5. {If Drake is correct (pp. 85-90 of *Galileo at Work*) Galileo first came upon the phenomenon of the 1,3,5,... progression in conducting inclined plane experiments (ca 1603), and then subsequently discovered its relation to delta(v)=a∗Δ(t) (sometime before 1615)
    a. Discovered that this rule yields the progression, perhaps from knowledge of Medieval work
    b. And saw no way that delta(v)=a∗Δ(s) could yield it}

C. The Inclined Plane Experiment in the "Third Day"

1. Inclined plane experimental program described in *Two New Sciences* [212f] in response to Simplicio's request to adduce an experiment in support of earlier claim that natural motion conforms with the mathematical theory

> "Like a true scientist, you make a very reasonable demand, for this is usual and necessary in those sciences which apply mathematical demonstrations to physical conclusions, as may be seen among writers on optics, astronomers, mechanics, musicians, and others who confirm their principles with sensory experiences that are the foundations of all the resulting structure." [212]

2. Inclined plane 12 braccia long and from 1 to 2 braccia in height, with smooth groove covered with vellum, and hard, well-rounded polished bronze ball {1 braccio = 22.99 in (Drake), 22.7 (Settle)}
    a. Measured times of descent via a relatively crude water clock, opening and closing an aperture and weighing the amounts of collected water on a delicate balance
    b. Descent from various fractions of total lengths, at different inclinations -- "experiments repeated a full hundred times"
    c. In particular, time for total length twice that of time for 1/4 of length -- an easy measurement
    d. Result: spaces always as times squared, with variation with inclination as subsequently claimed -- "never a difference of even the tenth part of a pulse-beat"
3. Questions have been raised, especially by Koyré, about whether he could have gotten the claimed results with such a crude device for measuring time
    a. Total time (rolling) for 12 braccia is 4.90 sec when h=1 and 3.46 sec when h=2
    b. Comparison of full length to 3/4 length when h=1 is 4.90 to 4.24 sec, and when h=2 is 3.46 sec to 3.00 sec
    c. Suppose in case of latter a 0.02 sec error, say 3.02 instead of 3.00 sec: then implied space 7.03 cm different from 9 braccia
    d. All this even assuming that ball rolling perfectly, with no bounce, no sag of plane etc.
4. Mersenne, who tried to replicate the experiment (from a much cruder description in the *Dialogue* pp. 23-31, including a figure not at a low angle of inclination), even using a fast pendulum, could not get such compelling results (see Appendix)

> "I question whether Lord Galileo ever did the experiments of falls along the plane, since he nowhere says so, and the proportion he gives often contradicts experiment." *Harmonie Universelle*, 1636, p.112

a. Difficult to get the "right" results in the experiment even when know what they are supposed to be
b. Therefore terribly easy to get "wrong" results, potentially falsifying theory without knowing whether just a shortcoming in experimental design
c. Mersenne's problem (see Appendix) appears to have been imperfect rolling -- e.g. at angles too high – and not imprecise time measurement, but main point remains either way: experiment not straightforward to pull off, requiring careful design (and fairly small angles of inclination)
d. The special care and effort needed to get the experiment to yield the "right" result is not unique to this example: a general situation in science

5. Tom Settle's modern repetition of the experiment, following Galileo's instructions, was far more successful (Appendix)
   a. With practice (and warm-up) measured times from water-clock within 1/10 sec of predicted times (as Galileo said), and most within ± 1/20 sec
   b. Good agreement for 6.86 deg of inclination (vs. Galileo's announced maximum of 9.6 deg), as well as 3.7 deg
   c. The question, then, is how much effort Galileo put into the development of this experiment
6. The experimental program thus could at least have shown that the observed results were compatible (to within observational errors) with the 1,3,5, ... progression -- i.e. the results did not clearly falsify the claim -- and they may have shown much more (e.g. evidence for Galileo's "postulate")
   a. Quotation of data themselves would have helped us see just how strongly the results supported the claim
   b. But no data quoted, either in *Two New Sciences* or in notebooks, and hence cannot assess this
   c. Nor can assess whether he began to encounter confuting data at higher angles -- e.g. at 30 deg, for which t in theory 2 sec
   d. {For reasons that will become evident below, if not already from Mersenne's data, the 1,3, 5,... progression will almost certainly cease to hold as the angle of inclination is increased}

D. The Earlier Inclined Plane Experiment -- Drake (*Galileo at Work*)
1. Drake has reconstructed an earlier inclined plane experiment, primarily from a notebook entry with a list of numbers that he interprets to be an observed instance of the 1,3,5,... pattern
   a. Data points: 33, 130, 298, 526, 824, 1192, 1620, 2123 [2104], where latter is taken to be a correction
   b. Compared with: 33, 132, 297, 528, 825, 1188, 1617, 2112
2. Outfitted inclined planes with frets that would yield slight sound when ball passed, and then moved frets until ball passed each in uniform times