b. See Drake's Glossary, but always be cautious in taking Galilean concepts to be ours, for more often than you would think, they are not – especially so with '*momenta*'

c. For thorough analysis, see Galluzzi's *Momento, Studi galileiani*

B. Abrupt Versus Continuous Change in Speed

1. With some concepts -- e.g. uniform acceleration -- Galileo shows concern over their appropriateness for describing nature

   ...so I may, without offence, doubt whether this definition, conceived and assumed in the abstract, is adapted to, suitable for, and verified in the kind of accelerated motion that heavy bodies in fact employ in falling naturally." [198]

   a. Definitions are arbitrary, but something more is demanded here

   b. In other words, Galileo was aware of role of empirical considerations in shaping concepts and distinctions

2. One concern: continuous increase in speed, passing through intermediate degrees, versus abrupt change to e.g. full speed

   a. Abrupt change in speed what we seem to see at moment when moveable impacts the ground, and have trouble seeing any gradual development of speed with naked eye

   b. So, why is concept of continuous change of speed apropos at all

3. Answer: compare the effects of impact -- e.g. the depth of impressions in soft soil -- from dropping the same object from different heights

   a. Greater effects from greater heights, but this because of greater speeds (since effects from speed when weight the same)

   b. But continuous gradation of effects of impact, depending on height from which object dropped

   c. Hence continuous range of speeds, from very small to great, related to distance of fall

4. Galileo here adopting "percussive force" -- i.e. "quality and quantity of impact" -- as an indicator of speed [199]

   a. In fact the percussive effects on impact are a function of speed squared, not speed, as he might have realized from their correlation with height of fall

   b. But his argument still goes through for concluding that speeds in fall seem to admit of continuous degrees

5. Note also, in passing, how Galileo dispenses with Zeno-like arguments against having to pass through an infinity of different degrees of speed to reach given speed [200f]

   "This would be so, Simplicio, if the moveable were to hold itself for any time in each degree; but it merely passes there, without remaining beyond an instant"

6. Key point though is that he invokes empirical phenomena to show that concept of continuously increasing speed is "suitable" to the task at hand

C. Motion Versus Rest: Impetus and Momenta

1. Because the new science is one about motion, the distinction between rest and motion does not as such play much of a role here
    a. For Aristotle a distinction of kind, not of degree
    b. Still, a pertinent question that one might want to ask Galileo
2. In a brief digression Sagredo offers a physical picture of the cause of motion under which the distinction would be more one of degree than of kind [201f]
    a. A body hurled upwards progressively loses the "*virtu*" impressed on it by the thrower -- the *virtu* that continues to drive the object upward after it leaves the hand of the thrower
    b. Once the remaining *virtu* diminishes to the point where it is in equilibrium with the *virtu* corresponding to its heaviness, "the moveable stops rising and passes through a state of rest"
    c. Impressed *virtu* then continues to diminish, so that the *virtu* from heaviness progressively out-balances it, causing progressive acceleration
3. Most interesting aspect of this conceptualization of the process of deceleration and acceleration is that Sagredo continues by trying to reconcile static with dynamic *virtu*

    > "Thus, when you support a rock in your hand, what else are you doing but impressing on it just as much of that upward impelling *virtu* as equals the power of its heaviness to draw it downward.... The rock always starts with just as much of the *virtu* contrary to its heaviness as was needed to hold it at rest" [202]

4. Notice how elusive the (Newtonian) concept of force is, under which only acceleration and not motion itself requires force; and how difficult it is to relate the force exerted by a heavy static object -- say on a pulley -- to forces causing motion
    a. We will be seeing the concept of dynamic force emerging as we proceed
    b. Kuhn has claimed (I think wrongly) that not even Newton was always clear about how to reconcile his concept with that of static force -- reconciliation not complete until the middle of the 18th century
5. Also notice how Salviati immediately badmouths Sagredo's physical conjecture, in the process marking a distinction between what we now call kinematics and dynamics [202]
    a. One of several passages cited as evidence for the claim that Galileo wanted science to answer "how" and not "why" questions
    b. This in spite of the fact that he elsewhere is quick to address "why" questions -- e.g. his theory of the tides

D. Alternative Concepts of Uniform Acceleration

1. Galileo now in a position to appeal to simplicity arguments to justify his definition of uniformly accelerated motion
    a. In effect, try simplest "rule" first and see how it conforms with *naturalia experimenta* [197]

b. Trouble: why is uniform in time simpler than uniform in space

$$\Delta(v) = a*\Delta(t) \text{ versus } \Delta(v) = a*\Delta(s)$$

2. Notice that at the point Sagredo raises the issue in *Two New Sciences* [203] this is a conceptual, not an empirical question
   a. According to Drake, Galileo himself for a long time thought the two were equivalent, but could find no way to obtain the 1,3,5, ... progression he had observed on an inclined plane from it
   b. But here he presents the issue as a conceptual one, eschewing the appeal to the 1,3,5,... progression
   c. Save for pointing out that impact effects seem to be proportional to height of fall, and Galileo had said these effects came from the speed acquired (and not the speed squared)
3. The argument Galileo offers has generally been interpreted as trying to show that $\Delta(v)=a*\Delta(s)$ is incoherent
   a. Given two spaces, one twice the other, then velocities acquired must be proportional to these; but times for traversing proportional to the spaces, and inversely proportional to the velocities; consequently times the same
   b. The trouble is that the alternative acceleration rule is not incoherent: $s=c*\exp(at)$ and hence $v=c*a*\exp(at)$
   c. The only real fault of the alternative rule: it requires v not to be 0 at the beginning of motion
   d. Hence, Galileo's argument generally regarded as fallacious, though what he says does hold if t varies as s/v
4. {The question is whether the argument he offers is at least on the track of an underlying conceptual difficulty
   a. Drake's suggestion: argument envisages a one-to-one mapping between speeds in the half-space and speeds in the whole, from which Proposition II entails the same time for each space, implying instantaneous motion
   b. Fallacy would then be that he is in effect integrating with respect to space and time as if they are linearly correlated}
5. Of course, Galileo can scarcely be faulted for not having the mathematics needed to see what the alternative rule entails, and the reasons he gives in *Two New Sciences* notwithstanding, he did find empirical reasons to adopt $\Delta(v)=a*\Delta(t)$
   a. But it does bring out the way in which concepts that seem so automatic and clear to us in fact required great effort before they became that way
   b. And, while much of that effort was ultimately conceptual -- in the above case, mathematical -- the ultimate guiding factor for Galileo seems to have been empirical