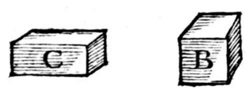
Descartes' rules governing collisions
Principles of Philosophy, II.45-53

[Translated from the 1644 Latin edition by V.R. and R.P. Miller in René Descartes, *Principles of Philosophy* (Dordrecht: Kluwer, 1983), pp. 64-69. The first illustration is from the 1644 edition; the rest were derived from an illustrations appearing in Victor Cousin's 1824 edition of Descartes' works.]

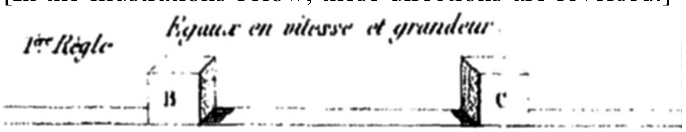
45
How it is possible to determine to what extent the movement of each body is changed by coming in contact with other bodies; and that this can be done according to the following rules.

In order to determine, from the preceding laws, how individual bodies increase or decrease their movements or turn aside in different directions because of encounters with other bodies; it is only necessary to calculate how much force to move or to resist movement there is in each body; and to accept as a certainty that the one which is the stronger will always produce its effect. Moreover, this could easily be calculated if only two bodies were to come in contact, and if they were perfectly solid, and separated from all others in such a way that their movements would be neither impeded nor aided by any other surrounding bodies; for then they would observe the following rules.

46
The first rule.

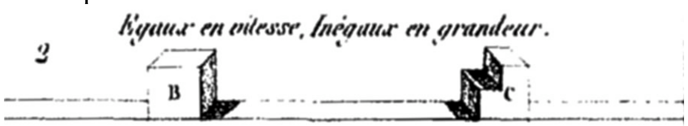


First, if these two bodies, for example B and C, were completely equal in size and were moving at equal speeds, B from right to left, and C toward B in a straight line from left to right; when they collided, they would spring back and subsequently continue to move. B toward the right and C toward the left, without having lost any of their speed. [In the illustrations below, these directions are reversed.]



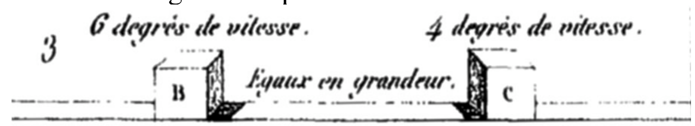
47
The second.

Second, if B were slightly larger than C, and everything else were as previously described, then only C would spring back, and both would move toward the left at the same speed.



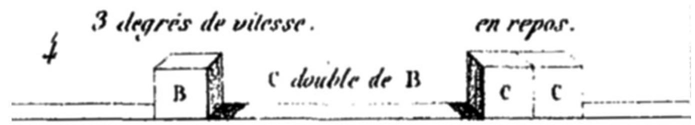
48
The third.

Third, if the two bodies were equal in size, but if B were moving slightly more rapidly than C; after their collision not only would both continue their movement toward the left, but also one half of B's additional speed would be transferred from it to C. For example, if B had initially been traveling at six degrees of speed, and C at a speed of only four, both would subsequently move toward the left at five degrees of speed.



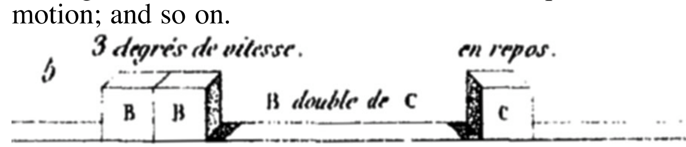
49
The fourth.

Fourth, if the body C were entirely at rest, and if C were slightly larger than B; the latter could never move C, no matter how great the speed at which B might approach C. Rather, B would be driven back by C in the opposite direction: because a body which is at rest puts up more resistance to high speed than to low speed; and this resistance increases in proportion to the difference in the speeds. Consequently, there would always be more force in C to resist than in B to drive.



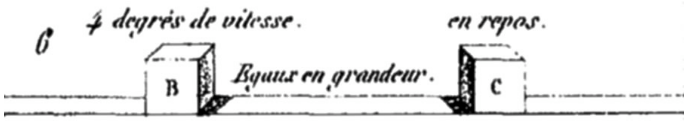
50
The fifth.

Fifth, if the body C were at rest and smaller than B; then, no matter how slowly B might advance toward C, it would move C with it by transferring to C as much of its motion as would permit the two to travel subsequently at the same speed. Thus if B were twice as large as C, it would transfer to C one third of its quantity of motion; because that one third would move the body C at the same speed as the remaining two thirds would move the body B which is twice as large as C. Therefore, after B had collided with C, its speed would be reduced by one third; that is to say, B would then need as much time to travel a distance of two feet as it previously did to travel a distance of three feet. Similarly, if B were three times as large as C, it would transfer to C one quarter of its motion; and so on.



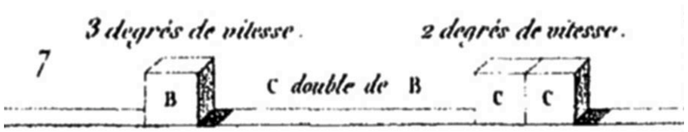
51
The sixth.

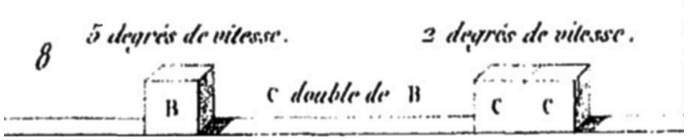
Sixth, if the body C were at rest and exactly equal in size to body B, which was moving toward it; necessarily, C would be to some extent driven forward by B and would to some extent drive B back in the opposite direction. Thus, if B were to approach C with four degrees of speed, it would communicate one degree to C, and be driven back in the opposite direction with the remaining three.



52
The seventh.

Finally, if B and C were traveling in the same direction, C more slowly than B, so that B (which would be following C) would eventually strike it; and if C were larger than B but B's speed exceeded C's by a greater extent than C's size exceeded B's: then B would transfer to C as much of its speed as would be required to permit them both to travel subsequently at the same speed and in the same direction. However, if, on the contrary, B's speed exceeded C's by a smaller extent than C's size exceeded B's; B would be driven back in the opposite direction, and would retain all its movement. The effect of the extent to which these ratios exceed each other is calculated as follows: if C were twice as large as B, and if B were not moving twice as rapidly as C, B would not drive C forward but would be driven back in the opposite direction: if, however, B were moving more than twice as fast as C, it would drive C forward with as much of its motion as is required to cause both to move at the same speed. Thus, if C had only two degrees of speed, and B had five: two degrees of speed would have to be taken away from B, and once transferred to C would form only one degree, since C is twice as large as B: as a result, the two bodies B and C would each subsequently travel with three degrees of speed; and so on. These things require no proof, because they are obvious in themselves.





53
That the application of these rules is difficult, because each body is always surrounded by many contiguous ones.

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, we must simultaneously calculate the effects of all those bodies which surround the bodies in question and which affect their motion. These effects differ greatly, depending on whether the surrounding bodies are solid or fluid....