reason in this, for aside from circular movement, which does not occur naturally, there is no movement which is more like standing still than this one. Since every part of the movement is exactly like every other part, the mobile is always, it seems, the same as it was. And our experience confirms this, for when we are moving in this way, we do not feel it; we seem not to be moving at all.

Nevertheless, the mobile is not the same as it was, for it is no longer *where* it was, even within the time of its movement. As it moves, it is elsewhere and elsewhere. If to be in *this* place were the same as to be in *that* place, this place would have to be that place. Even if the places do not differ in kind, the one is not the other. Thus, as it moves, the mobile is changing, so that to speak of a "state of moving" is to speak of a "state of changing," how-

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ever reluctant one may be to say so. But perhaps it is a mistake to insist upon this point, as if it were a matter of dispute. Is it a rational enterprise to enquire whether local movement is a change of place, or whether change of place is a change? Or is it rather like asking whether triangles have three corners, or squares have two diagonals?

But there is another difficulty here, more subtle and perhaps more interesting. So far as I know, it has not been noted by the commentators. In Definition IV, Newton speaks of a "force" exerted upon a body "in order to change its state, either of rest, or of uniform motion in a right line." Now one may ask: Just what is this force the cause of? When the body has been at rest, the force was not the cause of the rest; nor is it the cause of the motion which follows. Rather, it is the cause of the change from rest to motion. But here is the difficulty: Is there any such thing as a change from rest to motion? Is Newton perhaps positing a cause for a non-existent effect, affecting, as he would say, "the pomp of superfluous causes?" A similar question arises concerning a change of direction. Let us lay out the reasons and examine them.

1 No such change is observed. We see the mobile rest, and then we see it moving. No intermediate change is observed. There is a moment which divides the one from the other, observed, like all limits, along with the things it limits. But no other change is observed.

2 When the mobile has been resting, but now is moving, we might say it has changed from rest to movement. For in general, if a thing is different now than it was before, we are inclined to say that it has changed: It has changed from what it was to what it is. But there will not always be a change; there cannot be change without difference, but there can be difference without change, even when the difference comes later in time. The present instance is a case in point. Moving is different from resting, so that the mobile is no doubt different now than it was before. But if it follows from this that there must have been an intermediate change, then, since there was also a time when that

intermediate change was not occurring, there would have to have been yet another intermediate change, leading up to that change, and so on *ad infinitum*. Now one might say that there are other reasons than the one mentioned above for assuming, as if it were an evident matter of fact, that there is a change from rest to motion. But what might these reasons be?

3 If there is a change between the rest and movement, when does this change occur? There is no time between the two in which a change might occur. Does it occur, then, in the indivisible moment which divides them?

A) Change, properly speaking, does not occur in a moment. There is the moment in which a change is *completed*, but the completion of change is not itself a change. In that moment, the mobile *has changed*, but *is not changing*.

B) When we do speak of an instantaneous change, we are indicating a coming-to-be which terminates a preceding change. For example, an alteration is ordered to and results in the coming-to-be of a new substance. This coming-to-be is indeed instantaneous. But on this account the subject *is* what it *becomes* at that instant. In the case of substantial change, the new substance already *is* at the instant of the change. Thus, if we say that it changes in that instant, we must also say that it has changed in that instant. To speak in general, then, if a thing changes in an instant, it has changed in that same instant. In such cases, there is no real difference between the change and the result of the change. If, then, the mobile changes from rest to movement in the moment which divides them, it will also *have changed* in that same moment. But when a thing has changed, it already is that to which it was changing. Thus, the mobile is already moving in that indivisible moment of division, which is absurd.

Much of the same objection arises against the assumption that there is a change of direction. When might such a change occur? Up to a particular moment, the mobile is moving in one direction; from that moment, it is moving in another direction, or in other directions. If there is a change of direction, it can

only occur in that moment. But, as argued above, if a mobile changes in a moment, it must also have changed in that moment, so that there must already be a new direction within that moment. But direction belongs to movement and cannot exist without it. Therefore, if the mobile has a new direction in a moment, it must also have movement in that moment, which is absurd.

What solution would Newton offer to these difficulties, if he were disposed to take such difficulties seriously? One plausible solution has been offered along these lines. The change in question, it is said, is not from rest to movement as such, but to a movement of a particular speed or velocity. It takes time to go from rest to any particular speed, and this time is the time of the change which the force causes. For example, it may take 6 seconds for the mobile to achieve a speed of 10; this 6 second period is the time occupied by the change. This is because the rest is followed immediately, not by a uniform movement with a determinate speed, but by an accelerated movement in which no determinate speed is maintained for any length of time, and there is no least among the speeds reached. This acceleration is conceived as imperfect actuality, corresponding to Aristotle's definition of movement, and with reason, since the mobile does not have any determinate speed in act until it is moving uniformly. And Newton's language seems to support this solution, since he speaks of a "change of state"; the "states" are rest and uniform movement in a straight line, and the acceleration is between these states.

However, this solution does not meet the difficulties. Let us consider some of the reasons:

1 "Every thing which comes to be or passes away comes from or passes into, its contrary or an intermediate." (*Physics*, 188^b21-23) For example, a change from sickness can only be a change to health, for health is the contrary of sickness. Thus also, if the mobile changes from rest, it must change to the contrary of rest. Movement is the contrary of rest, and there is no intermediate. Speed is not movement, but a mode or property

of movement. Thus, a mobile changes from rest to movement *per se*, but to speed or a particular speed only *per accidens*, insofar as speed is said of movement. The proposed solution is thus fallacious, for it confounds the *per se* with the *per accidens*.

2 If "change of color" means a change from one color to another, and "change of size" means a change from one size to another, then "change of state" will mean a change from one state to another. And there are only two states for the mobile; rest and uniform movement in a straight line. But the action of an impressed force will not result in a uniform movement, except *per accidens*, as the pilot may cause the loss of a ship by his absence, or fire may cause cooling by its withdrawal. (*Physics*, 251^a28-^b1) Uniform motion is acquired only insofar as the force ceases to act, and is maintained solely by the *vis inertiae* within the body. Thus an impressed force cannot be defined as causing a change of state, since it is accidental to the action of a force that uniform movement result. And thus, it is also accidental that a particular speed results, for the mobile has no determinate speed until it is moving uniformly. Therefore, the action of a force does not change the mobile from a state of rest to some speed, except perhaps *per accidens*.

An interesting corollary is that, on Newton's suppositions, there is no *per se* cause whatsoever of uniform movement. There is no *per se* cause of its acquisition, and no *per se* cause of its maintenance. For a body exerts its *vis inertiae* only "when another force, impressed upon it, endeavors to change its condition." Though perhaps it would be truer to say that uniform movement would be impossible, given that centripetal forces are everywhere and always. There is no cause, *per se* or *per accidens*, of the impossible. Similar considerations would apply to rest.

But if any movement, whether uniform or not, is a "state," one might perhaps say that a force changes a body from a state of rest to a state of accelerated movement, for as soon as the body has the accelerated movement, it has ceased to be at rest. But then one would again be asserting a change from rest to movement, which was shown to be impossible.

3 The argument can be put another way. If there is a change *to* a particular speed, it must be *from* another speed. So if there is any change here, there must be two changes: a change from rest to movement, and a change from one speed to another. If, then, force is defined as changing a body from rest to some speed, it will refer to two changes, the first of which was shown to be impossible. Thus, it could only be the cause of a change of speed.

4 When a body has been at rest, and is now accelerating, can it *properly* be said that its speed is changing? For if so, the body (or the movement) must be changing from one speed to another. But from what speed is it changing or has it changed? "Zero velocity" is a fiction, useful no doubt, but still a fiction.

5 Is change of speed, *properly* speaking, a change at all? If one takes "change" *commonly* to mean any sort of difference which follows in time (as the afternoon, for example, follows the morning), then no doubt there are changes of speed. But if one takes "change" *properly*, to mean a distinct but imperfect actuality *between* the differences (as becoming hot is other than being cold and being hot, and between them, and change of place is other than being here and being there, and between them), it seems that there cannot be a change of speed.

For what would be the primary *subject* of such a change, that is, *what* changes its speed primarily and *per se*? Since *fast* and *slow* are said of movement primarily, *becoming faster* and *becoming slower* will also be said of movement primarily. The mobile is not said to be fast or slow, except equivocally, as when one calls a runner "fast" because he can run fast. Thus, speed as such is not attributed to the mobile but is simply a mode or property of the movement which is attributed to it, and it will be *movement* which changes speed. (This is yet another reason why there cannot be a change from rest to some particular speed—rest is said of the mobile, while speed is said of the motion.) But how can change undergo a change?

A) Speed is not present in movement as a distinct reality, the way color is present in surface, for example. It is rather a mode

or condition of its being, like the intensity of a particular color. And just as a body becomes light blue, rather than its blue becoming light, so a body acquires a movement of a particular speed, rather than the movement itself acquiring that speed.

B) Speed and differences of speed pre-suppose and depend upon the continuous divisibility of movement. And there are differences in speed in a movement insofar as one part of it is faster and another slower. But the movement itself is not at one time faster and at another time slower, except *per accidens*, insofar as one *part* of it is faster than another. Neither the whole movement nor any part of it is faster at one time and slower at another, except *per accidens*. Therefore, a movement cannot properly be said to undergo a change from one speed to another, because there is nothing which *per se* becomes any different than it was before. Thus what is called "change of speed," speaking commonly, is in truth just a *difference* between one part of movement and another.

In conclusion, then, it would seem that the "force" Newton speaks of, whose influence we feel in some way in the movement of heavy bodies, is not the cause of some fictitious "change of state," nor of some equally fictitious "change of velocity," but simply a cause of the accelerated movement which we observe, and thus of the differences in speed that are characteristic of such a moment.