Math is everywhere

New Horizon in Mathematical Sciences

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Reiko Miyaoka（Tohoku U.）

Seems difficult …

$$y = \frac{\ln\left(\frac{x}{M} - as\right)}{r^2}$$

$$r^2 y = \ln\left(\frac{x}{M} - as\right)$$

$$e^{r^2 y} = \frac{x}{M} - as$$

$$e^{r^2 y} + as = \frac{x}{M}$$

$$M\left(e^{r^2 y} + as\right) = x$$

$$Me^{r^2 y} + mas = x$$

$$Me^{rry} = x - mas$$

This is a joke, but

- Math is everywhere.

- Regardless good or bad at it, we use Math unconsciously, and Math is indispensable.

Do you know Benford's law?

Frequency distribution of leading digits in many (but not all) real-life sets of numerical data.

Eg. In the data of area of countries, population, or quantity of wheet in a year etc., which number 1, 2 ,3, ⋯ 8, 9 appears most in the leading digit of such data? Equally appear?

Rice field area and quantity（2013)

北海道	112,000	629,400	東京	161	668	滋賀	33,400	176,700	香川	14,700	73,900
青森	49,600	302,600	神奈川	3,150	15,600	京都	15,500	82,200	愛媛	15,300	75,400
岩手	55,400	300,300	新潟	119,700	664,300	大阪	5,640	28,300	高知	13,000	58,400
宮城	72,200	398,500	富山	39,700	216,800	兵庫	38,400	194,300	福岡	38,700	185,400
秋田	92,500	529,100	石川	26,700	139,400	奈良	9,190	48,400	佐賀	26,700	130,600
山形	68,300	415,300	福井	26,500	139,400	和歌山	7,380	37,300	長崎	13,500	63,200
福島	68,200	382,600	山梨	5,260	29,000	鳥取	14,100	73,200	熊本	38,400	192,800
茨城	75,900	411,400	長野	34,400	217,400	島根	19,100	98,200	大分	23,800	115,200
栃木	66,200	363,400	岐阜	24,700	122,300	岡山	33,100	169,500	宮崎	18,900	93,600
群馬	17,600	89,600	静岡	17,100	89,100	広島	26,000	135,200	鹿児島	23,500	114,900
埼玉	35,400	170,300	愛知	30,300	157,300	山口	22,900	111,500	沖縄	890	2,350
千葉	60,900	337,400	三重	30,200	156,100	徳島	13,400	65,300			

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The answer is 1. Benford's law

- Frequency
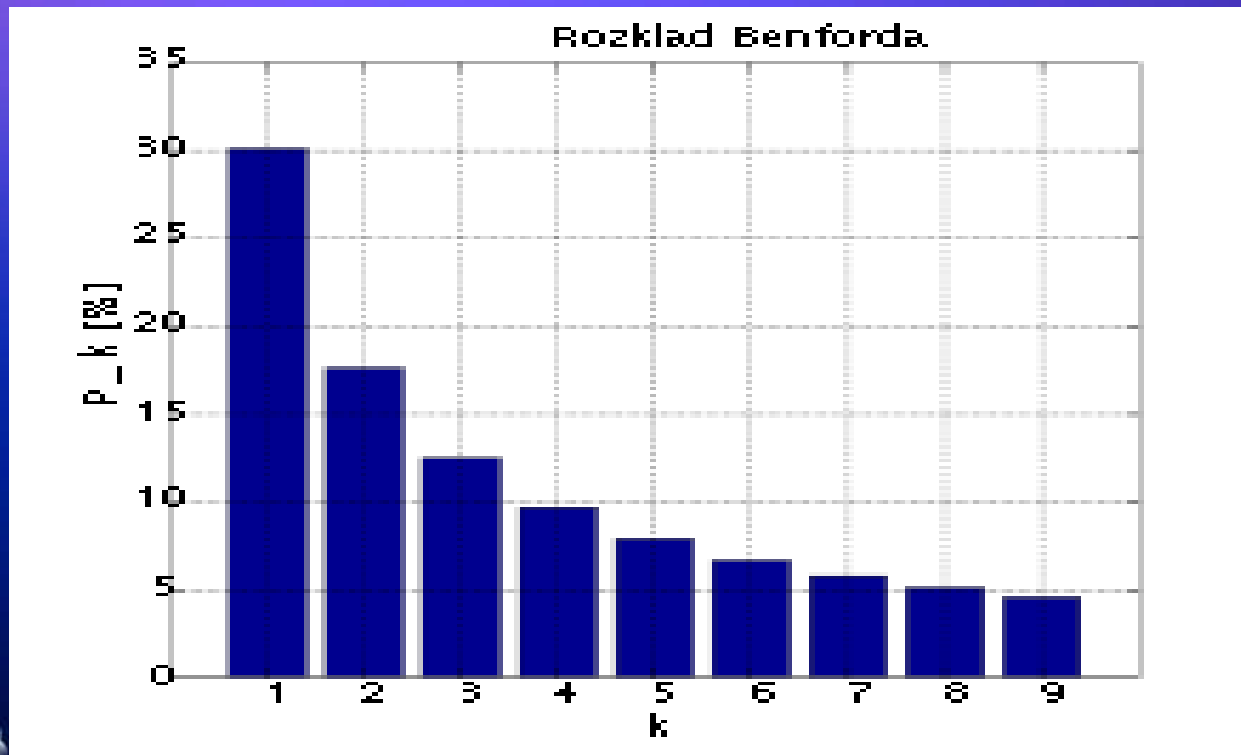
Intuitive proof

- Make ¥100 into ¥200：twice
- Make ¥200 into ¥300：1.5 times
- Make ¥300 into ¥400：1.3times
- ．．．
- Make ¥800 into ¥900：1.1times

Most difficult is to make ¥100 into ¥200

This law is proved theoretically,

and is used actually to <u>check if a tax declaration is right or not</u>.

- This topic and its proof make high school students' eyes shine.

Math is used both open and covert

- In science and technology, a use of Math is of no surprise, but in any daily life, Math plays an important role.

- Talk plan:

  Importance of Math

  Subjects related to Math

  What we expect to Riken New Team

Congratulations to iTHES!

分野横断型数理科学連携研究チーム

- iTHES regards Math as
  `a transversal axis" among theoretical
  sciences. A new alliance team starts!

- Mathematical side: began to know
  problems occurring in our life, science,
  industry, which Math can help.

Two aspects

- One of aims of this new team is to develop <u>theoretical sciences,</u> such as Quantum physics, Mathematical Biology, Cosmic sciences, ⋯ via Math.

- Another aim: <u>collaboration with industry</u>. This might require some achievement in a limited time.

However be careful!

- ``What works immediately becomes useless immediately''
- すぐに役立つものはすぐに役立たなくなる（by Shinzo Koizumi，小泉信三）.

It takes time for Theoretical Science and Math to work out in society.

My brief self-introduction

- My major is differential geometry :
  Minimal surface theory,
  Harmonic maps theory

  ↓

  Theory of integrable systems
  Symplectic Geometry
  (since around 2000)

My new position

- Institute of Liberal Arts and Sciences since this April.
- Among 9 retired professors in this Inst., 2 are philosophers and 2 are mathematicians.
- I was shocked to hear that ``In general, Math and Philosophy seem useless''.

At least, Math is quite useful!!!
Who can survive without Math???

Alliance for break through between Math and Sciences by Nishiura

The first JST area containing Math → continuing to

Tsuboi CREST

&

Kokubu PRESTO

(started in 2015)

I've been a member of these advisory boards since 2007.

JST Nishiura project

I myself became to know lots of fields related to Math. through this project.

What kinds of fields are included?

- CREST（13 projects, one female leader)
- PRESTO（34 projects, four female leaders)

- Pure Math : Minimal energy problem, Explosion of solutions of non-linear PDE, Knot theory

- Material sc : Material sciences, Young measure

- Engineering : Robot, Transportations

- Life & Biology sc. : Animal locomotion, Biological network

- Chemistry: Protein

- Information sc. : Groebner basis, Numerical simulation, Cryptography, Computer assisted sc.

- Economy : Macro-economy, Quality certification, Insurance, Bayesian prediction

- Medical sc. : Cancer, Circulatory organ, Skin barrier, Infection disease

- Physics : Vortex, Interfacial tension, Oscillation

- Others : Animation, Visual perception

How Math is related?

- Blood flow in aorta ←→

                    Geometry of curves or tubes

- New material ←→

             Discrete geometry, Harmonic maps

Transportation ←→

                   Theory of integrable systems

Interfacial tension ←→ Surface theory

- Animal locomotion ←→
           Discrepancy function
- Vortex ←→ Fluid mechanics
- Visual perception ←→ Wavelet
- Protein ←→ Persistent homology
- Animation ←→ Representation theory

JST applicants

``Math and Sciences'', ``Math Alliance'', ``Math Modeling'' are fields of which base is Math.

However, the number of applicants from Math are decreasing, in my impression.

Moreover, applicants from other fields misunderstand that [Math=Computer].

Why? Hesitation of (non-)mathematician

- Mathematics used in other fields is rather elementary in research level.
  →Awarded as a result of Math?
  Evaluated as a mathematician?

For non-mathematician
  → Needs translation to Math people.
 → Needs time and efforts → Give up!

How to overcome the hesitation

To young people:
- Give various accessible problems and tell how Math can do to solve such problems (like Benford's law).
- Give a broad problem consciousness and an extensive human network.

From my experience

- In 2004, I organized an international conference on Integrable Systems and Visuarization in Kyushu U.

- There were talks on advanced computer graphics and software.

Eg. Takeo Igarashi: Teddy
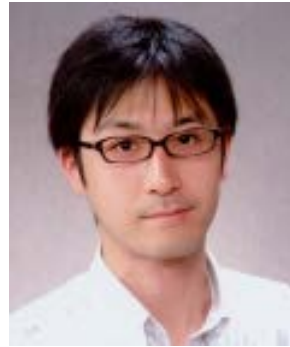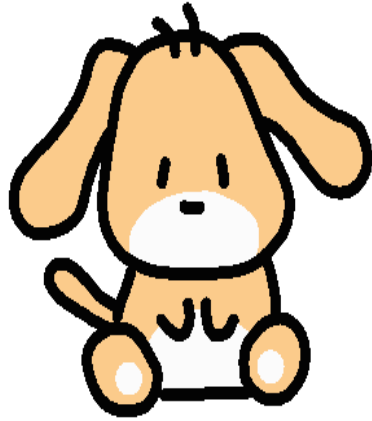
One of graduate students from Nagoya wrote in questionnaire that ``If I had known such fields earlier, I might have chosen such field.''

This means:

- Young people have no chances to know applied math if they once belong to math dept. in Japan (except for a few universities like Kyushu).

- There are still <u>barrier between pure and applied math</u>. in Japan.

On the other hand,

- I had a bad experience:

- In 2009, I held the 5th Japan-China Geometry Conference in OIST.
  I added several talks on Biological Math, Protein, etc. so as to fit OIST.

- Mathematicians were <u>not pleased with</u> such talks.

In other countries

- In Europe, difference between pure and applied math has already disappeared → Math students are good at computer science, such as programing, data analysis, numerical computation because they learn.

- Lifetime earnings is more if they do Math（A good motivation!）.

Another problem in Japan

- There are few business managers in companies who have Dr degree (in USA, many).

- We need to send many young PD to companies. Later, they will become managers having PhD.

What we expect from the new RIKEN team

- Top level researchers are like magnet attracting other best researchers.
- Offer a stimulus, calm, attractive research atmosphere in every field.
- Efforts to have a comfortable accommodation, offering nice rooms, nice foods, nice gym, kind staffs…, to invite people from all over the world.

Established Research Inst.

- Each established research inst. such as RIMS, ISM, IMI, MIMS, TFC, … has its own role, mission and history, and so should contunue individual activity.

- It is important among them to <u>share information</u> such as current projects, workshops, visiting people, coming research thema etc.

In iTHES lecture series
(a new trial: Omiai)

- Automatic driving ← AI, Computer sc.
- Financial engineering ← Computer, Math
- Numerical experiment ← Computer sc.
- Automatic translation ← Language
- Artificial Intelligence ← Deep learning
- Computational drug discovery ← Data analysis
- Automatic driving and AI ←Computer sc.
- Agricultural management and big data ←Data analysis

Arts and Sciences

- We need also to remove the barrier between Arts and Sciences!!!

- A prime minister with science background might fail (?) to manage polytical matters.

Sorry!

Analysis → Synthesis

- Old Math：mainly individual analysis

- Recent Math： Synthesis of various objects, fields.

- Such tendency will become trendy.

Barrier free

- If we succeed to remove various barriers from our life, we would have more freedom which makes us happy!

  Start with alliance between Science and Math in RIKEN!

Math is everywhere

Thank you very much
for your attention!