CHAPTER ELEVEN

Of motion, and of rest in general, and of simple motion

DEFINITION OF MOTION.

§.211. Motion is the passage of a body from the place it occupies to another place.

THREE KINDS OF MOTION.

§.212 One distinguishes three kinds of motion: absolute motion, common relative motion, and motion relative to itself.

OF ABSOLUTE MOTION.

§.213. Absolute motion is the successive relationship of a body to different bodies considered as stationary, and strictly speaking, this is real motion.

OF COMMON RELATIVE MOTION.

§.214. A body experiences common relative motion when, being at rest in relation to the bodies that surround it, it nonetheless develops with them successive relationships, in relation to other bodies that are considered stationary; and this is the case in which the absolute place of the bodies changes, though their relative place stays the same; this is what happens to a pilot who sleeps at the tiller while his ship moves, or a dead fish carried along by the current.

OF MOTION RELATIVE TO ITSELF.

§.215. Motion relative to itself is the one experienced when, being transported with other bodies in a common relative motion, one nonetheless changes one's relationship with them, as when I walk on a sailing ship; for I keep changing my relationship with the parts of this ship that transports me.

EXAMPLES OF DIFFERENT KINDS OF MOTION.

§.216. The parts of all moving objects are in relative common motion; but, if they came to separate and went on moving as before, they would acquire a motion relative to themselves.

§.217. If a ship went toward the orient [east], and a man walked in this ship from the prow to the poop deck, that is to say, from the orient toward the occident [west], with the same speed as the boat, this man would have, while he traverses the length of this boat, a motion relative to himself, but his absolute motion would only be apparent, since in constantly changing his position in relation to the parts of this ship, he would remain in correspondence to the same points outside the ship.

If, on the contrary, this man walked on this ship from the poop deck to the prow, that is to say, in the same direction as the ship carrying him, he would have at the same time a common relative motion with the ship, and a motion relative to himself; for he would constantly change his position with the parts of this ship and with the bodies outside of the ship. It is this kind of motion that all bodies walking on Earth experience, for the Earth moves ceaselessly.

§.218. If instead of this man, one imagines a stone thrown horizontally in this ship, in a direction contrary to that in which the ship goes, but with a speed equal to that at which it is carried, this stone will appear to those who are on the ship to have a motion relative to itself, in the direction in which it was thrown; but those who are on the shore will see it in absolute rest, in relationship to its horizontal direction, and this rest is its real state.

This stone is in absolute rest in relation to its horizontal motion, because, moving with this ship, it acquired in the direction in which this ship goes a force equal to that by which the ship was carried. Now, supposing that it is thrown in a contrary direction by a force equal to that which carries the ship; these two equal and opposite forces cancel each other, and the stone stays in absolute rest in relation to the horizontal motion; for the hand that threw it found in it a real force, and the one the hand imparted to it was consumed, canceling that force. It would be otherwise if this stone were thrown into the ship by a hand outside the ship; for then the stone would really have motion relative to itself from the orient toward the occident, and it would fall into the sea surrounding the ship.

§.219. In regard to the motion of this stone toward the center of the Earth, it never stops; for neither the horizontal motion which has been imparted to it, nor that of the ship is opposed to the motion that its gravity imparts to it toward the center of the Earth.[101]

101. The image of the ship comes from Newton and was commonly used to illustrate these relationships. Du Châtelet uses it in chapter 21 as part of her proof of *forces vives*, and in a famous description in chapter 12 "Of compound motion" (§.284), where she listed all the possible motions acting on the body thrown on the ship: gravity, the flow of the river, the turning of the Earth on its axis and around the Sun, and so on. She notes, however, that "it is only the first two which pertain to it in relation to those who are transported with the body in this ship; for all bodies which have a motion in common with us are as if at rest in relation to us . . ." (Emilie Du Châtelet, *Institutions de physique* [Paris: Chez Prault fils, 1740], 251–52).

WHY THE RIVERBANK SEEMS TO MOVE AWAY, WHEN ONE DISTANCES ONESELF FROM IT.

He who is on the ship and who believes that the stone went from orient to occident attributes to the stone the motion that only pertains to the ship; and he is deceived by his senses just as we are when we believe that the shore we are leaving behind is moving away, though it is the ship we are on that is sailing away. For we judge objects to be at rest when their images always occupy the same points on our retina. Thus, as we walk with this ship, its parts always occupy the same place in our eyes, but the parts of the shore, in contrast occupying now one part and now another, we judge them to be in motion for this reason. Thus, true motion and apparent motion are sometimes very different.

OF REST IN GENERAL.

§.220. Rest is the continuous existence of a body in the same place. One makes a distinction between relative rest and absolute rest.

OF RELATIVE REST.

§.221. Relative rest is the continuation of the same relationships of the body being considered to the bodies which surround it, though these bodies move with it.

OF ABSOLUTE REST.

§.222. Absolute rest is the permanence of a body in the same absolute place, this is to say, the continuation of the same relationships of the body being considered to the bodies that surround it, considered as stationary.

§.223. When the active force or the cause of motion is not in the body which can move, this body is at rest, and this is, strictly speaking, real rest.

EXAMPLES OF THESE TWO KINDS OF REST.

§.224. No body on Earth is in absolute rest, for the Earth constantly changes its relationship to all the bodies around it.

The bodies attached to the Earth such as the trees, plants, etc. are in relative rest. For these bodies do not change the relationship between them, but the Earth to which they are attached, and the bodies which surround them, being in constant motion, are in relative common motion. Thus, a body can be in relative rest, though it moves in a relative common motion.

§.225. But, in order to avoid the complexities these distinctions would introduce in discourse, it is ordinarily supposed, when speaking of motion and rest, that this is absolute motion and absolute rest; for the only real motion is that which operates by a force residing in the body that moves, and the only real rest is the absence of this force.

In this sense, there is no rest in nature, for all the particles of matter are always in motion, though the bodies of which they are composed may be at rest; thus it can be said that there is no internal rest.[102]

§.226. There is no degree of rest, as there is of motion; for a body can move more or less fast, but when it is once at rest, it is neither more nor less so.

However, rest and motion are often only comparative for us, for bodies that we believe at rest and that we see as at rest are not always so.

§.227. A body at rest will never begin to move by itself; since all matter is endowed with passive force, by which it resists motion, it cannot move by itself. In order for motion to happen with sufficient reason, there must be a cause that sets this body in motion. Thus, any bodies at rest would forever stay at rest, if some cause did not set them in motion, as, for example, when I withdraw a plank on which a stone is placed, or when some moving body communicates its motion to another body, as when one billiard ball pushes another.

§.228. By the same principle of sufficient reason, a moving body would never cease to move if some cause did not stop its motion, consuming its force; for by its inertia matter resists motion and rest equally.

§.229. The active and passive force of bodies is modified by their impact, according to certain laws that can be reduced to three principles.

GENERAL LAWS OF MOTION.[103]

First Law

A body perseveres in the state it is in, be it rest or motion, unless some cause brings an end to its motion or to its rest.

Second Law

The change that happens in the motion of a body is always proportional to the motor force that acts on it; and no change can happen to the speed and the direction of the moving body except by an exterior force; for without that, this change would happen without sufficient reason.

102. Again, Du Châtelet, like Leibniz, is envisioning a universe of constant motion, and one in which all bodies have an inherent force, similar to the modern concept of *energy*. See also §§.227–28.

103. Du Châtelet is restating Newton's "Laws of Motion" from Book I of the *Principia*, but she is adding metaphysical causation with her references to "sufficient reason." Note that she does not dwell on the corollaries to the Third Law here, but has already presented a number of their essential ideas in earlier sections and will cover others in later sections.

Third Law

The reaction is always equal to the action; for a body could not act on another body if this other body did not resist it. Thus the action and the reaction are always equal and opposite.

WHAT MUST BE CONSIDERED IN MOTION.

§.230. Several things are considered in motion:

1. The force that imparts the motion to the body.
2. The time during which the body moves.
3. The space the body traverses.
4. The speed of motion, this is to say, the relationship between the space the body has traversed and the time used to traverse it.
5. The mass of the bodies, according to which they resist the force that wants to impart or to take away motion from them.
6. The quantity of motion.
7. The direction of motion, be it simple or compound.
8. The elasticity of the bodies to which the motion is imparted.
9. The effect of the force of the moving bodies, or the quantity of obstacles that they can disrupt in consuming their force.[104]
10. Finally, the way in which the motion is communicated.

§.231. There is no motion without a force that imparts it.

1. OF MOTOR FORCE.

The active cause that imparts the motion to the body, or which incites it to move, is called motor force.

The effect of this force, when it is not destroyed by an invincible resistance, is to make the body traverse a certain space, in a certain time, in a space that does not perceptibly resist; and in a space that resists, its effect is to make it overcome some of the obstacles it encounters.

This cause, which draws the stationary body from the state of rest it was in, and which makes it traverse a certain space and overcome a certain quantity of obstacles, communicates to this body a force that it did not have when at rest, since according to the First Law, the body by itself would never leave its place.

§.232. By the same Law, when a moving body ceases moving, some

104. Du Châtelet here enunciates Johann Bernoulli's and Leibniz's ideas, that a body's motion can be understood and calculated by "obstacles overcome." See also her section on "motor force," §§.234–35, and §.268.

force equal and opposite to its own must have stopped its motion and consumed its force.

§.233. Any efficient cause is equal to its fully completed effect; thus equal forces when used up will always produce equal effects.

§.234 One calls an *obstacle* all that opposes the motion of a body, and that consumes its force completely, or in part.

MOTION WOULD BE ETERNAL IN A VOID.

§.235. Since, according to the First Law of motion, a body of its own accord always perseveres in the state in which it is; and the force by which a body moves, can only be consumed completely or in part by overcoming obstacles, a body, once moving in the absolute void (if an absolute void were possible), would continue to move for all eternity in this void, and would forever traverse there equal spaces in equal times, since in the void no obstacle would consume the force of this body neither in total nor in part.

§.236. So all motion contains an infinity of time, since all motion could last forever in the void. But all motion does not contain an infinity of speed, for a body that moved forever in the void could only move with a more or less great speed.

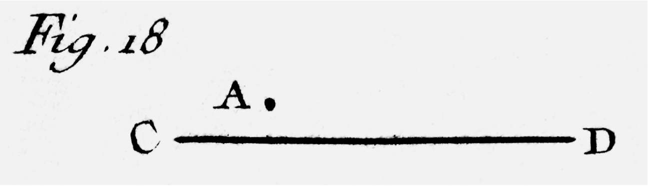
§.237. The space traversed by a body is the line described by this body during its motion.

2. OF THE SPACE TRAVERSED.

If the body in motion were a point, the space traversed would only be a mathematical line; but as there is no body without extension, the space traversed always has some width. When the path of a body is measured, only its length is taken into account.

3. OF THE TIME DURING WHICH THE BODY MOVES.

§.238. If body A traverses the space CD a certain portion of time will elapse, during which it will go from C to D, however small the space CD might be; for the moment when the body is at C will not be that when it will be at D, it being impossible for a body to be in two places at once; thus any space traversed is traversed in some time.



4. OF THE SPEED OF A MOVING BODY.

§.239 In addition to the space that a moving body traverses, the force that makes it traverse it, and the time that it uses to do it, one identifies yet another thing in motion that one calls *speed*; by this word is understood the property that a mobile body has of traversing a certain space in a certain time.

[*Fig. 18 also appeared here in the original.*]

The speed of a body is known by the space it traverses in a given time; thus the speed is all the greater when the mobile body traverses more space in less time. Consequently, if body A traverses the space CD in two minutes, and body B traverses the same space in one minute, the speed of body B will be twice that of body A.

THERE IS NO MOTION WITHOUT A DETERMINED SPEED.

There is no motion without some speed, for any space traversed is traversed in a certain time; but this time can be more or less long to infinity; for space CD, which I suppose to be a *pied*, can be traversed by body A in one hour, or in one minute, which is the 60th part of one hour, or in one second which is the 3600th part of it, etc.

§.240. Motion, that is to say, its speed, can be uniform or not uniform, accelerated or slowed, equally or unequally accelerated and slowed.

OF UNIFORM MOTION.

§.241. Uniform motion is that which makes the mobile body traverse equal spaces in equal times; thus, in uniform motion the spaces traversed are as the speeds of the mobile body, and as the time of its motion.

§.242. In an infinitely small time, one always considers the motion as being uniform, that is to say, that at each infinitely small instant the mobile body is supposed to traverse equal spaces, whether its motion in a finite time be accelerated or slowed, uniform or not uniform.

§.243. It is only in a space offering no resistance that a perfectly uniform motion could happen, just as it is only in such a space that perpetual motion would be possible; for in this space nothing would be encountered that could accelerate or slow the motion of bodies.

PROOF OF THE IMPOSSIBILITY OF PERPETUAL MECHANICAL MOTION.[105]

§.244 The inequality of all motions that we are familiar with is a demonstration against the mechanical perpetual motion that many people have

105. The concept of perpetual motion fascinated the natural philosophers and skilled mechanical artisans of eighteenth-century Europe. Basing their designs on complex clocklike mech-

sought: for this inequality only comes from continual losses of force that moving bodies experience from the resistance of the surrounding matter in which they move, the friction of their particles, etc. Thus for perpetual mechanical motion to happen, it would be necessary to find a body that was exempt from friction or had received an infinite force from the Creator, since it would be necessary to make this force surmount constantly repeated resistance, and without it ever running out, which is impossible.

PERFECTLY EQUAL MOTION IS UNKNOWN TO US.

§.245. Although, precisely speaking, there is no perfectly uniform motion, nevertheless, when a body moves in a space without perceptible resistance, and this body is subjected neither to acceleration nor perceptible slowing in its motion, this motion is considered as if it were perfectly uniform.

OF NONUNIFORM MOTION.

§.246. Nonuniform motion is that which is subjected to some increase or some decrease in its speed. . . .

[§§.247–51. Du Châtelet defines accelerated and slowed motion.]

MORE FORCE IS NECESSARY TO ACCELERATE MOTION THAN TO IMPART IT.

§.252. A greater quantity of force is necessary to increase the speed of a body by a degree than to impart to it the first degree of speed, when it is at rest.

§.253. If the motion is uniform, that is to say, if the speed of the body remains the same, the space traversed will increase in the same proportion as the time of the motion of this body (leaving aside obstacles), so that if one multiplies the speed of this body by the time of its motion the product will be the space traversed; if the space is divided by the time, the product will provide the speed, and this same space, divided by the speed, will give the time. Thus in uniform motion, when one has two of these things, space, time, and speed, one will necessarily have the third. . . .[106]

[§§.254–55. Du Châtelet describes a variety of ways in which these relationships change when one of the three factors changes, and when the motions of several bodies are compared.]

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anisms, inventors such as Jacques Vaucanson (1709–1782) made a mechanical duck, a mechanical boy playing a flute. At Lunéville, King Stanislas of Poland, who reigned as Duke of Lorraine, 1737–66, had an entire life-size mechanical rural village designed and constructed in his garden.

106. Du Châtelet is describing the now familiar s [speed/rate] × t [time] = d [distance], and its variations.

WHAT IS MEANT BY ABSOLUTE SPEED AND RESPECTIVE SPEED.

§.256. One distinguishes between *absolute* and *respective* speeds.

A body's own, or absolute speed, is the relationship between the space it traverses and the time during which it moves.

The respective speed is the speed with which two bodies move toward or away from each other in a certain space in a determined time, whatever their absolute speeds might be; thus, absolute speed is something positive, but respective speed is only a simple comparison the mind makes of two bodies, according to whether they move toward or away from each other.

5. OF THE MASS OF BODIES.

§.257. Bodies equally resist motion and rest. This resistance being a necessary consequence of their inertial force, it is proportional to the quantity of their own matter, since inertial force pertains to even a *minimum* of matter. So a body resists the motion that one wants to impart to it, all the more when it contains a greater quantity of its own matter in a similar volume. This is to say that the more mass, the more it resists, all other things being equal.

Thus, the more mass a body has, the less speed it acquires by the same pressure, and vice versa.

§.258. It is easier to impart a certain speed to a body than to impart to the same body a speed twice that of the first; thus, a double pressure is necessary to impart to the same body a doubled speed. And precisely the same pressure is necessary to give a body two degrees of speed, or to give one degree of speed to another body whose mass is double that of the first.

Thus the pressure that makes different bodies move with the same speed is always proportional to the mass of these bodies, all other things being equal.

The motion of a body is all the more difficult to stop, as this body has more mass. Thus the same force is necessary to stop the motion of a body moving with any speed whatever, and to communicate to this same body the same degree of speed it was forced to lose.

OF THE EQUALITY OF ACTION AND REACTION.

§.259. This resistance that all bodies present when one wants to change their current state is the foundation of the Third Law of motion, by which the reaction is always equal to the action.

The establishment of this law was necessary so that bodies might act on one another, and that motion, being once produced in the universe, might be communicated from one body to another with sufficient reason.

THERE CANNOT BE ACTION WITHOUT RESISTANCE.

In any action, the body that acts, and that against which it acts, fight each other, and without this kind of fight there can be no action; for I ask how a force can act against that which does not offer any resistance.

When I pull a body attached to a rope, however easily I may pull it, the rope is stretched taut equally on both sides, which indicates the equality of the reaction, and if this rope was not stretched taut, I could not pull the body.

OBJECTION TO THE EQUALITY OF THE ACTION AND REACTION.

ANSWER.

But someone will ask: can I make this body move forward if I am pulled by it with a force equal to that which I am using to pull it? Those who ask this question do not pay attention to the fact that when I pull this body and make it move forward, I do not use all my force to overcome the resistance with which it opposes me, but when I have overcome it, a part of the force still remains with me, which I use to move forward myself; and this body advances by the force I communicated to it and that I used to overcome its resistance. Thus, although the forces are unequal, the action and reaction are always equal.

The reason for this equality of action and reaction is that a body could not use a degree of force to overcome the resistance of another body without itself losing a quantity equal to what it used to achieve that; for this body cannot keep and use its force at the same time. This force that it uses to overcome this resistance is not lost, but the body that resists acquires it. . . .

[Du Châtelet explains that this Law applies to bodies of unequal masses.]

We have seen above that the communication of motion happens in relation to mass, which is again a proof that action is equal to the resistance; for bodies resist in direct proportion to their mass.

§.260. Bodies react from their force of inertia and, in reacting, tend to change the state of the body pushing them and that they resist, and in this reaction they acquire the force that the body acting on them consumes in acting on them, for these bodies resist in acquiring the motion; thus, the force bodies acquire in order to move they acquire in part by their force of inertia, which is the principle of their reaction. So precisely speaking, all the force of matter, be it at rest or moving, be it communicating motion or receiving it, all its action and its reaction, all its impulsion and its resistance, are nothing other than this *vis inertia* in different circumstances.

IT IS THE EQUALITY OF ACTION AND REACTION THAT MAKE A BOAT GO BY ITS OARS.

§.261. A boat goes by means of oars because the oars push the water in the opposite direction, and the water reacts against the oars and repulses with them the boat to which they are attached with a force equal to that with which the oars have cut it. Thus the vessel goes all the faster as there are more oars, as the oars are bigger, and as they are moved faster and with more strength.

It is by this method that one supports oneself swimming in the water; for feet and hands then serve as oars.

It is the same with birds. When they fly, they move in the air with their wings in the same way as men swimming in the water with their feet and hands.

[6.] OF THE QUANTITY OF MOTION.

§.262. There is yet another thing to consider in motion, namely, the quantity; for the quantity of motion in an infinitely small instant is proportional to the mass and the speed of the moving body, so that the same body has more motion when it moves faster. And of two bodies moving with equal speed, the one having the most mass has the most motion; for the motion imparted to any body can be conceived of as divided into as many particles as this body contains of its own matter, and the motor force belongs to each of these particles that participate equally in the motion of this body, in direct proportion to their size. Thus the motion of the whole is the result of the motion of all of the particles, and consequently the motion is doubled in a body whose mass is double that of another, when these bodies move with the same speed. . . .

7. OF THE DIRECTION OF MOTION. OF SIMPLE MOTION.

§.263. There is no motion without a particular direction; thus any mobile body that is moving tends toward some point.

When a moving body obeys only a single force directing it toward a single point, this body moves in a simple motion.

OF COMPOUND MOTION.

§.264. Compound motion takes place when the mobile body obeys several forces that make it tend toward several points at the same time.

Simple motion is the only one I examine here. I will discuss compound motion in the next chapter.

§.265. In simple motion the straight line drawn from the mobile body to the point toward which it tends represents the direction of motion of this body, and if this body moves, it will certainly follow this line.

Thus, all bodies that move in simple motion describe a straight line while they move.

Strictly speaking, we know no simple motion other than that of bodies falling perpendicularly toward the center of the Earth by the sole force of gravity, unless bodies move on a stationary plane; for gravity acting equally on all bodies at each indivisible instant, its action mixes with all motions, and if simple, it makes them become compound.

§.266. Gravity or weight is also one of the reasons why there could not be uniform motion in an absolute void or on a stationary plane; for this force causes bodies to traverse unequal spaces in equal times.

8. OF THE ELASTICITY OF BODIES.

§.267. Bodies receiving or communicating motion can be either completely hard, that is to say, incapable of compression, or completely soft, that is to say, incapable of reconstitution after the compression of their particles, or again elastic, that is to say, capable of regaining their original shape after the compression. We do not know any body that is completely hard, or completely soft, or perfectly elastic; for as M. de Fontenelle says, *nature does not allow any such precision*.[107]

But to make explanations more intelligible, the most exact precision is presumed; thus it is assumed that all bodies that recoil spring back perfectly.

Hard bodies are those whose shape is not altered perceptibly by impact, such are, for example, diamonds; and *soft*, the bodies an impact causes to take a new shape which they keep after the impact, like wax, clay, etc. Further on in this work I shall discuss elastic bodies and the way in which motion is communicated between them.

9. OF THE FORCE OF MOVING BODIES.

§.268. When a moving body encounters an obstacle, it strives to displace this obstacle; if this effort is destroyed by an invincible resistance, the

107. Bernard le Bovier de Fontenelle (1657–1757), a mathematician and physicist, was a leading member of the French Royal Academy of Sciences. He served as its perpetual secretary from 1697 until 1741. He presented numerous memoirs to the Academy on a variety of subjects and was the author of the best-selling *Entretiens sur la pluralité des mondes* [Conversations on the Plurality of Worlds]. He was a family friend of Du Châtelet's.

force of this body is a *force morte* [dead force], that is to say, it does not produce any effect, but it only tends to produce one.

If the resistance is not invincible, the force then is *force vive* [live force], for it produces a real effect, and this effect is called *the effect of the force of this body*.

The quantity of this *force vive* is known by the number and the size of the obstacles the moving body can displace by using up its force.

There are great disputes among philosophers about whether this *force vive* and the *force morte* must be estimated differently, and this will be discussed in chapter 21 of this work.[108]

10. OF THE COMMUNICATION OF MOTION.

§.269. Finally, the last thing that remains for me to examine about motion is the way it is communicated; for experiment teaches us that a moving body that encounters another at rest communicates to it part of the force that it had in order to move, and then the body with which it has collided passes from the state of rest in which it was, to that of motion, and it continues to move after the collision until some obstacle has consumed its force.

§.270. The reason why this body continues to move after the absence of a driving force is a consequence of the inertial force of matter, the force by which bodies stay in the same state, if some cause does not take them out of it. Now when my hand throws a stone, this stone and my hand begin moving together; I withdraw my hand, and there is a cause that stops its motion in that direction, but the stone I have not withdrawn continues to move until the resistance of the air has caused it to lose projectile motion, which I had communicated to it, or gravity makes it fall down toward the Earth. Thus the continuation of the motion of this stone, after the absence of my hand, is the effect of the force that I communicated to it.

It is for this reason that when a vessel is sailing very fast and is stopped suddenly, the things in this ship, tending to conserve the motion they ac-

108. In her description of force Du Châtelet is measuring it in the way in which Johann Bernoulli advocated in his two memoirs for the French Royal Academy of Sciences (1724 and 1726). In modern terms *force morte* is equivalent to potential energy and *force vive* to kinetic energy. There was confusion in Du Châtelet's day about these two concepts. Leibniz favored the concept of "force vive," which Du Châtelet discusses at length in her chapter twenty-one where she disputes the 1728 memoir written by Jean-Jacques Dortous de Mairan supporting Descartes' views on motion. Dortous de Mairan was close to Fontenelle and succeeded him as perpetual secretary of the Academy in 1741. I am grateful to Paul Veatch Moriarty for his clarifications of these concepts.

quired by being transported with it, might well be hurled forward, if they were not tied down.

WHY THE ROLLING OF A SHIP CAUSES VOMITING.
It is for the same reason that the sea causes the rolling of a ship, and even more the turmoil of a storm, makes men sick and makes them vomit, especially if they are not accustomed to the sea. For, the liquids in their bodies only gradually gain a movement in *harmony* with that of the ship, and until they have acquired it, there is disorder and commotion in the body, which takes the form of vomiting and other illnesses; and so, almost the same thing happens in the bodies of men as in a vase filled with water that is spun around; for the water only slowly acquires the motion of the vase, and it maintains it some time after this motion is stopped.

CHAPTER TWENTY-ONE

Of the force of bodies

[In §§.557–72 Du Châtelet describes the ways in which force acts on bodies; for example, force is successively acquired. Force acts even if just as a tendency when a body resists; for example, a body resists the force of gravity when placed on a table. This "harmless effect" of the force is *force morte* and is retained by the body as long as its motion is opposed by an invincible obstacle. The formula for determining *force morte* is mv (mass × velocity). She explains that all mathematicians agree on this definition and this formula for its determination. Leibniz was the first to distinguish between *force morte* and *force vive* in his memoirs for the *Acta Eruditorum* (1686 and after). As she describes it, *force vive* is the successive acquisition of force by a body. She uses gravity as an example and cites Galileo's formula measuring the force of gravity as the square of the speed of fall. Thus, she concludes that *force vive* is measured by the square of the speed of motion of the body multiplied by its mass, mv2 (expressed as ½ mv2 today). Although experiments confirm this conclusion, she notes that it is considered a "kind of heresy in physics." She then answers the principal objection to *force vive*, the argument of "time," as a determining factor in the measurement of force. Opponents, she explains, argue that a force increases as it takes longer to act on a body; for example, a spring closing. She responds that the force can only be measured by the obstacles it overcomes and by which it is consumed; the time is of no consequence, and making time a determining factor in the equation