

Descartes, Space and Body

Isaac Newton

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[Brackets] enclose editorial explanations. Small ·dots· enclose material that has been added, but can be read as though it were part of the original text. Occasional •bullets, and also indenting of passages that are not quotations, are meant as aids to grasping the structure of a sentence or a thought. Every four-point ellipsis. . . indicates the omission of a brief passage that seems to present more difficulty than it is worth.—This paper was an enormous ‘digression’—four-fifths of the whole!—in *De Gravitatione et Aequipondio Fluidorum*, a Latin paper on hydrostatics written in about 1666. Newton didn’t complete the paper, but the ‘digression’ can stand on its own.—In it, Newton criticizes Descartes (weakly in section 4, more effectively in 5 and 6), and then starts expounding his own positive views in 7. The most exciting part starts at section 11.—The division into named and numbered sections has been added in this version.—References of the form 0:00 are to Part and Section of Descartes’s *Principles of Philosophy*.

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1. The start of the hydrostatics paper

There are two good ways to approach the science of gravity, and of equilibria of fluids and of solid bodies in fluids. (1) To the extent that this study belongs to the mathematical sciences, it's reasonable for me to handle it without bringing in physical considerations much. And that's why I plan to give strict geometrical demonstrations of its individual propositions, inferring them from abstract principles that readers will know well enough. (2) This science can also be seen as somewhat akin to physics, in that it can be applied to explaining many of the phenomena of physics. For that reason, and also to •show clearly how useful this science is and to •give its principles further confirmation, I shan't hesitate to give plenty of experimental illustrations as well •as rigorous demonstrations•. But I'll put that informal •empirical• material in notes, so that it won't be confused with the rigorous stuff that is treated in lemmas, propositions and corollaries.

The foundations from which this science can be demonstrated are •definitions of certain words, and •axioms and postulates that everyone accepts. I'll start on these right away.

Definitions:

The terms 'quantity', 'duration' and 'space' are too well known to be definable in terms of other words.

Def. 1. A *place* is a part of space that something fills evenly.

Def. 2. *Body* is what fills place.

Def. 3. *Resting* is remaining in the same place.

Def. 4. *Motion* is change of place.

2. The start of the 'digression'

Note: When I said that a •body 'fills' a place, I meant that it *saturates* that part of space so completely that •it—as an impenetrable being—wholly excludes other things of the same kind, i.e. other bodies. I could have defined *place* as 'a part of space in which something is evenly distributed', •dropping the verb 'fill'. That would leave open the possibility of a place's being occupied by something that is penetrable—spread evenly through the place but not excluding everything else of the same kind•. But my only concern here is with bodies, which are *impenetrable*; so I have preferred to define *place* as a part of space that things *fill*—•in the excluding-everything-else sense of 'fill'•.

•My definition of *body* also merits a comment•. What I am going to be investigating in this work is not

•body considered as a physical substance endowed with sensible qualities.

but rather

•body considered merely as something that is extended, mobile and impenetrable.

Rather than defining *body* in the way philosophers do, I shall abstract from the sensible qualities—•such as colour, taste, etc.—and attend only to the properties that bodies must have if they are to move. (Actually, that's what philosophers should do too; they should regard the sensible 'qualities of bodies' as mental events or states caused by the motions of bodies.) So you can take my topic to be *not* •real physical bodies *but rather* •abstract figures such as they are taken to be by geometers when they assign motion to them, as in Euclid's *Elements* 1:4,8....

I have defined *motion* as 'change of place' because 'motion', 'transition', 'translation', 'migration' and so on all seem to mean the same. If you prefer, let motion be the transition

or translation of a body from place to place. [In Newton's day, 'translation' could have a meaning that it now doesn't have—one that comes from its origin in a pair of Latin words meaning 'carry across'.]

3. What Descartes says about motion

In these definitions, I take it that space is distinct from body; and I define *motion* in terms of how the moving thing relates to •parts of that space, not of how it relates to •the position of neighbouring bodies. Both points go contrary to the Cartesians; and so that you won't think I do this casually or thoughtlessly, I shall try to dispose of Descartes's fictions.

I can summarise his doctrine in these three propositions:

[The first proposition is an implicit denial of *this*: 'For a given body at a given time, ordinary language and common sense gives us a choice of different accounts of whether and how it moves, depending on what other bodies we choose to relate it to.' Descartes is removing that choice.]

(1) As a matter of objective truth, there is only one way a body can be said to move ·at a given time·. *Motion* is defined as the translation of one body away from the bodies that immediately touch it (which are regarded as being at rest) and into contact with other bodies. (2:25,28)

(2) A body that 'moves' according to this definition doesn't have to be •a particle of matter—•an atom—•or •a body composed of parts that aren't moving relative to one another. It may be a body consisting of many parts that have different relative motions, the whole lot of them being transferred from one group of neighbouring bodies into contact with another. (2:25)

(3) As well as this particular motion that each body has ·in accordance with the definition·, it can also have countless other motions by being a part of other bodies that have other motions (2:31). That is, it's colloquially all right to say this; but it isn't strictly, scientifically, objectively correct. (2:24,25,28,31; 3:28,29). ·For example, let *x* be a comet that is strictly moving, i.e. moving in relation to the bodies that brush up against it; and let *y* be an inner part of *x*, a part that is not strictly moving, i.e. not moving in relation to *its* immediate neighbours; it is still colloquially all right to say that *y* is 'moving', attributing to it a movement that it •derives from the strict movement of the comet·.

To go with his two types of motion, namely **(a)** particular (or strict, scientific) and **(b)** derivative, Descartes has two kinds of place from which something may be said to move—**(a)** the surfaces of immediately surrounding bodies (2:15) and **(b)** the position in relation to any other bodies (2:13, 3:29).

4. Three self-contradictions by Descartes

1. This whole doctrine has absurd consequences that convince us of how confused and incongruous with reason it is; and Descartes himself seems to admit this—by contradicting himself! He says that the earth and the other planets don't *move*, using this term in its strict scientific sense; and someone who says that it [the earth?] 'moves' because of its translation with respect to the fixed stars—well, that's just ordinary language, and not really reasonable. (3:26,27,28,29) [Actually, Descartes says that even the ordinary loose way of talking *doesn't* allow us to say that the earth 'moves', though it does allow us to say that the other planets 'move'.] Yet later on he attributes to the earth and planets a tendency to recede

from the Sun as the centre around which they are revolving, this tendency being counter-balanced by a similar tendency of the revolving vortex (3:140). [•Here and throughout, the word translated by ‘tendency’ could mean ‘effort’. •Descartes’s ‘vortex’ is a supposed large spherical mass of fluid matter whirling around the sun, holding the earth and planets in their orbits.] What’s going on here? Is the ‘receding’ that’s in question here true scientific motion, or rather laymen’s ordinary-language ‘motion’? •And that’s not the end of the trouble. [Newton now offers an extremely difficult sentence, in which he criticises *Principles* 3:119–120, which he says give an inconsistent account of the movement of comets. We can spare ourselves the difficulties, because the criticism is in any case mistaken. Descartes writes about (1) what we can *say first* about how the comet moves and (2) about what we can *say later* when we take more things into account. Newton reports him as writing about (1) how the comet *moves at first* and (2) about how it *moves later*. Newton continues:] So Descartes is now •admitting into the structure of his science the vulgar concept of ‘motion’ that he rejected a little earlier, and •rejecting as worthless the ‘motion’ that he earlier said was the only true and scientific one, the only one that fits the nature of things. Actually, the vulgar sense *is* the one he should be adopting, because a tendency to recede from the sun *would* be caused by a comet’s ‘whirling around the Sun’ in the vulgar sense, and *would not* be caused by its ‘whirling around the sun’ in Descartes’s •strict• scientific sense.

2. Descartes seems to contradict himself when he says that to each body there corresponds a single motion that is

- according to the nature of things,

and yet is

- a product of our imagination,

because it is a translation from the neighbourhood of bodies that *seem* to be at rest but that may instead be moving—as

is more fully explained in 2:29,30. He thinks that this will enable him to handle the difficult question concerning why—when two bodies are in contact with one another and then cease to be in contact—one of them is said to move rather than the other. [This is another misunderstanding. In 2:29,30 Descartes is saying when two contiguous bodies stop being contiguous, there is (a) the absolutely strict, scientific, objective fact that *at least one of them moves*, and there is (b) our decision, on the basis of such ‘vulgar’ things as conventions and convenience and ‘imagination’, about *which* of them to describe as moving. There is no inconsistency in this.] And Descartes also thinks that what he is saying here will enable him to explain why a boat on a flowing stream is said to be at rest when—because a wind is blowing it in the upstream direction—it doesn’t change its position with respect to the banks (2:15). [Newton shows that this clashes with Descartes’s official view about movement, strictly understood. His unduly difficult way of doing this is omitted.]

3. Descartes seems hardly consistent when he supposes •that according to the truth of things each body has •at most• a single motion, and yet also says •that there really are innumerable motions *in* each body (2:31). For the motions that really are *in* any body are

- natural motions, and thus

- motions in the scientific sense, or

- motions according to the truth of things;

though Descartes contends that they are ‘motions’ only in the vulgar sense. Take a case where a whole thing moves while its parts are at rest in relation to one another—i.e. it is moving but not undergoing any inner turbulence. In that case, *the parts really and truly don’t move*; or if you want to treat them as having the movement that the whole thing has, then *the parts really and truly do move*, and by that standard they do indeed have innumerable motions according to the truth of things.

5. Eight other troubles in Descartes's account of motion

1. Inconsistencies aside, we can see from its consequences how absurd Descartes's doctrine is. Here is one. He fiercely insists that the Earth doesn't move, because it isn't translated from the neighbourhood of the ether that immediately surrounds it.

[The ether in question is the vortex that whirls the earth along in its orbit around the sun. Newton is here invoking Descartes's thesis that strictly speaking the motion of any body must consist in changes in its spatial relations to whatever it is *immediately* in contact with. (Suppose that there is no turbulence inside the earth: then if we start from the centre of the earth and move outwards, continually asking 'Have we yet come to an instance of what Descartes's theory would count as movement in the strict sense?' we won't get the answer 'Yes' until we have moved out of the earth into the solar vortex and right *through* that to a place where rotating-vortex-ether is immediately next to ether that isn't part of the vortex and doesn't rotate.) Newton now re-applies this line of thought to a consideration of a solid body that *is* moving in relation to its immediate neighbours.]

From the same principles it follows that when a solid body is moving, no particle *x* within it is moving if *x* isn't being translated from the neighbourhood of the particles that immediately surround it. The same is true for those surrounding particles, and for ones surrounding *them*, and so on until we get to particles that constitute the surface—the outermost shell or skin of the body in question. And this line of thought that we have pursued for •the whole body also holds for •each of the particles composing its skin: the smaller particles composing them don't move, strictly speaking, except for ones that have a surface which is part of the surface of the whole body. All the particles that lie deeper in the body than that can be said to 'move' only in a

derivative way, a courtesy title that they get from being parts of something larger that really does move, i.e. has a motion that is •all its own and not •derived from anything of which it is a part. So there's something wrong with Descartes's basic definition of motion, because it attributes to bodies something that belongs only to surfaces, and denies that any body can have a motion that is all its own.

2. If we attend only to 2:25, we get the result that each body has not merely one motion all of its own but countless such motions, provided that when a whole thing *moves* properly •and strictly• and according to the truth of things, its parts properly and strictly move also. And Descartes has to accept that proviso, because he takes 'the body' whose strict and proper motion he is defining to include *all* that is translated together, •i.e. all the body's parts•. •And there may be countless motions, because• the parts of a moving body may have many other motions among themselves, •in addition to the uniform motion that they all derive from the movement of the body as a whole•. Think of •a vortex whirling around the sun and taking •our earth with it, •a ship (•on our planet•) floating in the sea along with everything in it, •a man walking on the deck of the ship along with all the contents of his pockets, •a watch in the man's pocket, along with its wheels and springs and so on. [Having presented these five examples, Newton now elegantly combines them as successive layers of a single onion-like example.] Unless you say that the motion of a whole aggregate can't be considered as proper motion and as belonging to the aggregate's parts according to the truth of things, you'll have to admit that all these motions of the •wheels, the •man, the •ship, the •earth, and the •vortex are truly and scientifically speaking also motions of the •particles of the wheels.

What emerges from all this is •that Descartes isn't entitled to pick on *any* one motion as the true, absolute and proper

one in preference to the rest, and •that •he is committed to holding that •all these motions—the ones relative to immediately neighbouring bodies and the ones relative to remote bodies—are equally scientifically valid; and you couldn't dream up anything more absurd than *that!* Here are the alternatives:

(1) Any body has just one physical [= 'really out there in the world'] motion, and the rest of its changes of relation and position with respect to other bodies are merely external relational facts about the body—facts that are about *it* only in the way that it might be a fact about *you* that you have just become a sibling.

(2) Things like this are the case: the Earth

- tends to recede from the centre of the Sun because of a motion relative to the fixed stars, and
- tends less strongly to recede because of a lesser motion relative to Saturn and the sphere of ether in which it is carried, and
- tends less strongly still to recede because of its relation to Jupiter and the swirling ether that gives *it* its orbit, and
- tends even less strongly still to recede because of its relation to Mars and *its* ethereal sphere, and
- tends *much* less strongly to recede because of its relation to other spheres of ether which, though they don't carry planets with them, are closer to the annual orbit of the Earth, and
- doesn't tend to do anything relative to its own sphere, because it doesn't move in it.

Since all these tendencies and non-tendencies in (2) can't be completely reconciled with one another, the right thing to say is that (1) is correct: the Earth has just one natural and absolute motion, namely the motion that causes the Earth

to tend to recede from the Sun; and its translations relative to external bodies are mere external relations.

3. The Cartesian doctrine implies that •motion can be generated without any input of •force. Suppose, for example, that God suddenly caused our vortex to stop spinning, without applying any force to the Earth to make *it* stop at the same time. Descartes would •have to• say that in this event the Earth would be moving—really 'moving' in a scientific sense because of its translation from the neighbourhood of the vortex fluid that was immediately all around it; yet he earlier said that in this case the Earth would be 'motionless' in the same scientific sense.

4. It also follows from that same doctrine that God himself couldn't generate motion in certain bodies even if he shoved them with the greatest force. Suppose this for example:

- God gives an enormous push to the starry heaven (along with all the most remote parts of creation) in such a way as to make it revolve with the Earth at its centre—which is what some people think does happen every day.

According to Descartes, •this must be a misdescription of the event, because it's an attempt to describe a state of affairs in which •really

•the Earth alone moves, while the heavens stay still (3:38). This implies that there would be *no difference* between this:

- (i) God uses a tremendous force to cause the skies to turn clockwise

and this

- (ii) God uses a small force to turn the Earth counter-clockwise.

Indeed there is the same relative motion of the bodies in both cases, but the two (i) could be distinguished. In case (i) the force exerted on the heavens gives **them** a tendency to

recede from the centre of the revolution that the force causes, which shows that in strict and absolute terms (rather than vulgar and relative terms) *they* are the only bodies that are moved. In case (ii) the force exerted on the Earth gives **its parts** a tendency to recede from the centre of revolution that the force causes, so that *it* is the only body that is properly and absolutely moved. (Presumably no-one will think that the parts of the Earth would tend to recede from its centre because of a force impressed only on the heavens!) Thus, real absolute motion is to be defined by something other than translation, which should be relegated to the category of the 'merely external'.

5. It seems contrary to reason that bodies should change their relative distances and positions without really moving; but Descartes says that the Earth and the other planets and the fixed stars are properly speaking immobile, and yet they change their relative positions.

6. It seems equally contrary to reason to suppose that this could happen: *A number of bodies maintain the same relative positions through a time when one of them really moves while others are motionless.* But Descartes is committed to saying that this could happen. Suppose the following event:

God causes one planet to stand still, so that it continually keeps the same position relative to the fixed stars, while the sun's vortex keeps whirling around the sun without taking that planet with it.

Descartes would have to say that in this case although the stars are not moving, the planet *is* now really moving because of its translation from the matter of the vortex.

7. What makes it all right for us to say that a body really strictly *moves* at a time when we don't see—*can't* see—that the bodies from whose neighbourhood it is transported are at rest? [Slightly expanding what Newton wrote:] For example, Descartes repeatedly says that the sun's vortex *rotates*; by

his standards this ought to imply that the outermost parts of that vortex are changing their spatial relations to the matter that immediately encloses the sun's vortex; but we can't know that this is so, because we can't know whether that surrounding matter is motionless. . . . If Descartes handles the translation that real movement involves not in terms of the individual particles of the vortices but in terms of the 'generic space' (his phrase) in which those vortices exist, then at last we have something we agree on. And he does say that when we are distinguishing space from bodies, we ought to understand motion in terms of space.

8. As a final revelation of *how* absurd Descartes's position is, I remark that it implies that a moving body has no determinate speed and no definite line along which it moves. Worse still: the speed of a body moving without resistance can't be said to be uniform, nor can the line along which it moves be said to be straight. This is all wrong! Any possible motion must have a definite speed and direction.

6. Definite speed and direction

I'll try to clarify the point I was making in 8 above. Start with this fact:

•When a body *x* stops moving, it's impossible—according to Descartes—to say exactly where its movement *began*. Why? Because according to him that place can only be defined or assigned in terms of the position of the surrounding bodies, and by the time *x* comes to a halt the position of the surrounding bodies is different from what it was at the start of *x*'s movement.

For example, *where exactly was the planet Jupiter a year ago?* What can the Cartesian philosopher base his answer

on? Not on the positions of the particles of the fluid matter of the sun's vortex, because the positions of these particles have greatly changed over the past year. Nor can he go by the positions of the sun and the fixed stars. [Newton cites several ways in which, according to Descartes, the sizes and positions of the 'fixed' stars may change (3:104,111,114), and then continues:] Truly there are no bodies in the world whose relative positions remain unchanged for long, and certainly none that don't move in the Cartesian sense of 'move'. . . . So there's no basis on which we can *now* pick out a *past* place, .i.e. a place defined by what was in it or near it at a specified past time; we haven't even a basis for saying that the place in question still exists, is out there in the natural world and could in principle be discovered. According to Descartes, a thing's *place* is either •the surface of the bodies surrounding the thing or •the thing's position in relation to some other more distant bodies; so that according to his doctrine the thing's place can exist in nature only for as long as there is no movement by any of the bodies in terms of which the place is defined. *Where exactly was the planet Jupiter a year ago?* It turns out that a Cartesian must say that not even God himself could answer this because the place in question no longer exists.

So we get this: now that the body *x* has stopped moving, it's impossible to pick out the place where it started to move, because that place no longer exists; so *x*'s journey doesn't have a beginning, which means that it doesn't have a length either; and so—because speed depends on distance travelled in a given time—*x* didn't do its journey at any particular speed. That's the first thing I set out to prove. Furthermore: what I have said about the starting-point of *x*'s journey applies also to every point along the way; so the journey had no beginning and no intermediate parts, which means that there *wasn't* any journey and thus there *wasn't* any

determinate motion—which is the second thing I wanted to prove. There's no question about this: Cartesian 'motion' isn't motion, because it has no speed, no definite track, and no distance traversed by it. So what we need for there to be definite •places and thus for there to be definite •motion is a relation to something that doesn't move at all—such as *extension* or *space* regarded as truly distinct from bodies. A Cartesian theorist may be more willing to allow this if he notices •that Descartes himself had an idea of extension as distinct from bodies, which he tried to distinguish from corporeal extension by calling it 'generic' (2:10,12,18). And also •that the rotations of the vortices are implicitly based on generic extension. That is because there is nothing else Descartes could base them on; he certainly couldn't base them on relations with the matter surrounding a vortex, because (I repeat) we don't and can't have any information about that. This is an important point, because it's from the rotations of vortices that Descartes derived the ether's tendency to recede their centres, and thus the whole of his mechanical science.

7. What extension (or space) is

The only reason for having any confidence in Descartes's view about motion is a thesis of his that many people regard as having been proved in 2:4,11, namely that there is no difference between •body and •extension. He sets aside hardness, colour, weight, cold, heat and the other qualities that aren't essential to body, because a body can lack them, and all he is left with is a body's extension in length, width and depth—so that these are the whole of the essence of body. I'll now reply to this line of thought by explaining what •extension and •body are, and how they differ from one

another. The division of substances into thinking things and extended things, or rather into thinkings and extensions, is the chief foundation of Cartesian philosophy; and he claims that this distinction is even better known than mathematical demonstrations; so I think it is important to overthrow that system as regards extension, in order to lay truer foundations for the mechanical sciences.

You may be wanting to confront me with the choice: 'Extension is either **(1)** substance or **(2)** accident or **(3)** nothing at all—*which?*' I certainly shan't choose, because extension has its own manner of existence which won't go into either the substance or the accident pigeon-holes. **(1)** It isn't substance, and I have two reasons for saying so. •Extension isn't absolute in itself, but is a kind of upshot of—something that emanates from—God; it's a way of existing that all existing things have. •And it doesn't have the kinds of states or properties that show something to be a substance, namely *actions*, such as thoughts in the mind and motions in body. [Two comments: •Newton writes that extension doesn't *substat* such states or properties, i.e. doesn't *stand under* them. This is a mild play on words, because 'substance' and its Latin *substantia* comes from words meaning 'stand under'. •In this context, 'an action by x' means, roughly, 'an event in respect of which x is active'.] For although philosophers don't *explicitly* define 'substance' as 'entity that can act on things', they all *tacitly* understand 'substance' in that way; it's clear that they would cheerfully allow extension to be substance, just as body is, if only extension could move and act as body can. And they would hardly allow that body is substance if it couldn't move or *act*—e.g. couldn't *arouse* in the mind any sensation or perception whatever. *I'll say more about this in section 14.* **(2)** And extension doesn't exist as an accident either, i.e. as something that inheres in *or is had by*—some *thing*. We can clearly conceive extension existing without any *thing* that *has* it: •we imagine spaces outside the

world or places *within the world* that have no body in them, and •we believe that extension exists wherever there are no bodies, and we can't believe that if God were to annihilate a body its extension would perish with it! **(3)** And it's even *more* wrong to say that extension is nothing, because it is nearer to being an •accident than to being •nothing; indeed it's nearer to being a •substance than it is to being •nothing! There is no idea of nothing, and *nothing* doesn't have any properties; but we have an exceptionally clear idea of extension—one in which we set aside the dispositions and properties of a body, leaving only the uniform and unlimited stretching out of space in length, breadth and depth. And it has many properties that are associated with this idea. I'll list these properties—*six of them*—so as not only to show that extension *isn't* nothing but also to show what it *is*.

8. The properties of extension (or space)

1. In all directions, space can be distinguished into parts whose shared limits we usually call 'surfaces', and these surfaces can be distinguished in all directions into parts whose shared limits we usually call 'lines', and again these lines can be distinguished in all directions into parts that we call points. Thus, surfaces don't have depth, lines don't have breadth, and points don't have *size in any* dimension. (The only way out of this would be to contend that adjacent spaces penetrate each other—merge into each other at their edges—so that the boundary between a body and its surroundings would have a certain depth after all; and similarly with lines and points.) Furthermore, spaces are everywhere right next to spaces, and extension is everywhere placed next to extension; and so adjacent items always have shared boundaries. That is, there are everywhere surfaces acting

as a boundary to solids on each side of them, lines at which parts of the surfaces touch each other, and points at which the continuous parts of lines are joined together. [In this context a 'solid' is an item that is three-dimensional—it could be a body, but it could instead be a stretch of empty space, and the next sentence shows that Newton is thinking of 'solids' in the latter way.] So there are everywhere all kinds of figures [= 'shapes'], everywhere spheres, cubes, triangles, straight lines, everywhere circular, elliptical, parabolic and all other kinds of figures, of all different sizes, even though we don't actually see them. A physical drawing of any figure doesn't launch that figure into space; the figure was there already, though we couldn't sensorily detect it; and the drawing is merely a corporeal representation of that already existing figure. When an iron sphere moves from one place to another, it passes through spaces each of which is spherical, although the sphere doesn't leave behind it any sensorily detectable *trail*. Of each of those spheres of space through which the iron sphere passes we firmly believe that it was spherical before the iron sphere reached it; that's why it was able to *contain* the iron sphere; and all through space there are spaces that can snugly contain any material sphere; so it's clear that space is everywhere spherical. And everywhere cubic, and. . . so on through all the other shapes. . . . So much for space being nothing!

2. Space extends infinitely in all directions: we can't imagine any limit anywhere without at the same time understanding that there's space beyond it. So all straight lines, paraboloids, hyperboloids, as well as all cones and cylinders and other figures of that sort, continue to infinity and aren't bounded anywhere. . . . Here is a down-to-earth instance of infinity:

Imagine a triangle ABC whose base BC and one side AB are at rest while the remaining side AC rotates—while fixed at C—in the plane of the triangle, so that

the triangle is made progressively more open at its vertex. If the line that was AC rotates far enough to the right, it will become parallel to AB, which means that however far you extend each of those lines they will never meet. As the moving line approaches that state of affairs, the possible meeting-point of it (extended) and AB (extended) gets further and further away. *Question*: how far away was the furthest-away of those meeting-points, i.e. the last of them before the moving line becomes strictly parallel to AB?

It was certainly greater than any assignable distance; or—a better way of putting it—*none of the possible meeting-points was the last*. And so the straight line on which all those meeting-points lie—i.e. our moving line extended far enough to have on it all its possible meeting-points with AB—is in fact greater than finite. Don't say that this is infinite only •in imagination, and not •in fact. [When Newton goes on to speak of actually *drawing* a triangle, he evidently means actually *starting to draw* a triangle, drawing the base and making a start on the other two sides.] When any triangle is actually drawn, its sides are always •in fact directed towards some common point at which they would meet if they were extended far enough; so there always is such an actual point where the extended sides would meet, even in a case where it falls outside the limits of the physical universe. So the line traced by all these points will be real, even though it extends beyond all distance.

9. An aside on 'infinite' and 'indefinite'

You may want to object that we can't *imagine* that there is infinite extension. I agree! But I contend that we can *understand* it. We can imagine a greater extension, and then a greater one, but we understand that there exists a greater

extension than any we can imagine. This, by the way, clearly distinguishes the faculty of understanding from the faculty of imagination.

You may have this other objection: 'We can understand what an infinite being is only by negating the limitations of a finite being, and this is a negative and faulty conception.' I don't agree! 'That is, I don't agree that this way of understanding an infinite being is negative and faulty'. A limit or boundary is a restriction or negation of a greater reality or existence in the limited being, and the *less* we conceive any being to be constrained by limits the *more* we attribute to it, i.e. the more positively we conceive it. And thus by negating all limits the conception becomes positive in the highest degree. 'End' [Latin *finis*] is a word whose sense is negative 'because it conveys the thought *no further*'; and so 'infinity' [Latin *infinitas*], which is the negation of a negation, is a word whose meaning—and whose relation to our perception and comprehension—is positive in the highest degree, though it seems grammatically negative. . . .

If Descartes now says that extension is not *infinite* but rather *indefinite*, he should be corrected by the grammarians. For the word 'indefinite' is never applied to something that actually exists, but only to a future possibility—merely signifying something that isn't yet determined and definite. For example, before God had decreed anything about the creation of the world (if there ever was such a time), the quantity of matter, the number of the stars and all other things were indefinite; once the world was created they were fixed, made definite. A second example: matter is indefinitely •divisible, but any given portion of matter is •divided either finitely or infinitely (1:26, 2:34). So an indefinite line is one whose future length is still not fixed; an indefinite space is one whose future size isn't yet fixed. Something that actually exists now isn't something that 'is to be fixed'; it is fixed

or definite; it either does have limits or it doesn't, meaning that it is either finite or infinite. You may want to defend Descartes thus: 'He only takes space to be indefinite *in relation to us*. His view is simply that we don't know its limits and aren't absolutely sure that it doesn't have any' (1:27). This is still wrong, for two reasons. •We are indeed ignorant beings, but God at least understands that space has no limits—understanding this certainly and positively, not merely in the negative way associated with indefiniteness. •Although we only *negatively imagine* space to transcend all limits, we *positively and most certainly understand* that it does so. I can see what led Descartes astray here: he was afraid that if he regarded space as outright infinite, that would give it a perfection that might make it qualify as God. But this fear is empty. Infinity isn't a perfection except when a perfect thing has it. Infinity of intellect, power, happiness etc. is the height of perfection; but infinity of ignorance, weakness, wretchedness etc. is the height of *imperfection*; and infinity of extension is a perfection only to the extent that the extended item in question is itself perfect.

10. The properties of space (resumed)

3. The parts of space are motionless. If they did move, we would have to choose between two stories about what was going on. We could say that a part of space 'moves' in the sense in which Descartes says that bodies strictly and properly 'move', which implies that

(i) when a part of space moves, it is translated from the neighbourhood of the parts of space that immediately surround it into the neighbourhood of some other parts of space.

Or we could say that

(ii) when a part of space moves, it is translated from one place to another.

·But a place *is* a part of space, so· **(ii)** implies that the moving part of space is translated out of itself; unless we postulate that there are two ·complete· spaces that everywhere coincide, a moving one S_m and one that is at rest S_r , so that the movement of a part of S_m involves a translation of that item from the corresponding part of S_r to a different part of S_r . ·That is crazy·. And I have already sufficiently shown the absurdity of **(i)**. The best way to understand the immobility of space is by comparing space in a certain way with time. The parts of time—e.g. individual days—get their individuality from their order: if yesterday could switch places with today, it would stop being yesterday and would become today. Similarly, the parts of space get their individuality from their positions, so that if any two of them x and y could switch positions they would stop being the regions they are— x would become y , and y would become x , which is to say that there wouldn't have been a switch after all! Our notion of what individual part of space (or time) we are thinking about comes from how it relates to the rest of space (or time); there is no way of identifying it except through its spatial (or temporal) location. That's why nothing could count as changing the location of any part of space or time.

4. . . . No being exists—no being *can* exist—without being related to space in some way. God is everywhere, a created mind is somewhere, a body is in the space that it fills [see start of section 2]; and anything that isn't ·everywhere and isn't ·somewhere in particular doesn't exist. It follows from this that space is something that necessarily comes with the basic fact that *there are beings*: supposing that something exists involves supposing that there is space. And the same holds for time; for both ·spatiality and temporality· are. . . attributes in terms of which we say quantitative things

about the presence and duration of any individual thing. Thus,

the temporal quantity of God's existence is: *eternal*;
the spatial quantity of God's existence is: *infinite*.

And as regards the quantity of a created thing ·such as your body·: its temporal quantity is the stretch of time from its creation to its dissolution; its spatial quantity is that of the space that it takes up.

In case you are thinking that on this account God is, as bodies are, extended and divisible into parts, I should tell you that ·spaces themselves aren't actually divisible, ·so that God's being everywhere in space doesn't automatically make him divisible·. And anyway, ·any existing thing has its own particular way of being in space. For example, a body's relation to space is very different from a time's relation to space: we don't ascribe to the different parts of space different times; we say that they all exist together. This very moment ·when I write this· is the same in Rome and in London, on the earth and on the stars, and throughout all the heavens, because that's the way times relate to space. And just as we have the thought of ·a minute of time as diffused throughout all spaces without having any thought of ·the minute's parts, so also we can without contradiction think of ·a mind as diffused through space—relating to space in the special way that minds *do*—without having any thought of ·the mind's parts.

5. The positions, distances and movements of bodies are all to be understood in terms of the parts of space. You'll see this more clearly if you ·attend to items **1.** and **4.** in the list I am giving of the properties of space; and more so still if you ·have the thought that there are little bits of empty space scattered between the particles, or if you ·attend to what I have already said about motion. I would also add this: Space itself contains no force of any kind that could in

any way hinder or help any change in the motions of bodies. That's why projectiles travel in straight lines at a uniform speed unless they meet with an impediment from some other source. But more of this later [late in section 14].

6. Space is eternal in its duration, and unchangeable in its nature, because it is an effect of—because it *emanates from*—an eternal and immutable being. If there had ever been a time when space didn't exist, then at that time God wouldn't have been anywhere. To get from that state of affairs to one in which space exists, God would have to have created space; and that would involve one or other of these:

- He created space without being *in* it, which implies that he *acted* where he *wasn't*.
- He created space along with creating his ubiquity, *his own everywhere*.

These two versions of the theory that 'Starting with a state of affairs in which there was no space, God created space' are equally contrary to reason. However able we are to imagine there being nothing in space, we can't have the thought of space as not existing (just as we can't have the thought of there being no time, though we may be able to tell a consistent story about there being nothing that lasts through time [and no events that occur in time?]). Imagining space with nothing in it? Clearly we can do that, because we imagine the world to be finite, which forces us to suppose that there are spatial regions beyond the world—although they *aren't* revealed to us by God, or *detected* through our senses, or dependent on *and therefore inferrable from* the existence of the spaces within the world. It's commonly believed that these spaces are nothing. Wrong! They are true *spaces*. If a region of space is empty of body, that doesn't mean that it is in itself an emptiness. There's *something* there—a region of space is there, though that's all. As between space that does have some world in it and space that doesn't, there

is no difference in how real they are, or how true it is that each *is* a space. If you think otherwise, you must hold that when God created the world in this space he at the same time created space in itself, or that if God were to annihilate the world in this space he would also annihilate the space in it. When there is more reality in one *part of* space than in another, that must be because there is more body in one than in the other. It's easier to grasp this if we get rid of the childish prejudice that extension is inherent in bodies—is something that bodies *have*—like a property-instance that can exist only because some subject *has* it.

11. Launching a metaphysic of body

Having described *extension*, I now have to give an account of the nature of *body*. I'll have to be more cautious about this, though, because *body*—*unlike space*—doesn't exist necessarily; it exists because God chose that it should exist, and it's really not for *us* to know the limits of God's power, i.e. to choose between:

- There is only one way in which matter could be created, and
- There are several ways in which *bodies*, or anyway *things similar to bodies*, could be produced.

It hardly seems credible that God could create beings that

- were similar to bodies—so similar that they behaved and interacted in exactly the way that bodies do—and yet *weren't* actually bodies because they didn't have the essential metaphysical constitution of bodies.

But I don't say outright that he couldn't, because I don't have any clear and distinct perception of this matter *of the essential nature of body*. I'll steer clear of saying positively what the nature of bodies is by describing a certain kind of

thing that is similar in every way to bodies, so that we can hardly say that it *isn't* body; the point of this being that the stuff in question is undeniably something that God *could* create, as I shall show.

You are conscious that you can move your body at will, as I can mine; and we both think that all men enjoy the same power of moving their bodies in this way by thought alone. So we can't deny that God also has this power to •move bodies by thought, given that his faculty of thought is infinitely greater and faster than ours. And by parity of argument we have to agree that God can, purely by thinking and willing, •prevent a body from entering this or that region of space. [The next paragraph amplifies Newton's words in ways that •small dots• can't easily signify. Because this is the most important thing in this essay, a conservative translation of it is appended at the end.]

Let R be a particular region of space, roughly the size and shape of a typical mountain, and placed on the surface of the earth like a mountain. Now, suppose that God has exercised the power of his we have been talking about, by making R impenetrable by bodies, including light. Isn't it inevitable that we'll think that R is a mountain? Because it's impenetrable, you can slap R with your hand and your hand will be stopped at its surface; so it is tangible. It's visible, opaque and coloured, because of how it reflects light. It resonates when struck (•e.g. with an ice-pick•), because the adjacent air is disturbed by the blow. So the evidence of our senses indicates that what we have before us here is •not merely a peculiar region of space but• a mountain; and in questions like this our senses are all we have to go by.

Now let's try this different story: There are empty spaces scattered through the world, and one of them—defined by where its limits are—is caused by God to be impenetrable to bodies, so that •bodies that impinge on it are stopped or bounced back, and •it has all the properties of a corporeal

particle, except for being motionless. Now take that story a step further: There is always one part of space that is impenetrable; it's not always the same one, though it always has the same size and shape; and there are *laws* that govern how this impenetrability is passed from region to region—especially a law ensuring that the impenetrability moves *continuously* from region to region, not skipping some of the intervening regions. Now we have something possessing all the properties of a movable body. It would have shape, be tangible and mobile, and be capable of reflecting and being reflected, and would constitute a part of the structure of things just as much as any other corpuscle does. [Regarding what is to come: Newton doesn't have any such expression as 'perhaps-particle', but the phrase is handy for expressing a concept that certainly is at work here.] And I can see no reason why the perhaps-particle I have been describing couldn't enter into causal inter-relations with our minds, just as other particles do. The perhaps-particle is just an effect that God has on certain regions of space; God can certainly •stimulate our perception by his own will; so of course he can if he wishes •confer on one of his effects a power to stimulate our perceptions.

Keeping to this story but enlarging it: If many regions of this kind were impenetrable by bodies and by each other, and if they all conformed to the laws I have spoken of, they would go through courses of events just like those of corpuscles, exhibiting all the same phenomena. And now for the final enlargement: if our entire world consisted of beings of this kind, it would hardly seem different from how it does seem in fact. So these perhaps-particles—these sequences of impenetrable regions of space—either •are bodies or •resemble bodies. If they •are bodies, then we can define *bodies as determinate quantities of space that omnipresent God has caused to satisfy certain conditions*. There are three

of these conditions. **(1)** The perhaps-particles are mobile. (That's why I spoke not of •regions or parts of space, but of •'quantities' of space; because regions can't move, whereas definite quantities may be transferred from one place to another.) **(2)** No two of them can coincide anywhere. (That makes them impenetrable by one another, so that when two of them collide they stop and are bounced back in accordance with certain laws.) **(3)** They can cause various perceptions of the senses and the imagination in created minds, and they can be moved by created minds. . . .

[For discussion see www.earlymoderntexts.com/jfb/howmat.pdf.]

12. Clarifications

Here are some points—five of them—that may help to clarify the ideas I have been presenting.

1. We can suppose that these things—these perhaps-particles—exist without having to suppose some unintelligible 'substance' in which various properties 'inhere'. Their existence requires just two things: •extension and •an act of God's will. God's will brings it about that *extension*—a quantity of space—has the properties of bodies, so extension is playing the part of the •unintelligible •'substantial subject'. . . .

[We are about to see that Newton doesn't mind calling things 'substances' or using the notion of 'a substance'. He has been expressing his dislike of the concept of *substance*, understood as a supposed ingredient in the concepts of *pebble*, *planet*, *dog*, *diamond* and so on, all these being *substances*.]

2. These beings won't be less real than bodies, or less entitled to be called 'substances'. When we regard bodies as real, we do so purely on the basis of their phenomena and sensible qualities. So the perhaps-particles, whose phenomena and sensible qualities are exactly the same, will

be equally entitled to be regarded as real. And they will be just as much substances as actual bodies are: they won't be qualities or properties or accidents that exist only because they are *in* substances or because substances *have them*; they will themselves have accidents or properties, and the only thing they will depend on for their existence is God.

3. The relation between •extension and •its impressed form—i.e. the impenetrability etc. that God confers on certain quantities of extension—is almost exactly the same as the relation that the Aristotelians say there is between the •*materia prima* and substantial forms. [According to the Aristotelian view that Newton is talking about here, *materia prima* or 'most basic matter' is the whatever-it-is that *has* the qualities—the 'form'—of a thing. It isn't ordinary matter which is heavy, impenetrable and so on; a pebble, for example, consists of some *materia prima* **and** various qualities of shape, weight, and so on. You may recognize the concept of *materia prima* as pretty much like the 'idea of substance in general' that gave Locke so much trouble.] The Aristotelians say that the same •most basic matter can have any form, and that it's the form of some matter that makes it count as an individual body. Well, what I am supposing here is that

what Newton wrote next: *quamvis formam per quaelibet spatia transferri posse, et idem corpus ubique denominare.*

conservatively translated: any form may be transferred through any space, and everywhere denote the same body.

what he was getting at: a given individual 'form'—consisting of an instance of impenetrability etc.—can move from region to region, and while it is passing through (or resting in) a region, it makes that region constitute a body, and for a given individual form it is always the same body.

4. [This short paragraph is extremely condensed. Here's the content of its first half, made easier to grasp by the inclusion of some things that Newton certainly had in mind but didn't get explicitly onto paper: A crucial difference

between my proposal and the Aristotelian theory concerns the status of (my) extension and (his) *materia prima*. The trouble with *materia prima* is that it is officially indescribable: any description we might give of it would automatically go on the ‘form’ side of the matter/form line. In contrast with that, regions of extension are very describable: ‘What is it?’, ‘What’s it like?’, ‘How big is it?’—we have answers to these. Because of that difference, •extension has more reality than does *materia prima*. Also, •my proposal is intelligible in a way that Aristotle’s isn’t, because the only attributing-of-a-form-to-something that I invoke is exactly the same as our familiar everyday attribution of a form or properties to a *body*. Then:] If there is any difficulty in making my proposal intelligible, it doesn’t concern •the form that God imparts to space, but •how he imparts it. That’s a question about how God moves bodies (or stops them from moving), because what he does to make a region impenetrable, and thus to acquire form of body, is to •expel all the bodies from that region and •prevent the expelled bodies or any others from getting back into it again. ·We don’t have any account of *how* God does this, but· that’s not an obstacle ·because we can be confident that there is an explanation of *how*·. The same question arises about how *we* move our bodies, yet we do believe that we *can* move them. If we understood how we do that, we could re-apply that understanding to the question of how *God* can move bodies in the way I have described.

5. [In the course of this next paragraph we’ll meet the term ‘eminently’. Newton’s use of it reflects a view, which he will outright endorse on the next page, that

if x causes y to be F, then x itself must have Fness either
•straightforwardly or •eminently

—meaning ‘either •straightforwardly or •in some higher form’. The friends of this view had reasons (never mind what) for holding that effects must get their properties from their causes, which must therefore *have* them; but they wanted God to cause something to be square (for example)

without himself being square, and so they said that God contains squareness not straightforwardly but in a higher form, ‘eminently’.] In my way of highlighting our power to move our own bodies, in my presentation of my proposal, I have been aiming at three results. (1) Any difficulties there may be in the proposal finally come down to just that question about how we move our own bodies. (2) We can have in our innermost consciousness a sense of God as having created the world solely by an act of will, just as we move our bodies solely by an act of will. (3) God’s faculties are more like ours than philosophers have so far realized. The Bible says that we were created in God’s image [here = ‘likeness’]. How brightly his image would shine in us if the similarity between his faculties and ours extended—with the same degree of similarity—to his power of creating! You may want to object: ‘Our *created* minds can’t have any power that parallels God’s power of creating *minds*.’ Well, suppose that you are right, and that no faculty of a created mind can contain a parallel to (or sketch of, or likeness of) God’s power of creating minds; ·that doesn’t imply that it hasn’t something like the power of creating bodies. And there is good reason to think it has·. Because it’s the image of God, a created ·human· mind is of a much nobler nature than body, so that it might contain corporeality *eminently*. Still, when we move ·our· bodies we don’t create anything; we *can’t* create anything; all we can do is to simulate the power of creation. We can’t make any space impervious to bodies! All we can do is to move bodies, and indeed *only* our own bodies, to which we are united not by our own will but by the divine constitution of things. And we can’t move our bodies in any way we choose, but only in accordance with the laws that God has imposed on us. If you like, say that what we have is the *finite and lowest* level of the power through which God is the creator; this doesn’t take anything away from his power, any

more than it lessens his intellect to say that we have that too, in a finite degree. . . . It may be thought that God could produce a thinking creature so perfect that *it* could—God willing—produce creatures lower down the perfection scale; and that wouldn't detract from God's power either. Indeed it adds greatly—I won't say infinitely—to God's power that he should be able to •make bodies by •making things that make bodies. So some people may suppose that God creates a soul for the world, and assigns to *it* the task of endowing definite spaces with the properties of bodies—preferring this to the thesis that God does this work himself, directly. If that is what happened we shouldn't say that the world is created by its soul; the credit would still be entirely due to God, who created the soul and gave it a nature such that the world necessarily emanates ·from it·. But I don't see any reason why God himself shouldn't have directly 'informed' space with bodies. . . .

13. Metaphysical benefits of this account of matter

The account I have been giving of the nature of body is *useful*—as witness the fact that it clearly involves, confirms and explains the chief truths of metaphysics. For we can't postulate bodies of the kind I have described without at the same time supposing that **(1)** God exists, that **(2)** he has created bodies in empty space out of nothing, and that **(3)** bodies are distinct from created minds but able to form a union with minds. I challenge you to name even one already well-known system that throws light on any one of these truths, rather than opposing and obscuring all of them. If we say with Descartes that extension is body, don't we clearly open the door to atheism? Why? Because •extension isn't **(2)** created, but has existed eternally; and

because •we have an absolute idea of it [= 'an idea of it considered just in itself, on its own, not bringing in any of its relational properties'] without any relationship to God, so that we could conceive of extension while imagining the **(1)** non-existence of God. And Descartes's philosophy doesn't make the distinction between mind and body intelligible. It risks implying that mind has no extension at all, and so it isn't substantially present in any extension, i.e. it doesn't exist *anywhere*, which •seems to amount to denying that minds exist, or at least to •making their union with bodies totally unintelligible, not to say impossible. Furthermore, if ·Descartes is right in saying that· thinking substances are perfectly, completely, top-to-bottom distinct from extended substances, then God doesn't eminently contain extension within himself; which implies that God can't create extension—God and extension will be two substances that are separately complete and absolute—'substances' in the very same sense. But if on the other hand extension *is* eminently contained in God, i.e. the highest thinking being, then the idea of extension *is* eminently contained within the idea of thinking; and in that case the distinction between these two ideas won't be so great as to rule out the possibility that they might both fit a single created substance, i.e. the possibility that a body might think, i.e. that a thinking thing might be extended. But if we adopt the vulgar [= 'ordinary plain person's'] notion of body (it's really the vulgar *non*-notion of body!), according to which each body contains a certain unintelligible reality that they call 'substance', in which all the body's qualities inhere, things don't get any better. [This notion of •substance in which •attributes inhere is very like the Aristotelian notion, mentioned on pages 14–15, of •*materia prima* that has been given a certain •form. A few lines further on we'll find Newton equating the two, by bracketing 'substantial forms' with 'attributes'.] This view. . . .has the same awkward consequences as the Cartesian view. Because we can't

understand bodily substance ·on this account of it·, we can't understand its distinctness from the substance of the mind. We can't secure their distinctness through the distinctness of the two sets of substantial forms or attributes, ·i.e. the distinctness of mentalistic properties from materialistic ones·. If bare substances don't have any essential difference between some and others (·and just because they are 'bare' they *can't*·), none of them can be more fit for mentalistic attributes than for materialistic ones, or vice versa; which means that a single substance might be both mind and body—if not both at once then turn about. As long as we have no idea of what it could be for bare substances—·deprived of attributes·—to be unlike one another, we can't claim to know that mind and body are different substances. And if they *are* different, we cannot discover any basis for their union. Furthermore, the philosophers who accept this 'bare substance' approach imply that the bare substance underlying a pebble (say) is just as real as the bare substance underlying God—i.e. God abstracted from his attributes. They don't *say* this, but it's how they *think*, because they conceive of these two substances, deprived of qualities and forms, in just the same way. Well, strictly speaking they don't *conceive* them; but they give them the same treatment in their confused ideas about an unintelligible reality. So it's not surprising that atheists come forward ascribing to corporeal substances attributes that are really God's alone. Indeed, when we look around for *reasons* for atheism, almost the only thing we find is this notion of bodies as having—as it were—a complete, absolute and independent reality of their own, ·existing without having to depend on anything else·. That, I think, is the view of bodies that most of us have uncritically retained from childhood, so that when we *say* that bodies are created and dependent we are just producing words. [The next sentence goes a bit beyond Newton's words, in ways that ·dots· can't

easily indicate, but it's in the spirit of what he wrote.] I also think that this holdover from childhood explains ·why the scholastics apply the word 'substance' in the same sense to ·God and to ·things created by him; and also ·why philosophers get into such a mess—staggering around in a hallucinatory dazzle—when they try to capture ·things that depend on God through ·an idea that doesn't depend on the idea of God. It can't be done. Anything that can't exist independently of God can't be truly understood independently of the idea of God. God supports his creatures just as much as they support their qualities. [In that sentence, 'support(s)' translates *substa(n)t*, which was a standard word for the 'standing-under' that substances were supposed to provide for qualities. Without saying outright that the things God creates are really qualities that he has, Newton is at least *likening* that relation to the one between substances and their qualities.] So ·created substances are intermediate between ·God and ·qualities—intermediate in how real they are and in how dependent they are. So the idea of (say) a pebble involves the concept of God just as much as the idea of the pebble's smoothness involves the concept of the pebble. So the pebble—or any body—should be credited only with having a derivative and incomplete reality. So we must lay aside the old prejudice about bare substances and their qualities, and instead ascribe substantial reality to

- these kinds of attributes that are real in themselves, and intelligible in themselves, and don't need to be inherent in a subject,

rather than to

- a subject—a 'bare substance'—which we can't conceive as dependent, let alone form any idea of it.

And we can do this quite easily if we ·have the idea of body that I have presented and also ·remember that we can conceive of space existing without any subject (·i.e. without any substantial *thing* that has extension as a quality·); this

being something we do whenever we think of a vacuum. So space is capable of having some substantial reality. Indeed, if its parts could move around (Descartes's story about them!), and this mobility was an ingredient in the idea of vacuum, then there would be no question about it—parts of space would be corporeal substance. In the same way, if we had an idea of the attribute or power by which God creates things purely through the action of his will, we would conceive of that attribute as subsisting by itself without any substantial subject. . . . But we can't form an idea of this attribute, or even of *our own* power to move our bodies, so it would be rash to say anything about what the substantial basis of mind might be.

So much for the nature of bodies. In setting that out, I think I have shown well enough that •a creation of the sort I have expounded would most clearly be God's work, and that •our actual world could have come from that creation or at least from one very like it. And my account throws a satisfactory light on the difference between body and extension—i.e. between a body and a region of space. The raw materials of each are the same in their properties and nature, and differ only in how God created them. [That seemingly strange remark is to be unpacked into: •God created bodies in the manner described in sections 11–12, and •God created extension *not at all*.] •And that difference is huge: extension is eternal, infinite, uncreated, uniform throughout, in no way mobile, unable to affect how bodies move or how minds think; whereas body is opposite in every respect. (That body is mobile depends on God's not having created it always and everywhere; •because if there had never been any empty space, there would never have been room for bodies to move in. I wouldn't venture to say that God *couldn't* have done that, •i.e. couldn't have brought it about from all eternity that space was full. . . .)

14. Against Descartes's argument against the existence of vacuum

[The argument of the next paragraph is complex and, in Newton's compact presentation of it, horribly difficult to follow. The present version goes beyond his wording (in ways that the •dots• convention can't easily signify) but it doesn't add anything to what is obviously Newton's line of thought in the paragraph. A conservative translation of the paragraph is given at the end.] As well as making those points, I want to come to grips with Descartes's *argument* for the thesis that extension is the whole essence of body, i.e. that anything extended is a body. The argument starts by asking us to do this:

Take any body chosen at random, and abstract from it—i.e. set aside in your thought—its •weight, hardness and all sensible qualities such as colour and taste etc., retaining only •what belongs to its essence.

Descartes holds that this process of abstracting or setting-aside all the non-essentials will leave nothing but *extension*, but that's wrong. To get down to the level where only extension remains, we would have to set aside also the faculty or power by which bodies stimulate the perceptions of thinking beings. Call this power 'P' for short. There are two things that I want to say about it:

(1) P is not essential to extension. Thought and extension are so different from one another that there couldn't be any basis for a necessary connection between them; the only connection there can be is one that God has set up. That amounts to saying that a given part of extension E that has P could lose it through natural causes; so P is accidental to E, not part of its essence.

(2) P is essential to bodies. Nothing could count as a body that didn't have (P) the power to cause perceptual states in minds.

Put those two together and you get the result that extension is not the whole essence of body, because (2) P is also part of body's essence, and (1) P is genuinely additional to extension, and not something that automatically and necessarily comes along with extension.—You might want to object:

Bodies can't directly arouse perceptions in minds unless they are *united to* minds; some bodies are not united to minds, and thus don't have (P) the power to cause perceptual states in minds; which means that P is not of the essence of body.

But that's wrong. What I have been talking about is (P) the *power or ability* that bodies have to affect minds; so if you are right that the actual affecting of minds by bodies requires actual union between them, then my topic has been not •actual union of bodies with minds but a body's •ability to come into union with a mind through the forces of nature. And there's good reason to say that all bodies have *that*. The parts of the brain, especially the more subtle ones to which the mind is united, are in a continual flux, with matter constantly flowing in to replace matter that flies away; and this happens without creating any interruption in the person's mental life, such as there would be if some bodies were incapable of entering into a mind-body union; so it's clear that (P) the power to affect minds is something that all bodies have. As for the question of whether it really is of the essence of *body*, I say that whether you look at this from the angle of God's action or of the nature of bodies, removing (P) the power to affect minds is nothing less than [*non minoris est*] removing the other power that bodies have, namely the power to affect one another, communicating motion through

collisions; and removing *that* would obviously be turning body into empty space.

Or so I say, but *would* it? You might think that it doesn't, and that bodies' resistance to other bodies is not essential to them, on the grounds that it is so variable:

- liquid mercury resists the movement of solid bodies more strongly than does
- water, which resists such movement more strongly than does
- air, which resists such movement more strongly than does
- ether.

But I say that if we set aside *altogether* x's force of resistance to the passage of bodies, we'll be no longer thinking about x as a *body*. If subtle matter put up *no* resistance to the motion of globules, I wouldn't think of it as subtle *matter* any more, but rather as a scattered *vacuum*. If there were any aerial or etherial space that allowed comets or other projectiles to go through without *any* resistance, I would regard that as a region of space that was utterly empty. For it's impossible for there to be a corporeal fluid that doesn't impede *at all* the motion of bodies passing through it. [Newton wrote in the margin at this point a reference to something he wrote to Mersenne. The passage says that a body might pass through a fluid medium without *any* resistance if at each moment the fluid medium moved out of the way of •the moving body, doing this at exactly •its speed.]

Clearly, a region of space can be deprived of this body-impeding power only if space is different from body, that being what's needed for there to be space with no body in it. So you shouldn't affirm (1) that space can't exist without body in it, unless you have *first* proved (2) they that space and body are one and the same thing. If you do affirm (1) without having proved (2), you risk arguing in a circle.

If you still aren't quite convinced, notice that from things I said earlier in this paper it follows that there's empirical evidence that there are empty spaces in the natural world. Contrast two possible states of affairs:

(1) Ether is a corporeal fluid with no pockets of vacuum in it. In that case, it's as dense as any other fluid, and just as sluggishly resistant to allowing bodies to move through it.

'What if the ether is enormously finely divided?' That makes no difference. 'What if the intruding body is porous?' That would *increase* the ether's resistance to its movement, because there would be resistance not only at the projectile's outer surface but also at the surfaces of all its internal pores.

(2) The actual state of affairs. In actual fact, ether makes very little resistance to projectiles' passing through it—so little that the resistance put up by liquid mercury is *much* greater—ten times as great or maybe a hundred thousand times as great!

That's a good reason for us to think that by far the largest part of the etherial space is empty, consisting of pockets of vacuum scattered among the etherial particles. We can also conjecture that there are vacua on the basis of the various weights of these fluids: the rates at which heavy bodies fall, like the lengths of oscillations of pendulums, are in proportion to their densities, i.e. in proportion to *how much matter* each contains, with the rest of its volume being taken up by vacuum. But this isn't the place to go into all that.

So you see how fallacious and unsound this Cartesian argument is—I mean the one that I reported at the start of this section. Here is a quick repeat of my main objection to it. Descartes was wrong in thinking that when we set aside all the accidents of a body, all that remains is extension; something else remains, namely the faculties or powers

by which the body can stimulate perceptions in the mind and move other bodies. If we set those aside too, and also set aside all power of moving, then what is left will be a conception of uniform space—just that and nothing more. Does *that* provide Descartes with all he needs to fabricate vortices, and a world? No indeed, unless he first invokes God, who alone can create bodies in those spaces (which he would do by restoring those powers—that corporeal nature—that I explained in section 11). So I was right to maintain that those powers to move bodies and to affect minds are the nature of *body*.

Winding all this up: Spaces aren't themselves bodies; they are only the places in which bodies exist and move; and I think that puts my account of motion on a firm footing. I don't see what more anyone could ask for on this topic. . . .

15. After the 'digression'

I have already digressed enough; let us return to the main theme, picking up where I left off at the end of section 1.

Definition 5. Force is the causal principle of motion and rest. . . . [and so on, for about five very technical pages on hydrostatics].

Two crucial paragraphs revisited

Excerpt from section 11, conservatively translated: If he should exercise this power, and cause some space projecting above the Earth, like a mountain or any other body, to be impervious to bodies and thus stop or reflect light and all impinging things, it seems impossible that we should not consider this space to be truly body from the evidence of our senses (which constitute our sole judges in this matter);

for it will be tangible on account of its impenetrability, and visible, opaque and coloured on account of the reflection of light, and it will resonate when struck because the adjacent air will be moved by the blow. (From *Unpublished Scientific Papers of Isaac Newton* (Cambridge University Press, 1962), translated and edited by A. R. Hall and Marie Boas Hall.)

Excerpt from section 14, done by the same translators: As for the rest of the Cartesian argument I now respond more strictly: we take from body (just as he bids) gravity, duration, and all sensible qualities, so that nothing finally would remain except what belongs to its essence. Will, accordingly, extension only remain? Not at all. For we reject additionally that capacity or power by which the perceptions of thinking things move. For when the distinction is only between the ideas of thinking and extension so that something would not be manifest to be the foundation of the connection or relation unless that be caused by divine power; the capacities of bodies can be rejected with this reserved extension, but it would not be rejected with the reserved bodily nature. Obviously, the changes which can be induced in bodies by natural causes are only accidental

and not denoting the substance actually to be changed. But if anything could induce the change which transcends natural causes, it is more than accidentally and has radically attained the substance. According to the sense of the demonstration those only are being rejected of which body, by force of nature, can be void and deprived. But no one would object that bodies which are not united to minds cannot immediately move their perceptions. And hence when bodies are given united to minds by nothing, it will follow (that) this power is not among their essentials. The observation is that this does not act by actual union but only by the capacity of bodies by which they are capable of this union by force of nature. As by whatever capacity belongs to all bodies, it is manifest from it that the parts of the brain, especially the more subtle by which the mind is united, are in continual flux, the new ones succeeding to those flying off. And it is not lesser to take (off) this, whether regarding the divine achievement or bodily nature, than to take (off) the other capacity by which bodies in themselves are able alternately to transfer mutual actions, that is, than to force body back into empty space.