



Pencil

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A **pencil** is a writing implement or art medium constructed of a narrow, solid pigment core inside a protective casing which prevents the core from being broken or leaving marks on the user's hand during use.

Pencils create marks by physical abrasion, leaving behind a trail of solid core material that adheres to a sheet of paper or other surface. They are distinct from pens, which instead disperse a trail of liquid or gel ink that stains the light colour of the paper.

Most pencil cores are made of graphite mixed with a clay binder which leaves grey or black marks that can be easily erased. Graphite pencils are used for both writing and drawing and result in durable markings: though writing is easily removable with an eraser, it is otherwise resistant to moisture, most chemicals, ultraviolet radiation, and natural aging. Other types of pencil core are less widely used, such as charcoal pencils, which are mainly used by artists for drawing and sketching. Coloured pencils are sometimes used by teachers or editors to correct submitted texts, but are typically regarded as art supplies, especially those with waxy core binders that tend to smear on paper instead of erasing. Grease pencils have a softer, crayon-like waxy core that can leave marks on smooth surfaces such as glass or porcelain.

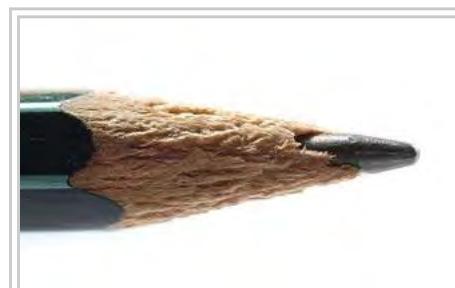
The most common type of pencil casing is of thin wood, usually hexagonal in section but sometimes cylindrical, permanently bonded to the core. Similar permanent casings may be constructed of other materials such as plastic or paper. To use the pencil, the casing must be carved or peeled off to expose the working end of the core as a sharp point. Mechanical pencils have more elaborate casings which support mobile pieces of pigment core that can be extended or retracted through the casing tip as needed.



HB graphite pencils



Coloured pencils (Caran d'Ache)



Macro of a pencil

Contents

- 1 History
 - 1.1 Camel's hair pencil
 - 1.2 Discovery of graphite deposit
 - 1.3 Wood holders added
 - 1.4 Discovery of graphite and clay mixing
 - 1.5 The pencil in America
 - 1.6 Eraser attached
 - 1.7 Pencil extenders
 - 1.8 Lead poisoning

- 2 Manufacture
- 3 Grading and classification
- 4 External colour and shape of pencils
- 5 Notable pencil users
- 6 Types
 - 6.1 By marking material
 - 6.2 By use
 - 6.3 By shape
 - 6.4 By size
 - 6.5 By manufacture
 - 6.6 Other types
- 7 See also
- 8 References
- 9 Bibliography
- 10 Further reading
- 11 External links

History

Camel's hair pencil

Pencil, from Old French *pincel*, from Latin *penicillus* a "little tail" (see *penis*—*pincellus* is Latin from the post-classical period^[1]) originally referred to an artist's fine brush of camel hair, also used for writing before modern lead or chalk pencils.^[2]

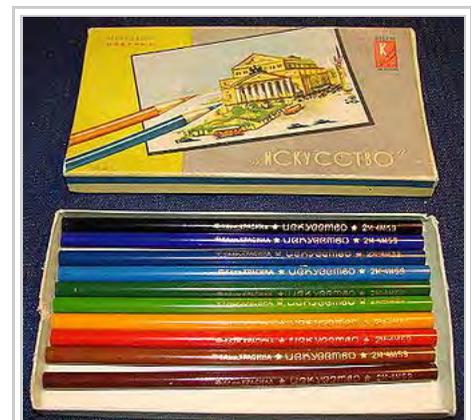
Though the archetypal pencil was an artist's brush, the stylus, a thin metal stick used for scratching in papyrus or wax tablets, was used extensively by the Romans,^[3] and for palm-leaf manuscripts.

Discovery of graphite deposit

The meaning of "graphite writing implement" apparently evolved late in the 16th century.^[4]

Prior to 1565 (some sources say as early as 1500), a large deposit of graphite was discovered on the approach to Grey Knotts from the hamlet of Seathwaite in Borrowdale parish, Cumbria, England.^{[5][6][7][8]} This particular deposit of graphite was extremely pure and solid, and it could easily be sawn into sticks. This remains the only large-scale deposit of graphite ever found in this solid form.^[9] Chemistry was in its infancy and the substance was thought to be a form of lead. Consequently, it was called *plumbago* (Latin for "lead ore").^{[10][11]} Many people have the misconception that the graphite in the pencil is lead,^[12] and the black core of pencils is still referred to as *lead* even though it never contained the element lead.^{[13][14][15][16][17][18]} The words for pencil in German (*Bleistift*), Irish (*Peann Luaidhe*), Arabic (قلم رصاص *qalam raṣāṣ*), and other languages literally mean *lead pen*.

The value of graphite was soon realised to be enormous, mainly because it could be used to line the moulds for



Old Soviet colored pencils with box (circa 1959)

cannonballs, and the mines were taken over by the Crown and guarded. When sufficient stores of graphite had been accumulated, the mines were flooded to prevent theft until more was required. Graphite had to be smuggled out for use in pencils. Because graphite is soft, it requires some form of encasement. Graphite sticks were initially wrapped in string or sheepskin for stability. The news of the usefulness of these early pencils spread far and wide, attracting the attention of artists all over the known world.

England continued to enjoy a monopoly on the production of pencils until a method of reconstituting the graphite powder was found. The distinctively square English pencils continued to be made with sticks cut from natural graphite into the 1860s. The town of Keswick, near the original findings of block graphite, still manufactures pencils, the factory also being the location of the Cumberland Pencil Museum.^[19]

The first attempt to manufacture graphite sticks from powdered graphite was in Nuremberg, Germany, in 1662. It used a mixture of graphite, sulphur, and antimony.^{[20][21][22][23]}

Residual graphite from a pencil stick is not poisonous, and graphite is harmless if consumed.^[24]

Wood holders added

Around 1560,^[25] an Italian couple named Simonio and Lyndiana Bernacotti made what are likely the first blueprints for the modern, wood-encased carpentry pencil. Their version was a flat, oval, more compact type of pencil. Their concept involved the hollowing out of a stick of juniper wood. Shortly thereafter, a superior technique was discovered: two wooden halves were carved, a graphite stick inserted, and the halves then glued together—essentially the same method in use to this day.^[26]



Palomino Blackwing 602 pencils

Discovery of graphite and clay mixing

English and German pencils were not available to the French during the Napoleonic Wars; France, under naval blockade imposed by Great Britain, was unable to import the pure graphite sticks from the British Grey Knotts mines – the only known source in the world. France was also unable to import the inferior German graphite pencil substitute. It took the efforts of an officer in Napoleon's army to change this. In 1795, Nicolas-Jacques Conté discovered a method of mixing powdered graphite with clay and forming the mixture into rods that were then fired in a kiln. By varying the ratio of graphite to clay, the hardness of the graphite rod could also be varied. This method of manufacture, which had been earlier discovered by the Austrian Joseph Hardtmuth, the founder of the Koh-I-Noor in 1790, remains in use.^[27] In 1802, the production of graphite leads from graphite and clay was patented by the Koh-I-Noor company in Vienna.^[28]

In England, pencils continued to be made from whole sawn graphite. Henry Bessemer's first successful invention (1838) was a method of compressing graphite powder into solid graphite thus allowing the waste from sawing to be reused.^[29]

The pencil in America

American colonists imported pencils from Europe until after the American Revolution. Benjamin Franklin advertised pencils for sale in his *Pennsylvania Gazette* in 1729, and George Washington used a three-inch

pencil when he surveyed the Ohio Territory in 1762.^[30] It is said that William Munroe, a cabinetmaker in Concord, Massachusetts, made the first American wood pencils in 1812. This was not the only pencil-making occurring in Concord. According to Henry Petroski, transcendentalist philosopher Henry David Thoreau discovered how to make a good pencil out of inferior graphite using clay as the binder; this invention was prompted by his father's pencil factory in Concord, which employed graphite found in New Hampshire in 1821 by Charles Dunbar.

Munroe's method of making pencils was painstakingly slow, and in the neighbouring town of Acton, a pencil mill owner named Ebenezer Wood set out to automate the process at his own pencil mill located at Nashoba Brook. He used the first circular saw in pencil production. He constructed the first of the hexagon- and octagon-shaped wooden casings. Ebenezer did not patent his invention and shared his techniques with anyone. One of those was Eberhard Faber of New York, who became the leader in pencil production.^[31]

Joseph Dixon, an inventor and entrepreneur involved with the Tantiusques granite mine in Sturbridge, Massachusetts, developed a means to mass-produce pencils. By 1870, The Joseph Dixon Crucible Company was the world's largest dealer and consumer of graphite and later became the contemporary Dixon Ticonderoga pencil and art supplies company.^{[32][33]}

By the end of the 19th century over 240,000 pencils were used each day in the US. The favoured timber for pencils was Red Cedar as it was aromatic and did not splinter when sharpened. In the early 20th century supplies of Red Cedar were dwindling so that pencil manufacturers were forced to recycle the wood from cedar fences and barns to maintain supply.

One effect of this was that "during World War II rotary pencil sharpeners were outlawed in Britain because they wasted so much scarce lead and wood, and pencils had to be sharpened in the more conservative manner – with knives."^[34]

It was soon discovered that Incense cedar, when dyed and perfumed to resemble Red Cedar, was a suitable alternative and most pencils today are made from this timber which is grown in managed forests. Over 14 billion pencils are manufactured worldwide annually.^[35] Less popular alternatives to cedar include basswood and alder.^[34]

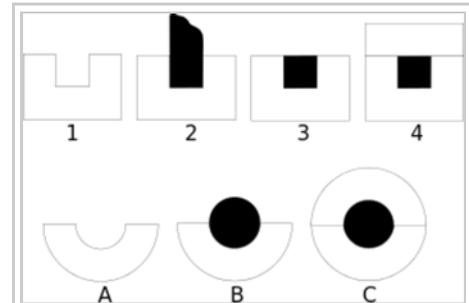
In Southeast Asia the wood Jelutong may be used to create pencils (though the use of this rainforest species is controversial).^[36] Environmentalists prefer the use of Pulai – another wood native to the region and used in pencil manufacturing.^{[37][38]}

Eraser attached

On 30 March 1858, Hymen Lipman received the first patent for attaching an eraser to the end of a pencil.^[39] In 1862, Lipman sold his patent to Joseph Reckendorfer for \$100,000, who went on to sue pencil manufacturer Faber-Castell for infringement.^[40] In 1875, the Supreme Court of the US ruled against Reckendorfer declaring



Pencil, perhaps made by Henry David Thoreau, in the Concord Museum

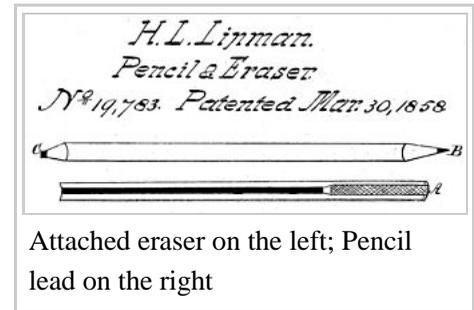


Pencil manufacturing. The top sequence shows the old method that required pieces of graphite to be cut to size; the lower sequence is the new, current method using rods of graphite and clay.

the patent invalid.^[41]

Pencil extenders

Historian Henry Petroski notes that while ever more efficient means of mass production of pencils has driven the replacement cost of a pencil down, before this people would continue to use even the stub of a pencil. For those who "did not feel comfortable using a stub, pencil extenders were sold. These devices function something like a *porte-crayon*...the pencil stub can be inserted into the end of a shaft...Extenders were especially common among engineers and draftsmen, whose favorite pencils were priced dearly. The use of an extender also has the advantage that the pencil does not appreciably change its heft as it wears down."^[34] Artists currently use extenders to maximize the use of their colored pencils.



Lead poisoning

Although lead has not been used for writing since antiquity, lead poisoning from pencils was not uncommon. Until the middle of the 20th century the paint used for the outer coating could contain high concentrations of lead, and this could be ingested when the pencil was sucked or chewed.^[42]

Manufacture

Modern pencils do not contain lead as the "lead" of the pencil is actually a mix of finely ground graphite and clay powders. Before the two substances are mixed, they are separately cleaned of foreign matter and dried in a manner that creates large square cakes. Once the cakes have fully dried, the graphite and the clay squares are mixed together using water. The amount of clay content added to the graphite depends on the intended pencil hardness (lower proportions of clay makes the core softer),^[43] and the amount of time spent on grinding the mixture determines the quality of the lead. The mixture is then shaped into long spaghetti-like strings, straightened, dried, cut, and then tempered in a kiln. The resulting strings are dipped in oil or molten wax, which seeps into the tiny holes of the material and allows for the smooth writing ability of the pencil. A juniper or incense-cedar plank with several long parallel grooves is cut to fashion a "slat," and the graphite/clay strings are inserted into the grooves. Another grooved plank is glued on top, and the whole assembly is then cut into individual pencils, which are then varnished or painted. Many pencils feature an eraser on the top and so the process is usually still considered incomplete at this point. Each pencil has a shoulder cut on one end of the pencil to allow for a metal ferrule to be secured onto the wood. A rubber plug is then inserted into the ferrule for a functioning eraser on the end of the pencil.^[44]

Grading and classification

Many pencils across the world, and almost all in Europe, are graded on the European system using a continuum from *H* (commonly interpreted as "hardness") to *B* (commonly "blackness"), as well as *F* (usually taken to mean "fineness", although *F* pencils are no more fine or more easily sharpened than any other grade). The standard writing pencil is graded *HB*.^[45]

According to Petroski, this system might have been developed in the early 20th century by Brookman, an English pencil maker. It used *B* for black and *H* for hard; a pencil's grade was described by a sequence or successive *H*s or *B*s such as *BB* and *BBB* for successively softer leads, and *HH* and *HHH* for successively

harder ones.^[46]

The Koh-i-Noor Hardtmuth pencil manufacturers claim to have originated the HB standard of gradations, with *H* standing for Hardtmuth, *B* for the company's location of Budějovice, and *F* for Franz Hardtmuth, who was responsible for technological improvements in pencil manufacture.^{[47][48]}

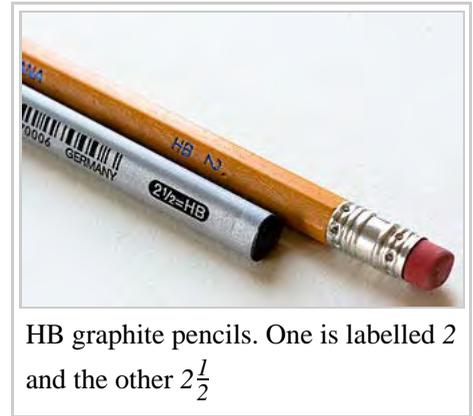
As of 2009, a set of pencils ranging from a very hard, light-marking pencil to a very soft, black-marking pencil usually ranges from hardest to softest as follows:

9H 8H 7H 6H 5H 4H 3H 2H H F HB B 2B 3B 4B 5B 6B 7B 8B 9B
 Hardest → Medium → Softest

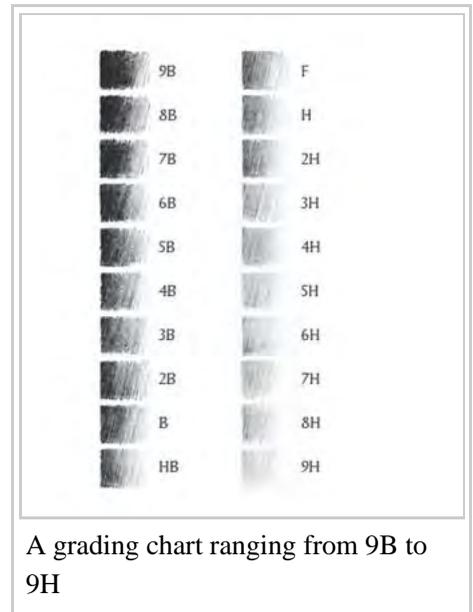
Koh-i-noor offers twenty grades from 10H to 8B for its 1500 series;^[49] Mitsubishi Pencil offers twenty-two grades from 10H to 10B for its Hi-uni range;^[50] Derwent produces twenty grades from 9H to 9B for its graphic pencils^[51] and Staedtler produces sixteen from 6H to 8B for its Mars Lumograph pencils.^[52]

The main market for such wide range of grades are artists who are interested in creating a full range of tones from light grey to black. Engineers prefer harder pencils which allow for a greater control in the shape of the lead. This is reflected in the way pencils are packaged and marketed. For example, for its Graphic pencils Derwent offers three packages of 12 pencils each: Technical (with hard grades from 9H to B), Sketching (with soft grades H to 9B), and Designer (with medium grades 4H to 6B).

Pencils graded using this system are used to measure the hardness and resistance of varnishes and paints. The resistance of a coating (also known as its pencil hardness) is determined as the grade of the hardest pencil that does not permanently mark the coating when pressed firmly against it at a 45 degree angle.^{[53][54]}



HB graphite pencils. One is labelled 2 and the other 2½



A grading chart ranging from 9B to 9H

Conté/Thoreau^[55]

Tone	US	World
	#1	B
	#2	HB
	#2½*	F
	#3	H
	#4	2H
* Also seen as 2¼, 2.5, 2⅕		

Another method uses numbers to designate the grade of a pencil. It was originally created by Conté and adopted in the US by John Thoreau, father of Henry Thoreau, in the 19th century.^[56]

Although Conté/Thoreau's system is widely accepted, not all manufacturers follow it; for example, Faber-Castell uses a different equivalence table in its *Grip 2001* pencils: 1 = 2B, 2 = B, 2½ = HB, 3 = H, 4 = 2H.

The various graphite pencil grades are achieved by altering the proportion of graphite to clay: the more clay the harder the pencil.^{[57][58][59]} Two pencils of the same grade but different manufacturers will not necessarily make a mark of identical tone nor have the same hardness.^[60]

External colour and shape of pencils



A typical yellow no. 2 pencil

The majority of pencils made in the US are painted yellow.^[61]

According to Henry Petroski,^[62] this tradition began in 1890 when the L. & C. Hardtmuth Company of Austria-Hungary introduced their Koh-I-Noor brand, named after the famous diamond. It was intended to be the world's best and most expensive pencil, and at a time when most pencils were either painted in dark colours or not at all, the Koh-I-Noor was yellow. As well as simply being distinctive, the colour may have

been inspired by the Austro-Hungarian flag; it was also suggestive of the Orient at a time when the best-quality graphite came from Siberia. Other companies then copied the yellow colour so that their pencils would be associated with this high-quality brand, and chose brand names with explicit Oriental references, such as Mikado (renamed Mirado)^{[63][64]} and Mongol.^{[65][66]}

Not all countries use yellow pencils. German and Brazilian pencils, for example, are often green, blue or black, based on the trademark colours of Faber-Castell, a major German stationery company which has plants in those countries. In southern European countries, pencils tend to be dark red or black with yellow lines, while in Australia, they are red with black bands at one end. In India, the most common pencil colour scheme was dark red with black lines, and pencils with a large number of colour schemes are produced by various companies.

Pencils are commonly round, hexagonal, or sometimes triangular in section. Carpenters' pencils are typically oval or rectangular, so they cannot easily roll away during work.

Notable pencil users

- Thomas Edison had his pencils specially made by Eagle Pencil. Each pencil was three inches long, was thicker than standard pencils and had softer graphite than was normally available.^[35]
- Vladimir Nabokov rewrote everything he had ever published, usually several times, in pencil.^[35]
- John Steinbeck was an obsessive pencil user and is said to have used as many as 60 a day. His novel *East of Eden* took more than 300 pencils to write.^[35]
- Vincent van Gogh used only Faber pencils as they were "superior to Carpenters pencils, a capital black and most agreeable".^{[35][67]}
- Johnny Carson regularly played with pencils at his *Tonight Show* desk. These pencils were specially made with erasers at both ends to avoid on-set accidents.^[68]
- Roald Dahl used only pencils with yellow casing to write his books. He had 6 sharpened pencils ready at the beginning of each day and only when all 6 pencils became unusable did he sharpen them.^[69]

Types

By marking material

Graphite pencils

These are the most common types of pencil, and are encased in wood. They are made of a mixture of clay and graphite and their darkness varies from light grey to black. Their composition allows for the smoothest strokes.

Solid graphite pencils

These are solid sticks of graphite and clay composite (as found in a 'graphite pencil'), about the diameter of a common pencil, which have no casing other than a wrapper or label. They are often called "woodless" pencils. They are used primarily for art purposes as the lack of casing allows for covering larger spaces more easily, creating different effects, and providing greater economy as the entirety of the pencil is used. They are available in the same darkness range as wood-encased graphite pencils.

Charcoal pencils

Are made of charcoal and provide fuller blacks than graphite pencils, but tend to smudge easily and are more abrasive than graphite. Sepia-toned and white pencils are also available for duotone techniques.

Carbon pencils

They generally are made of a mixture of clay and lamp black, but are sometimes blended with charcoal or graphite depending on the darkness and manufacturer. They produce a fuller black than graphite pencils, but are smoother than charcoal.

Coloured pencils, or pencil crayons

These have wax-like cores with pigment and other fillers. Multiple colours are often blended together.^[70]

Grease pencils

They write on virtually any surface (including glass, plastic, metal and photographs). The most commonly found grease pencils are encased in paper (Berol and Sanford Peel-off), but they can also be encased in wood (Staedtler Omnichrom).^[70]

Watercolour pencils

These are designed for use with watercolour techniques. The pencils can be used by themselves for sharp, bold lines. Strokes made by the pencil can also be saturated with water and spread with brushes.^[70]

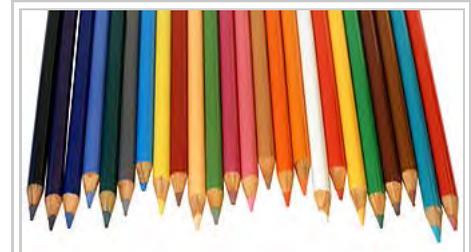
By use

Carpenter's pencils

These are pencils that have two main properties: their shape prevents them from rolling, and their graphite is strong.^[71] The oldest surviving pencil is a German carpenter's pencil dating from the 17th Century and now in the Faber-Castell collection.^{[72][73]}

Copying pencils (or indelible pencils)

These are graphite pencils with an added dye that creates an indelible mark. They were invented in the late 19th century for press copying and as a practical substitute for fountain pens. Their markings are often visually indistinguishable from those of standard graphite pencils, but when moistened their



Coloured pencils



Promotional pencils

markings dissolve into a coloured ink, which is then pressed into another piece of paper. They were widely used until the mid 20th century when ball pens slowly replaced them. In Italy their use is still mandated by law for voting paper ballots in elections and referenda.^[74]

Erasable colour pencils

Unlike wax-based coloured pencils, these can be easily erased. Their main use is in sketching, where the objective is to create an outline using the same colour that other media (such as wax pencils, or watercolour paints) would fill^[75] or when the objective is to scan the colour sketch.^[76] Some animators prefer erasable colour pencils as opposed to graphite pencils because they don't smudge as easily, and the different colours allow for better separation of objects in the sketch.^[77] Copy-editors find them useful too, as their markings stand out more than graphite but can be erased.^[78]

Non-reproducing

or non-photo blue pencils make marks that are not reproduced by photocopiers^[79] (Sanford's Copy-not or Staedtler's Mars Non-photo) or by whiteprint copiers (Staedtler's Mars Non-Print).

Stenographer's pencil

Also known as a **steno pencil**. These pencils are expected to be very reliable, and their lead is break-proof. Nevertheless, steno pencils are sometimes sharpened at both ends to enhance reliability. They are round to avoid pressure pain during long texts.^[80]

Golf pencil

Golf pencils are usually short (a common length is 9 cm (3.5 in)) and very cheap. They are also known as **library pencils**, as many libraries offer them as disposable, unspillable writing instruments.

By shape

- Triangular (more accurately a Reuleaux triangle)
- Hexagonal
- Round
- Bendable (flexible plastic)

By size

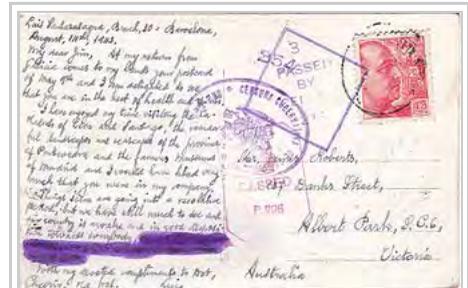
Typical

A standard, hexagonal, "#2 pencil" is cut to a hexagonal height of $\frac{1}{4}$ -inch (6 mm), but the outer diameter is slightly larger (about $\frac{9}{32}$ -inch (7 mm))

A standard, #2, hexagonal pencil is 19 cm (7.5 in) long.



Two "woodless" graphite pencils, two charcoal pencils, and two grease pencils



Obliteration by indelible pencil to censor mail in 1943

Biggest

On 3 September 2007, Ashrita Furman unveiled his giant US\$20,000 pencil – 76 feet (23 m) long, 18,000 pounds (8,200 kg) (with over 4,500 pounds (2,000 kg) for the graphite centre) – after three weeks of creation in August 2007 as a birthday gift for teacher Sri Chinmoy. It is longer than the 65-foot (20 m) pencil outside the Malaysia HQ of stationers Faber-Castell.^{[81][82][83]}

By manufacture

Mechanical pencils

There are also pencils which use mechanical methods to push lead through a hole at the end. These can be divided into two groups: propelling pencils use an internal mechanism to push the lead out from an internal compartment, while clutch pencils merely hold the lead in place (the lead is extended by releasing it and allowing some external force, usually gravity, to pull it out of the body). The erasers (sometimes replaced by a sharpener on pencils with larger lead sizes) are also removable (and thus replaceable), and usually cover a place to store replacement leads. Mechanical pencils are popular for their longevity and the fact that they may never need sharpening. Lead types are based on grade and size; with standard sizes being 2.00 mm (0.079 in), 1.40 mm (0.055 in), 1.00 mm (0.039 in), 0.70 mm (0.028 in), 0.50 mm (0.020 in), 0.35 mm (0.014 in), 0.25 mm (0.0098 in), 0.18 mm (0.0071 in), and 0.13 mm (0.0051 in) (ISO 9175-1 (http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=16778))—the 0.90 mm (0.035 in) size is available, but is not considered a standard ISO size.



Lead for mechanical pencils



Flexible pencils

Pop a Point Pencils

Pioneered by Taiwanese stationery manufacturer Bensia Pioneer Industrial Corporation in the early 1970s, the product is also known as **Bensia Pencils**, stackable pencils or non-sharpening pencils. It is a type of pencil where many short pencil tips are housed in a cartridge-style plastic holder. A blunt tip is removed by pulling it from the writing end of the body and re-inserting it into the open-ended bottom of the body, thereby pushing a new tip to the top.

Plastic pencils

Invented by Harold Grossman^[84] for Empire Pencil Company in 1967 and subsequently improved upon by Arthur D. Little for Empire from 1969 through the early 1970s; the plastic pencil was commercialised by Empire as the "EPCON" Pencil. These pencils were co-extruded, extruding a plasticised graphite mix within a wood-composite core.^[85]

Other types

- The Quadrachromic Pencil is a slightly enlarged pencil with four colours equally partitioned on the tip. The use of each colour while drawing is accomplished by rotating the pencil between the fingers.
- Penny pencil

- Recycled newspaper pencil

See also

- Blackwing 602
- IKEA pencil
- Pencil drawing
- Tortillon
- *I, Pencil*
- Pencil fighting

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Further reading

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External links

- How pencils are made (<http://science.discovery.com/tv-shows/how-its-made/videos/how-its-made-pencils.htm>) (video)



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