a. *Le Monde*, except that it was not published, and Descartes appears not to have circulated it even within Mersenne's narrow circle

b. Galileo intimates the principle in some of his replies to arguments against the earth's motion in the *Dialogue*, and he offers what seems in retrospect to be an explicit version of it for horizontal motion in *Two New Sciences*; but he also seems to commit himself to a principle of continuing circular motion in the *Dialogue*

c. Gassendi announces the principle in published letter in 1641 (*De Motu impresso a motore translato*), in which he offers various experimental results bearing on Galilean claims (including objects falling from masts and circular arc versus inclined plane times)

> "All that has no other aim than to make us understand that motion impressed [on a body] through void space where nothing either attracts or resists will be uniform, and perpetual; ... so that in whatever direction you throw a stone, if you suppose that, at the moment in which it leaves the hand, by divine power, everything besides this stone is reduced to nothing, it would result that the stone will continue its motion perpetually and in the same direction in which the hand has directed it" (translation from Franklin)

(1) A generalization of Galileo: uniform straight-line motion everywhere, not just on the horizontal

(2) Underlying rationale: nothing would disturb the motion of Gassendi's corpuscles (i.e. atoms) unless they were to contact some other corpuscles, and his corpuscles were moving in all directions

d. But elsewhere in the same work (see Appendix) Gassendi speaks of the perpetual continuation of uniform circular motion, seemingly missing the implication of inertia that Descartes stresses

e. *Principia Philosophiae*: the most influential statement of the principle prior to Huygens's *Horologium Oscillatorium* (1673), if not to Newton's *Principia*

4. Gassendi's *De Motu impresso a motore translato* was important for other reasons as well

a. The principle we call Galileo's principle of relativity -- the motion of objects within the hull of a boat is the same whether the boat is stationary or moving forward uniformly -- was put forward in replying to anti-Copernican arguments in the *Dialogue*

b. Gassendi announced in the letter that he had carried out experiments confirming it, such as dropping an object from the top of a mast with a boat moving and not moving

5. This is a ninth Galilean principle to be added to the eight from *Two New Sciences* of the last class

6. Gassendi, it should be noted, was far more skeptical than Descartes about our capacity to establish conclusions about unseen processes, mechanisms, and entities

a. He viewed his corpuscularеanism as forever merely a hypothesis that could never achieve the same status as an observed matter of fact

b. That view carried over in Locke's writings through Charlton and Boyle, both of whom were very much followers of Gassendi, though Boyle was no less influenced by Bacon

E. Some Issues with the Principle of Inertia

1. Complications, e.g. in the case of Descartes, because he is putting the principle forward in the context of a conceptual scheme that is in some respects at variance with Newton's
    a. Rest and motion are different kinds of state for Descartes, and not just different degrees of a single kind of state
    b. Descartes requires different forces to initiate motion from rest and to change motion
    c. Hence, in some ways a different concept of force involved
    d. And no notion of mass involved, only one of bulk (*moles* versus *massa* in Latin), while our modern notion of inertial motion, if not Newton's, has *mv* equal to a (vector) constant, and of course no distinction about rest versus motion is made in forces effecting changes of motion
2. The logical or epistemic status of the principle of inertia has been a long standing source of concern within philosophy of science
    a. It is scarcely an empirical generalization, from observations
    b. In making a claim about what happens in the absence of (unseen and unknown) external causes, it borders on a definition of what an external cause of motion is -- anything that impedes in such a way as to change speed or direction -- and hence of what a dynamic force is
    c. The principle itself includes no independent way to determine forces, and hence it is hard to find a way to test it in isolation from other claims
    d. Yet it seems empirical, even in Descartes, who appeals to the sling
3. Notice again, however, that whether it is empirical or not, it is first and foremost a proposed way of conceptualizing motion, with important implications for curvilinear motion!
4. My view now is that the principle of inertia was the end product of a several step reconceptualization of motion in which the Aristotelian way of conceptualizing it gradually gave way to a new way of conceptualizing it
    a. Several people, including Galileo and Gassendi, saw unimpeded motion as continuing, in contrast to Aristotle -- i.e. continuing motion requires no explanation
    b. Descartes was the first to emphasize that curvilinear motion has to be something other than unimpeded, which ends up being the most important feature historically
    c. Others, notably Huygens, adopted the principle in extending Galileo's theory of local motion
    d. Modern conceptualization fully clear only after Newton's *Principia*
    e. A gradual process in which no one person gets all the credit for putting it forward, but Descartes has claim to it more than anyone else because of his conclusions about curvilinear motion
5. Finally, let me emphasize once again that formulating and proposing the principle of inertia is one thing, providing compelling empirical evidence for it is entirely another
    a. Kuhn, for one, would question whether one can legitimately say that the Aristotelian conceptualization of motion was wrong and the modern one right

b. Rather, for him they represent two different ways of trying to make sense of the world

c. An important dimension of this course is to stay on the lookout for any subsequent developments that provide evidence for the principle of inertia

F. The Third Law of Motion

1. The statement of the law in *Principia* expands on that in *Le Monde*

"When a body meets another, if it has less force (*vim*) to continue to move in a straight line than the other has to resist it, it is turned aside in another direction, retaining its quantity of motion and changing only the direction of that motion. If, however, it has more force; [sic] it moves the other body with it, and loses as much of its motion as it gives to that other" (40)

*Le Monde*: When one of these bodies pushes another, it cannot give the other any motion except by losing as much of its own at the same time; nor can it take away from the other body's motion unless its own is increased by as much" (p. 65)

2. Notice what the problem is: how is total motion maintained when local motion changes ("*ubi corpus quod movetur alteri occurrit*")

a. Answer: it depends on, and only on, the local situation

b. Case 1: perfectly elastic reflection, with no change of either B∗v; in this case the moving body never becomes one at rest (see Spinoza, for example in the Appendix)

c. Case 2: a transfer of motion, with B∗v changing in both

3. "Proof" of the first part: change in determination or direction alone does not produce a change in the motion of the body

a. Only changes in local motion have to be explained in order to explain how motion globally preserved

b. If local motion diminished, a compensating increase would have to show up somewhere else, which it doesn't

c. "Proof" here ignores question why both bodies don't change

4. "Proof" of the second part "theological": God maintains in the same way that he created motion, namely by causing "some of the parts to push others and to transfer their motion to these others" (42)

a. Hence follows from immutability of God

b. "Proof" here ignores question why some third body doesn't change, via action at a distance

5. Again notice that Descartes is offering us a way of conceptualizing change of motion, but now with an additional conceptual element, force (*vis*)

a. Either motion is preserved or transferred, with total remaining the same

b. In former, encounter shows up via change in direction, yielding answers to questions arising out of Law II

c. In latter, encounter shows up via transfer of motion from one to the other, yielding answers in response to other questions about change of state of motion