International School of Physics “Enrico Fermi”
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Fundamentals of Metrology

What is measurement and what might it become?

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The opinions expressed here do not necessarily represent the view of the Joint Committee for Guides in Metrology (JCGM) Working Group 2 (VIM)

“What is measurement?”:
why should we be interested in such a question?

“This is an opinion” “This is a measurement result”

I suppose we agree that the difference is not purely lexical:
obtaining information by means of measurement
is, in some sense to be discussed, *better*

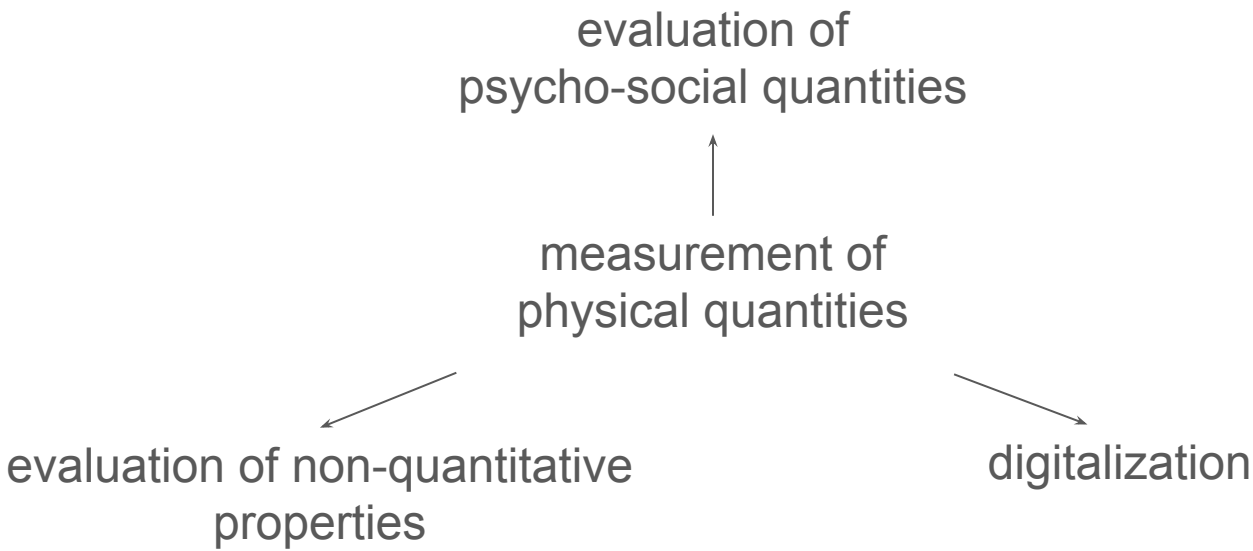
But **how can this be justified?**

Measurement is something we do, not something we find in nature:
we cannot do an experiment to find an answer

(*and “measurement” is not a trademarked term*)

“What is measurement?”:
why should we be interested in such a question **now?**

Due to its “epistemic prestige”, ‘measurement’ is variously stretched:



How broad can the scope of measurement be made?

For measurement to serve society effectively,
measurement results must be consistently understood
across countries, cultures, economies, …

For example, we communicate the reliability of measurement-related processes, procedures, instruments, and results using terms such as uncertainty, error, accuracy, trueness, precision, sensitivity, selectivity, …

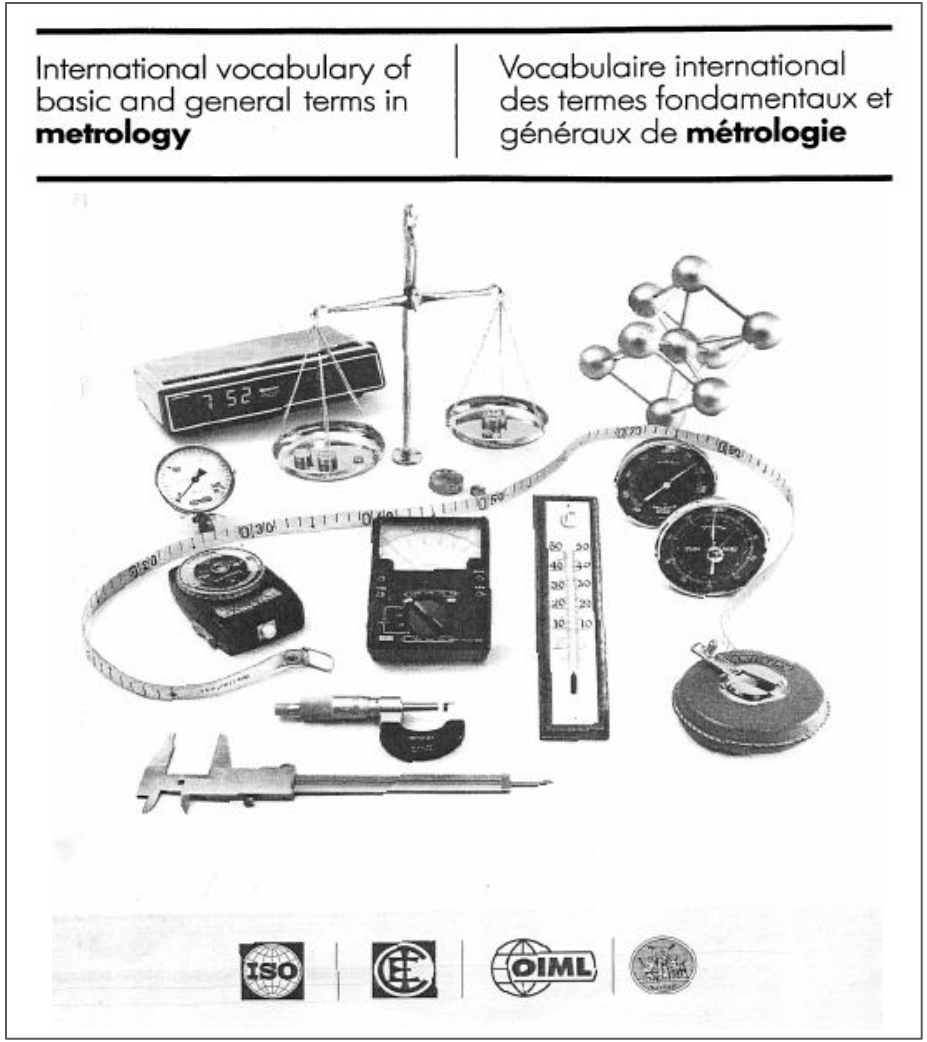
But what exactly do we mean by these terms?

1984

This Vocabulary has been prepared simultaneously in English and French by a joint working group consisting of experts appointed by:

BIPM	International Bureau of Weights and Measures
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
OIML	International Organization of Legal Metrology

The Vocabulary is published in the name of these organizations.

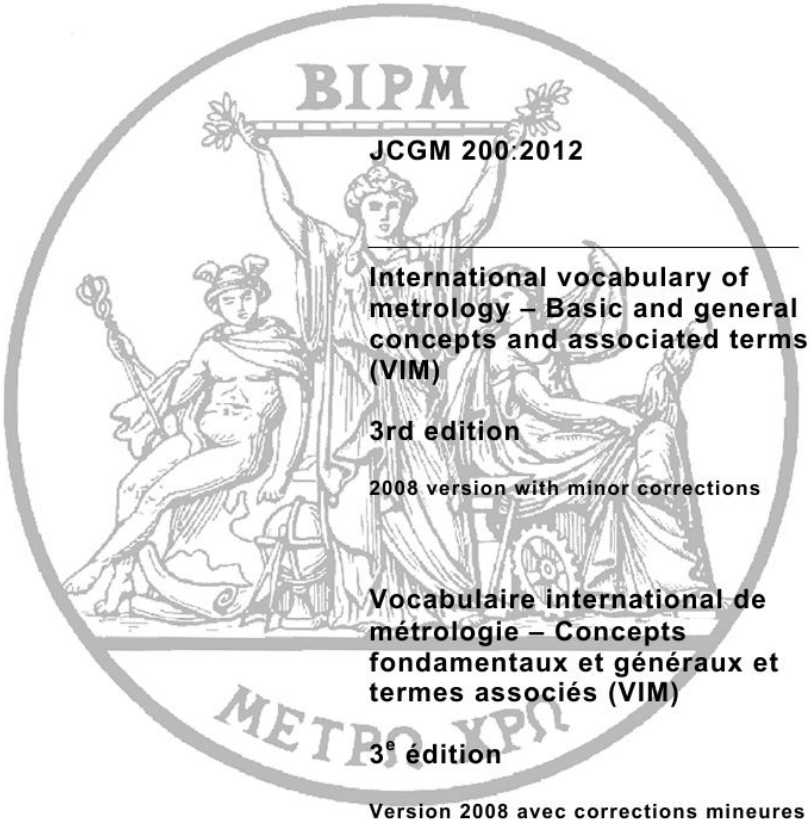


Ten years later: Joint Committee for Guides in Metrology

The current membership of the JCGM:

- the two inter-governmental organizations concerned with metrology:
  - the Bureau International des Poids et Mesures (**BIPM**)
  - the Organisation Internationale de Métrologie Légale (**OIML**)
- the two principal international standardization organizations:
  - the International Organization for Standardization (**ISO**)
  - the International Electrotechnical Commission (**IEC**)
- three international unions:
  - the International Union of Pure and Applied Chemistry (**IUPAC**)
  - the International Union of Pure and Applied Physics (**IUPAP**)
  - the International Federation of Clinical Chemistry and Laboratory Medicine (**IFCC**)
- one international accreditation organization:
  - the International Laboratory Accreditation Cooperation (**ILAC**)

The International Vocabulary of Metrology



https://www.bipm.org/en/committees/jc/jcgm/publications

International Vocabulary of Metrology

Fourth edition – Second Committee Draft (VIM4 2CD)

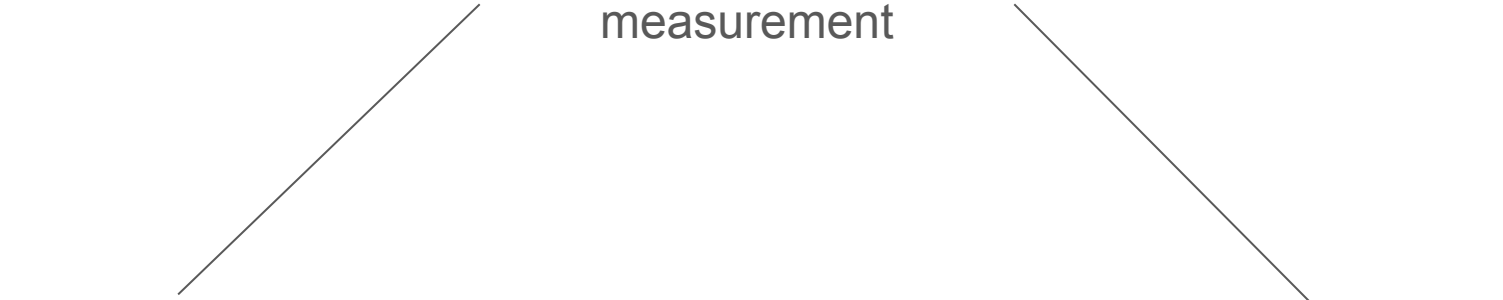
31 July 2023

https://www.bipm.org/documents/20126/115700832/VIM4_2CD_clean/c6d0dfb2-ddbf-059e-1f74-9b025c9c59d8

A one-slide course in terminology

(**definitions** expressing **concepts** in
a body of knowledge)

what we know about
measurement



the English term
“measurement”

(**terms** in
a language)

a measurement

(**entities** in
the world)

A (good) **vocabulary** is then also a **concept system** and an **ontology**

“What is measurement?”: **is it a new question?**

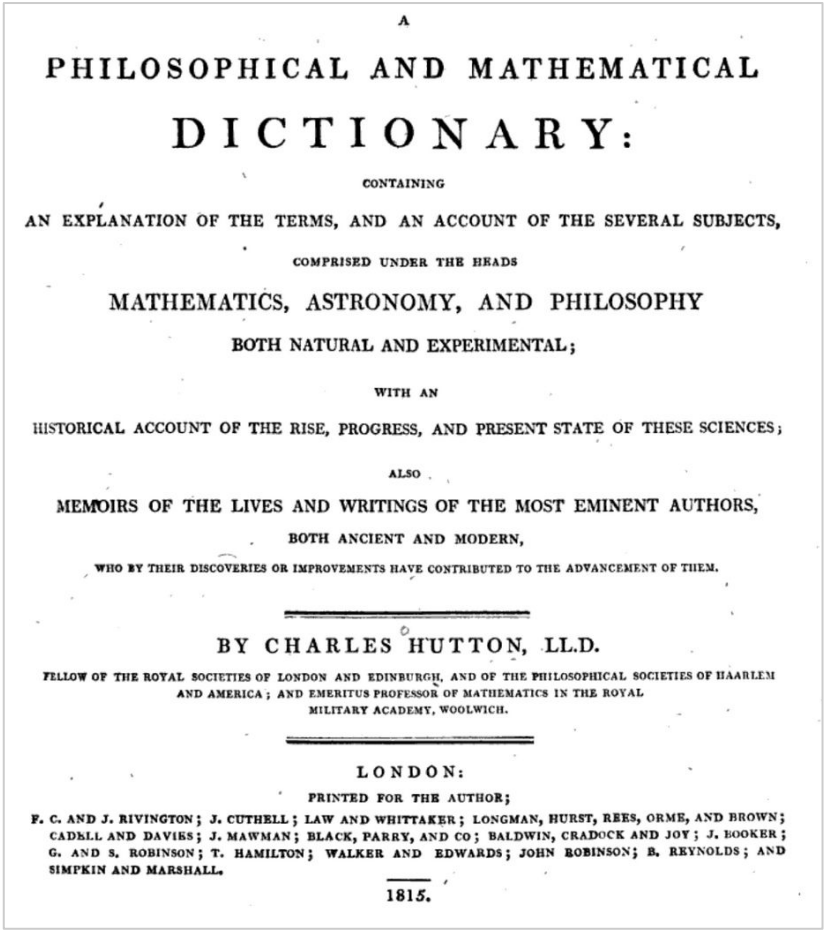
No, but the answers given in the past are not adequate anymore

(*hint: what is the source of the expression “weights and measures”?*)

To justify this claim, let’s take a look for example at…

MEASURE, denotes any quantity, assumed as unity, or one, to which the ratio of other homogeneous or like quantities may be expressed.

MENSURATION, the act, or art, of measuring figured extension and bodies; or of finding the dimensions and contents of bodies, both superficial and solid.



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PHILOSOPHICAL AND MATHEMATICAL

DICTIONARY:

CONTAINING

AN EXPLANATION OF THE TERMS, AND AN ACCOUNT OF THE SEVERAL SUBJECTS,

COMPRISED UNDER THE HEADS

MATHEMATICS, ASTRONOMY, AND PHILOSOPHY

BOTH NATURAL AND EXPERIMENTAL;

WITH AN

HISTORICAL ACCOUNT OF THE RISE, PROGRESS, AND PRESENT STATE OF THESE SCIENCES;

ALSO

MEMOIRS OF THE LIVES AND WRITINGS OF THE MOST EMINENT AUTHORS,

BOTH ANCIENT AND MODERN,

WHO BY THEIR DISCOVERIES OR IMPROVEMENTS HAVE CONTRIBUTED TO THE ADVANCEMENT OF THEM.

BY CHARLES HUTTON, LL.D.

FELLOW OF THE ROYAL SOCIETIES OF LONDON AND EDINBURGH, AND OF THE PHILOSOPHICAL SOCIETIES OF HAARLEM AND AMERICA; AND EMERITUS PROFESSOR OF MATHEMATICS IN THE ROYAL MILITARY ACADEMY, WOOLWICH.

LONDON:

PRINTED FOR THE AUTHOR;

F. C. AND J. RIVINGTON; J. CUTHELL; LAW AND WHITTAKER; LONGMAN, HURST, REES, ORME, AND BROWN; CADELL AND DAVIES; J. MAWMAN; BLACK, PARRY, AND CO; BALDWIN, CRADOCK AND JOY; J. BOOKER; G. AND S. ROBINSON; T. HAMILTON; WALKER AND EDWARDS; JOHN ROBINSON; B. REYNOLDS; AND SIMPKIN AND MARSHALL.

1815.

A

TREATISE

ON

MENSURATION,

BOTH IN

THEORY and PRACTICE.

By CHARLES HUTTON.

NEWCASTLE UPON TYNE:

Printed by T. SAINT for the AUTHOR, and for JOHN WILKIE in *St Paul's Church Yard*, and RICHARD BALDWIN in *Pater-noſter Row*, *London*. 1770.

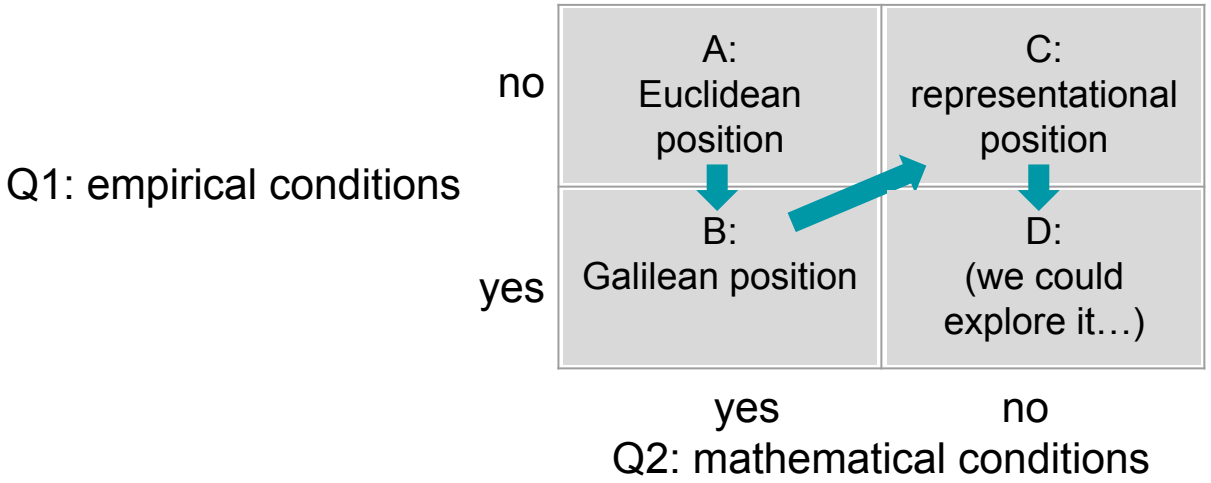
PREFACE.

BY Menſuration I underſtand the art and ſcience which is concerned about the meaſure of extention, or the magnitude of figures; and it is, next to arithmetic, a ſubject of the greateſt uſe and importance, both in affairs that are abſolutely neceſſary in human life, and in every branch of the mathematics: A ſubject by

Let us introduce a simple framework, based on two questions:

(Q1) are **empirical** conditions relevant for the definition of ‘measurement’?

(Q2) are **mathematical** conditions relevant for the definition of ‘measurement’?



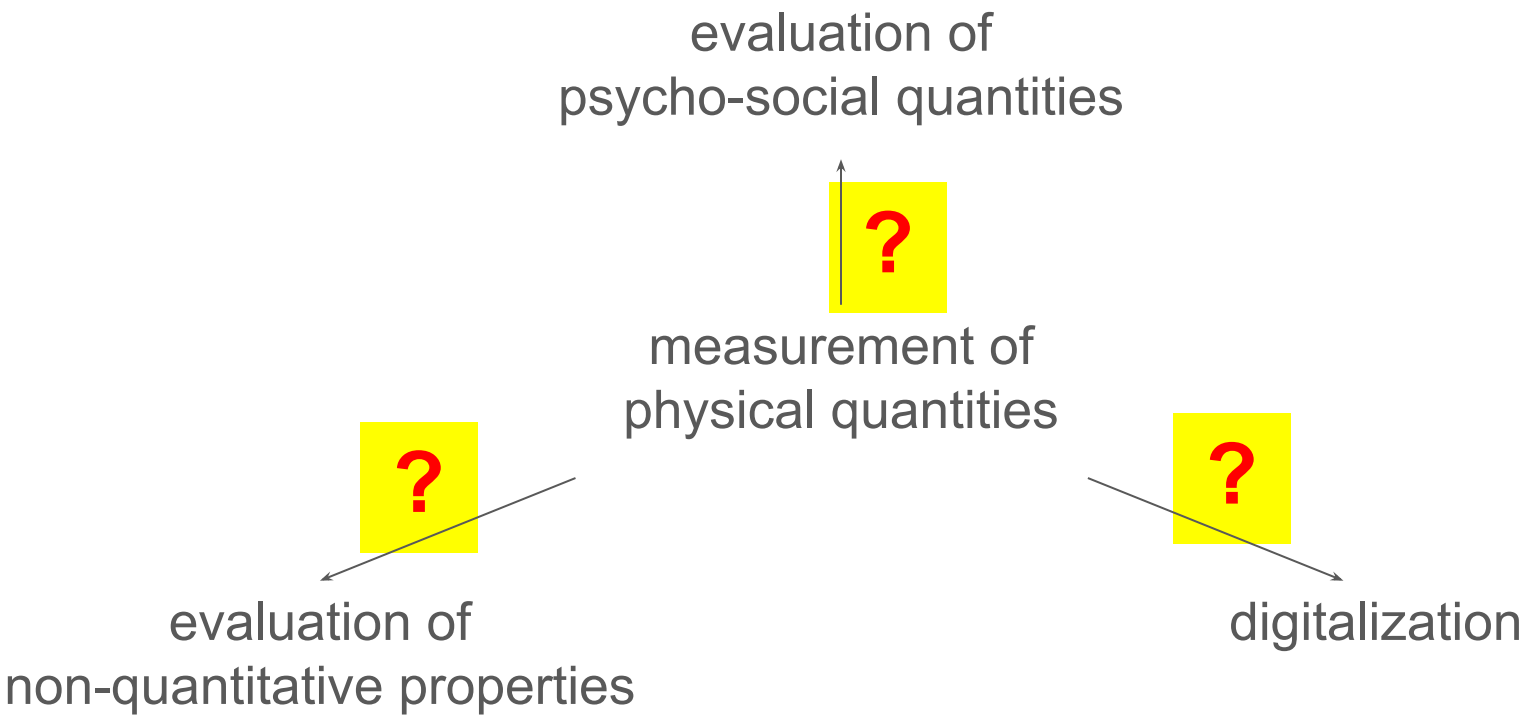
“What is measurement?”: back to the roots (about its “epistemic prestige”)

It is not a matter of truth or of quality…
(*there is nothing contradictory in bad measurement*)

… but of **public and transparent statement of reliability**…
(hence, *what is contradictory is the idea of black box measurement*)

… where establishing how reliable a measurement result is depends on:

- the connection between the result and what is measured
  (*that is why measuring instruments are improved*)
  → object relatedness, i.e., **objectivity**
- the shared understanding of the result
  (*that is why metrological systems—including systems of units, measurement standards, traceability chains—are improved*)
  → subject independence, i.e., **intersubjectivity**


evaluation of
psycho-social quantities
?
measurement of
physical quantities
?
?
evaluation of
non-quantitative properties
digitalization

A lot of open issues!

But it is clear (to me...) is that our society needs tools for producing information equipped with **public and transparent statement of reliability**…

… and measurement is the best of such tools we developed in human history

Thank you for your attention

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