

International Mathematical Knowledge Trust Charter

The Global Digital Mathematics Library
Working Group

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1. Preamble

This is the proposed Charter of a new international non-profit organization, the **International Mathematical Knowledge Trust** (IMKT), as drafted by the Global Digital Mathematical Library Working Group appointed by the Committee on Electronic Information and Communication of the International Mathematical Union (CEIC). The creation of the IMKT has been influenced by the recommendations of the report *Developing a 21st Century Global Library for Mathematics* by the National Research Council of the National Academies of the USA. It is intended that IMKT be created as an independent non-profit organization, dedicated to increasing both the quantity and quality of mathematical knowledge accessible to the mathematical community, to enhancing the depth of semantic representation and integration of this knowledge, and to facilitating high quality open information services based on the knowledge represented.

1.1 Mathematical Knowledge and Open Mathematical Data

Mathematical Knowledge comprises the definitions, concepts and properties of formal mathematical objects, and the relations among them. The definitions are expressed clearly and unambiguously. The properties are determined by carefully chosen axiom systems and rules of inference, resulting in provably correct observations and highly developed theories. Well-posed questions and conjectures have objective answers, which once demonstrated remain true forever. Mathematical knowledge is presently a function of human understanding, but it can be represented for communication or archival purposes. Traditionally, this representation has been in the form of printed mathematical documents of various types, such as expository books, journal articles and other forms of literature, which ultimately engender under-

standing when read. With the growth of information and communications technology, mathematical knowledge has increasingly been represented in born-digital documents and websites. The nature of mathematical knowledge allows these digital assets, together with retro-digitized assets, to open the door to mechanized processing.

Since the size of the collection of all mathematics is tens of millions of documents, computer support will help in dealing with it and the mathematical knowledge formulated in it. Representing knowledge explicitly turns knowledge into data which can be processed automatically and may support semantic services. Using open, interoperable representation standards and open knowledge licenses turns mathematical knowledge into **Open Mathematical Knowledge Data** and the body of mathematical knowledge into a public resource that can drive future mathematical research and practice: the **Mathematical Knowledge Commons**.

2. IMKT Mission

2.1 Short Statement

The purpose of the International Mathematical Knowledge Trust, IMKT, is to establish a mathematical knowledge commons — a public resource consisting of mathematical knowledge represented in non-proprietary, machine-readable formats and an international network of knowledge providers, information systems, and semantic services based on it, that is, a global digital mathematical library.

2.2 Full Statement

The mission of the IMKT is to construct a mathematical knowledge commons as a global public good, an effective knowledge base of open mathematical knowledge data, encompassing the world's mathematics through collaborations deploying both present and future technology, and to foster a supporting community. In particular, the IMKT should work to

- enhance accessibility of all mathematical knowledge world-wide, present, past and future,
- promote the creation of open standards and best practices for management of mathematical data, and encourage the use of such standards,
- serve people in research mathematics, education, and applications of mathematics,
- facilitate the development of open source tools and open mathematical data repositories,

- facilitate creation, dissemination and open archiving of semantically rich forms of mathematical data,
- encourage the collaborative development of open services based on representations of mathematical knowledge.

The mathematical knowledge commons resulting from these efforts of the IMKT and affiliated organizations should be a truly global resource, which matches the highest possible standards of independence, of reliability, and of data protection.

3. Structural Aspects

3.1 IMKT Incorporation

The IMKT will be incorporated as a not-for-profit corporation with a professional staff led by an Executive Director.

3.2 The Global Digital Mathematics Library (GDML)

The IMKT will work to organize the mathematical knowledge commons in the form of open mathematical knowledge data: there will be a collection of resources available on the web that will, as a whole, be called the **Global Digital Mathematics Library** (GDML). IMKT will seek to hold the trademark on the name “Global Digital Mathematics Library” and the string “GDML” and a logo, in all suitable jurisdictions.

The contents of the GDML consist of mathematical data and knowledge represented in open formats, either directly under the purview of the IMKT or held by others but endorsed by the IMKT, together with references to other external materials with unendorsed formats or licenses.

The GDML is thus an aggregate rather than a knowledge base in itself, and as such is independent of a particular platform or portal.

3.3 The International Mathematical Union (IMU)

The IMKT is an independent non-profit organization set up to further goals of the IMU as set out in the world digital library resolution of 2006. The IMKT

expects to make annual reports to the IMU on its activities and the state of mathematical knowledge, in the hope that the IMU Executive Committee will give feedback to the IMKT. The IMKT is an autonomous entity, which will seek and obtain its own funding.

3.4 Regional Affiliates

It is intended that organizations affiliated with the IMKT shall be created in various countries and jurisdictions, typically to direct local funding and resources towards regionally based projects that serve the global goal.

3.5 Other Organizations

The activities of the IMKT will include cooperation with organizational partners. Organizations of significance to the IMKT's mission include academic publishers, software companies, scholarly societies, research agencies, information providers, libraries and standardization organizations.

3.6 IMKT Endorsement

The IMKT may add mathematical knowledge not directly under its purview to the GDML by **endorsing** it. IMKT endorsement certifies the suitability of data as open mathematical knowledge in respect of its licensing conditions and representation format and thus as a contribution to the mathematical knowledge commons. The IMKT will judge material for endorsement based on its

- “Openness”, e.g., by maintaining lists of approved “open knowledge licenses” for mathematics
- “Mathematical nature”, e.g., assured by curation or categorization within the Mathematics Subject Classification
- “Knowledge representation”, e.g., by validating it against open representation standards

- “Best data practices”, e.g., by auditing accessibility, versioning, and distribution conditions.

In endorsing knowledge, the IMKT does not assert correctness or validity of mathematical statements or identities endorsed. It is the responsibility of the creators of mathematical knowledge to do that, taking into account the guides for best practices for that purpose which may be provided by the IMKT.

3.7 Copyright and Licensing

IMKT can hold copyrights to documents it may produce, e.g., reports, listings of mathematical resources, digital resources and its website. Furthermore IMKT may hold copyrights to mathematical documents entrusted to it by the mathematical community for the purpose of providing them to the world. All documents must be made publicly available with an open knowledge or open document license.

3.8 Receipt of Donations

It is planned that IMKT shall be able to receive financial donations, and donations of expertise or gifts in kind, from individuals and organizations, including scholarly societies, commercial publishers, and both proprietary and open source software companies. But such donations cannot be considered as payment for any kind of service. IMKT does not provide services beyond those freely available to the public.

4. IMKT Activities

4.1 Development of Mathematical Data Standards

IMKT will create and promote standards for mathematical data, including standards for languages, validation of formats for mathematical expressions, and assertions of truth or correctness of mathematical statements. The IMKT cannot be legally responsible for the correctness or otherwise of mathematical formulas or theorems published.

4.2 Corpus Identification

A main IMKT activity, whether carried out by staff or contractors, should be

- location and listing of stores of mathematical knowledge,
- identification of rights issues, quantity and quality of data,
- inventory of, and high-level metadata for, well documented, standards compliant, open formats.

4.3 Basic Digitization Efforts

The IMKT is committed to preserving and expanding upon the world's mathematical heritage, and can carry out projects to that end.

The collection and digitization of existing mathematical documents and their metadata is a relatively well understood activity. The IMKT will participate in global standardization efforts to enable scaling up the collection of

mathematical data and resources. The IMKT will encourage open provision of metadata about mathematical publications from all sources.

4.4 Semantic Enhancement of Digital Mathematical Documents

Mathematical knowledge can be encoded by annotating fragments of mathematical documents with information about their functions or relations to context. Even though this only partially fixes meaning, the knowledge represented in such annotations can be a valuable base for semantic services. Annotation processes are incremental, allowing for stepwise formalization of mathematical knowledge.

The IMKT will engage in the development of standards, best practices, and tools for semantic annotation and use of annotations, and will actively promote the incorporation of annotation processes into the GDML.

4.5 Formalization, Computation and Proof

The IMKT will foster the cooperation of research groups on formal and automated mathematical reasoning and its relation to machine learning, artificial intelligence and natural language processing. The aim of such cooperations should be to create open mathematical knowledge bases, at various levels of formality, that can be machine-processed for a variety of purposes, such as automated search, verification, mutual integration, completion, and restructuring of mathematical knowledge.

4.6 Mathematical Knowledge Framework

The IMKT will coordinate with researchers, developers and software providers to establish a cooperative framework for the creation of standard ontologies for mathematical objects, definitions, and results.

The IMKT will coordinate with researchers, developers and software providers to create and maintain software tools of specific value to mathematical data and services. This can include the adaptation to mathematical

purposes of more general tools, such as editors for metadata, annotation, navigation and presentation tools. It can also include specialized tools for mathematical web services including search, curation and collaboration, interfaces to computational engines, and tools for the manipulation of knowledge bases.

Commercial and non-commercial software developers may provide tools that participate in this environment through open standards. All tools developed by IMKT will be open source.

5. GDML WG Membership

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- Bruno Buchberger (Linz, Austria)
- Patrick Ion (Ann Arbor, MI USA) [chair]
- Michael Kohlhase (Bremen, Germany)
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