Chapter 41

WHAT IS THE PROPER ROLE OF MATHEMATICS IN PHYSICS?

> *"Mathematics is largely a science of absolutes. Physics is largely a science of relationships. One must be very careful when attempting to relate one to the other."*
>
> *Anonymous*

The science of physics deals with our physical experiences with respect to the phenomena of nature, which we can observe with our senses or detect and measure with our technologies and our experiments. Based on the above, we attempt to discover relationships (connections or parallelisms) between such experiences that may increase our knowledge and allow us to make certain conclusions or generalizations, which we call theories or laws of nature. Mathematics may assist the physicist to recognize and understand certain relationships and parallelisms between measurements that are "not at all predictable or discoverable without the use of mathematics." (Dingle, 1972, p.123)

> "By extending this [process] over as wide a range of measurements as possible, we reach the vast body of related experiences that constitutes modern physics." (*Id.*)

Richard Feynman agreed with this role of mathematicians assisting physicists. "[M]athematical reasonings which have been developed are of great power and use for physicists." (Feynman, 1950, p. 50) For example, "mathematics has a tremendous application in physics in the discussion of detailed phenomena in complicated situations…" (*Id.*, p. 30) This type of application may help physicists to predict, recognize or discover physical laws. Likewise, mathematical parallelisms may help physicists to generalize a physical law, or to relate or unify several laws.

Mathematics may also help physicists to express, analyze, understand, and confirm an experiment or a physical law. Take, for example, Kepler's second law of planetary motion: 'The ellipse of a planet's orbit sweeps equal areas in equal times.' This physical law may be expressed in several ways: by experience (empirical measurements), by words, by geometry, by algebraic symbols and by calculus. The last four methods impart much more meaning in much less time than the first. They also helped Newton to analyze, understand, and confirm Kepler's second law and relate it to gravitation. (see Feynman, 1965, pp. 34 – 39) However, unless the first method occurs and it is correct, the last four methods basically constitute only meaningless speculation or calculation. In other words, if our experiences, measurements, experiments, observations, interpretations and/or our basic premises are not correct, then no amount of words, logic or mathematical reasoning based thereon can make them meaningful or empirically valid.

On the other hand, the conventions of "mathematics…[are] independent of experience," observations and measurements. (Dingle, 1972, p. 122) "Mathematics…belongs wholly to the realm of pure thought."[1] (*Id.*) The numerical symbols that constitute arithmetic, and their rules of addition, subtraction, multiplication, division, etc., have nothing to do with experience. The arbitrary symbols (i.e., lines, circles, etc.) of geometry, Euclidian or otherwise, and the axiomatic disciplines that may be assigned to them, have little or nothing to do with experience. Likewise, the letter symbols of algebra, and the disciplines that may be assigned to them, have nothing to do with experience. (*Id.*) These realms of mathematics are entirely composed of manmade conventions.

[1] In this regard, mathematics is similar to the physics of the Greeks, which was based primarily upon thought and reason, rather than on observation or experimentation. (see Chapter 2)

> "[A]ll that is required of or implied by the resulting corpus of theorems is that it conforms faithfully to" such symbols and disciplines. (*Id.*, p. 123)

Mathematics is a language, but it "is *not* just another language." (Feynman, 1950, p. 34)

> "Mathematics is a language plus reasoning; it is like a language plus logic. Mathematics is a tool for reasoning. It is in fact a big collection of the results of some person's careful thought and reasoning. By mathematics it is possible to connect one statement to another. (*Id*.)

> "The apparent enormous complexities of nature, with all its funny laws and rules…are really very closely interwoven. However, if you do not appreciate the mathematics, you cannot see, among the great variety of facts, that logic permits you to go from one to the other." (*Id*., p. 35)

Thus, "mathematics is just organized reasoning." (*Id*.)

It is one thing to state that: "physics…must be mathematical." (Feynman, 1965, p. 45) It is quite another to suggest that 'physics is mathematics,' as many current mathematical physicists state or imply. Did Feynman try to assert this conclusion? No.

> "Physics is not mathematics, and mathematics is not physics. One helps the other. But in physics you have to have an understanding of the connection of words with the real world. It is necessary at the end to translate what you have figured out into English, into the world, into the blocks of copper and glass that you are going to do the experiments with. Only in that way can you find out whether the consequences are true. This is a problem which is not a problem of mathematics at all." (Feynman, 1965, p. 49)

> "Mathematicians are only dealing with the structure of reasoning and they do not really care what they are talking about. They do not even need to *know* what they are talking about, or, as they themselves say, whether what they say is true." (*Id*.)

> "In other words, mathematicians prepare abstract reasoning ready to be used if you have a set of axioms about the real world. But the physicist has meaning to all his phrases." (*Id*.)

> "Mathematicians like to make their reasoning as general as possible,…[whereas] the physicist is always interested in the special case." (Feynman, 1950, p. 50) "[T]he poor mathematician translates [the special case] into equations, and as the symbols do not mean anything to him he has no guide but precise mathematical rigour and care in the argument." (*Id*.)

Therefore, it is up to the physicist to narrow the scope of the problem and define what is required of the mathematician in rather specific terms.

Strangely enough, Feynman concluded his discussions on the relation of mathematics to physics with the following observation: "the mathematical rigour of great precision is not very useful in physics." (*Id*., pp. 50 – 51) The reason is that great precision can dampen or limit the intuition and creative imagination of the physicist, which he needs in order to modify his original ideas or guess at new solutions. (*Id*., p. 51) An approximate mathematical conclusion is often more helpful.

Dingle concluded that there is a "contingent element in the relation between mathematics and experience." (*Id.*, p. 124) We can only discover by the process of trial and error that parallelisms that may be revealed by mathematics actually physically apply to a specific range of experiences. In other words, we can only confirm or disprove such mathematical parallelisms by experience itself. (*Id*.)

> "It is the insight of this fact, and the <u>illegitimate</u> assumption that there is some *necessity* for whatever is <u>true in mathematics</u> to impose its inevitability on experience, that is primarily responsible for the [theory] of special relativity…" (*Id.*)

> "…[T]he basic misconception of modern mathematical physicists [which results in "wild speculations"]…is the idea that <u>everything that is mathematically true must have a physical counterpart</u>; and not only so, but must have the particular counterpart that happens to accord with the theory that the mathematician wishes to advocate." (Dingle, 1972, pp. 124-125)

On the contrary, it can be demonstrated that not everything that is mathematically true must have a physical counterpart. Take, for example, the simple mathematical equations $1 + 1 = 2$ or $x + x = 2x$. Mathematical generalizations of these equations are not necessarily physically true. "If we add one drop of water to one drop of water we get not two drops of water but one larger drop. [In biology], if we add one rabbit to one rabbit we may get a continent of rabbits. Even believers in special relativity will assert that if we add a velocity of 1 foot a second to a velocity of 1 foot a second we get a velocity slightly less than 2 feet a second." (Dingle, 1972, p. 125)

> "So it is with other operations of mathematics. In algebra, if a = b, then 2a = 2b. This was applied in the Middle Ages to prove the immortality of the soul. To be half dead was the same as to be half alive: double both, and it follows that to be dead is to be alive." (*Id*.)

Dingle, then described several other examples of the above misconception, and concluded:

> "I think these are enough to show how general and how dangerous is the prevailing illusion that all that is necessary to entitle a physical theory, however absurd, to respect is to discover some mathematical process whose symbols can be arbitrarily correlated with the physical entities of the theory, without regard to evidence or probability or commonsense. We shall see in due course that the supposed justification of special relativity by the 'mathematicians,' to whom the 'experimenters' entrust it, lies wholly in the impeccability of its mathematical structure; the impossibility of the application to experience of that structure, in the manner postulated by the theory, is left out of consideration altogether." (Dingle, 1972, p. 127)

Thus, by the axiomatic process of mathematics alone, the "modern mathematician imagines, and persuades others, that he is discovering the secrets of nature." [2] (*Id.*, p. 128)

This process of mathematicians persuading and even dictating to physicists (experimenters) what they should observe and believe, often results in at least three unscientific consequences: 1) "the invention [by physicists] of unobserved phenomena to suit the mathematics" (Dingle, 1972, p. 131); 2) the literal or physical interpretation by

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[2] "The processes of mathematics are to be contrasted rather than identified with the process of rational thought." (Dingle, 1972, p. 128) It should be noted that Professor Dingle has ample credentials to make these judgments. He was a mathematical physicist, he wrote extensively on the subject of Special Relativity, and at one time in his career he was the President of the Royal Society.

physicists of mathematical metaphors [3] (*Id.*, p. 141); and 3) making it acceptable and even fashionable for physicists to condemn and ridicule rational thinking and common sense.

Bertrand Russell also described what can happen when mathematics is arbitrarily applied to the physical world:

> "The aim has been to obtain mathematical laws which gave correct results wherever they could be tested by observation. The fewer and more general and more comprehensive the laws, the more scientific taste was gratified…<u>But at every stage the subject-matter of physics grows more abstract, and its connection with what we observe grows more remote</u>." (Russell, 1927, p. 87)

> "[For example, with Minkowski's relativistic mathematical world of space-time] we start from the formula for interval [ds^2] (together with certain other assumptions), and we deduce by mathematics a world having certain mathematical characteristics." (*Id.*) "[This] world of…deductive relativity-theory is <u>wholly abstract</u>." (*Id.*, p. 88)

When a mathematical physicist then adds inductive reasoning to his deductive reasoning:

> "the same mathematical characteristics are arrived at, but they are now those which may be supposed to belong to the physical world <u>in its entirety</u> if we supplement observation by means of the postulate that everything happens in accordance with simple general laws. (Russell, 1927, pp. 87 – 88)

> "The appearance of <u>deducing actual phenomena from mathematics</u> is delusive; what really happens is that the phenomena afford inductive verification of the general principles from which our mathematics starts. Every observed fact retains its full evidential value; but now it confirms not merely some particular law, but the general law from which the deductive system starts. There is, however, no logical necessity for one fact to follow given another, or a number of others, because <u>there is no logical necessity about our fundamental [mathematical] principles</u>." (*Id.*, p. 88)

In other words, we arrive at generalized circular imaginations and bootstrap speculations.

One of the earlier examples of such unscientific application of mathematics to physics was Lorentz's 1904 transformation theory, which theoretically resulted in the

[3] Dingle also gave several examples of such unscientific consequences.

unobserved phenomena of contracted matter and expanded time as the result of the falsely assumed absolute velocity of matter with respect to a hypothetical substance called ether. A year later, in June of 1905, Albert Einstein modified and extrapolated Lorentz's mathematical metaphors to new heights of speculative imagination with his contrived mathematical Special Theory of Relativity.

It is true, as stated by D'Abro, that mathematics can give us "a deeper insight into the problems of nature, revealing unsuspected harmonies and extending our survey into regions of thought whence the human intelligence would otherwise be excluded." (D'Abro, 1950, p. v) There are many examples of these insights in science: Kepler's discovery of mathematical relationships between the planets, their orbits and the Sun; the mathematical discovery of the planet Neptune; Maxwell's mathematical descriptions of electromagnetics and EM radiation (light); and the part played by mathematics in developing the atomic bomb. These are only a few obvious examples.

However, in the last analysis, mathematics is only a tool and a logical language that can be applied by the human mind. Its effectiveness is directly related to and limited by the intelligence, experience, knowledge and competence of the person who applies it. If the person who applies mathematics to physical experiences and measurements is basically operating under fundamental false assumptions, then the mathematical results will most likely be just as flawed, because they also will reflect, describe and extend such false assumptions. Similarly, if alleged physical experience and measurements are in fact primarily or solely based upon someone's imagination, then the mathematical results will also be *ad hoc*, abstract and not based upon any empirical observations or experiments. More often than not they will be meaningless and worthless.

What happens if the mathematician then takes such flawed mathematical results and attempts to extend them by the means of further imagination, speculation and extrapolation? Such extensions, speculations and extrapolations will most likely suffer the same fate. At this point, we will be far removed from the original lofty goals for mathematics with which we started this discussion.

In this treatise, we have demonstrated that all of the above unscientific scenarios are what happened with respect to Einstein's Special Theory of Relativity. For example, Einstein falsely assumed that the limited terrestrial concept of Galileo's Relativity was a universal law of nature, and that its mathematical counterpart (vis. the 'Galilean transformation equations') was the physical equivalent of the real thing. Based on the null results of numerous electromagnetic experiments, Einstein falsely assumed and postulated that a radical mathematical version of Galileo's Relativity should apply to electromagnetics and light as well as mechanics. Einstein also misapplied such Galilean transformation equations of mechanics to the constant transmission velocity of light at c, and falsely assumed that such constant velocity of light at c changes to c – v or c + v when referred to material objects moving linearly at v. He then incorrectly assumed and postulated that a light ray propagates at the same constant rate of speed relative to a stationary object and relative to a linearly moving object, which (of course) is an impossibility.[4] (D' Abro, 1927, p. 162; Smolin, 2006, pp. 227 – 228)

Einstein then imagined radical new sets of mathematical transformation equations and laws of motion, which he assumed would be necessary in order to algebraically justify and confirm his false assumptions. They turned out to be the same transformation

[4] Einstein himself acknowledged this impossibility, unless time varies with relative velocity. (Einstein, early 1917, [Collected Papers, Vol. 7, p. 5])

equations that Lorentz invented in 1904 with similar mathematical consequences. Einstein also imagined various new concepts of measurement that he assumed would be necessary in order to justify his mathematical (Lorentz) transformation equations and his impossible velocity of light.

Einstein then began searching for mysterious experimental results that he could claim were explained by his new mathematical theory. He already knew that two radical mathematical consequences of his theory appeared to be a hypothetical explanation for the Michelson and Morley paradox: vis., the contraction of matter and the expansion of time depending upon relative velocity. But the real explanations of the M & M paradox are much different. (see Chapters 9 – 12) Einstein later claimed that his new theory explained the mysterious results of Fizeau's 1851 light experiment. In fact, there was only an approximate and coincidental correlation with Fizeau's experiment. (see Chapter 29)

Einstein applied the Lorentz transformations to the empirical Doppler effect of light, and two completely new mathematical concepts resulted. It turns out that neither was valid. (see Chapter 30) He also claimed that the similarity between a plotted curve of the Lorentz transformations and Kaufmann's 1901 – 1902 experimental results that suggested that electromagnetic mass increases with velocity was not merely a coincidence, but instead resulted from the predictive powers of his Lorentz transformations. Einstein's conjectures and speculations based on the mathematical consequences of the Lorentz transformations and their magical predictive powers seemed to be never ending.[5]

All of these conjectured claims and abstract predications resulted from applications of Einstein's *ad hoc* mathematical equations along with a few basic false assumptions and interpretations. The author does not believe that Einstein's wild speculations, radical metaphysical concepts and bizarre mathematical consequences were what Dingle, Russell, D'Abro, and Feynman had in mind when they described the proper <u>limited</u> role for mathematics in physics.

The necessity of defining and adhering to such a proper limited role is not to say that imagination in conjunction with mathematics cannot have a critical part to play in science. It can. Newton used his imagination to connect the falling apple with the orbiting Moon, and then with the aid of mathematics demonstrated an approximate correlation between the two. The structure of DNA was discovered by a leap of imagination that connected Rosalind Franklin's groundbreaking work with the double helix and mathematical data produced by others.

The connections between imagination and mathematics, which resulted in Maxwell's equations for electromagnetism and the transmission velocity of light at *c*, are perhaps unique in all of science. Maxwell imagined that a 'displacement current' existed in a dielectric (a non-conductor), which theoretically is impossible, in order to give his electromagnetic equations the symmetry and physical basis that he believed they needed.[6] He even postulated "the actual physical reality of his 'displacement current' as a justification for his mathematics." (Dingle, 1972, pp. 130 – 131) Maxwell then used

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[5] The above dubious claims are only a few that refer to Special Relativity. There are also many more similar examples with regard to the General Theory of Relativity and Einstein's mathematical cosmological theories.

[6] Maxwell got away with this 'artificial conception' of a 'displacement current' because the physical effect which it described does actually occur, but for a different reason. (Dingle, 1972, p. 131)

his imagination to complete the formulation of his equations based on illustrations and theories that he had derived from mechanics and the fictitious medium of stationary ether.[7] Nevertheless, against all odds, Maxwell's equations worked and they still describe or relate to all applications of electromagnetism.[8] Later, based upon a mathematical relationship contained in his equations, Maxwell guessed that light was an electromagnetic phenomenon, and that its velocity is *c*. He was right.

Regardless of Maxwell's outstanding unorthodox success, to use this unique and isolated example as a model for all mathematical theories to emulate would be very foolhardy indeed. Yet, this is exactly what occurred in physics after the ultimate triumph of Maxwell's equations in the 1890's:

> "Experiments more and more confirmed the deductions that were made from the theory when the symbols in the equations were given certain physical meanings, while the justification for giving the symbols those meanings continued to elude everyone. [In 1904], Lorentz generalized Maxwell's theory to make it apply to moving as well as static systems…and, all unconsciously, a state of mind was generated in physicists by which, while still formally adhering to the principle that observation was basic and mathematics a useful tool, they were ready to accept mathematical requirements as an adequate substitute for a genuine theory, even though they could see nothing intelligible that corresponded to it physically. It was a short step from acceptance of the physically unintelligible to the physically absurd." (Dingle, 1972, p. 132)

Both Lorentz's and Einstein's similar contraction of matter and expansion of time theories involve unobservable phenomena. No one has ever observed the contraction of an electron or the contraction of a rigid rod depending upon its relative velocity. Likewise, no one has ever observed Lorentz's and Einstein's local time (which is based on the 'true time' of ether) or the expansion (interpreted as slowing down) of time on

[7] Ether was merely a peripheral false assumption that was irrelevant to Maxwell's equations, and not a fundamental false premise upon which they depended.
[8] This great success was undoubtedly due in part to the later simplification and reformulation of Maxwell's equations by Helmholtz, Heavyside, Hertz and Lorentz. (see Chapter 6)

such contracted moving rigid rod. Such unobservable theoretical phenomena are not the same as Maxwell's artificial rationalization of a displacement current, because (as earlier pointed out) the physical effect described by Maxwell was actually physically observed.[9] Dingle concluded his discussion on this subject with the following statement:

> "I hope it has been made clear how the atmosphere of the time had become propitious for the advent of a theory [Special Relativity] that in earlier days would have been dismissed without a second thought." (*Id.*)

Largely because of Maxwell, Lorentz, and especially Einstein and Minkowski, mathematical physicists now feel free to invent any physical theory, however absurd, based solely upon some mathematical process whose symbols can be arbitrarily correlated with the physical entities of the theory, without regard to evidence or probability or commonsense.[10] (Dingle, 1972, p. 127) In many current physics books it is asserted that Special Relativity defies elementary human reasoning power, logic, and common sense, and that a lesson is to be learned from this. The lesson is that mathematics and consequences inferred from equations always trump logic. With the almost universal acceptance of Special Relativity, this philosophy has become a paradigm for mathematical physicists. [11]

One of the more recent examples of this unscientific philosophy is the wildly speculative superstring theory. Based on little more than an agenda to explain a mystery in another speculative theory and to formulate a theory of gravity that is consistent with quantum theory and Einstein's Relativity (Clese, p. 205), this mathematical theory asserts

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[9] Also, as it turned out, Maxwell's 'displacement current' was only a peripheral concept that was irrelevant to his equations (except for purposes of symmetry). It was not a fundamental false premise upon which his equations were based.

[10] It is commonplace for them to then state: "It is no use objecting to the results themselves; the critics should find flaws in the trains of mathematical deduction…" (E. Milne, 1935 [Dingle, 1972, p. 126])

[11] Many aspects of current 'mathematical physics' would be much better defined or characterized as 'theoretical mathematics.'

that everything in the universe is composed of one-dimensional superstrings, each with a length of about 10^{-35} m existing in 26 dimensional space-time and with energy scales of about 10^{19} GeV, far in excess of even theoretical possibilities. (see Smolin, pp. xiii – xviii) There is, of course, no empirical evidence whatsoever for superstrings, nor any way to test the theory, and yet most particle theoreticians are ardent believers. (WSJ, 6.23.06, p. B1; also see Chapter 35)

During the last century, a myriad of other *ad hoc* mathematical theories have been invented. Most were based solely on imagination, conjecture, mathematics, and pure thought, and they exemplify the current non-empirical, highly speculative and axiomatic role of mathematics to physics.[12] With this role in force, the sky is literally the limit. There are no restraints on imagination and mathematics, and certainly not those restraints of logic, common sense, unique predictions, empirical testing and empirical confirmations. Based almost entirely upon Einstein's theories and Minkowski's spacetime geometry, plus further imagination, inductive reasoning and mathematics, new physical theories are now being constructed at an unprecedented rate. Little wonder that some scientists conclude that what we now "know for certain about [the laws of nature] is no more than we knew back in the 1970's."[13] (Smolin, p. viii)

This mindset of the absolute invincibility of mathematics in physics is not warranted by any of the above-cited examples. There is nothing scientific about arbitrarily equating geometric or algebraic symbols with physical observations the way Lorentz, Einstein and countless others have done in order to achieve each mathematician's agenda. This treatise has demonstrated that Einstein's Special Theory of

[12] "The more sophisticated physical theories of [the 20th] century contain mathematics in a very essential way. Mathematics, then, almost becomes part of the model." (Rohrlich, pp. 12 – 13)
[13] This conclusion may even be wildly optimistic.

Relativity was premised upon numerous false assumptions, which in turn formed the theoretical basis for the remainder of his mathematical theories. It has also demonstrated that actually there is no experimental confirmation of Special Relativity or its many mathematical consequences.

It is suggested that this Einsteinian philosophy of the invincibility of pure mathematics in every physical theory, no matter how absurd the physical results, must suffer an early demise! Mathematics must again assume its classical role of limited assistance to physics. Logic and commonsense must again be respected. As Hubble and De Sitter asserted during the early part of the 20th century, most theories must begin and end with observation in order to be taken seriously. (see Hubble, 1942, pp. 104 – 105; De Sitter, 1932, p. 6) "The final test necessarily is comparison with observations; no theory can survive which is not able successfully to stand this test." (De Sitter, 1932, p. 7) Thus, Galileo's credo must also be reinstated: "Never…assume as true that which requires proof." (see Reston, p. 33)

