

- (2) Descartes here speaks of "the resistance to receiving twenty degrees of speed"
- b. Rule 5: if smaller at rest, then it loses the contest, with the minimum amount of speed transferred to it as needed to end the contest
 - c. Rule 6: if same size, then a compromise between the preceding two rules: "the two effects must be equally shared"
3. Finally, Rule 7 generalizes Rules 4, 5, and 6 to the case of objects moving in the same direction, but at different speeds
 - a. Contest again, but this time between B_1*v_1 and B_2*v_2 ; the object with the greater motion wins, where v designates (scalar) speed, not (vectorial) velocity
 - b. When impacting body smaller, it recoils, with no change in speed of impacted
 4. In a subsequent letter to Clerselier, Descartes enunciates a principle underlying these rules (see Appendix)
 - a. A principle of least modal mutation, which together with that of conservation of total motion yields a unique solution
 - b. Spinoza states this principle outrightly (Proposition xxiii)
 - c. Trouble is that Rule 6 does not conform to this, but instead to a principle of the mean
 5. Thus, whether Descartes himself had clear principles underlying the rules is a matter of some controversy, and we can say with some confidence that if he did, they do not appear in print
 - a. (Gabbey develops this point at length: pp. 247- 272)
 - b. However important it is to understanding Descartes, its main importance historically is that it invites others to reconceptualize the problem here, since they have trouble understanding Descartes' conceptualization
 - c. Spinoza's account instructive, for intended to be sympathetic to Descartes (Props. xxiv- xxxvii, as in Appendix)
- C. Empirical Problems: Descartes' Defense
1. As Descartes openly acknowledges, "experience often seems to contradict the rules" (53)

"However, because there cannot be any bodies in the world which are thus separated from all others, and because we seldom encounter bodies which are perfectly solid; it is very difficult to perform the calculation to determine to what extent the movement of each body may be changed by collision with others. Since, {before we can judge whether these rules are observed here or not,} we must simultaneously calculate the effects of all those bodies which surround the bodies in question and which affect their motion"
 2. In effect, then, Descartes' reply to the obvious line of empirical objection is that the rules are idealizations
 - a. No effects from surrounding medium and perfect elasticity
 - b. Rules address encounters between two bodies at a time; in real world many bodies involved in all encounters

3. The surrounding medium can make it possible for a body to be put into motion with very little force
 - a. For a small $B \cdot v$ can augment the large sum $B \cdot v$ 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