

Symphilosophie

International Journal of Philosophical Romanticism

On Mathematical Thinking

J.W. von Goethe

Translated and Introduced by David W. Wood*

The following is a brief selection of miscellaneous excerpts drawn from Goethe's oeuvre that I have assembled together under the title "On Mathematical Thinking." The original German sources for this English translation are signaled in the footnotes.¹

There exist a number of informative studies on Goethe and mathematics.² However, it is not as well-known as it should be, even among scholars of Goethe's natural scientific writings, that his main scientific work is grounded in a *qualitative* form of mathematical thinking in the axiomatic Euclidean tradition. Goethe presents and defends this deductive method especially in his essay "The Experiment as Mediator between Subject and Object." The idea of qualitative mathematical thinking and proceeding is repeatedly touched upon in many of the excerpts below.

In this journal it is worth noting in conclusion that Goethe was in favour of joint collaborations, i.e. symphilosophizing or sym-scientific work. He writes in the section on mathematics in his 1810 *Theory of Colour*:

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¹ Many of the German texts can be found among others in: J.W. Goethe, *Sämtliche Werke, Schriften zur Allgemeinen Naturlehre, Geologie und Mineralogie* (henceforth: SAN), eds. Wolf von Engelhardt, Manfred Wenzel, I. Abteilung, Band 25 (Frankfurt am Main: Deutscher Klassiker Verlag, 1989), pp. 34-35, 65-77, 87-92; 906-912.

² Among others, see: Martin Dyck, "Goethe's Views on Pure Mathematics", *Germanic Review* 31/1 (1956): 49-69; Renatus Ziegler, *Goethes Ideen zur Mathematik. Materialien zu Goethes Mathematikverständnis* (Dornach, 1993); Troy Vine, "Goethes Newton-Kritik als interne Kritik", in: A. Klug et al (eds.) *Goethe, Ritter und die Polarität: Geschichte und Kontroversen* (Brill, 2021), 31-58.

... we should get accustomed to working collaboratively. To be sure, we live in an epoch that is diametrically opposed to this ideal. Everyone wants to be original in their views, and independent in the conduct of their lives and activities from the efforts of others, or at least convince themselves that they are. It can be often observed that certain people, who despite having accomplished a good deal, only quote themselves – their own writings, journals, or compendia. It would be much more beneficial for the individual and the world if people joined together in collaborative projects.³

³ Goethe, *Zur Farbenlehre* (On Theory of Colour), vol. 1 (Cotta: Tübingen, 1810), § 728, p. 271.

I hear that I'm accused of being an adversary, an enemy of mathematics in general. However, no one values mathematics more highly than myself, for it accomplishes exactly what is wholly denied to myself to achieve. Concerning this I would gladly clarify my position and choose to this end a single means – the words and lectures of other significant and notable people.¹

We should learn from mathematicians that circumspect manner of only connecting together what is most immediate, or rather of only deriving the most immediate from the most immediate. And even there, where no calculation is required, we should proceed as though we were accountable to the most stringent geometer.

For on account of its deliberation and purity it is actually the mathematical method that immediately exposes every jump in an assertion. Its proofs are nothing more than elaborate explanations of connections that were already implicitly there in the basic parts, and the results are considered correct and irrefutable in their entire scope and under all conditions. Hence, its demonstrations are actually more *expositions and recapitulations* than *arguments*. Since I have drawn this distinction here, please permit me the following overview.

There is a considerable difference between a mathematical demonstration – in which basic elements are arrived at by means of numerous interconnections – and a proof based on the arguments of a clever orator. Arguments can contain completely separate facts, and yet intelligence and imagination may sufficiently bring them together into a single point to generate a surprising semblance of right or wrong, of truth or falsity. Similarly, if a person wishes to support a particular hypothesis or theory, it is possible to devise certain experiments – just like in an argument – in order to carry out a more or less deceptive proof.²

¹ Goethe, “Über Mathematik und deren Missbrauch” (On Mathematics and its Misuse), SAN, 65.

² Goethe, “Der Versuch als Vermittler zwischen Objekt und Subjekt” (The Experiment as Mediator between Object and Subject), 1792/1823, SAN, 34-35.

I revere mathematics as the most sublime and useful science as long as it's applied in its rightful place. I can't praise it at all when people misuse it for matters that don't belong in its domain. This noble science then appears as nonsense. As if something only exists when it can be mathematically proven. It would be foolish for a young man to disbelieve in his beloved's love just because she cannot mathematically prove it to him! She can mathematically prove her dowry to him but not her love. Remember, it wasn't a mathematician who discovered the metamorphosis of plants! I accomplished that without mathematics and the mathematicians had to accept it. In order to grasp the theory of colour nothing more is required than pure observation³ and a sound mind. Unfortunately, both are rarer than you'd think.⁴

Relationship of the Theory of Colour to Mathematics⁵

§ 722

One could demand of a physicist – who seeks to comprehensively treat the theory of nature – that he ought to be a mathematician. In earlier epochs mathematics was the supreme instrument through which researchers hoped to take possession of the secrets of nature. Unsurprisingly, the art of measurement is still dominant in certain branches of natural science.

§ 723

The author cannot boast of any expertise in this regard, and therefore remains in those regions that are independent of the art of measurement, regions which have become more broadly opened up in modern times.

§ 724

Everyone agrees that to a certain degree mathematics – as one of the most remarkable human faculties – has been of considerable benefit to physics. However, it is also undeniable that a misapplication of its methods has at

³ *reines Anschauen* – also translated as pure intuition.

⁴ Goethe, *Conversation with Eckermann*, 20 December 1826.

⁵ Goethe, *Zur Farbenlehre* (On Theory of Colour), vol. 1 (Cotta: Tübingen, 1810), 269-271.

times harmed this science. This is now being reluctantly admitted in some quarters.

§ 725

In this regard the theory of colour has particularly suffered, and its progress has been especially hindered by conflating it with optics as such, a field that does indeed require measurement. Even though the theory of colour can be studied completely independently of optics.

§ 726

That unfortunate state of affairs then occurred in which a great mathematician became possessed of a false notion concerning the physical origin of colour. Due to his lofty achievements as an expert in the science of measurement the mistake that he made as a natural scientist long became sanctioned by a world that continues to be entangled in prejudices.⁶

§ 727

The author of the present treatise has attempted to keep the theory of colour completely separate from mathematics, even though it is obvious that it would be desirable to treat certain points with the aid of measurement. Had not a few unbiased mathematicians, with whom he has had the good fortune of dealing with, not been prevented from joining forces with him due to other work, then a treatment of the subject from this perspective might have been full of merit. However, this deficiency might also end up proving advantageous, insofar as it is now up to gifted mathematicians themselves to discover where the theory of colour requires their assistance, and where they could make their own contribution to the perfection of this branch of natural science.

⁶ A reference to Isaac Newton's optics.

More on Mathematics and Mathematicians⁷

Tycho Brahe, a great mathematician, was only able to partly break free of the old system, which was at least in line with the senses. However, wishing to be right he sought to replace it with a complicated framework that could neither be perceived by the senses nor attained in thought.

Newton has such a lofty reputation as a mathematician that one of his clumsiest errors, namely that clear, pure and eternally unadulterated light is composed of dark light, has persisted to this day. And isn't it mathematicians who continue to defend this absurd error, who like bad listeners merely repeat words that don't make any sense?

Mathematicians are concerned with the quantitative, with everything that can be determined by number and measure, and therefore in a certain sense with the externally knowable universe. However, if we consider the universe according to our own abilities and with the utmost intelligence and in all its ramifications then we will realize that quantity and *quality* should count as the two poles of phenomenal existence. This is why mathematicians so greatly elevate the language of their formulas – in order to additionally capture as much as possible the immeasurable within the measureable and countable world. Everything then appears comprehensible, understandable, and mechanical to them. Yet by attempting to grasp the immeasurable – what we call God – mathematicians are suspected of harboring a clandestine form of atheism, for they do not seem to ascribe any special or unique kind of existence to it.

Maxims and Reflections⁸

Mathematics, like dialectics, is an organ of the higher inner sense. The exercise of it is similar to the art of eloquence. For the two of them nothing is of value except the form; the content is not of importance. Whether mathematics calculates pennies or guineas, whether rhetoric defends the true or false, is altogether one and the same to them.

⁷ Goethe, "Fernerer über Mathematik und Mathematiker", SAN, 87.

⁸ Goethe, "Betrachtungen und Aphorismen", SAN, 120.

However, here it depends on the nature of the person working in this occupation or practicing this kind of art. A formidable lawyer defending a just case or a powerful mathematician contemplating the starry heavens – both equally appear godlike.

In mathematics, what is more exact than exactness itself? And is the latter not a consequence of an inner feeling for the truth?

The mathematician is perfect only to the extent he is a perfect human being, insofar as he can inwardly experience the beauty of truth within himself. Only then will he appear thorough, lucid, circumspect, pure, graceful, and even elegant. All this is necessary to become like *Lagrange*.

It doesn't follow that the hunter who kills the game also has to be the cook who prepares it for dinner. By chance a cook could join the hunt and shoot well. But he'd be drawing the wrong conclusion if he thought that one has to be a cook in order to shoot well. That's how those mathematicians appear to me who maintain that with regard to physical things you cannot see or discover anything if you aren't a mathematician. They should be happy when someone brings something into the kitchen for them so they can sprinkle their formulas over it and prepare it how they wish.⁹

Various sayings in antiquity, which are frequently repeated, actually had a completely different meaning from the one attributed to them in later times. The saying: "Let no one unacquainted or ignorant of geometry enter the philosopher's school", does not mean you have to be a geometer to become a sage. Rather, one had in mind here the first elements of geometry as they are presented in Euclid, just as every beginner commences with them. In this sense geometry constitutes the most perfect preparation, indeed, the most perfect introduction, to philosophy itself.¹⁰

Mathematicians are like a species of Frenchmen: whatever you say to them they translate into their own language and suddenly it becomes something entirely different.¹¹

⁹ Goethe, "Maximen und Reflexionen", in: *Goethes Poetische Werke, Vollständiger Ausgabe*, vol. 2 : *West-östlicher Divan, Epen, Maximen und Reflexionen* (Cotta: Tübingen, 1950), 835.

¹⁰ Goethe, "Maximen und Reflexionen", *ibid.*, 755.

¹¹ Goethe, "Maximen und Reflexionen", *ibid.*, 835.

It is said that mathematics is certain; yet it is no more certain than any other kind of knowledge and acting. It is only certain when it intelligently deals with things of which we can be certain, and to the extent that they lead to certainty.¹²

When a boy begins to understand that an invisible point has to precede a visible one, and that the shortest path between two points has to be conceived of as a line even before it is drawn on a piece of paper, he feels a certain pride and satisfaction. And justifiably so, for the source of all thought has now been revealed to him – he has become clear about the idea and the realized, about *potentia et actu*. The philosopher cannot teach him anything new; the geometer has already unveiled the foundation of all thought.¹³

¹² Goethe, “Maximen und Reflexionen”, *ibid.*, 850.

¹³ Goethe, “Maximen und Reflexionen”, *ibid.*, 756.