3. The surrounding medium can make it possible for a body to be put into motion with very little force
    a. For a small B∗v can augment the large sum B∗v of all the fluid particles impacting an object on one side, thereby overcoming its force to remain at rest (for total bulk of impacting particles will exceed its bulk, bringing Rule 5 into play)
    b. {Descartes will not be the last person who struggles with understanding fluid resistance; the mechanism remained a problem in physics until around 1900!
    c. Descartes himself says that a science of resistance is impossible -- see letter to Mersenne, 13 Nov 1629

        As for the cause of the air resistance, ..., in my view it is impossible to answer this question since it does not come under the heading of knowledge. For the air resistance varies, depending on whether it is hot or cold, dry or wet, clear or cloudy, and numerous other factors. Moreover the same can be said about all the questions you raise about air resistance: the degree of resistance varies depending on whether the weight is made of lead or iron or wood, on whether it is round or square or some other shape, and numerous other factors.}

4. Problem: how can one confirm the rules empirically, for motion of the fluid particles is not directly observable?
    a. I.e. the rules are empirically unfalsifiable
    b. Final sentence in the French text to Article 52:

        "The demonstrations of this are so certain that, even if experience were to appear to show us the opposite, we would nevertheless be obliged to place more trust in our reason than in our senses"

    c. In effect, a claim about no plausible alternative for conceptualizing change of motion under impact, and hence a challenge to others
5. The Rules are not entirely immune to empirical considerations, for they underlie the celestial vortex theory
    a. A possible source of empirical support: the success of the theory based on them to explain celestial phenomena
    b. But this not a defense against internal inconsistency (if this is a legitimate complaint), nor against the claim that there are still better ways of conceptualizing motion under impact
6. The important thing to realize is that what is at issue here is how we are to conceptualize the causal interaction of impacting bodies, and as is so typical of all issues about fundamental conceptualization, it is hard to bring empirical considerations directly to bear
    a. Empirical considerations presuppose a way of describing what is happening, and hence a conceptualization
    b. I.e., just as Kuhn says, empirical considerations are not conceptualization-neutral

D. Relativity of Motion: "Internal" Problems
1. Some have argued that Descartes' Rules are incoherent within his own philosophical system insofar as they violate the relativity of motion principle which he announces in Articles 24 and 25

a. Idea of relativity of motion -- e.g. as expressed by Galileo -- is that descriptions before and after should be equivalent to one another regardless of which is at rest and which is moving
b. Regardless of which object observer is on and whether observer can tell whether that object is in motion

2. Descartes' Rules 4, 5, and 6 violate this principle
   a. If sitting on larger body, taken to be at rest, then get a different result for relative motion after than sitting on smaller body, taken to be at rest
   b. Equally so if sitting on a third body which has the same overall motion as one of the other two
3. This line of "internal" criticism of the Cartesian system carried some weight in subsequent years, but it really does seem to be missing Descartes' point
   a. He is perfectly prepared to concede that not all motion is relative from a metaphysical stand-point, for forces of resistance distinguish between bodies at rest and bodies in motion
   b. Motion considered geometrically is only relative; forces are not geometric, but metaphysical
4. As various commentators have pointed out (Gueroult and Gabbey among others), there are two "levels" in Part II, with the first half devoted to a geometric characterization and the second half to a deeper metaphysical one
   a. Forces ultimately determine true, absolute situation, so that can distinguish between bodies at absolute rest and bodies in absolute motion on Descartes' view
   b. Puts him into a position to reject the Tychonic system, as he had in *Le Monde*
   c. (And here anticipating Newton's argument, whether Newton recognized this or not)
5. Last Article of Part II not really a denial of this, for not claiming there that motion as conceived geometrically will suffice to account for all phenomena
6. Questions about relativity of motion, the principle of relativity, and what motions can be distinguished will continue to be of concern as we proceed
   a. Descartes may be subject to criticism here, but the criticism should not be one of flagrant inconsistency
   b. Rather it will have to take the form of claiming that there is (in some sense) a better way to conceptualize motion and its change

E. Descartes on "True" Motion
1. As just noted, early in Part II Descartes introduces a distinction between "motion in the ordinary sense" and "motion properly speaking" that seems to assert the relativity of motion
   a. Article 24: local motion "as commonly interpreted is nothing other than *the action by which some body travels from one place to another*"
   b. Article 25: "what should be understood by movement, according to the truth of the matter…, is *the transference of one part of matter or of one body, from the vicinity of those bodies immediately contiguous to it and considered as at rest, into the vicinity of others*"

2. Notice, however, that the latter asserts something stronger than just that true motion has to be referred to some other body "considered as at rest"
    a. Rather, true motion has to be referred to bodies "immediately contiguous" that are considered at rest and has to consist in no longer being immediately contiguous to those bodies
    b. By contrast, in *Le Monde* contains nothing like this, but only an insistence, contra Aristotle, on limiting talk of motion to cases of change of place:

        > The philosophers also suppose several motions that they think can be accomplished without any body's changing place, such as those they call *motus ad formam*, *motus ad calorem, motus ad quantitatem* ("motion with respect to form," "motion with respect to heat," "motion with respect to quantity"), and myriad others. As for me, I conceive of none except that which is easier to conceive of than the lines of mathematicians: the motion by which bodies pass from one place to another and successively occupy all the spaces in between [p. 63]

3. Descartes' new, restrictive notion of true motion shows up again, though seemingly only in passing, at the end of Part II, while discussing the transport of a body by a moving fluid stream
    a. The specific context involves explicating the difference between solid and fluid bodies initiated in Article 54
    b. Following which the principal concern seems to be the transfer of motion between fluids and bodies immersed in them (Articles 56-60) in relation to the Rules -- a topic not raised at all in Galileo's *Two New Sciences*
4. One upshot of this discussion is the seemingly innocuous conclusion reached in Article 61:
    a. *That when an entire fluid body moves simultaneously in some direction, it must necessarily carry along with it any solid body which is immersed in it* -- a conclusion that is asserted to be consistent with Rule 4
    b. An obvious reason for Descartes' including this is to prepare the way for his vortex theory of planetary motion in Part III
5. The very next Article makes an assertion that is not innocuous at all, but on its surface rather extraordinary: *That a solid body, which is carried along by a fluid, is not therefore moving*

    > If, moreover, we turn our attention to the true and absolute nature of movement; which consists in the transfer of a moving body from the vicinity of other bodies contiguous to it, and which is equal in both the body which is said to move and the contiguous body away from which [it is said that] it moves, although it is not customary to speak of the two in the same way {and to say that both move}; we will clearly know that a solid body which is thus carried along by the fluid in which it is contained does not, strictly speaking, move as much as it would if it were not carried along by this fluid; for it certainly moves away less from the neighboring particles of this fluid {when it follows its current than when it resists it}.

    a. This conclusion represents something much stronger than just the need to refer all motion to some body considered at rest
    b. For it says that a body carried by a fluid is strictly speaking not moving at all no matter how much it and the fluid surrounding it are moving relative to other bodies considered at rest

6. We shall be returning to this conclusion next week and again when we turn to Newton, who took strong exception to it, in the process initiating his famous discussions of absolute space, time, and motion

Select Sources

Descartes, René, *Le Monde ou Le Traité de la lumière* (1664) facing pages tr. Michael Sean Mahoney, Abaris Books, 1979.

--------, *Traité de l'homme* (1664), French text with Translation and Commentary by Thomas Steele Hall, Harvard University Press, 1972.

--------, *Discourse on Method, Optics, Geometry, and Meteorology*, tr. Paul J. Olscamp, revised ed., Hackett Publishing, 2001.

--------, *La Géometrie*, facing pages tr. David Eugene Smith and Marcia L. Latham, Open Court, 1952.

--------, *Geometria*, Latin tr. with commentary by F. van Schooten, 2nd ed., Amsterdam, 1659.

--------, *Principles of Philosophy*, tr. Valentine Rodger Millar and Reese P. Miller, Reidel, 1983/84.

--------, *Principia Philosophiae*, Elzevier (1644, 1650, 1656, 1664, 1672, 1677); vol. X in *Oeuvres de Descartes*, ed. Charles Adams and Paul Tannery, 2nd ed, Paris, 1974-1986.

--------, *The Search for Truth*, in *The Philosophical Writings of Descartes*, Col. II, tr. John Cottingham, Robert Stoothoff, and Dugald Murdoch, Vol. II, Cambridge University Press, 1984, pp. 399-420.

--------, *The Correspondence*, in *The Philosophical Writings of Descartes* , Vol. III, tr. Cottingham, Robert Stoothoff, Dugald Murdoch, and Anthony Kenny, Cambridge University Press, 1991.

--------, *Epistolae*, Latin tr. Johannes de Raei, 2 vols., Elzevir, 1668.

Spinoza, Baruch, *Principles of the Philosophy of René Descartes* (1663), in *Earlier Philosophical Writings*, tr. Frank A. Hayes, Bobbs-Merrill, 1963, pp. 13-103.

Gaukroger, Stephen, *Descartes: An Intellectual Biography*, Clarendon Press, 1995.

--------, "The Autonomy of Natural Philosophy: From Truth to Impartiality," in *The Science of Nature in the Seventeenth Century*, ed. Peter R. Antsey and John A. Schuster, Springer, 2005, pp. 131-163.

--------, "The foundational role of hydrostatics and statics in Descartes' natural philosophy," in *Descartes' Natural Philosophy*, ed. Stephen Gaukroger, John Schuster, and John Sutton, Routledge, 2000, pp. 60-80.

Garber, Daniel, *Descartes' Metaphysical Physics*, University of Chicago Press, 1992.

--------, "Descartes' Physics," in *The Cambridge Companion to Descartes*, ed. John Cottingham, Cambridge University Press, 1992, pp. 286-334.

--------, "Descartes and Experiment in the *Discourse* and *Essays*," in *Essays on the Philosophy and Science of René Descartes*, ed. Stephen Voss, Oxford University Press, 1993, pp. 288-310.

--------, "A different Descartes: Descartes and the programme for a mathematical physics in his correspondence," in *Descartes' Natural Philosophy*, ed. Stephen Gaukroger, John Schuster, and John Sutton, Routledge, 2000, pp. 113-130.

Gabbey, Alan, "Force and Inertia in seventeenth century dynamics," *Studies in History and Philosophy of Science*, vol. 2, 1971, pp. 1-67.

--------, "Force and Inertia in the Seventeenth Century: Descartes and Newton," in *Descartes: Philosophy, Mathematics, and Physics*, ed. Stephen Gaukroger, The Harvester Press, 1980, pp. 230-320.

--------, "Descartes's Physics and Descartes's Mechanics: Chicken and Egg?," in *Essays on the Philosophy and Science of René Descartes*, ed. Stephen Voss, Oxford University Press, 1993, pp. 311-323.

Gueroult, Martial, "The Metaphysics and Physics of Force in Descartes" in *Descartes: Philosophy, Mathematics, and Physics*, ed. Stephen Gaukroger, The Harvester Press, 1980, pp. 196-229.

Clarke, D. M., *Occult Powers and Hypotheses*, Oxford University Press, 1989.

--------, "Causal powers and occasionalism from Descartes to Malebranche," in *Descartes' Natural Philosophy*, ed. Stephen Gaukroger, John Schuster, and John Sutton, Routledge, 2000, pp. 131-148.

Schuster, John A., "'Waterworld': Descartes' Vortical Celestial Mechanics – A Gambit in the Natural Philosophical Contest of the Early Seventeenth Century," in *The Science of Nature in the Seventeenth Century*, ed. Peter R. Antsey and John A. Schuster, Springer, 2005, pp. 35-79.

--------, "Descartes' *opticien*: the construction of the law of refraction and the manufacture of its physical rationales, 1618-1629," in *Descartes' Natural Philosophy*, ed. Stephen Gaukroger, John Schuster, and John Sutton, Routledge, 2000, pp. 258-312.

Bos, Henk J. M., *Redefining Geometrical Exactness: Descartes' Transformation of the Early Modern Concept of Construction*, Springer, 2001.

Dear, Peter, "Circular Argument: Descartes' Vortices and their Crafting as an Explanation of Gravity," in *The Science of Nature in the Seventeenth Century*, ed. Peter R. Antsey and John A. Schuster, Springer, 2005, pp. 81-97.

--------, *Mersenne and the Learning of the Schools*, Cornell University Press, 1988.

Hattab, Helen, "From Mechanics to Mechanism: The *Quaestiones Mechanicae* and Descartes' Physics," in *The Science of Nature in the Seventeenth Century*, ed. Peter R. Antsey and John A. Schuster, Springer, 2005, pp. 99-129.

McLaughlin, Peter, "Force, Determination, and Impact," in *Descartes' Natural Philosophy*, ed. Stephen Gaukroger, John Schuster, and John Sutton, Routledge, 2000, pp. 81-112.

Ranea, Alberto Guillermo, "A 'science for *honnêtes hommes'*: *La Recherche de la Vérité* and the deconstruction of experimental knowledge," in *Descartes' Natural Philosophy*, ed. Stephen Gaukroger, John Schuster, and John Sutton, Routledge, 2000, pp. 313-329.

McClaughlin, Trevor, "Descartes, experiments, and a first generation Cartesian, Jacques Rohault," in *Descartes' Natural Philosophy*, ed. Stephen Gaukroger, John Schuster, and John Sutton, Routledge, 2000, pp. 330-346.

Gassendi, Pierre, *De motu impresso a motore translato, epistolae duae*, Paris, 1642, (available on-line through ECHO).

Charlton, Walter, *Physiologia Epicuro-Gassendo-Charletoniana: or, A fabrick of science natural, upon the hypothesis of atoms, founded by Epicurus, repaired by Gassundus, augmented by Walter Charleton, Dr. in medicine, and physician to the late Charles, Monarch of Great Britain*, London, 1654.

Lolordo, Antonia, *Pierre Gassendi and the Birth of Early Modern Philosophy*, Cambridge University Press, 2007.

Osler, Margaret J. (ed.), *Atoms*, Pneuma, *and Tranquility: Epicurean and Stoic Themes in European Thought*, Cambridge University Press, 1991.

Dugas, René, *Mechanics in the Seventeenth Century Century (from the Scholastic Antecedents to Classical Thought)*, tr. Freda Jacquot, Central Book Company, 1958.

Damerov, V., Freudenthal, G., McLaughlin, P., and Renn, J., *Exploring the Limits of Preclassical Mechanics: A Study of Conceptual Developments in Early Modern Science: Free Fall and Compounded Motion in the Work of Descartes, Galileo, and Beeckman*, Springer-Verlag, 1992.

Franklin, Allan, *The Principle of Inertia in the Middle Ages*, Colorado Associated University Press, 1976.

Pav, Peter Anton, "Gassendi's Statement of the Principle of Inertia," *Isis*, vol. 57, 1966, pp. 24-34.

Aiton, Eric, *The Vortex Theory of Planetary Motions*, Elsevier, 1972.

Westfall, Richard S., *The Construction of Modern Science*, Cambridge University Press, 1977.

Middleton, W. E. Knowles, *The History of the Barometer*, Johns Hopkins Press, 1964.

Blair, Ann, *The Theater of Nature: Jean Bodin and Renaissance Science*, Princeton University Press, 1997.

Zilsel, Edgar, "The Genesis of the Concept of Physical Law," *The Philosophical Review*, vol. 51, 1942, pp. 245-279.

Credits for Appendix

Slides 4-6: Gaukroger (1995)

Slides 7-9, 21: Descartes (2001)

Slides 10, 11: Descartes (1952)

Slides 12, 14-17: Descartes (1974-1986)

Slide 19: Westfall (1977)

Slides 22-24, 26, 29, 35, 38, 39, 41: Descartes (1983/84)

Slides 27, 28, 34: Descartes (1983/84, 1979)

Slides 25, 37: Spinoza (1963)

Slide 30: Franklin (1976)

Slide 31: Charleton (1654)

Slide 32: Dugas (1958)

Slide 36: Aiton (1972)

Slide 40: Descartes (1979)