Leibniz vs. Descartes on Motion

Philosophy 22N
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Leibniz’s objection to Descartes’s physics

- In these slides we shall illustrate an objection raised by Leibniz against the physics of Descartes.
- Leibniz regarded Descartes as having made as simple error.
- “Nothing is simpler than this proof. Descartes fell into error here only because he had too much confidence in his own thoughts, even when they were not sufficiently ripe” (*Discourse on Metaphysics*, Article 17).

Aristotle on falling bodies

- Aristotle had defined relative weight in terms of the speed at which bodies fall naturally.
- "By lighter or relatively light we mean that one, of two bodies endowed with weight and equal in bulk, which is exceeded by the other in the speed of its natural downward movement" (*On the Heavens,* Book IV, Chapter 1, 308a 30)
- So if body B moves downward naturally four times as fast as body A of the same size, body B is four times heavier than body A.

Galileo on falling bodies

- The speed of the fall of two bodies (where there is no resistance from the medium) is independent of their weight.
- Body B, which is four times heavier than body A, will fall from the same height at the same speed as does body A.
- This conclusion was supported by experimental evidence using balls rolled down inclined planes.

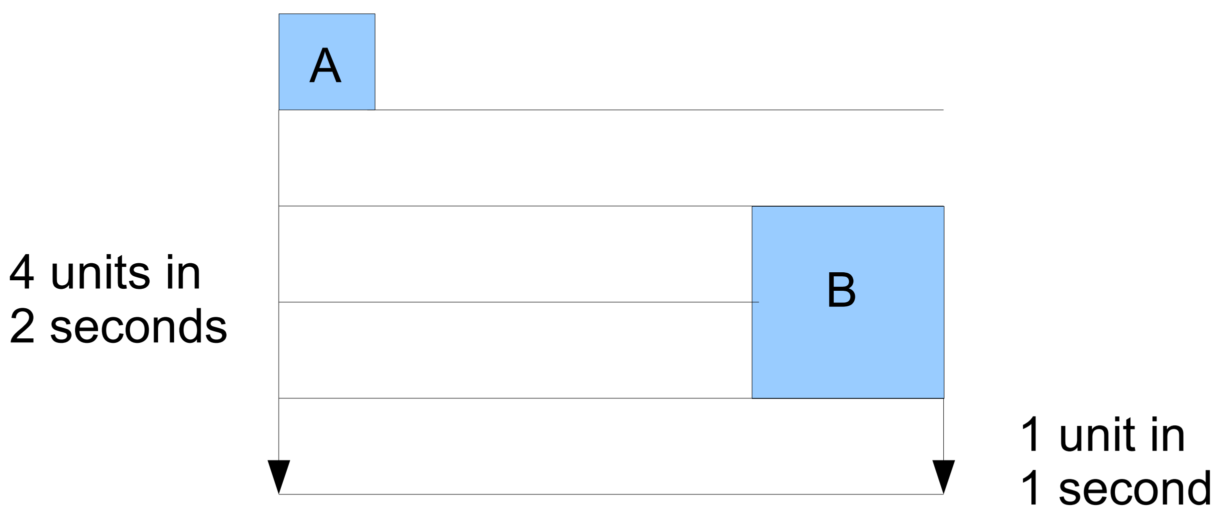
Uniform acceleration

- Galileo also argued that falling bodies increase their speed at a uniform rate.
- Earlier scientists had held that the increase is a function of the *distance traveled*.
- Galileo argued that the increase is a function of the *time taken* in falling.
- The ratio of the distances covered by two falling bodies is equal to the ratio of the square of the times taken to fall those distances.

An example of acceleration

- Suppose body A drops distance D in two seconds and body B drops distance d in one second.
  - $d/D = t^2/T^2$
  - $t^2/T^2 = 1/4$
  - $D = 4$, $d = 1$
- In other words, body A covers four times the distance as is covered by body B, although in only twice the amount of time.

A falls 4 times as far as B in twice the time



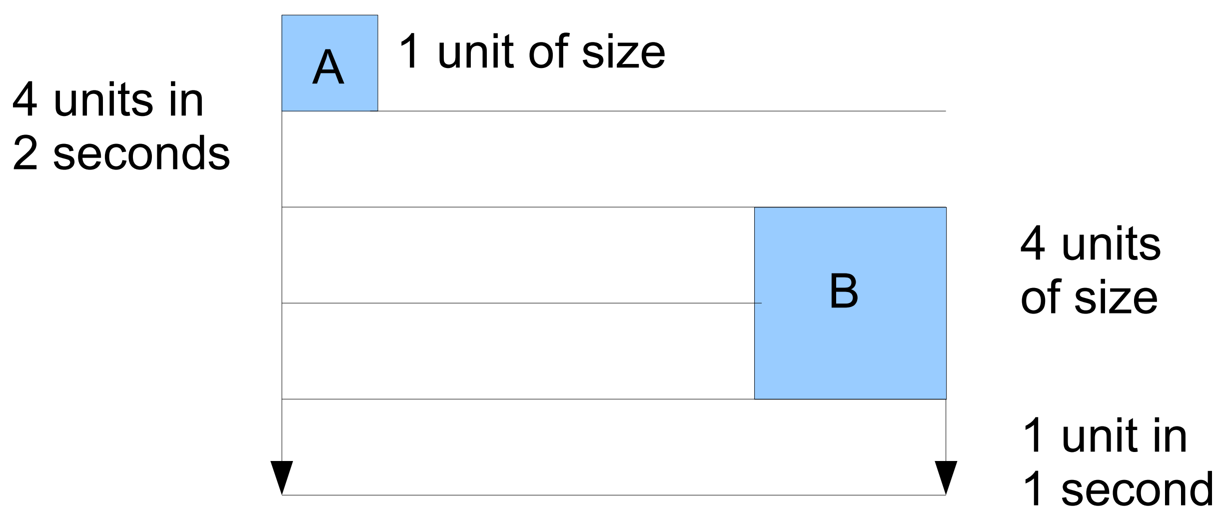
Conservation of quantity of motion

- According to Descartes, there is a quantity which is constant throughout the history of the universe.
- This quantity is the quantity of motion.
- “If one part of matter moves twice as fast as another which is twice as large, we must consider that there is the same quantity of motion in each part” (*Principles of Philosophy*, II, 36).
- The quantity of motion in an object is the speed times the size.

An Example

- Let body A have a size of 1 and body B a size of four.
- Let the speed of A be twice the speed of B.
- Then the quantity of motion of A = 1 x 2 = 2.
- The quantity of motion of B = 4 x 1 = 4.
- Now apply this to the case of the falling bodies.
- A is moving twice as fast as B.
  - Speed of A = 4 units of space in 2 seconds = 4/2 = 2
  - Speed of B = 1 unit of space in 1 second = 1/1 = 1

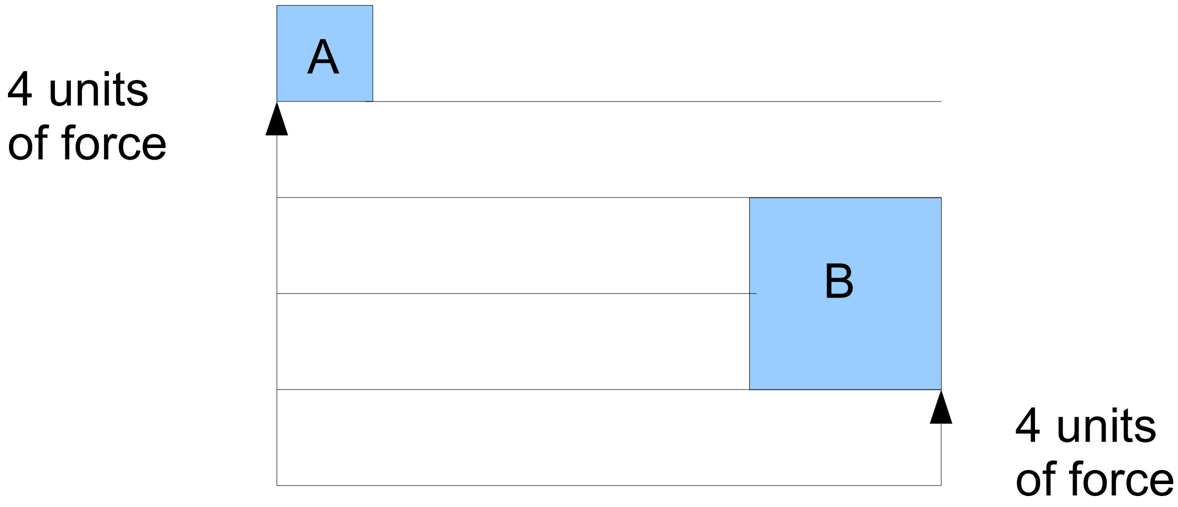
A has twice the speed of B
B has four times the size of A



Rising and falling bodies

- According to Leibniz, the *force* of a falling body is equal to the force needed to raise the body back to the height it fell.
- This can be seen from the action of a pendulum, where (discounting friction), the weight rises to the height from which it fell.
- The same force is needed to lift a body of one unit of size to four units of distance as to raise a body of four units of size one unit of distance.

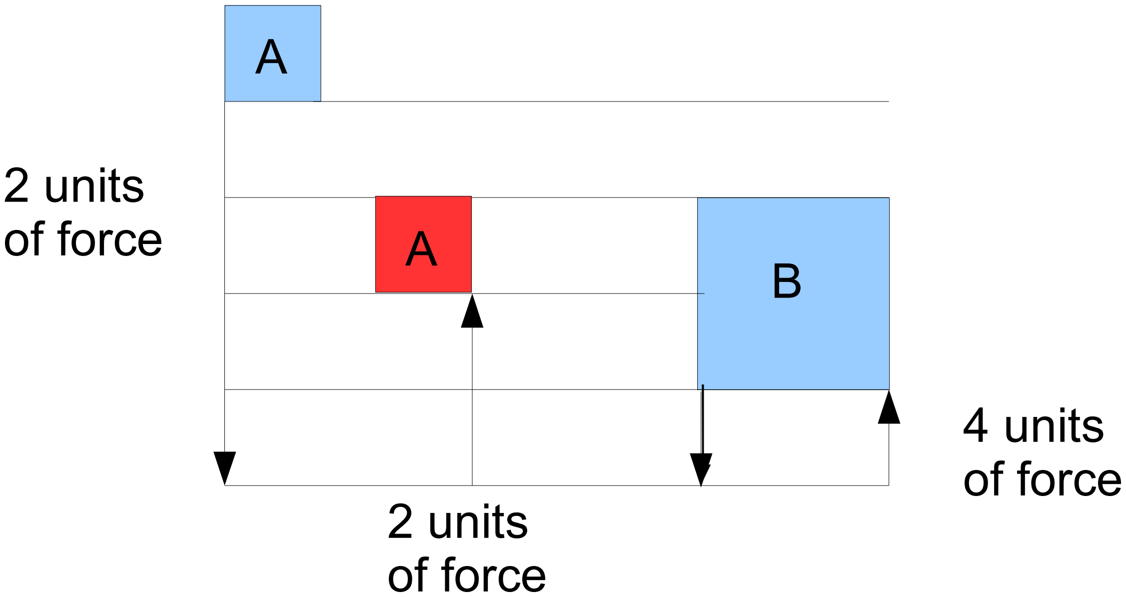
Force needed to lift A and B



The problem for Descartes

- Suppose force = quantity of motion.
- Then the quantity of the *descending* body A is half that of the *descending* body B.
- But it then follows that this force is enough to lift body A only two units of height.
- In that case, force is lost (and not simply transferred).
- So force should not be understood as quantity of motion.

Inequality of forces



Conservation of force

- Leibniz concluded that the only quantity that could function as force in Cartesian physics is not conserved.
- He thought he had a way of understanding force by which it is conserved.
- This quantity he called “living force,” (*vis viva*).
- There ensued a lengthy debate between the followers of Leibniz and those of Descartes and Newton about what exactly is conserved.