= History of the metric system =

Concepts similar to those behind the metric system had been discussed in the 16th and 17th centuries . Simon Stevin had published his ideas for a decimal notation and John Wilkins had published a proposal for a decimal system of measurement based on natural units . The first practical realisation of the metric system came in 1799 , during the French Revolution , when the existing system of measure , which had fallen into disrepute , was temporarily replaced by a decimal system based on the kilogram and the metre . The work of reforming the old system of weights and measures had the support of whoever was in power , including Louis XVI . The metric system was to be , in the words of philosopher and mathematician Condorcet , " for all people for all time " . In the era of humanism , the basic units were taken from the natural world : the unit of length , the metre , was based on the dimensions of the Earth , and the unit of mass , the kilogram , was based on the mass of water having a volume of one litre or one thousandth of a cubic metre . Reference copies for both units were manufactured and placed in the custody of the French Academy of Sciences . By 1812 , due to the unpopularity of the new metric system , France had reverted to a measurement system using units similar to those of their old system .

In 1837 the metric system was re @-@ adopted by France , and also during the first half of the 19th century was adopted by the scientific community . In the middle of the century , James Clerk Maxwell put forward the concept of a coherent system where a small number of units of measure were defined as base units , and all other units of measure , called derived units , were defined in terms of the base units . Maxwell proposed three base units : length , mass and time . This concept worked well with mechanics , but attempts to describe electromagnetic forces in terms of these units encountered difficulties . By the end of the 19th century , four principal variants of the metric system were in use for the measurement of electromagnetic phenomena : three based on the centimetre @-@ gram @-@ second system of units (CGS system) , and one on the metre @-@ kilogram @-@ second system of units (MKS system) . This impasse was resolved by Giovanni Giorgi , who in 1901 proved that a coherent system that incorporated electromagnetic units had to have an electromagnetic unit as a fourth base unit .

Until 1875 , the French government owned the prototype metre and kilogram , but in that year the Convention of the metre was signed , and control of the standards relating to mass and length passed to a trio of inter @-@ governmental organisations , the senior of which was the General Conference on Weights and Measures (in French the Conférence générale des poids et mesures or CGPM) . During the first half of the 20th century , the CGPM cooperated with a number of other organisations , and by 1960 it had responsibility for defining temporal , electrical , thermal , molecular and luminar measurements , while other international organisations continued their roles in how these units of measurement were used .

In 1960 , the CGPM launched the International System of Units (in French the Système international d 'unités or SI) which had six " base units " : the metre , kilogram , second , ampere , degree Kelvin (subsequently renamed the " kelvin ") and candela ; as well as 22 further units derived from the base units . The mole was added as a seventh base unit in 1971 . During this period , the metre was redefined in terms of the wavelength of the waves from a particular light source , and the second was defined in terms of the frequency of radiation from another light source . Since the end of the 20th century , an effort has been undertaken to redefine the ampere , kilogram , mole and kelvin in terms of the basic constants of physics .

= = Development of underlying principles = =

The first practical implementation of the metric system was the system implemented by French Revolutionaries towards the end of the 18th century . Its key features were that :

It was decimal in nature .

It derived its unit sizes from nature .

Units that have different dimensions are related to each other in a rational manner .

Prefixes are used to denote multiples and sub @-@ multiples of its units .

These features had already been explored and expounded by various scholars and academics in the two centuries prior to the French metric system being implemented .

Simon Stevin is credited with introducing the decimal system into general use in Europe . Twentieth @-@ century writers such Bigourdan (France , 1901) and McGreevy (United Kingdom , 1995) credit the French cleric Gabriel Mouton (1670) as the originator of the metric system . In 2007 a proposal for a coherent decimal system of measurement by the English cleric John Wilkins (1668) received publicity . Since then writers have also focused on Wilkins ' proposals : Tavernor (2007) gave both Wilkins and Mouton equal coverage while Quinn (2012) makes no mention of Mouton but states that " he [Wilkins] proposed essentially what became ... the French decimal metric system " .

= = = Work of Simon Stevin = = =

During the early medieval era , Roman numerals were used in Europe to represent numbers , but the Arabs represented numbers using the Hindu numeral system , a positional notation that used ten symbols . In about 1202 , Fibonacci published his book Liber Abaci (Book of Calculation) which introduced the concept of positional notation into Europe . These symbols evolved into the numerals " 0 " , " 1 " , " 2 " etc .

At that time there was dispute regarding the difference between rational numbers and irrational numbers and there was no consistency in the way in which decimal fractions were represented . In 1586 , Simon Stevin published a small pamphlet called De Thiende (" the tenth ") which historians credit as being the basis of modern notation for decimal fractions . Stevin felt that this innovation was so significant that he declared the universal introduction of decimal coinage , measures , and weights to be merely a question of time .

= = = Work of John Wilkins = = =

In the mid seventeenth century John Wilkins , the first secretary of England 's Royal Society , was asked by the society to devise a " universal standard of measure " . In 1668 he attempted to codify all knowledge in his 621 @-@ page book An Essay towards a Real Character and a Philosophical Language . Four pages of Part II in Chapter VII were devoted to physical measurement . Here Wilkins also proposed a decimal system of units of measure based on what he called a " universal measure " that was derived from nature for use between " learned men " of various nations .

Wilkins considered the earth 's meridian , atmospheric pressure and , following a suggestion by Christopher Wren and demonstrations by Christiaan Huygens , the pendulum as the source for his universal measure . He discarded atmospheric pressure as a candidate ? it was described by Torricelli in 1643 as being susceptible to variation (the link between atmospheric pressure and weather was not understood at the time) and he discarded a meridian as being too difficult to measure ; leaving the pendulum as his preferred choice . He proposed that the length of a " seconds pendulum " (approximately 993 mm) which he named the " standard " should be the basis of length . He proposed further that the " measure of capacity " (base unit of volume) should be defined as a cubic standard and that the " measure of weight " (base unit of weight [mass]) should be the weight of a cubic standard of rainwater . All multiples and sub @-@ multiples of each of these measures would be related to the base measure in a decimal manner . In short , Wilkins " proposed essentially what became ... the French decimal metric system " .

= = = Work of Gabriel Mouton = = =

In 1670 , Gabriel Mouton , a French abbot and astronomer , published the book Observationes diametrorum solis et lunae apparentium in which he proposed a decimal system of measurement of length for use by scientists in international communication , to be based on the dimensions of the Earth . The milliare would be defined as a minute of arc along a meridian and would be divided into 10 centuria , the centuria into 10 decuria and so on , successive units being the virga , virgula ,

decima , centesima , and the millesima . Mouton used Riccioli 's estimate that one degree of arc was 321 @,@ 185 Bolognese feet , and his own experiments showed that a pendulum of length one virgula would beat 3959 @.@ 2 times in half an hour . Current pendulum theory shows that such a pendulum would have had an equivalent length of 205 @.@ 6 mm ? using today 's knowledge of the size of the earth , the virgula would have been approximately 185 @.@ 2 mm . He believed that with this information scientists in a foreign country would be able to construct a copy of the virgula for their own use .

= = = 17th @-@ century developments = = =

Communication of metrological information was one of the issues facing mid @-@ seventeenth century savants ; many discussed the possibility of scholarly communication using a so @-@ called " universal measure " that was not tied to a particular national system of measurement . Mouton 's ideas attracted interest at the time ; Picard in his work Mesure de la Terre (1671) and Huygens in his work Horologium Oscillatorium sive de motu pendulorum (1673) both proposing that a standard unit of length be tied to the beat frequency of a pendulum .

The French Academy of Sciences (Académie Royale des Sciences) interest in the pendulum experiments were effectively announced by Picard in his work Mesure de la Terre . The length of a " second pendulum " was measured at a number of locations outside France , in 1671 at Uraniborg , an island 26 km north of Copenhagen and in 1672 Jean Richer measured one at Cayenne in French Guiana , 5 ° north of the equator . There was no discernible difference between the Uraniborg pendulum and the Paris one , but there was a 2 @.@ 81 mm difference between the lengths of the Cayenne pendulum and that from Paris . Cooperation with the English Royal Society showed no discernible difference between pendulums measured in London and Paris , but measurements taken at Gorée in Senegal , in West Africa were more in line with those taken at Cayenne . Meanwhile , in England , Locke , in his work An Essay Concerning Human Understanding (1689) , made references to the " philosopher 's foot " which he defined as being one third of a " second pendulum " at 45 ° latitude .

In 1686 Englishman Newton , in his book Philosophiæ Naturalis Principia Mathematica , gave a theoretical explanation for the " bulging equator " which also explained the differences found in the lengths of the " second pendulums " , theories that were confirmed by the Académie 's expedition to Peru in 1735 .

= = = 18th @-@ century international cooperation = = =

In the late eighteenth century proposals , similar to those of the seventeenth century for a universal measure , were made for a common international system of measure in the spheres of commerce and technology ; when the French Revolutionaries implemented such a system , they drew on many of the seventeenth @-@ century proposals .

In the early ninth century , when much of what later became France was part of the Holy Roman Empire , units of measure had been standardised by the Emperor Charlemagne . He had introduced standard units of measure for length and for mass throughout his empire . As the empire disintegrated into separate nations , including France , these standards diverged . It has been estimated that on the eve of the Revolution , a quarter of a million different units of measure were in use in France ; in many cases the quantity associated with each unit of measure differed from town to town , and even from trade to trade . Although certain standards , such as the pied du roi (the King 's foot) had a degree of pre @-@ eminence and were used by scientists , many traders chose to use their own measuring devices , giving scope for fraud and hindering commerce and industry . These variations were promoted by local vested interests , but hindered trade and taxation . In contrast , in England the Magna Carta (1215) had stipulated that " there shall be one unit of measure throughout the realm " .

By the mid @-@ eighteenth century , it had become apparent that standardisation of weights and measures between nations who traded and exchanged scientific ideas with each other was

necessary . Spain , for example , had aligned her units of measure with the royal units of France , and Peter the Great aligned the Russian units of measure with those of England . In 1783 the British inventor James Watt , who was having difficulties in communicating with German scientists , called for the creation of a global decimal measurement system , proposing a system which , like the seventeenth @-@ century proposal of Wilkins , used the density of water to link length and mass , and in 1788 the French chemist Antoine Lavoisier commissioned a set of nine brass cylinders ? a [French] pound and decimal subdivisions thereof for his experimental work .

In 1789 French finances were in a perilous state , several years of poor harvests had resulted in hunger among the peasants and reforms were thwarted by vested interests . On 5 May 1789 Louis XVI summoned the Estates @-@ General which has been in abeyance since 1614 , triggering a series of events that were to culminate in the French Revolution . On 20 June 1789 the newly formed Assemblée nationale (National Assembly) took an oath not to disband until a constitution had been drafted , resulting in the setting up , on 27 June 1789 , of the Assemblée nationale constituante (Constituent Assembly) . On the same day , the Académie des sciences (Academy of Sciences) set up a committee to investigate the reform of weights and measures which , due to their diverse nature , had become a vehicle for corruption .

On 4 August 1789 , three weeks after the storming of the Bastille , the nobility surrendered their privileges , including the right to control local weights and measures .

Talleyrand , Assemblée representative of the clergy , revolutionary leader and former Bishop of Autun , at the prompting of the mathematician and secretary of the Académie Condorcet , approached the British and the Americans in early 1790 with proposals of a joint effort to define a common standard of length based on the length of a pendulum . Great Britain , represented by John Riggs Miller and the United States represented by Thomas Jefferson agreed in principle to the proposal , but the choice of latitude for the pendulum proved to be a sticking point : Jefferson opting for 38 ° N , Talleyrand for 45 ° N and Riggs @-@ Miller for London 's latitude . On 8 May 1790 Talleyrand 's proposal in the Assemblée that the new measure be defined at 45 ° N " or whatever latitude might be preferred " won the support of all parties concerned . On 13 July 1790 , Jefferson presented a document Plan for Establishing Uniformity in the Coinage , Weights , and Measures of the United States to the U.S. Congress in which , like Wilkins , he advocated a decimal system in which units that used traditional names such as inches , feet , roods were related to each by the powers of ten . Again , like Wilkins , he proposed a system of weights based around the weight of a cubic unit of water , but unlike Wilkins , he proposed a " rod pendulum " rather than a " bob pendulum " . Riggs @-@ Miller promoted Talleyrand 's proposal in the British House of Commons .

In response to Talleyrand 's proposal of 1790 , the Assemblée set up a new committee under the auspices of the Académie to investigate weights and measures . The members were five of the most able scientists of the day ? Jean @-@ Charles de Borda , Joseph @-@ Louis Lagrange , Pierre @-@ Simon Laplace , Gaspard Monge and Condorcet . The committee , having decided that counting and weights and measures should use the same radix , debated the use of the duodecimal system as an alternative to the decimal system . Eventually the committee decided that the advantages of divisibility by three and four was outweighed by the complications of introducing a duodecimal system and on 27 October 1790 recommended to the Assemblée that currency , weights and measures should all be based on a decimal system . They also argued in favour of the decimalization of time and of angular measures . The committee examined three possible standards for length ? the length of pendulum that beat with a frequency of once a second at 45 ° latitude , a quarter of the length of the equator and a quarter of the length of a meridian . The committee also proposed that the standard for weight should be the weight of distilled water held in cube with sides a decimal proportion of the standard for length . The committee 's final report to the Assemblée on 17 March 1791 recommended the meridional definition for the unit of length . Borda , inventor of the repeating circle was appointed chairman . The proposal was accepted by the Assemblée on 30 March 1791 .

Jefferson 's report was considered but not adopted by the U.S. Congress , and Riggs @-@ Miller lost his British Parliamentary seat in the election of 1790 . When the French later overthrew their monarchy , Britain withdrew her support. and France decided to " go it alone " .

= = = Roles of Wilkins and Mouton = = =

In the past many writers such as Bigourdan (France , 1903) and McGreevy (United Kingdom , 1995) credited Mouton as the " founding father " of the metric system . In 2007 the late Australian metric campaigner Pat Naughtin investigated Wilkins ' proposal for a universal system of measurement in Wilkins ' essay , a work that pre @-@ dated Mouton 's proposal by two years . Wilkins ' proposal , unlike Mouton 's , discussed an integrated measurement system that encompassed length , volume and mass rather than just length .

Wilkins ' Essay was widely circulated at the time , but the main interest in the Essay was his proposal for a philosophical language in general rather than just a universal standard for units of measure . Subsequent interest in Wilkins ' Essay was confined mainly to those interested in the field of onomasiology rather than metrology : for example , Roget in the introduction of his Thesaurus (1852) , noted Wilkins ' Essay as being one of the leading seventeenth @-@ century works in onomasiology . British commentators of the Essay devoted little space to Wilkins ' proposals of measurement ; Vernon et al . (1802) made a passing comment on the section on measurements in an eight @-@ page study of the Essay while Wright @-@ Henderson (1910) , in a four @-@ page study of the Essay , made no comments about measurements at all .

Mouton 's proposals were taken seriously by , amongst others , the seventeenth @-@ century scientists Jean Picard and Christiaan Huygens , but a hundred years were to elapse before the French again took interest in the underlying theory of the development of systems of measure .

Shortly after the introduction of the metric system by the French , a letter by an anonymous but regular contributor to The Philosophical Magazine (1805) noted the lack of acknowledgement by the French of Wilkins ' publication . The writer accused the editors of the Encyclopédie of giving unwarranted attention to the work of Mouton and Huygens at the expense of Edward Wright who , in 1599 had proposed using the earth 's meridian as a standard , and of Wilkins who had proposed a measurement system . He took British writers to task for not " defending their countrymen " . He went on to note that there was considerable communication between scientists on either side of the Channel , particularly with Huygens and Leibniz either visiting or being members of both the Royal Society and the Académie Royale des Sciences .

= = Implementation in Revolutionary France (1792 ? 1812) = =

When the National Assembly accepted the committee 's report on 30 March 1791 , the Académie des sciences was instructed to implement the proposals . The Académie broke the tasks into five operations , allocating each part to a separate working group :

Measuring the difference in latitude between Dunkirk and Barcelona and triangulating between them (Cassini , Méchain , and Legendre)

Measuring the baselines used for the survey (Monge , Meusnier)

Verifying the length of the second pendulum at 45 ° latitude (de Borda and de Coulomb) .

Verifying the weight in vacuo of a given volume of distilled water (Antoine Lavoisier and René Just Haüy) .

Publishing conversion tables relating the new units of measure to the existing units of measure (Tillet) .

On 19 June 1791 - the day before Louis XVI 's flight to Varennes - Cassini , Méchain , Legendre and Borda obtained a royal audience where the king agreed to fund both the measurement of the meridian and repeating the measurements made by Cassini 's father . The king 's authorization arrived on 24 June 1791 .

During the political turmoil that followed the king 's flight to Varennes , the reform of weights and measures and in particular the measurement of the meridian continued albeit with interruptions , though the structure of the commission changed with the changing political climate . In May 1792 Cassini , loyal to Louis XVI but not to the Revolution was replaced by Delambre and on 11 July 1792 the Commission formally proposed the names " metre " , " litre " and multipliers " centi " , " kilo " etc.

to the Assembly .

Louis XVI was executed on 21 January 1793 and on 8 August of that year , on the eve of the Reign of Terror the new de facto government executive , the Committee of Public Safety suppressed all academies and with it the commission , requiring them to justify their existence . Antoine François , comte de Fourcroy , a member of the convention argued that the importance of reforming weights and measures was such that the work of the commission should be allowed to continue . On 11 September 1793 the commission was reconstituted as the commission temporaire .

On 7 April 1795 the metric system was formally defined in French law and provisional standards based on Cassini 's survey of 1740 adopted . On 22 October 1795 the work of the commission (since reconstituted as a three @-@ man agence temporaire under Legendre 's directorship) was taken over by the newly formed National Institute of Arts and Science and under the new government , the Directory , was transferred to the " Office for Weights and Measures " under the Minister of the Interior .

On 15 November 1798 Delambre and Méchain returned to Paris with their data , having completed the survey of the Dunkirk @-@ Barcelona meridian . The data was analysed and a prototype metre constructed from platinum with a length of 443 @.@ 296 lignes . At the same time a prototype kilogram was constructed ? the mass of a cube of water at 4 ° C , each side of the cube being 0 @.@ 1 metres . The prototype metre was presented to the French legislative assemblies on 22 June 1799 .

= = = Decimal time (1793) = = =

The decree of 5 October 1793 introduced the Republican Calendar into France and with it decimalised time . The day was divided into 10 " decimal hours " , the " hour " into 100 " decimal minutes " and the " decimal minute " into 100 " decimal seconds " . The " decimal hour " corresponded to 2 hr 24 min , the " decimal minute " to 1 @.@ 44 min and the " decimal second " to 0 @.@ 864 s . The revolutionary week was 10 days , but there were still twelve months in a year , each month consisting of three " weeks " . Each year had five or six intercalary days to make up the total of 365 or 366 days .

The implementation of decimal time proved an immense task and under the article 22 of the law of 18 Germinal , Year III (7 April 1795) , the use of decimal time was no longer mandatory , though the Republican Calendar was retained . On 1 January 1806 , France reverted to the traditional timekeeping .

= = = Angular measure (c . 1793) = = =

Although there was no specific decree regarding angular measure which was also decimalised during the 1790s , it is reported to have been used in 1794 , but was not mentioned in the metric system decree of 1795 . In particular , the repeating circle , invented in about 1787 by Borda , himself a strong proponent of decimalization , was adapted to use decimal angles .

A grade (or gon) was defined as being 1 ? 100 of a quadrant , making 400 grades in a full circle . Fractions of the grade used the standard metric prefixes , thus one centigrade was 1 ? 10000 of a quadrant , making one centigrade of longitude approximately one kilometre .

The adoption of the grade by the cartographic community was sufficient to warrant a mention in the Lexicographia @-@ neologica Gallica in 1801 and its use continued on military maps through the nineteenth century into the twentieth century . It appears not to have been widely used outside cartography . The centigrade , as an angular measure , was adopted for general use in a number countries , so in 1948 the General Conference on Weights and Measures (CGPM) recommended that the degree centigrade , as used for the measurement of temperature , be renamed the degree Celsius . The SI Brochure (2006) notes that the gon is now a little @-@ used alternative to the degree .

= = = Draft metric system (1795) = = =

In France , the metric system of measure was first given a legal basis in 1795 by the French Revolutionary government . Article 5 of the law of 18 Germinal , Year III (7 April 1795) defined six new decimal units . The units and their preliminary values were :

The metre , for length ? defined as being one ten millionth of the distance between the North Pole and the Equator through Paris

The are (100 m2) for area [of land]

The stère (1 m3) for volume of firewood

The litre (1 dm3) for volumes of liquid

The gramme , for mass ? defined as being the mass of one cubic centimetre of water

The franc , for currency

Decimal multiples of these units were defined by Greek prefixes : " myria- " (10 @,@ 000) , " kilo- " (1000) , " hecta- " (100) and " deka- " (10) and submultiples were defined by the Latin prefixes " deci- " (0 @.@ 1) , " centi- " (0 @.@ 01) and " milli- " (0 @.@ 001) . Using Cassini 's survey of 1744 , a provisional value of 443 @.@ 44 lignes was assigned to the metre which , in turn , defined the other units of measure .

The final value of the metre was defined in 1799 when Delambre and Méchain presented the results of their survey between Dunkirk and Barcelona which fixed the length of the metre at 443 @.@ 296 lignes . The law 19 Frimaire An VIII (10 December 1799) defined the metre in terms of this value and the kilogramme as being 18827 @.@ 15 grains . These definitions enabled reference copies of the kilograms and metres to be constructed and these were used as the standards for the next 90 years .

= = = Meridianal definition = = =

The question of measurement reform in France was placed in the hands of the French Academy of Sciences who appointed a commission chaired by Jean @-@ Charles de Borda . Borda could be said to have been a fanatic for decimalization : he had designed the repeating circle , a surveying instrument which allowed a much @-@ improved precision in the measurement of angles between landmarks , but insisted that it be calibrated in " grades " (1 ? 100 of a quarter @-@ circle) rather than degrees , with 100 minutes to a grade and 100 seconds to a minute . The instrument was manufactured by Étienne Lenoir . For Borda , the seconds pendulum was a poor choice for a standard because the second (as a unit of time) was insufficiently decimal : he preferred the new system of 10 hours to the day , 100 minutes to the hour and 100 seconds to the minute .

Instead , the commission ? whose members included Lagrange , Laplace , Monge and Condorcet ? decided that the new measure should be equal to one ten @-@ millionth of the distance from the North Pole to the Equator (the quadrant of the Earth 's circumference) , measured along the meridian passing through Paris . Apart from the obvious nationalistic considerations , the Paris meridian was also a sound choice for practical scientific reasons : a portion of the quadrant from Dunkerque to Barcelona (about 1000 km , or one @-@ tenth of the total) could be surveyed with start- and end @-@ points at sea level , and that portion was roughly in the middle of the quadrant , where the effects of the Earth 's oblateness were expected to be the largest .

The task of surveying the meridian arc , which was authorized by Louis XVI and which was estimated to take two years , fell to Pierre Méchain and Jean @-@ Baptiste Delambre . The task eventually took more than six years (1792 ? 1798) with delays caused not only by unforeseen technical difficulties but also by the convulsed period of the aftermath of the Revolution . In the meantime , the commission calculated a provisional value from older surveys of 443 @.@ 44 lignes .

The project was split into two parts ? the northern section of 742 @.@ 7 km from the Belfry , Dunkirk to Rodez Cathederal which was surveyed by Delambre and the southern section of 333 @.@ 0 km from Rodez to the Montjuïc Fortress , Barcelona which was surveyed by Méchain .

Delambre used a baseline of about 10 km in length along a straight road , located close to Melun . In an operation taking six weeks , the baseline was accurately measured using four platinum rods ,

each of length two toise (about 3 @.@ 9 m) . Thereafter he used , where possible , the triangulation points used by Cassini in his 1744 survey of France . Méchain 's baseline , of a similar length , and also on a straight section of road was in the Perpignan area . Although Méchain 's sector was half the length of Delambre , it included the Pyrenees and hitherto unsurveyed parts of Spain . After the two surveyors met , each computed the other 's baseline in order to cross @-@ check their results and they then recomputed the kilometre . Their result came out at 0 @.@ 144 lignes shorter than the provisional value , a difference of about 0 @.@ 03 % .

= = = Mètre des Archives = = =

While Méchain and Delambre were completing their survey , the commission had ordered a series of platinum bars to be made based on the provisional metre . When the final result was known , the bar whose length was closest to the meridianal definition of the metre was selected and placed in the French National Archives on 22 June 1799 (4 messidor An VII in the Republican calendar) as a permanent record of the result : this standard metre bar became known as the mètre des Archives .

The metric system , that is the system of units based on the metre , was officially adopted in France on 10 December 1799 (19 frimaire An VIII) and became the sole legal system of weights and measures there from 1801 .

It soon became apparent that Méchain and Delambre 's result (443 @.@ 296 lignes) was slightly too short for the meridianal definition of the metre . Arago and Biot extended the survey to the island of Formentera in the western Mediterranean Sea in 1806 ? 1809 , and found that one ten @-@ millionth of the Earth 's quadrant should be 443 @.@ 31 lignes : later work increased the value to 443 @.@ 39 lignes . The modern value , for the WGS 84 reference spheroid , is 1 @.@ 000 196 57 m or 443 @.@ 383 08 lignes .

Nevertheless , the mètre des Archives remained the legal and practical standard for the metre in France , even once it was known that it did not exactly correspond to the meridianal definition . When , in 1867 , it was proposed that a new international standard metre be created , the length was taken to be that of the mètre des Archives " in the state in which it shall be found " .

= = = Kilogramme des Archives = = =

On 7 April 1795 , the gramme , upon which the kilogram is based , was decreed to be equal to " the absolute weight of a volume of pure water equal to a cube of one hundredth of a metre , and at the temperature of the melting ice " . Although this was the definition of the gram , the regulation of trade and commerce required a " practical realisation " : a single @-@ piece , metallic reference standard that was one thousand times more massive that would be known as grave . This mass unit , whose name is derived from the word " gravity " , defined by Lavoisier and René Just Haüy had been in use since 1793 . Notwithstanding that the definition of the base unit of mass was the gramme (alternatively " gravet ") , this new , practical realisation would ultimately become the base unit of mass . A provisional kilogram standard was made and work was commissioned to determine the precise mass of a cubic decimetre (later to be defined as equal to one litre) of water .

Although the decreed definition of the kilogramme specified water at 0 ° C ? a highly stable temperature point ? the scientists tasked with producing the new practical realisation chose to redefine the standard and perform their measurements at the most stable density point : the temperature at which water reaches maximum density , which was measured at the time as 4 ° C. They concluded that one cubic decimetre of water at its maximum density was equal to 99 @.@ 92072 % of the mass of the provisional kilogram made earlier that year . Four years later in 1799 , an all @-@ platinum standard , the " Kilogramme des Archives " , was fabricated with the objective that it would equal , as close as was scientifically feasible for the day , to the mass of cubic decimetre of water at 4 ° C. The kilogramme was defined to be equal to the mass of the Kilogramme des Archives and this standard stood for the next ninety years .

Note that the new metric system did not come into effect in France until after the French Revolution , when the new revolutionary government captured the idea of the metric system . The decision of

the Republican government to name this new unit the " kilogramme " had been mainly politically motivated , because the name " grave " was at that time considered politically incorrect as it resembled the aristocratic German title of the Graf , an alternative name for the title of Count that , like other nobility titles , was inconsistent with the new French Republic notion of equality (égalité) . Accordingly , the name of the original , defined unit of mass , " gramme " , which was too small to serve as a practical realisation , was adopted and the new prefix " kilo " was appended to it to form the name " kilogramme " . Consequently , the kilogram is the only SI base unit that has an SI prefix as part of its unit name .

= = Adoption of the metric weights and measures = =

During the nineteenth century the metric system of weights and measures proved a convenient political compromise during the unification processes in the Netherlands , Germany and Italy . In 1814 , Portugal became the first country not part of the French Empire to officially adopt a metric system . Spain found it expedient in 1858 to follow the French example and within a decade Latin America had also adopted the metric system . There was considerable resistance to metrication in the United Kingdom and in the United States , though once the United Kingdom announced its metrication program in 1965 , the Commonwealth followed suit .

= = = France = = =

The introduction of the metric system into France in 1795 was done on a district by district basis with Paris being the first district , but by modern standards the transition was poorly managed . Although thousands of pamphlets were distributed , the Agency of Weights and Measures who oversaw the introduction underestimated the work involved . Paris alone needed 500 @,@ 000 metre sticks , yet one month after the metre became the sole legal unit of measure , they only had 25 @,@ 000 in store . This , combined with other excesses of the Revolution and the high level of illiteracy made the metric system unpopular .

Napoleon himself ridiculed the metric system , but as an able administrator , recognised the value of a sound basis for a system of measurement and under the décret impérial du 12 février 1812 (imperial decree of 12 February 1812) , a new system of measure ? the mesures usuelles or " customary measures " was introduced for use in small retail businesses ? all government , legal and similar works still had to use the metric system and the metric system continued to be taught at all levels of education . The names of many units used during the ancien regime were reintroduced , but were redefined in terms of metric units . Thus the toise was defined as being two metres with six pied making up one toise , twelve pouce making up one pied and twelve lignes making up one pouce . Likewise the livre was defined as being 500 g , each livre comprising sixteen once and each once eight gros and the aune as 120 centimetres .

Louis Philippe I by means of the La loi du 4 juillet 1837 (the law of 4 July 1837) effectively revoked the use of mesures uselles by reaffirming the laws of measurement of 1795 and 1799 to be used from 1 May 1840 . However , many units of measure , such as the livre (for half a kilogram) , remained in colloquial use for many years .

= = = The Portuguese metric system = = =