20. Space and Motion are really Relations[1] **Aiv359**

[Early 1677?][2]

1968 If space is a certain thing consisting in a supposed pure extension, whilst the nature of matter is to fill space, and motion is change of space, then motion will be something absolute; and so when two bodies are approaching one another, it will be possible to tell which of them is in motion and which at rest; or, if both are moving, with what speed they are moving. And from this will follow those conclusions which I once showed in the Theory of Motion Abstractly Considered.[3] But in reality space is not such a thing, and motion is not something absolute, but consists in relation. And therefore if two bodies collide, the speed must be understood to be distributed between them in such a way that each runs into the other with the same force. Thus if two colliding bodies are understood to be equal, then all the phenomena consistent with experiments will at once be deduced from this fact alone. I assume, then, that hard bodies that are reflected after collision are one thing, and soft ones that remain together another. And I assert that when two equal and similar soft bodies with the same speed collide, they remain together after the collision; whereas hard ones are reflected with the speed with which they came.

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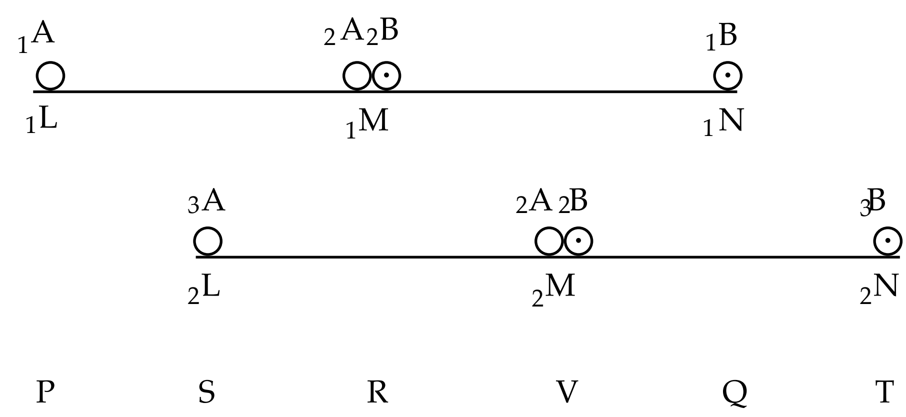
[1] LH XXXVII, 4: sheet 88, a slip of paper, 2 pages; edited by for the Vorausedition as-Ve503: 2384 (Fascicule 9, 1990). This piece explores the first of the outstanding problems of motion that Leibniz had noted were left unexamined in the Pacidius Philalethi, namely "the subject of motion, to make clear which of two things changing their mutual situation motion should be ascribed to". It contains the first clear statement of his mature view that space is not absolute but consists solely in relation, and shows how Leibniz conceives this to follow from the relativity of motion. It is also closely related in content to the piece following it, in which the metaphysical implications of the relativity of motion are further explored.

[2] Although the piece has no watermark, its close relation in content to the Pacidius and to "Motion is Something Relative" strongly indicate a date right at the beginning of the Hanover period.

[3] Here Leibniz is referring to his Theory of Abstract Motion of 1671 (A VI.ii N41), some excerpts of which are given in Appendix 1c below.

With[4] these things supposed, let there be a ship LMN in which two equal and similar bodies with the same speed collide. Then in the same time in which one comes from L through LM the other will come from N through NM equal to LM, and so they will be reflected with the same speed but in opposite directions, so that in the same time which before the collision they had come from L and N to M, after the collision they will go back to L and N. This, of course, is if they are perfectly elastic; otherwise, if they are soft, they will remain together at M. Meanwhile
1969 we suppose the ship to progress from $_1L_1M_1N$ to $_2L_2M_2N$, carrying with it the balls running along it. Let there now be an unmoving bank PT in which the points P.R.Q. correspond to the points $_1L_1M_1N$, and S.V.T. correspond to $_2L_2M_2N$.

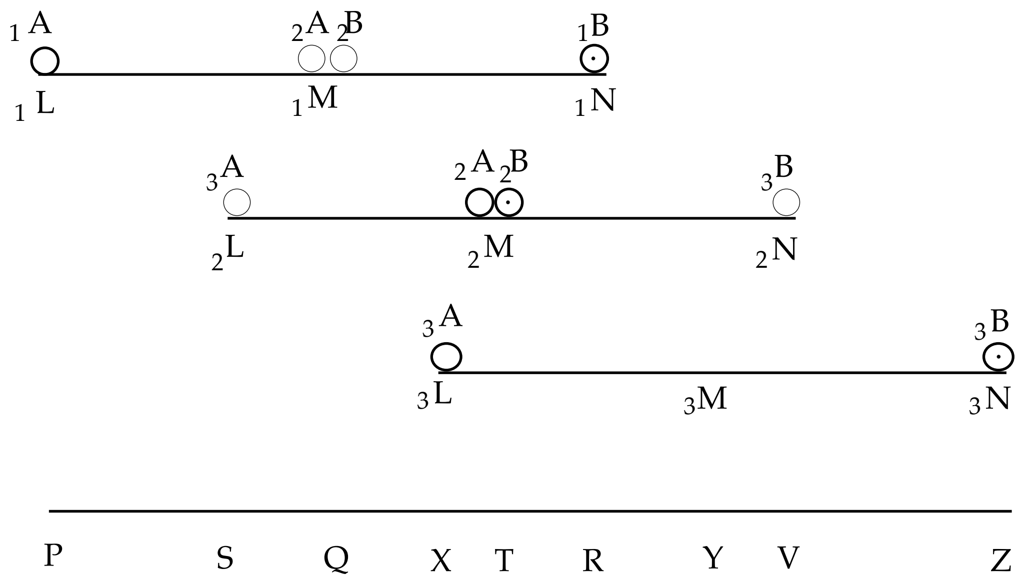
Figure 1



With these things supposed, let there be a ship LMN in which two equal and similar balls A and B collide, the one, A, coming from the prow L to the midpoint M in the same time as the other one, B, from the stern N to the same midpoint M, with a speed accordingly equal, and by a uniform, i.e. equable, motion. Now on colliding at M these two bodies A and B will be reflected, provided they are perfectly elastic, and will recoil in equal times with the same speed, A from M to L, and B from M to N.

[4] This paragraph, with its accompanying figure, were suppressed by Leibniz in favor of those following it.

Figure 2



Meanwhile, as these things are happening in the ship exactly as if it were at rest, the ship itself is being borne off straight downstream by an equable motion, in such a way that when the balls begin to move the ship is at the place 1L1M1N, but at the moment of collision it is at 2L2M2N, and finally at the moment of their absolute return, i.e. when the bodies A and B have returned to their former places after the collision, it is at place 3L3M3N. Now in the unmoving bank PY there are corresponding points, namely PQR corresponding to 1L1M1N, STV to 2L2M2N, and XYZ to 3L3M3N. It is clear that absolutely speaking, and with respect to the unmoving bank, it is exactly as if we said that the bodies A and B, colliding at T with speeds PT and RT, are reflected after the collision with speeds TX and TZ, from which, indeed, it is evident that (if the bodies are equal) the speeds and directions of the colliding bodies will be interchanged, i.e. TX is equal to RT and TZ to PT. For TX is equal to 2M2L or ML, minus 2L3L or XS, i.e. PS. And RT is 1N1M or NM or ML, minus 1M2M or 1L2L, i.e. PS. If, however, the bodies are soft they will remain together after the collision and be carried away by the ship, from 2M to 3M. Thus if two soft bodies collide with speeds PT and RT, after the collision they will go with a speed and direction TY, that is, in the direction of the faster body. But the speed TY or 2M3M or XS will be half the difference of the speeds PT and RT. For PS equals XS, or half PX, and PX is PT minus TX, or PT minus TR.