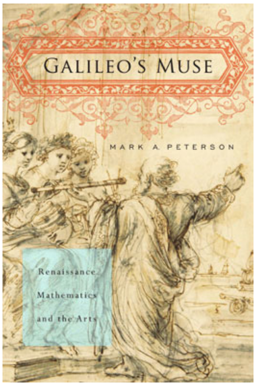

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Book Review

Mark A. Peterson

Galileo's Muse: Renaissance Mathematics and the Arts

Cambridge, MA: Harvard University Press, 2011

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Galileo Galilei (1564-1642) was one of the universal thinkers of the late Renaissance who was at home in both of the "two cultures", the sciences and the humanities, although today we think of him almost exclusively as a scientist, and in a still more restricted sense, as an astronomer. Mark Peterson's recent study, *Galileo's Muse*, does much to broaden our conception of the man known as the "the Father of modern science". This is no easy task, as Peterson notes:

> Galileo's mathematics is just as essential to his humanism as is his erudition in the arts, but studying these things in combination requires more kinds of expertise than perhaps anyone can honestly claim (p. 6).

One kind of expertise that he drew on in painting a new picture of Galileo was a knowledge of Dante (1265-1321 ca) and some of the imagery used in his *Divine Comedy*. Dante is convincingly presented as a precursor of Galileo.

The book begins with an introduction to Galileo himself, his background and especially his education: two years of formal education at a monastery, where he probably mastered Aristotelian logic; he also became well-versed in Latin and, at the knee of his father, Vincenzo Galilei, music theory. Then, when he was 19, came a life-changing encounter with Euclidian geometry, studied under the guidance of Ostilio Ricci (1540-1603), court mathematician to Medici Grand Duke Francesco I. Along the way he also became accomplished in drawing, painting and poetry: a true Renaissance man.

But what was mathematics to Galileo? According to Peterson, "What Galileo overheard from Ostilio Ricci was just … an abstraction" (p. 25), one whose meaning was unclear. What Galileo did over the course of his life was to try to make that meaning explicit and crystal clear.

Some of the ways he did this are evidently drawn from classical sources. What Peterson argues is that Galileo's most important sources were not the works and authors of the two major periods that preceded Galileo's own – the Roman and the Medieval– but of classical Greece (with one significant exception, Dante). The Renaissance was the period that brought many classical treatises back to light, but the science of Galileo's day

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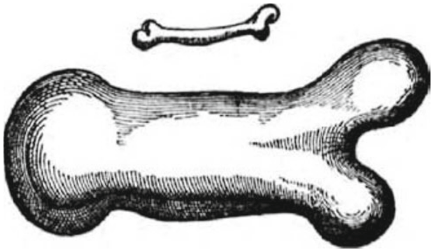
– indeed, Galileo himself – was pushing the envelope, giving mathematics new applications and new meanings that went beyond where the Greeks had taken it. For example, Peterson lists four of the possible meanings of geometry when Galileo was studying it: 1) an intellectual ornament for the nobility and those frequenting the nobility; 2) a body of finite knowledge perfected in an earlier epoch, rediscovered and transmitted, to be studied, understood and especially safeguarded, but not enlarged upon; 3) a practical tool in the day-to-day business of commerce, surveying, construction and so forth; 4) the geometry of astronomy, in the context of the Quadrivium, taught in the university. One of Galileo's achievements was to add a fifth meaning to that list: geometry as a metaphor for nature, a tool for understanding the world around us.

One of the very interesting aspects of *Galileo's Muse* is that it paints a very good picture of how science, including mathematics, is *done*: coming across a problem by reading, hearing, picking up or observing, then thinking, reasoning and insight, then experiment, then proof.

A clear, concrete example is Galileo's discovery of and work with the scaling laws, one of his best known results (a more detailed examination of Galileo's scaling laws than the one presented in *Galileo's Muse* is given in [Peterson 2002]). He began working with scale in a reflection on the dimensions of Hell as depicted by Dante. Seeking Medici patronage, in 1588 a young Galileo presented two lectures comparing rival architectural models of Dante's description in the *Inferno*. One of the key questions was whether the roof in the scheme conceived by Florentine architect Antonio Manetti (the one the audience of the lectures was rooting for) would be strong enough to support itself. In his lecture Galileo maintained that it would, a provided an explanation based on dimensions and scaling to support that. Sometime later, however, he became aware of a ghastly error in his reasoning: the model he had upheld as correct was actually fatally flawed. The reason lay precisely in scaling:

> Galileo had described a roof like a dome thirty braccia wide and four braccia thick … as evidence that a roof 3,000 miles wide and 400 miles thick would be strong enough. The small scale model *would* be strong enough, but just barely. … Scaling it up by one braccia to 100 miles is a factor of 300,000. As Galileo had now realized, the scaled-up dome of Manetti's Inferno would be weaker by that same enormous factor and would instantly fall… (p. 228).

It isn't known exactly when Galileo discovered his error, as he must have taken great pains to keep it a secret. But he did finally publish his correct scaling laws fifty later, in his *Two New Sciences* published in 1638, his last book and just four years before his death. There the scaling laws are presented in relation to the arts of shipbuilding (large ships out of water are liable to break under their own weight, where smaller ships do not) and architecture (a wooden beam's strength in resisting moment depends on the proportion of the transverse force to the cube of the beam's diameter). The famous explanation given to illustrate the scaling laws clearly and explicitly is that of why it is impossible for there to be a giant man, based on how large the bones would have to be:



In *Two New Sciences*, written in dialogue form to engage the reader and allow Galileo to use a Socratic method in expounding his discoveries, we have in his own words all the steps in doing science. Coming across a problem: “At times also I have been put to confusion and driven to despair of ever explaining something for which I could not account, but which my senses told me to be true” [Galileo 1914: 1]. Thinking, reasoning, insight: “My mind, like a cloud momentarily illuminated by a lightning-flash, is for an instant filled with an unusual light, which now beckons to me and which now suddenly mingles and obscures strange, crude ideas” [Galileo 1914: 3]. Trial and error: “… if we take a wooden rod of a certain size and length, fitted, say, into a wall at right angles, i.e., parallel to the horizon, it may be reduced to such a length that it will just support itself, so that if a hair’s breadth be added to its length it will break under its own weight” [Galileo 1914: 4]. Proof: “…we can demonstrate by geometry” [Galileo 1914: 3].

The valuable addition of Mark Peterson is putting Galileo’s well-known discovering of his scaling laws into relation with the little-known lectures on the *Inferno*, allowing us to see how an error led to a correct discovery, in short, how science is done.

The lengthy middle section of the book is devoted to the book’s subtitle, *Renaissance Mathematics and the Arts*, and is a discussion of poetry, painting, music and architecture seen through the lens of mathematics. The figures encountered here are well-known: Pacioli, Leonardo, Kepler, Vitruvius. Peterson covers some familiar ground in this discussion of arts and sciences in the Renaissance: classical studies on optics and the discovery of perspective; Platonic solids and golden section; Greek musical theory and the music of the spheres. What is less standard is the inclusion of poetry and specifically Dante. In attempting to depict the universe, the poet was struggling with the two seemingly irreconcilable attributes of God, that of being at once both the edges and the center, qualities described by Robin Evans as envelopment and emanation [Evans 1995: 23]. Here Dante is convincingly depicted by Peterson as building on Aristotle’s *On the Heavens* in envisioning Dante and Beatrice in a hypersphere, a device Dante arrived at to depict a finite universe with no edges. Further, Dante’s vision of God at the poem’s end is based on Archimedes’s *On the Measure of the Circle*. Nowadays the study of the *Divina Commedia* is limited to specialized courses in literature. In the Renaissance, however, it was familiar fare, long passages of it were often quoted from memory, and its vivid depiction of the universe taken as genuine cosmology. (In Italy it is still studied in high schools and recently the comedian Roberto Benigni, known to most English speakers for his exuberance at the 1999 Academy Awards, presented a recitation on Italian national television of various canti from the *Divina Commedia* which was absolutely spell-binding, as the high viewer ratings show.) It may have been Dante’s exceptional capacity to paint complex mathematical ideas in words that allowed him to provide precisely the meaning of mathematics that the textbooks and treatises did not.

The value of *Galileo's Muse* for this reviewer is the fine job it does of restoring lost knowledge. Knowledge can be lost for two reasons: 1) the time distance; and 2) cultural slant. Galileo is by now "famous" for his dispute with the Church regarding Copernican cosmology, and that single episode has overwhelmed all else that contributes to a well-rounded portrait of him. In other words, he has become a step along the way of a particular narrative of Western cultural history. So yes, he remains known to us, but rather as a two-dimensional billboard that puts all his other aspects in shadow. Except for a brief, almost obligatory mention in the Epilogue, Peterson avoids this episode of Galileo's life altogether in order to paint a new picture.

The final question is, of course, who was Galileo's muse? Of the nine muses, only one concerns herself with a science: Urania, muse of astronomy. Thus Peterson argues that we need a new muse:

> "a Muse of Earthly Things, or a Muse of Mathematical Experimental Science. If Astronomy could have a muse in Hellenistic times, then surely these more modern subjects, so aptly associated with Galileo, could have one now. There are many practicing scientists who would be glad to imagine that this Muse was hovering nearby to symbolize to others, or even to themselves, what it is that they do. … Such a divinity would personify Galileo's notion of science with about the right mix of seriousness and lightness…" (p. 297).

He suggests a name; can you guess it?

Galileo's Muse is rather oddly poised between being a scholarly work and a work for a broader readership. The rather general chapters dealing with the arts indicate that the reader was thought to be more familiar with sciences than with the arts (Peterson himself is a physicist and a mathematician). The notes are kept to a minimum, and there is no bibliography, although it is clear that a great deal of secondary literature was consulted, not to mention Galileo's own works. For the layman, a guide to further reading would have been helpful; for the more specialized reader, a bibliography of primary and secondary sources seems in order. This puts the burden on the reader to search for more information, but this is a minor flaw in an otherwise delightful study, one in which even readers with a good background in Renaissance sciences and the arts will find many new insights.

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About the reviewer

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