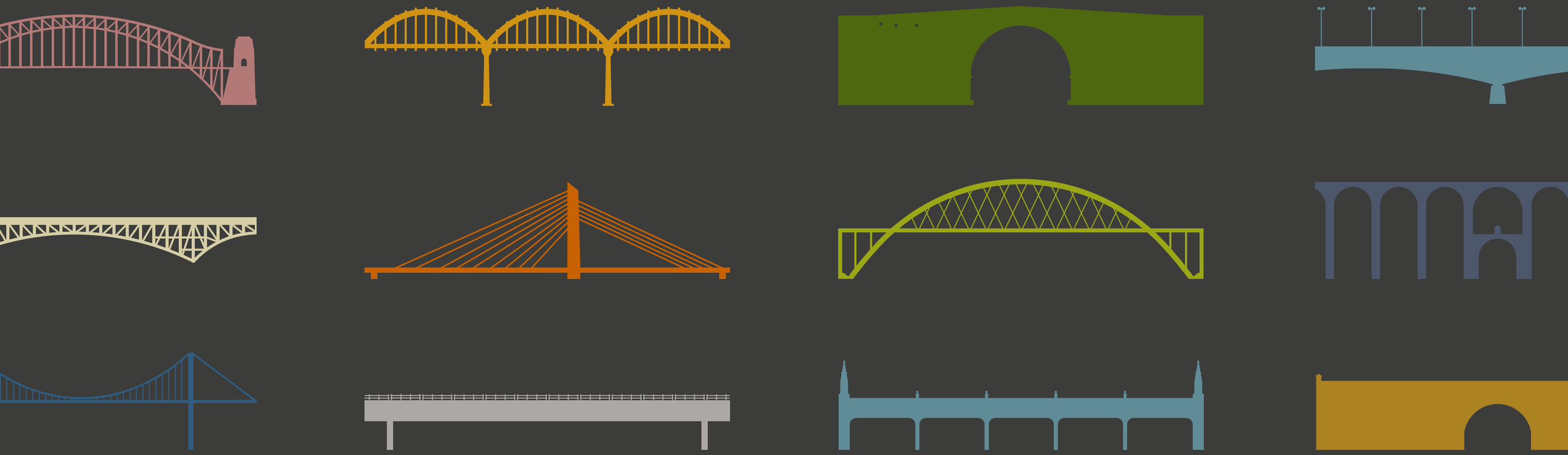
WWU
MÜNSTER



M A T H B R I D G E S

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AFO
Arbeitsstelle Forschungstransfer

Fachbereich 10
Mathematik und
Informatik

Universitäts
Gesellschaft
Münster

Zentrum für Lehrerbildung

Stadt Münster

Greetings

Dear enthusiasts of mathematics, bridges or art,

Speaking for myself, this calendar is likely to fascinate all of you. The whole idea to use famous bridges and their geometry as an access to illustrate mathematical problems and to merge any bridge's special aesthetics with mathematics is intriguing. Being a physicist myself, I hope that exchanging ideas and concepts on how to stir public interest in mathematics will be beneficial for both for mathematicians and the public alike. Hence, I very much supported the idea of having the Mathbridges Camp 2018 in Münster. I would like to express my sincere thanks to WWU's Innovation Office and our Department of Mathematics Education and Computer Science Education for its organization and to the Universitätsgesellschaft as well as to the City of Münster for supporting this Camp.

The Mathbridges Camp 2018 merged many aspects of the Rectorate's strategic ideas and goals for the coming years. For a start, it is our understanding that especially teachers play an important role in paving the way to a society that accepts science, scientific methods and hence scientific results as a basis for decisions. Being one of the largest facilities for teacher training in Germany, we clearly see our responsibility here. Also, bringing together scientists and students from so many different countries and engaging them in joint projects perfectly fits our internationalisation strategy.

At WWU, mathematics is considered as one of the bridging sciences between almost all disciplines. No wonder, as mathematics and bridges seem to be a perfect match: "'Mathematicians like to build bridges.' [...] Since mathematics consists of islands of knowledge in an ocean of ignorance, only such bridges allow exchanging ideas from one island to another[1]." In this sense, I am glad that in this calendar you are able to give a pictorial account of the uniting feature of the many facets of bridges.

Yours sincerely,

Prof. Dr. Johannes Wessels
Rector of the University of Münster

[1] Simon Singh (2000): Fermats letzter Satz, dtv Verlagsgesellschaft mbH & Co. KG, München, p. 224

Dear Ladies and Gentlemen,

May I present you with the result of an international project: the Mathbridges Camp. Within this project, bridges as such had a number of meanings: they were built between nations, between the City of Münster and the University of Münster. Bridges were calculated. They were brought to the attention of citizens. Pictures of them were exhibited and finally put together as a keepsake in this calendar.

The name "Mathbridges" was indeed program content in many aspects.

The City of Münster, in particular its International Office, was happy to support this project making use of existing bridges to its twin cities Ryazan (Russia), Kristiansand (Norway) and Lublin (Poland). Especially in current times it is important to maintain and nourish international contacts and friendships.

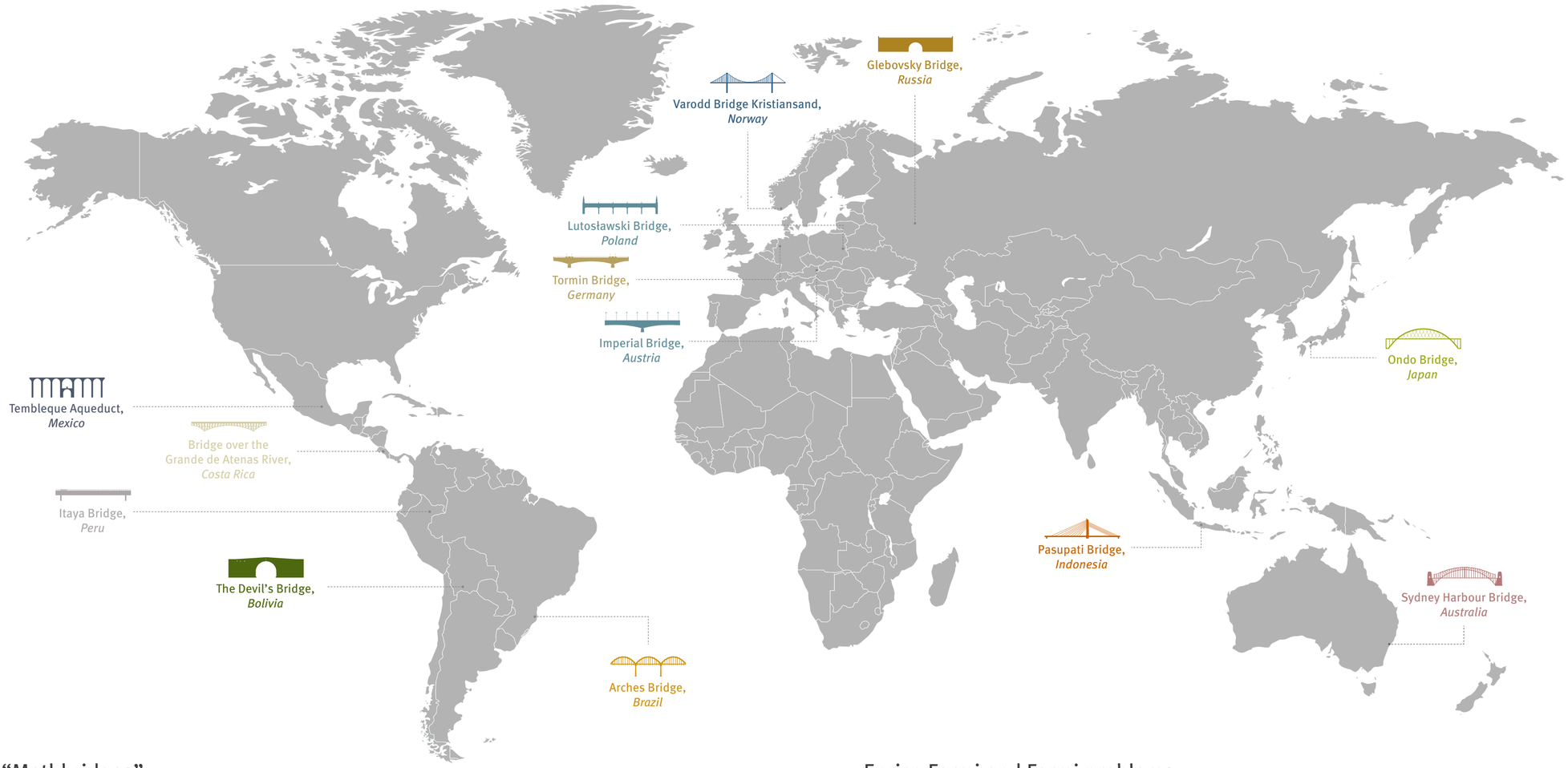
Personal relationships more than anything else enable long term peaceful interaction; it is only possible to learn from each other and solve problems together through direct cooperation. As long as we get to know people from other nations and talk with them rather than about them, we have the chance to understand each other. This is how we actively build bridges instead of walls. Isaac Newton already stated: "People build too many walls and too few bridges."

On that note, this project meets the ravages of time and illustrates clearly, that mathematics can also be of interest to those, who don't think they have or think they don't need an understanding for maths.

I am looking forward to further projects between the University and the City of Münster which help to build bridges into the world and also between all of us.

Yours sincerely,

Markus Lewe
First Mayor of Münster



Project "Mathbridges"

How much additional weight a bridge has to carry due to the added lovelocks? How many marathon runners can simultaneously be on the bridge? How many cyclists must be on the bridge to exceed the authorized weight of six tonnes? Such everyday estimating tasks, which are called "Fermi problems" in mathematics, were the focus of the international "Mathbridges Camp", which took place from 25 to 29 June 2018 at the University of Münster. Teachers and students of the Department of Mathematics Education and Computer Science Education of the WWU and of twelve international partner universities developed Fermi problems on twelve bridge motifs.

The present perpetual calendar is the result of this common work of mathematicians and students from Australia, Austria, Bolivia, Brazil, Costa Rica, Germany, Indonesia, Japan, Mexico, Norway, Poland and Russia, combining bridges and mathematical questions with a strong relation to reality.

The origin of the international Mathbridges Calendar was the regional calendar "Mathebrücken Münsterland", which used regional bridges of great cultural significance as source of inspiration for mathematics in everyday life. The team of the Expedition Münsterland chose twelve impressive regional bridges and the team of the Department of Mathematics Education developed an individual "Fermi problem" for each bridge. The approach of combining the perception of cultural heritage with mathematical didactic methods quickly proved to be internationally transferable. Thus, the idea of an international calendar was born and a consortium was brought together.

We thank all participating partner countries for their great contributions during the workshop week, as well as the team of the Department of Mathematics Education and Computer Science Education, the Universitätsgesellschaft Münster e. V., the City of Münster and the Zentrum für Lehrerbildung for their great cooperation and financial support. You are invited to venture into the world via a multitude of international bridges, by calculating!

Dr. Wilhelm Bauhus, *Head of the Innovation Office (AFO), University of Münster*
Anne Harnack, *Project Responsible, Innovation Office (AFO), University of Münster*

Enrico Fermi and Fermi problems

Enrico Fermi was born in Rome, Italy, in 1901. He gained the doctoral degree in physics in 1922 from the University of Pisa. On 10 December 1938, Fermi received the Nobel Prize for Physics for his disclosure of new radioactive elements produced by neutron irradiation and for the discovery of nuclear reactions caused by slow neutrons. Fermi was known for his excellent estimation sense. He made good approximate calculations with little or no information given. The most popular example is his approximate calculation of the strength of the atomic bomb. It is said that Enrico Fermi threw paper shreds into the air during the first atomic bomb test to estimate the explosive power of the bomb, before data could be read from measuring devices. Enrico Fermi died in Chicago, USA, in 1954. In mathematics education, one type of mathematical problem is called after Enrico Fermi: the Fermi problem. Fermi problems are open, non-standard problems which are closely tied to reality. One characteristic of Fermi problems is that they do not provide all the information which is necessary for solving them; instead, you need to estimate missing information. Moreover, you cannot solve Fermi problems by combining the numbers given in the problem via standard mathematical procedures. Usually, a problem solver can apply different solution methods and calculate different results. From the perspective of mathematics education, Fermi problems create a bridge over the gap between mathematics and real life. Typically, Fermi problems might relate to real-life situations or real-life objects such as public buildings or bridges. They show that doing mathematics is not always about getting exact answers through applying standard procedures. In that way, Fermi problems can make people think about the world in a new, mathematical way.

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The text is based on the following references:
Albarracín, L. & Gorgorió, N. (2014). Devising a plan to solve Fermi problems involving large numbers. Educational Studies in Mathematics, 86(1), 79–96.
Del Regato, Juan A. (1982). Enrico Fermi. International Journal of Radiation Oncology, Biology, Physics, 8(8), 1393–1416.

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Members of the rectorate and chairman of the boardof directors of the "Universitätsgesellschaft Münster e. V.", Dr. Paul-Josef Patt (front row, right), congratulate the representatives of supported funding projects for 2018.

The Universitätsgesellschaft Münster was founded as the "society of friends and sponsors of Münster University" in summer 1918, just months before the end of World War I. In this period, societies of friends and sponsors were set up at several German universities. Münster was one of the first at which such endeavours bore fruit – which quickly had positive consequences for the expansion of the academic infrastructure in Münster. During the first years of its existence, the Universitätsgesellschaft provided substantial financial assistance. One focus of such funding was the support for social facilities for students such as the expansion of the University's sports facilities and the construction of the refectory at lake Aasee. In the 1930s, the largest project to receive financial assistance from the society – apart from general support for academic activities – was the purchase of several pieces of property, which were placed at the University's disposal.

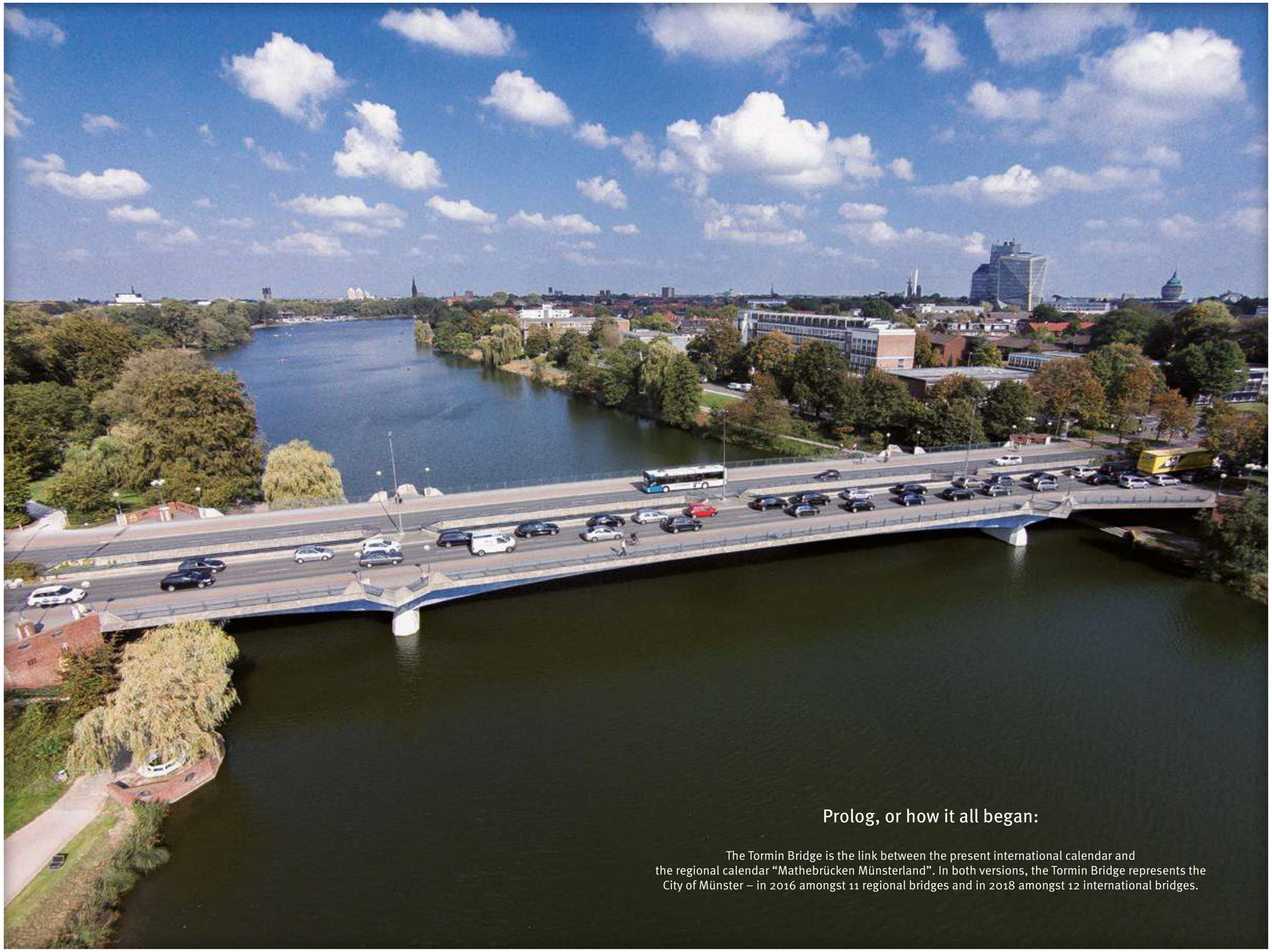
After World War II the Universitätsgesellschaft contributed actively to the reconstruction of Münster University. Among other things, it subsidized the building of new student halls and the students library. In the 1960s, Universitätsgesellschaft took over the administration of the Landhaus Rothenberge, which the University still uses today as a venue for seminars and conferences. The Landhaus Rothenberge was renovated with an impressive budget of nearly one million Euro and was reopened in 2017. Over the years, the society has continually extended its funding and increased the areas it supports, expanding also the number of foundations which it administers.

The Universitätsgesellschaft honors excellent academic achievements at Münster University. It awards two lucrative prizes: the Ernst Hellmut Vits Prize, worth 20,000 Euro, is awarded every two years for an outstanding academic contribution from the fields of natural sciences or medicine and the humanities. The Junior Academics Prize, worth 10,000 Euro, is awarded annually to outstanding junior researchers from various faculties.

From 2003, the Universitätsgesellschaft streamlined its structure and augmented its board of directors with an advisory council and a board of trustees. The board of trustees comprises leading representatives from the fields of politics, science, business and administration in Westphalia – with the purpose of strengthening the practical application of the various projects being undertaken. In 2012, the board of directors also instigated a comprehensive strategic realignment, which included, among other things, better public relations work, the acquisition of more members, events for members and the renaming of the society.

The new name "Universitätsgesellschaft Münster e. V.", should emphasize the wide range of support provided by the society and the connection to Münster University. "With our new name we want to make clear that we are an active society of friends and sponsors for the whole university including all its faculties," explains Dr. Paul-Josef Patt, the chairman of the board of directors of the Universitätsgesellschaft Münster e. V. In addition, a new logo and a new website were developed, on which anyone interested can inform themselves on the society's activities.

In 2018, the Universitätsgesellschaft Münster celebrated its 100th anniversary. There were numerous achievements during the last years. Many new members joined the Universitätsgesellschaft Münster. The membership fees exceeded the amount of 100,000 Euro, resulting in an increased financial support for projects at Münster University. Furthermore, the Universitätsgesellschaft launched a new event format where famous alumni of Münster University give speeches to a current topic. The first speakers were Paul Josef Cardinal Cordes from Rome and the former German Minister of the Environment, Prof. Dr. Klaus Töpfer. All these actions were taken to form a basis for the next successful 100 years of Universitätsgesellschaft Münster.



Prolog, or how it all began:

The Tormin Bridge is the link between the present international calendar and the regional calendar “Mathebrücken Münsterland”. In both versions, the Tormin Bridge represents the City of Münster – in 2016 amongst 11 regional bridges and in 2018 amongst 12 international bridges.

Tormin Bridge, *Germany*

The Tormin Bridge crosses the lake Aasee in the city center of Münster. Visitors of the Tormin Bridge have a good view on the Aasee and its surroundings as well as on the skyline of Münster with its church towers. Every Sunday, visitors of the bridge can listen to “The Lost Reflection”, a sound installation by Susan Philipsz, which has been installed during the Sculpture Projects Münster in 2007. Rarely, there is the occasion to walk through the hollow girders of the concrete bridge.

The relatively new Tormin Bridge in Münster, Germany has been built in 1988. Prior to this bridge, another bridge existed at exactly the same position, but it became too small. The new bridge is 140 m long and has two traffic lanes in both directions. Recently, there has been a traffic jam on the Tormin Bridge as well as on the related road, the Kolde-Ring, due to the closure of the motorway. How much additional weight the bridge would have to carry during occasional traffic jams?

Sydney Harbour Bridge, *Australia*

The Sydney Harbour Bridge, affectionately nicknamed "The Coathanger", is a steel through arch bridge across Sydney Harbour. It is the tallest steel arch bridge in the world, and it is among the top ten widest spanning, and longest spanning, arch bridges. Built from steel sheets as thick as a finger and manually rivetted together by 6 million rivets, the Coathanger carries trains, cars, bikes, and pedestrians.

According to a popular urban legend, the Sydney Harbour Bridge is painted by just one painter who, by the time he is finished painting the Bridge, must already begin the next round of painting. In reality, there are more than a dozen painters employed to maintain the layers of paint that are protecting the 485,000 m² of rivet-studded steel bridge surface from rust. How long do you think that it might take for these painters to paint the bridge just once?

University of New South Wales, *Australia*

Arches Bridge, *Brazil*

Inaugurated on 28 January 1951, the Engineer Antonio Vitorino Avila Filho Bridge, popularly today known as the Arches Bridge, has integrated the railway network of Santa Catarina Railway Co. The upper arches of the bridge are curved in the form of an inverted catenary, just as a suspended chain curves itself under the action of gravity.

The city of Blumenau, in the south of Brazil, is growing and traffic jams are very common. The city therefore wants to build a new bridge over the Itajaí-Açu river. The Arches Bridge will be used as a model for the new one. It was inaugurated on 28 January 1951 and has one railway lane and two lanes for cars. How long will the new bridge be?

FURB – Regional University of Blumenau, *Brazil*

The Devil's Bridge, *Bolivia*

El Puente del Diablo, the old bridge of St. Bartholomew, in Potosí is the oldest in the country. While historical documents mention it being built by a man named Diego Sayago in 1651, tradition tells the tale of its diabolic origin and makes the date of its construction and its authorship fuzzy. The fact that the bridge has remained standing and in use for more than 350 years, speaks of the quality of its construction and the suitability of the person in charge of the work.

A legend says that El Puente del Diablo was built in one night by the Devil Himself. He could not complete his task due to the interference of an angel, so a stone is missing in the middle of the bridge. Even today, the local people are afraid of walking through the bridge at night because of a mysterious black figure feeding ravens at midnight. What is the weight of the ravens when they are resting on top of the arc while being fed?

Private University of Santa Cruz Foundation – UPSA, *Bolivia*

Imperial Bridge, *Austria*

The Reichsbrücke is one of the most famous bridges over the Danube in Vienna and has already been rebuilt twice. The first bridge existed from 1876 to 1937, the second (a suspension bridge) until 1976. On 1 August 1976, the entire bridge collapsed, fortunately only five persons were hurt. In 1980, the third bridge was ceremonially opened. Since 1984, the Reichsbrücke is part of the course of the Vienna City Marathon.

After World War II, this Reichsbrücke was the only Austrian way of passing the Danube downstream from Linz. The traffic was very heavy and, on 1 August 1976, the entire bridge collapsed into the Danube. Thousands of runners cross the 865 m long and 26 m wide Reichsbrücke right after the start of the Vienna City Marathon. How many runners are simultaneously on the bridge, and how long might it take for all runners to cross the bridge?

Vienna University, *Austria*

Bridge over the Grande de Atenas river, *Costa Rica*

The railway bridge over the Grande de Atenas river was built in 1901 to transport heavy cargo and passengers. The intention was to link the Central Valley to Puntarenas, where one of the more important ports of Costa Rica is located. This route is currently not in use because the railroad stopped being a means of transport in the 1990s. In 2002, the bridge was declared a National Architectural Heritage site of Costa Rica.

A tourist company is interested in building a horizontal metal platform (parallel to the bridge) for bungee jumping. For this, the two bases of the main arch of the bridge must be joined and the jump zone should be directly under the highest part of the arch. How many meters below the middle of the bridge will the platform be?

Technical Institute of Costa Rica, *Costa Rica*

Pasupati Bridge, *Indonesia*

Pasupati Bridge was finished in 2005 and connects the north and the east of Bandung. Under the Pasupati Bridge, there is no river, but a park called Pasupati Park. At night, Pasupati Bridge is illuminated in colors. The illuminated bridge has become symbolic of the city of Bandung. The bridge is also connected to the main Cipularang Toll Road from Jakarta. The construction of the bridge has greatly improved the traffic flow from Jakarta into Bandung.

The Pasupati Bridge links Jakarta to the main area of Bandung and functions to reduce traffic jams that often occur during the weekends. The bridge has a length of 2.8 km and a width between 30 m and 60 m. In addition to cars (about 50 % of vehicles in Indonesia) and busses (10 % of vehicles), also motorbikes (40 % of vehicles) travel on the bridge. How many people are on the vehicles that can be on this bridge from end to end?

Ondo Bridge, *Japan*

Ondo no Seto is a waterway that links Kure Bay and Akinada, an open sea. Already in the Heian period (794–1185) the Ondo no Seto area was an important center of traffic for Aki Province and Itsukushima Island. At the narrowest point of the waterway, two mountains sandwich the waterway. In 1961, the Ondo Bridge was built over the narrowest point of the waterway.

The designer of Ondo Bridge had to construct the bridge girder high enough above sea level to allow all ships to pass through. Scarcity of ground space for cars to reach the 23.5 m bridge road altitude was overcome by the design and construction of a spiral shaped road to allow each car to drive from ground level to the bridge road. How wide is this spiral road and how long does it take each car to drive up the 2.5 circuits of the spiral?

Hiroshima University, *Japan*

Tembleque Aqueduct, *Mexico*

Built between 1555 and 1571 by Mexican indigenous craftsmen, the aqueduct is considered a Mestizo System since local and European workers exchanged knowledge and techniques. It was constructed under the supervision of Priest Tembleque, who paid 20 pesos annually to the community of Zempoala in exchange for the water transported to Otumba. The main water source is a spring, called “El Tecajete”.

The aqueduct was constructed between 1555 and 1571 when Franciscan friars settled in Mexico under the supervision of Padre Tembleque. It is divided into 2 branches with 137 visible arches, measuring 48.2 km. The largest component has 68 round arches of heavy stone masonry with lime-sand mortar. Those stones were presumably carried one by one, mostly by indigenous Mexicans. How many stones were used to build one column of the main arch?

Autonomous University of Hidalgo State, *Mexico*

Varodd Bridge Kristiansand, *Norway*

The city of Kristiansand lies on the rocky coast of Norway. To travel east, one needs to cross a fjord via the Varodd Bridges, which are two parallel bridges. The suspension bridge is for traffic leaving Kristiansand. The concrete bridge is of the type “cantilever bridge” and it is for the traffic entering Kristiansand. The two bridges are more than 600 m wide. The two towers of the suspension bridge are both 70 m high (from the sea to the top).

In the picture, you see two bridges with four lanes of traffic. However, for many years there was only a small ferry. The suspension bridge in front was built in 1956 and had two traffic lanes. In 1995, the concrete bridge was built alongside. The suspension bridge is now old and will be taken down. In 2020, there will be two parallel bridges, which together will have six lanes. In which year will an eight-lane bridge be needed?

University of Agder, *Norway*

Itaya Bridge, *Peru*

Opened in 1997, the Itaya Bridge is part of the highway that connects Iquitos city with Nauta city. Many tourists travel to the district of Nauta because canoes (or pequepeques) depart from here to the junction of the rivers Marañon and Ucayali, which lead into the Amazon River. The Itaya Bridge was constructed in the facilities of the Industrial Service of the Navy. From there it had to be transferred in parts by the rivers Nanay and Itaya to its final destination.

On 24 June, the patron saint festival of San Juan is celebrated in the Peruvian Amazon, the people of Iquitos and Nauta go around the river to celebrate this day with various activities. The municipality has organized a race of motor boats along the Itaya River. Due to a higher water level in June, motor boats can cross between the two columns under the Itaya Bridge. How many boats can pass under the bridge at the same time during this race without accident?

National University of Peruvian Amazon, *Peru*

Lutosławski Bridge, *Poland*

Nowadays, the city of Lublin, Poland, may pride itself on two historic (100 year-old) bridges in Hennebique technology. The Polish Engineer Marian Lutosławski, who was a pioneer within the field of use of Reinforced Concrete (RC), constructed both bridges. Both of them are unique and constitute a significant contribution to the world's RC technical heritage. One of the two was successfully renovated in 2012 and is now used as a pedestrian bridge and as a place of cultural events.

Lutosławski Bridge in Lublin is unofficially called the “Bridge of culture”, because inhabitants of Lublin can take part in many cultural events on this bridge. For example, concerts, parties, and exhibitions have been arranged here. How many people can safely fit on the bridge during a concert?

Lublin University of Technology, *Poland*

November

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30

Glebovsky Bridge, *Russia*

Glebovsky Bridge was built on the territory of Ryazan Kremlin in the 15th century. The bridge was made of wood and could be lifted up so that not everyone could get inside the fortified Kremlin. After a fire in the 17th century, the bridge was rebuilt only in the 19th century. Nowadays, it is made of stone and does not have the lifting mechanism. The Sobornaya bell tower together with Glebovsky Bridge form a picturesque unity which fascinates tourists that come to Ryazan.

Glebovsky Bridge was originally made of wood over the Trubezh River during the late Medieval Ages to protect the city center of Ryazan from enemies. Nowadays, it is made of bricks and connects Ryazan Kremlin with the modern part of the city. Every year, at least 1 million tourists visit the Kremlin. If they all cross Glebovsky Bridge and give 1 Euro to the street musicians there, then how big would a bag containing the coins from one day be?

Ryazan State University, *Russia*

Solutions

The following solutions are exemplary solutions. Different assumptions for missing data and different solution strategies are possible and correct!

00. Germany:
Supposing that an average car is 5 m long and would need 7 m space to the car in front and behind, which is the mandatory distance to be kept. Knowing that one traffic lane is 140 m long, there would be space for 20 cars in a row per traffic lane. Assuming that there are traffic jams on all 4 traffic lanes, there would thus be 80 cars on the bridge. Estimating the average weight per car being 2 t, the estimated additional weight on the bridge would be 160 t.

01. Australia:
To paint the bridge, more than one layer might be needed, say 3. Each painter paints an estimated 10 m²/h, so painting the Bridge with 3 layers of paint might take 12 painters 3 × 485,000 m²: (12 × 10 m²/h) ≈ 12,000 hours. If there are 6 hours of painting per working day, then this is roughly 2,000 days ≈ 400 weeks ≈ 8 years of painting. If the urban legend had been true, then the lone painter would never had finished painting the bridge for that would have taken 100 years to do!

02. Brazil:
The new bridge will have the same length as the old bridge. To estimate that length from the picture, one can use the length of the white car in the middle arch as a unit of measurement. Assuming that the van is about 5 m long and that 8 vans together span the length of each of the 3 arches, the total bridge length is about 3 × 8 × 5 m ≈ 120 m. You can also use trigonometry, by first measuring the angle between the bridge's floor and the upper arch corner (≈ 26°).

03. Bolivia:
Using the person in the small picture as a unit of measurement (1.80 m), the span and the width of the bridge may be estimated to be 15 m and 7 m, respectively. Thus, the area of the bridge is about 15 m × 7 m = 105 m². Assuming that an average raven weighs 1 kg and that one raven takes up 0.5 m × 0.2 m = 0.01 m², we find that there are 105 m²: 0.01 m² = 10,500 ravens. The total weight of ravens resting on top of the bridge arch is about roughly 10 t.

04. Austria:
Assume that 20 m of the bridge width can be used by runners (each direction has 3 lanes) and that each runner occupies 2 m² while running. There are then (20 m × 865 m): 2 m² = 8,650 ≈ 9,000 runners simultaneously on the bridge. Suppose that the first runner is 1,500 m ahead of the last. The last runner to cross the bridge must then run 865 m + 1,500 m = 2,365 m. If each person runs at 3 m/s, then it would take the runners 2,365 m: 3 m/s ≈ 788 s ≈ 13 min to all run over the bridge.

05. Costa Rica:
The length of the white car in the picture is 0.7 cm. The real length for that car is about 4 m. Draw a horizontal line between the two arch bases to represent the vertical position of the platform, and measure: it lies 2.6 cm below the middle of the bridge. If y is the distance to be found, then the proportions y/2.6 cm = 4 m/0.7 cm imply that the platform will lie about y ≈ 15 m below the middle of the bridge.

06. Indonesia:
For every 10 vehicles, there are 1 bus, 5 cars and 4 motorbikes. Each car, bus and motorbike carries 4, 50 and 2 passengers and, in a traffic jam, take up 7 m, 14 m and 3 m of the road, respectively. Motorbikes can stand two side by side, so on average, 10 vehicles need 1 × 14 m + 5 × 7 m + 4 × 1.5 m = 55 m of space. Assuming three traffic lanes, about 3 × (2,800 m: 55 m) × 10 ≈ 1,500 vehicles can be on the bridge, or 150 busses, 750 cars, and 600 motorbikes, carrying about 150 × 50 + 750 × 4 + 600 × 2 ≈ 11,700 people.

07. Japan:
To estimate the diameter of the spiral road, use one of the 23.5 m tall bridge beams as a unit of measure, for instance by overlaying the beam onto the white spiral road. The diameter is seen to be about 50 m. The circumference of the spiral road is then about 50 m × π ≈ 157 m, so the length of the 2.5 circuits is roughly 157 m × 2.5 ≈ 392 m. So, every car needs to drive about 400 m along the spiral road.

08. Mexico:
In the front face of the 1st section of the column, we count 8 corner stones and (4 × 5 × 5) × 8 = 800 smaller stones. As the width and the depth of the 2nd section are smaller on average by one stone, we have for the next 20 corner stones approximately (4 × 4 × 4) × 20 ≈ 1,300 smaller stones. The total number of corner stones is approximately (8 + 20) × 4 = 112. The final estimation is then 800 + 1,300 + 112 ≈ 2,200 stones for one column. Too many stones had to be carried by the Mexican people!

09. Norway:
2 lanes were sufficient for about 40 years, 4 lanes for about 25 years, and 6 lanes will suffice for x years. Assume that 40 – 25 – x decreases arithmetically; then x = 10. So, 8 lanes will be needed in 2020 + x = 2030, or later if more bicycles or autonomous cars will be used. Alternatively, assume that the periods decrease exponentially (with growth factor 25/40). Or, draw a graph with point (1956; 2), (1995; 4), (2020; 6) and estimate the last point by a smooth graph.

10. Peru:
Using the person in the picture as a unit of measurement (1.70 m), the distance between railing columns may be estimated to be 1.40 m. As there are 29 railings, the horizontal space under the bridge is about 1.40 m × 29 ≈ 40.5 m. If each boat is 1.50 m wide and a distance of 0.5 m between boats and bridge columns must be maintained, then the number of boats that are able to pass at the same time under the bridge is approximately (40.5 m – 0.5 m): 2 m = 20.

11. Poland:
Taking the height of the road sign (2 m) as a unit of measure, estimate the width of the bridge to be 14 m and the length of the first bridge segment to be 10 m, so the bridge is about 5 × 10 m = 50 m long. The area of the bridge is then 14 m × 50 m ≈ 700 m². Taking into consideration an area of 150 m² for event facilities, 700 m² – 150 m² = 550 m² remain for the people. If each person occupies 1.5 m², then about 550 m²: 1.5 m² ≈ 350 people can safely fit on the bridge during a concert.

12. Russia:
The radius of a 1€-coin is about 1 cm and its width is about 0.2 cm. So, the volume of one coin is about π × (1 cm)² × 0.2 cm ≈ 0.6 cm³. The average number of people on the bridge each day is about 1,000,000: 365 ≈ 2,740 people. The volume of 2,740 coins, and thus of the bag, is approximately 2,740 × 0.6 cm³ ≈ 1,650 cm³, or roughly 1.7 L .

Authors of the Fermi problems

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