

F. Commandino, de centro gravitatis solidorum, 1565

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Objektyp: **Article**

Zeitschrift: **Elemente der Mathematik**

Band (Jahr): **73 (2018)**

Heft 4

PDF erstellt am: **08.08.2024**

Persistenter Link: <https://doi.org/10.5169/seals-787384>

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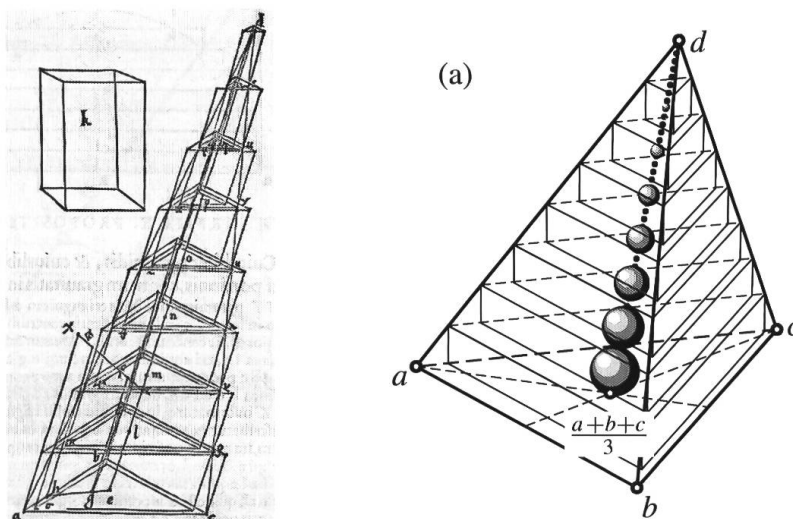
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Short note **F. Commandino, de centro gravitatis solidorum, 1565**

Gerhard Wanner

The importance of Federico Commandino (1506–1575) cannot be better described than by quoting E. Rosen¹: “In the sixteenth century, Western mathematics emerged swiftly from a millennial decline. This rapid ascent was assisted by Apollonius, Archimedes, Aristarchus, Euclid, Eutocius, Heron, Pappus, Ptolemy and Serenus – *as published by Commandino*”.

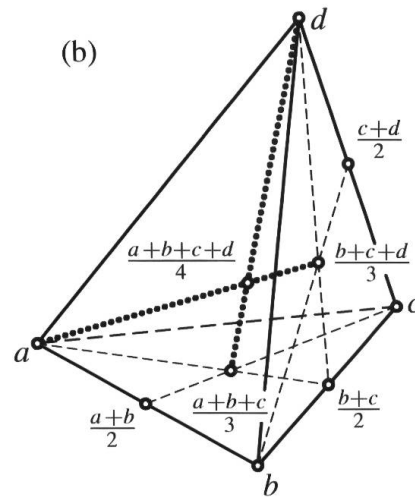
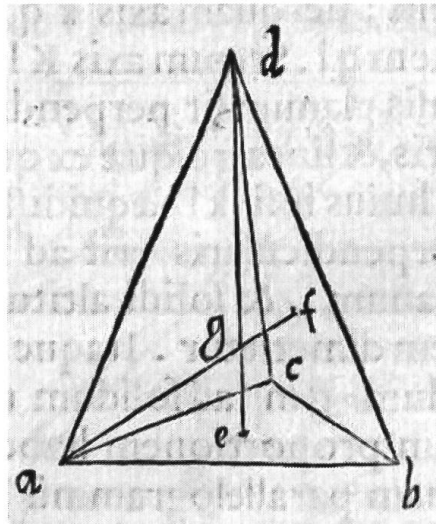
In addition to all this extraordinary editorial work, Commandino also developed his own research in [1] (4½ centuries ago), among which the determination of the center of gravity of the Tetrahedron led to one of the first new theorems above the Greek heritage.



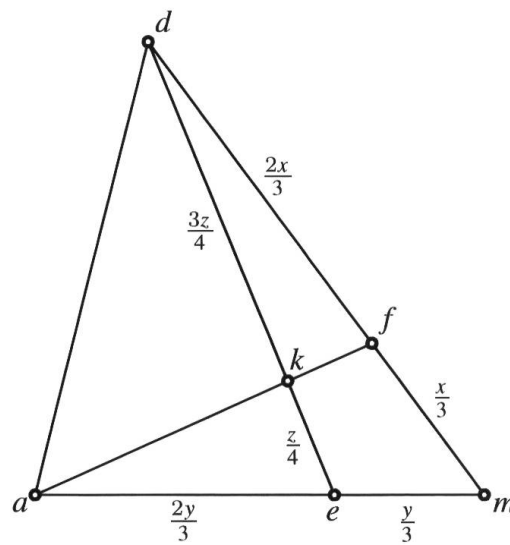
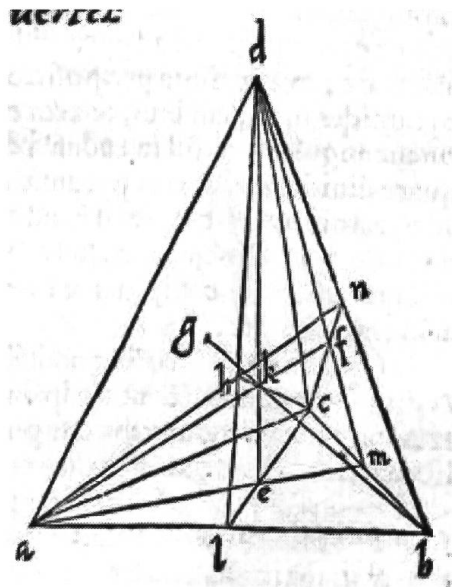
Theorema X. “*pyramidis ... centrum grauitatis in axe consistit*” [The barycentre of a tetrahedron lies on the median (i.e., the line connecting a vertex to the barycenter of the opposite triangle)].

¹Biography in *Dictionary of Scientific Biography*, New York 1970–1990, also reproduced in www-groups.dcs.st-and.ac.uk/history/Biographies/Commandino.html

Proof (inspired by Archimedes' *Equilibrium of planes*). Concentrate the masses of slim triangular prisms² in their centre of gravity, all lying on the median, and then concentrate *these* masses in one point, which lies on the median, too.



Theorema XIII. “*grauitatis centrum est in puncto, in quo ipsius axes conueniunt*” [The barycentre of a tetrahedron lies on the point where medians meet].



Sit pyramis, cuius basis triangulum a b c; axis d e; & grauitatis centrum K. Dico lineam d k ipsius K e triplam esse.

Theorema XVIII. “*Dico lineam dk ipsius ke triplam esse*” [The centroid divides the medians in ratio 3 : 1].

²If you look closer, you see that Commandino, like Archimedes, distinguished carefully between “upper and lower Riemann sums”. Also the method of indirect proofs, by drawing the points g, f and χ , was adopted from Archimedes.

Proof. We consider Commandino's triangle amd , where m is the mid-point of bc (see Figures). We know from Archimedes that f and e , which are the barycenters of two triangular faces, cut *their* medians, of lengths x and y respectively, in ratio $2 : 1$.

We reduce Commandino's proof, which extends over 2 pages, to one line by applying Menelaus' Theorem for the triangle dem (see, e.g., [3, pp. 87–88])

$$\frac{ek}{kd} \cdot \frac{df}{fm} \cdot \frac{am}{ae} = 1 \quad \text{or} \quad \frac{ek}{kd} = \frac{1}{2} \cdot \frac{2}{1} = \frac{1}{3},$$

which is the stated result. □

Remark. Exactly the same idea, after applying a second time Menelaus' Theorem to the triangle dea and dividing the results, allowed al-Mu'taman ibn Hūd (11th century) to give the first proof of what many centuries later became known as "Ceva's Theorem" (see [2]³).

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Acknowledgement. Thanks to Christian Aebi for suggestions.

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- [1] Federici Commandini Urbinatis, *Liber de centro gravitatis solidorum*, Bononiæ, Ex Officina Alexandri Benacii. MDLXV (Bologna 1565).
- [2] J.P. Hogendijk, *The lost geometrical parts of the Istikmāl of Yūsuf al-Mu'taman ibn Hūd (11th century) in the redaction of Ibn Sartaq (14th century): an analytical table of contents*, Arch. Internat. Hist. Sci. 53 (2003) 19–34.
- [3] A. Ostermann, G. Wanner, *Geometry by its history*, Springer, 2012.

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³The author is grateful to D. Paunić for this reference; see also the Proceedings of ICM 1994, Zürich, p. 1570.