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 Comparison of a wide range of lengths This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed.Find sources: "Orders of magnitude" length – news · newspapers · books · scholar · JSTOR (January 2020) (Learn how and when to remove this message) Objects of sizes in different order of magnitude (at inconsistent intervals) Graphical overview of sizes The following are examples of orders of magnitude for different lengths. Scale Range (m) Unit Example items ≥ < Subatomic – 0 – Gravitational singularity 10−36 10−33 ℓP Fixed value (not a range). Quantum foam, string 10−18 10−15 am Proton, neutron, pion Atomic to cellular 10−15 10−12 fm Atomic nucleus 10−12 10−9 pm Wavelength of gamma rays and X-rays, hydrogen atom 10−9 10−6 nm DNA helix, virus, wavelength of optical spectrum, transistors used in CPUs Cellular to human 10−6 10−3 μm Bacterium, fog water droplet, human hair's diameter[note 1] 10−3 1 mm Mosquito, golf ball, domestic cat, violin, football Human to astronomical 1 103 m Piano, human, automobile, sperm whale, football field, Eiffel Tower 103 106 km Mount Everest, length of Panama Canal and Trans-Siberian Railway, larger asteroid Astronomical 106 109 Mm The Moon, Earth, one light-second 109 1012 Gm Sun, one light-minute, Earth's orbit 1012 1015 Tm Orbits of outer planets, Solar System 1015 1018 Pm A light-year, the distance to Proxima Centauri 1018 1021 Em Galactic arm 1021 1024 Zm Milky Way, distance to Andromeda Galaxy 1024 1027 Ym Huge-LQG, Hercules–Corona Borealis Great Wall, Observable universe To help compare different orders of magnitude, the following list describes various lengths between 1.6 × 10 − 35 {\displaystyle 1.6\times 10^{-35}} metres and 10 10 10 122 {\displaystyle 10^{10^{10^{122}}}} metres. Factor (m) Multiple Value Item 0 0 0 Singularity 10−35 1 Planck length 0.0000162 qm Planck length; typical scale of hypothetical loop quantum gravity or size of a hypothetical string and of branes; according to string theory, lengths smaller than this do not make any physical sense.[1] Quantum foam is thought to exist at this scale. 10−24 1 yoctometre (ym) 142 ym Effective cross section radius of 1 MeV neutrinos[2] 10−21 1 zeptometre (zm) Preons, hypothetical particles proposed as subcomponents of quarks and leptons; the upper bound for the width of a cosmic string in string theory 7 zm Effective cross section radius of high-energy neutrinos[3] 310 zm De Broglie wavelength of protons at the Large Hadron Collider (4 TeV as of 2012[update]) 10−18 1 attometre (am) Upper limit for the size of quarks and electrons Sensitivity of the LIGO detector for gravitational waves[4] Upper bound of the typical size range for "fundamental strings"[1] 10−17 10 am Range of the weak force 10−16 100 am 850 am Approximate proton radius[5] Factor (m) Multiple Value Item 10−15 1 femtometre (fm, fermi) 1 fm Approximate limit of the gluon-mediated color force between quarks[6][7] 1.5 fm Effective cross section radius of an 11 MeV proton[8] 2.81794 fm Classical electron radius[9] 3 fm Approximate limit of the meson-mediated nuclear binding force[6][7] 750 to 822.25 fm Longest wavelength of gamma rays 10−12 1 picometre (pm) 1.75 to 15 fm Diametre range of the atomic nucleus[1][10] 1 pm Distance between atomic nuclei in a white dwarf 2.4 pm Compton wavelength of electron 5 pm Wavelength of shortest X-rays 10−11 10 pm 28 pm Radius of helium atom 53 pm Bohr radius (radius of a hydrogen atom) 10−10 100 pm 100 pm 1 ångström (also covalent radius of sulfur atom[11]) 154 pm Length of a typical covalent bond (C–C) 280 pm Average size of the water molecule (actual lengths may vary) 500 pm Width of protein α helix 10−9 1 nanometre (nm) 1 nm Diameter of a carbon nanotube[12] Diameter of smallest transistor gate (as of 2016)[13] 2 nm Diameter of the DNA helix[14] 2.5 nm Smallest microprocessor transistor gate oxide thickness (as of January 2007[update])[citation needed] 3.4 nm Length of a DNA turn (10 bp)[15] 6–10 nm Thickness of cell membrane 10−8 10 nm 10 nm Upper range of thickness of cell wall in Gram-negative bacteria[16] 10 nm As of 2016[update], the 10 nanometre was the smallest semiconductor device fabrication node[17] 40 nm Extreme ultraviolet wavelength 50 nm Flying height of the head of a hard disk[18] 10−7 100 nm 121.6 nm Wavelength of the Lyman-alpha line[19] 120 nm Typical diameter of the human immunodeficiency virus (HIV)[20] 400–700 nm Approximate wavelength range of visible light[21] Factor (m) Multiple Value Item 10−6 1 micrometre (μm) (also called 1 micron) 1–4 μm Typical length of a bacterium[22] 4 μm Typical diameter of spider silk[23] 7 μm Typical size of a red blood cell[24] 10−5 10 μm 10 μm Typical size of a fog, mist, or cloud water droplet 10 μm Width of transistors in the Intel 4004, the world's first commercial microprocessor 12 μm Width of acrylic fiber 17–181 μm Width range of human hair[25] 10−4 100 μm 340 μm Size of a pixel on a 17-inch monitor with a resolution of 1024×768 560 μm Thickness of the central area of a human cornea[26] 750 μm Maximum diameter of Thiomargarita namibiensis, the second largest bacterium ever discovered 10−3 1 millimetre (mm) ~5 mm Length of an average flea is 1–10 mm (usually 1 Rm – >105.7 billion light-years – size of universe beyond the cosmic light horizon, depending on its curvature; if the curvature is zero (i.e. the universe is spatially flat), the value can be infinite (see Shape of the universe) as previously mentioned. 2.764 Rm - 292.2 billion light-years – circumference of the observable universe, as it is in the shape of a sphere. ≈101010122light-years – the possible size of the universe after cosmological inflation. ≈∞ light-years – theoretical size of the multiverse if it exists. Fermi problem Scale (analytical tool) Spatial scale The Scale of the Universe ^ The diametre of human hair ranges from 17 to 181 μm Ley, Brian (1999). Elert, Glenn (ed.). "Diametre of a human hair". The Physics Factbook. Retrieved 8 December 2018. ^ a b The exact category (asteroid, dwarf planet, or planet) to which particular Solar System objects belong, has been subject to some revision since the discovery of extrasolar planets and trans-Neptunian objects ^ 10115 is 1 followed by 115 zeroes, or a googol multiplied by a quadrillion. 1010115 is 1 followed by a quadrillion googol zeroes. 101010122 is 1 followed by 1010122 (a googolplex10 sextillion) zeroes. ^ But not cloud or high-level fog droplets; droplet size increases with altitude. For a contradictory study indicating larger drop sizes even in ground fog, see Eldridge, Ralph G. (October 1961). "A Few Fog Drop-Size Distributions". Journal of Meteorology. 18 (5): 671–6. 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Astrophysical Journal. 700 (1): 137–148. arXiv:0902.3913. Bibcode:2009ApJ...700..137R. doi:10.1088/0004-637X/700/1/137. S2CID 11347166. How Big Are Things? – displays orders of magnitude in successively larger rooms. Powers of Ten – Travel across the Universe. Cosmos – Journey from microcosmos to macrocosmos (Digital Nature Agency). Scale of the universe – interactive guide to length magnitudes Video (4:29) on YouTube – Orders of Magnitude (March 2020). Portals: Physics Mathematics Astronomy Stars Spaceflight Outer space Solar System Science Retrieved from " 2Comparison of a wide range of lengths This article needs additional citations for verification. Please help improve this article by adding citations to reliable sources. Unsourced material may be challenged and removed.Find sources: "Orders of magnitude" length – news · newspapers · books · scholar · JSTOR (January 2020) (Learn how and when to remove this message) Objects of sizes in different order of magnitude (at inconsistent intervals) Graphical overview of sizes The following are examples of orders of magnitude for different lengths. Scale Range (m) Unit Example items ≥ < Subatomic – 0 – Gravitational singularity 10−36 10−33 ℓP Fixed value (not a range). Quantum foam, string 10−18 10−15 am Proton, neutron, pion Atomic to cellular 10−15 10−12 fm Atomic nucleus 10−12 10−9 pm Wavelength of gamma rays and X-rays, hydrogen atom 10−9 10−6 nm DNA helix, virus, wavelength of optical spectrum, transistors used in CPUs Cellular to human 10−6 10−3 μm Bacterium, fog water droplet, human hair's diameter[note 1] 10−3 1 mm Mosquito, golf ball, domestic cat, violin, football Human to astronomical 1 103 m Piano, human, automobile, sperm whale, football field, Eiffel Tower 103 106 km Mount Everest, length of Panama Canal and Trans-Siberian Railway, larger asteroid Astronomical 106 109 Mm The Moon, Earth, one light-second 109 1012 Gm Sun, one light-minute, Earth's orbit 1012 1015 Tm Orbits of outer planets, Solar System 1015 1018 Pm A light-year, the distance to Proxima Centauri 1018 1021 Em Galactic arm 1021 1024 Zm Milky Way, distance to Andromeda Galaxy 1024 1027 Ym Huge-LQG, Hercules–Corona Borealis Great Wall, Observable universe To help compare different orders of magnitude, the following list describes various lengths between 1.6 × 10 − 35 {\displaystyle 1.6\times 10^{-35}} metres and 10 10 10 122 {\displaystyle 10^{10^{10^{122}}}} metres. Factor (m) Multiple Value Item 0 0 0 Singularity 10−35 1 Planck length 0.0000162 qm Planck length; typical scale of hypothetical loop quantum gravity or size of a hypothetical string and of branes; according to string theory, lengths smaller than this do not make any physical sense.[1] Quantum foam is thought to exist at this scale. 10−24 1 yoctometre (ym) 142 ym Effective cross section radius of 1 MeV neutrinos[2] 10−21 1 zeptometre (zm) Preons, hypothetical particles proposed as subcomponents of quarks and leptons; the upper bound for the width of a cosmic string in string theory 7 zm Effective cross section radius of high-energy neutrinos[3] 310 zm De Broglie wavelength of protons at the Large Hadron Collider (4 TeV as of 2012[update]) 10−18 1 attometre (am) Upper limit for the size of quarks and electrons Sensitivity of the LIGO detector for gravitational waves[4] Upper bound of the typical size range for "fundamental strings"[1] 10−17 10 am Range of the weak force 10−16 100 am 850 am Approximate proton radius[5] Factor (m) Multiple Value Item 10−15 1 femtometre (fm, fermi) 1 fm Approximate limit of the gluon-mediated color force between quarks[6][7] 1.5 fm Effective cross section radius of an 11 MeV proton[8] 2.81794 fm Classical electron radius[9] 3 fm Approximate limit of the meson-mediated nuclear binding force[6][7] 750 to 822.25 fm Longest wavelength of gamma rays 10−12 1 picometre (pm) 1.75 to 15 fm Diametre range of the atomic nucleus[1][10] 1 pm Distance between atomic nuclei in a white dwarf 2.4 pm Compton wavelength of electron 5 pm Wavelength of shortest X-rays 10−11 10 pm 28 pm Radius of helium atom 53 pm Bohr radius (radius of a hydrogen atom) 10−10 100 pm 100 pm 1 ångström (also covalent radius of sulfur atom[11]) 154 pm Length of a typical covalent bond (C–C) 280 pm Average size of the water molecule (actual lengths may vary) 500 pm Width of protein α helix 10−9 1 nanometre (nm) 1 nm Diameter of a carbon nanotube[12] Diameter of smallest transistor gate (as of 2016)[13] 2 nm Diameter of the DNA helix[14] 2.5 nm Smallest microprocessor transistor gate oxide thickness (as of January 2007[update])[citation needed] 3.4 nm Length of a DNA turn (10 bp)[15] 6–10 nm Thickness of cell membrane 10−8 10 nm 10 nm Upper range of thickness of cell wall in Gram-negative bacteria[16] 10 nm As of 2016[update], the 10 nanometre was the smallest semiconductor device fabrication node[17] 40 nm Extreme ultraviolet wavelength 50 nm Flying height of the head of a hard disk[18] 10−7 100 nm 121.6 nm Wavelength of the Lyman-alpha line[19] 120 nm Typical diameter of the human immunodeficiency virus (HIV)[20] 400–700 nm Approximate wavelength range of visible light[21] Factor (m) Multiple Value Item 10−6 1 micrometre (μm) (also called 1 micron) 1–4 μm Typical length of a bacterium[22] 4 μm Typical diameter of spider silk[23] 7 μm Typical size of a red blood cell[24] 10−5 10 μm 10 μm Typical size of a fog, mist, or cloud water droplet 10 μm Width of transistors in the Intel 4004, the world's first commercial microprocessor 12 μm Width of acrylic fiber 17–181 μm Width range of human hair[25] 10−4 100 μm 340 μm Size of a pixel on a 17-inch monitor with a resolution of 1024×768 560 μm Thickness of the central area of a human cornea[26] 750 μm Maximum diameter of Thiomargarita namibiensis, the second largest bacterium ever discovered 10−3 1 millimetre (mm) ~5 mm Length of an average flea is 1–10 mm (usually 1 Rm – >105.7 billion light-years – size of universe beyond the cosmic light horizon, depending on its curvature; if the curvature is zero (i.e. the universe is spatially flat), the value can be infinite (see Shape of the universe) as previously mentioned. 2.764 Rm - 292.2 billion light-years – circumference of the observable universe, as it is in the shape of a sphere. ≈101010122light-years – the possible size of the universe after cosmological inflation. ≈∞ light-years – theoretical size of the multiverse if it exists. Fermi problem Scale (analytical tool) Spatial scale The Scale of the Universe ^ The diametre of human hair ranges from 17 to 181 μm Ley, Brian (1999). Elert, Glenn (ed.). "Diametre of a human hair". The Physics Factbook. Retrieved 8 December 2018. ^ a b The exact category (asteroid, dwarf planet, or planet) to which particular Solar System objects belong, has been subject to some revision since the discovery of extrasolar planets and trans-Neptunian objects ^ 10115 is 1 followed by 115 zeroes, or a googol multiplied by a quadrillion. 1010115 is 1 followed by a quadrillion googol zeroes. 101010122 is 1 followed by 1010122 (a googolplex10 sextillion) zeroes. ^ But not cloud or high-level fog droplets; droplet size increases with altitude. For a contradictory study indicating larger drop sizes even in ground fog, see Eldridge, Ralph G. (October 1961). "A Few Fog Drop-Size Distributions". Journal of Meteorology. 18 (5): 671–6. 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MOSFET technology node Semiconductordevicefabrication MOSFET scaling(process nodes) 020 µm – 1968 010 µm – 1971 006 µm – 1974 003 µm – 1977 1.5 µm – 1981 001 µm – 1984 800 nm – 1987 600 nm – 1990 350 nm – 1993 250 nm – 1996 180 nm – 1999 130 nm – 2001 090 nm – 2003 065 nm – 2005 045 nm – 2007 032 nm – 2009 028 nm – 2010 022 nm – 2012 014 nm – 2014 010 nm – 2016 007 nm – 2018 005 nm – 2020 003 nm – 2022 Future 002 nm ~ 2025 001 nm ~ 2027 Half-nodes Density CMOS Device (multi-gate) Moore's law Transistor count Semiconductor Industry Nanoelectronics vte In semiconductor fabrication, the International Technology Roadmap for Semiconductors (ITRS) defines the "10 nanometer process" as the MOSFET technology node following the "14 nm" node. Since at least 1997, "process nodes" have been named purely on a marketing basis, and have no relation to the dimensions on the integrated circuit;[1] neither gate length, metal pitch or gate pitch on a "10nm" device is ten nanometers.[2][3][4] For example, GlobalFoundries' "7 nm" processes are dimensionally similar to Intel's "10 nm" process.[5] TSMC and Samsung's "10 nm" processes are somewhere between Intel's "14 nm" and "10 nm" processes in transistor density. The transistor density (number of transistors per square millimetre) is more important than transistor size, since smaller transistors no longer necessarily mean improved performance, or an increase in the number of transistors.[citation needed] All production "10 nm" processes are based on FinFET (fin field-effect transistor) technology, a type of multi-gate MOSFET technology that is a non-planar evolution of planar silicon CMOS technology. Samsung first started their production of "10 nm-class" chips in 2013 for their multi-level cell (MLC) flash memory chips, followed by their SoCs using their 10 nm process in 2016. TSMC began commercial production of "10 nm" chips in 2016, and Intel later began production of "10 nm" chips in 2018.[needs update] The ITRS's original naming of this technology node was "11 nm". According to the 2007 edition of the roadmap, by the year 2022, the half-pitch (i.e., half the distance between identical features in an array) for a DRAM was projected to be 11 nm. In 2008, Pat Gelsinger, at the time serving as Intel's Chief Technology Officer, said that Intel saw a 'clear way' towards the "10 nm" node.[6][7] In 2011, Samsung announced plans to introduce the "10 nm" process the following year.[8][needs update] In 2012, Samsung announced eMMC flash memory chips that are produced using the "10 nm" process.[9] As of 2018, "10 nm" as it was generally understood was only in high-volume production at Samsung. GlobalFoundries had skipped "10 nm",[needs update] Intel had not yet started high-volume "10 nm" production, due to yield issues,[needs update] and TSMC had considered "10 nm" to be a short-lived node,[10] mainly dedicated to processors for Apple during 2017–2018, moving on to "7 nm" in 2018.[needs update] There is also a distinction to be made between "10 nm" as marketed by foundries and "10 nm" as marketed by DRAM companies. In April 2013, Samsung announced that it had begun mass production of multi-level cell (MLC) flash memory chips using a "10 nm-class" process, which, according to Tom's Hardware, Samsung defined as "a process technology node somewhere between 10-nm and 20-nm".[11] On 17 October 2016, Samsung Electronics announced mass production of SoC chips at "10 nm".[12] The technology's main announced challenge at that time had been triple patterning for its metal layer.[13][14][needs update] TSMC began commercial production of "10 nm" chips in early 2016, before moving onto mass production in early 2017.[15] On 21 April 2017, Samsung started shipping their Galaxy S8 smartphone, which used the company's version of the "10 nm" processor.[16][needs update] On 12 June 2017, Apple delivered second-generation iPad Pro tablets powered with TSMC-produced Apple A10X chips using the "10 nm" FinFET process.[17] On 12 September 2017, Apple announced the Apple A11, a 64-bit ARM-based system on a chip, manufactured by TSMC using a "10 nm" FinFET process, containing 4.3 billion transistors on a die of 87.66 mm2. In April 2018, Intel announced a delay in volume production of "10 nm" mainstream CPUs until sometime in 2019.[18] In July, the exact time was further pinned down to the holiday season.[19] In the meantime, however, they did release a low-power "10 nm" mobile chip, albeit exclusive to Chinese markets and with much of the chip disabled.[20][needs update] In June 2018 at VLSI 2018, Samsung announced their "11LPP" and "8LPP" processes. "11LPP" was a hybrid based on Samsung "14 nm" and "10 nm" technology. "11LPP" was based on their "10 nm" BEOL, not their "20 nm" BEOL like the "14LPP". "8LPP" was based on the "10LPP" process.[21][22][needs update] Nvidia released their GeForce 30 series GPUs in September 2020. They were at that time made on a custom version of Samsung's "8 nm" process, called "Samsung 8N", with a transistor density of 44.56 million transistors per mm2.[23][24][needs update] ITRS Logic DeviceGround Rules (2015) Samsung TSMC Intel Process name 16/14 nm 11/10 nm 10LPE(10 nm) 10LPP(10 nm) 8LPP(8 nm) 8LPU(8 nm) 8LPA(8 nm) 8N 10FF(10 nm) 10nm[25] 10nm SF(10 nm)[a] Transistor density (MTr/mm2) Unknown Unknown 51.82[22] 61.18[22] Unknown 55.75 52.51[26] 60.41[27] (100.76)[28][b] Transistor gate pitch (nm) 70 48 68 64 Unknown 64/68 66 54 Interconnect pitch (nm) 56 36 51 Unknown Unknown Unknown 44 36 Transistor fin pitch (nm) 42 36 42 Unknown 42 36 34 Transistor fin height (nm) 42 42 49 44 Unknown 48 42 53 Production year 2015 2017 2016 Q4 production[30] 2017 Q4 production[31] 2018 production 2018 risk production2019 production[32] 2021 production 2020 production 2016 risk production[15]2017 production[15] 2018 production[33] (Cannon Lake)[34] 2020 production (Tiger Lake)[35] ^ For 10nm ESF renamed Intel 7, see 7 nm[disputed – discuss] ^ Intel uses this formula:[29] N o . T r a n s i s t o r s / m m 2 = 0.6 · N A N D 2 Tr Count N A N D 2 Cell Area + 0.4 · Scan Flip Flop Tr Count Scan Flip Flop Cell Area {\displaystyle {\rm {No.\ Transistors/mm^{2}=0.6\cdot {\frac {\rm {NAND2\ Tr\ Count}}{\rm {NAND2\ Cell\ Area}}}+0.4\cdot {\frac {\rm {Scan\ Flip\ Flop\ Tr\ Count}}{\rm {Scan\ Flip\ Flop\ Cell\ Area}}}}}} Transistor gate pitch is also referred to as CPP (contacted poly pitch) and interconnect pitch is also referred to as MMP (minimum metal pitch). Samsung reported their "10 nm" process as having a 64 nm transistor gate pitch and 48 nm interconnect pitch. TSMC reported their "10 nm" process as having a 64 nm transistor gate pitch and 42 nm interconnect pitch. Further investigation by Tech Insights revealed even these values to also be false, and they have been updated accordingly. In addition, the transistor fin height of Samsung's "10 nm" process was updated by MSSCORPS CO at SEMICON Taiwan 2017.[36][37][38][39][40] GlobalFoundries decided not to develop a "10 nm" node, because it believed it would be short lived.[41] Samsung's "8 nm" process was at that time the company's last to exclusively use DUV lithography.[42][needs update] Main article: Dynamic random-access memory For the DRAM industry, the term "10 nm-class" is often used and this dimension generally refers to the half-pitch of the active area.[citation needed] The "10 nm" foundry structures are generally much larger.[citation needed] Generally "10 nm class" refers to DRAM with a 10-19 nm feature size, and was first introduced c. 2016. As of 2020, there were three generations of "10 nm class" DRAM : 1x nm (19-17 nm, Gen1); 1y nm (16-14 nm, Gen2); and 1z nm (13-11 nm, Gen3).[43] 3rd Generation "1z" DRAM was first introduced c. 2019 by Samsung, and was initially stated to be produced using ArF lithography without the use of EUV lithography;[44][45] subsequent production did utilise EUV lithography.[46] Beyond 1z Samsung named its next node (fourth generation "10 nm class") DRAM : "D1a" (expected at that time to have been produced in 2021), and beyond that "D1b" (expected at that time to have been produced in 2022)[needs update]; whilst Micron referred[needs update] to succeeding "nodes" as "D1α" and "D1β".[47] Micron announced volume shipment of 1α class DRAM in early 2021.[48] ^ "No More Nanometers – EEJournal". 23 July 2020. ^ Shukla, Priyank. "A Brief History of Process Node Evolution". design-reuse.com. Retrieved 9 July 2019. ^ Hruska, Joel. "14nm, 7nm, 5nm: How low can CMOS go? 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MOSFET technology node Semiconductordevicefabrication MOSFET scaling(process nodes) 020 µm – 1968 010 µm – 1971 006 µm – 1974 003 µm – 1977 1.5 µm – 1981 001 µm – 1984 800 nm – 1987 600 nm – 1990 350 nm – 1993 250 nm – 1996 180 nm – 1999 130 nm – 2001 090 nm – 2003 065 nm – 2005 045 nm – 2007 032 nm – 2009 028 nm – 2010 022 nm – 2012 014 nm – 2014 010 nm – 2016 007 nm – 2018 005 nm – 2020 003 nm – 2022 Future 002 nm ~ 2025 001 nm ~ 2027 Half-nodes Density CMOS Device (multi-gate) Moore's law Transistor count Semiconductor Industry Nanoelectronics vte In semiconductor fabrication, the International Technology Roadmap for Semiconductors (ITRS) defines the "10 nanometer process" as the MOSFET technology node following the "14 nm" node. Since at least 1997, "process nodes" have been named purely on a marketing basis, and have no relation to the dimensions on the integrated circuit;[1] neither gate length, metal pitch or gate pitch on a "10nm" device is ten nanometers.[2][3][4] For example, GlobalFoundries' "7 nm" processes are dimensionally similar to Intel's "10 nm" process.[5] TSMC and Samsung's "10 nm" processes are somewhere between Intel's "14 nm" and "10 nm" processes in transistor density. The transistor density (number of transistors per square millimetre) is more important than transistor size, since smaller transistors no longer necessarily mean improved performance, or an increase in the number of transistors.[citation needed] All production "10 nm" processes are based on FinFET (fin field-effect transistor) technology, a type of multi-gate MOSFET technology that is a non-planar evolution of planar silicon CMOS technology. Samsung first started their production of "10 nm-class" chips in 2013 for their multi-level cell (MLC) flash memory chips, followed by their SoCs using their 10 nm process in 2016. TSMC began commercial production of "10 nm" chips in 2016, and Intel later began production of "10 nm" chips in 2018.[needs update] The ITRS's original naming of this technology node was "11 nm". According to the 2007 edition of the roadmap, by the year 2022, the half-pitch (i.e., half the distance between identical features in an array) for a DRAM was projected to be 11 nm. In 2008, Pat Gelsinger, at the time serving as Intel's Chief Technology Officer, said that Intel saw a 'clear way' towards the "10 nm" node.[6][7] In 2011, Samsung announced plans to introduce the "10 nm" process the following year.[8][needs update] In 2012, Samsung announced eMMC flash memory chips that are produced using the "10 nm" process.[9] As of 2018, "10 nm" as it was generally understood was only in high-volume production at Samsung. GlobalFoundries had skipped "10 nm",[needs update] Intel had not yet started high-volume "10 nm" production, due to yield issues,[needs update] and TSMC had considered "10 nm" to be a short-lived node,[10] mainly dedicated to processors for Apple during 2017–2018, moving on to "7 nm" in 2018.[needs update] There is also a distinction to be made between "10 nm" as marketed by foundries and "10 nm" as marketed by DRAM companies. In April 2013, Samsung announced that it had begun mass production of multi-level cell (MLC) flash memory chips using a "10 nm-class" process, which, according to Tom's Hardware, Samsung defined as "a process technology node somewhere between 10-nm and 20-nm".[11] On 17 October 2016, Samsung Electronics announced mass production of SoC chips at "10 nm".[12] The technology's main announced challenge at that time had been triple patterning for its metal layer.[13][14][needs update] TSMC began commercial production of "10 nm" chips in early 2016, before moving onto mass production in early 2017.[15] On 21 April 2017, Samsung started shipping their Galaxy S8 smartphone, which used the company's version of the "10 nm" processor.[16][needs update] On 12 June 2017, Apple delivered second-generation iPad Pro tablets powered with TSMC-produced Apple A10X chips using the "10 nm" FinFET process.[17] On 12 September 2017, Apple announced the Apple A11, a 64-bit ARM-based system on a chip, manufactured by TSMC using a "10 nm" FinFET process, containing 4.3 billion transistors on a die of 87.66 mm2. In April 2018, Intel announced a delay in volume production of "10 nm" mainstream CPUs until sometime in 2019.[18] In July, the exact time was further pinned down to the holiday season.[19] In the meantime, however, they did release a low-power "10 nm" mobile chip, albeit exclusive to Chinese markets and with much of the chip disabled.[20][needs update] In June 2018 at VLSI 2018, Samsung announced their "11LPP" and "8LPP" processes. "11LPP" was a hybrid based on Samsung "14 nm" and "10 nm" technology. "11LPP" was based on their "10 nm" BEOL, not their "20 nm" BEOL like the "14LPP". "8LPP" was based on the "10LPP" process.[21][22][needs update] Nvidia released their GeForce 30 series GPUs in September 2020. They were at that time made on a custom version of Samsung's "8 nm" process, called "Samsung 8N", with a transistor density of 44.56 million transistors per mm2.[23][24][needs update] ITRS Logic DeviceGround Rules (2015) Samsung TSMC Intel Process name 16/14 nm 11/10 nm 10LPE(10 nm) 10LPP(10 nm) 8LPP(8 nm) 8LPU(8 nm) 8LPA(8 nm) 8N 10FF(10 nm) 10nm[25] 10nm SF(10 nm)[a] Transistor density (MTr/mm2) Unknown Unknown 51.82[22] 61.18[22] Unknown 55.75 52.51[26] 60.41[27] (100.76)[28][b] Transistor gate pitch (nm) 70 48 68 64 Unknown 64/68 66 54 Interconnect pitch (nm) 56 36 51 Unknown Unknown Unknown 44 36 Transistor fin pitch (nm) 42 36 42 Unknown 42 36 34 Transistor fin height (nm) 42 42 49 44 Unknown 48 42 53 Production year 2015 2017 2016 Q4 production[30] 2017 Q4 production[31] 2018 production 2018 risk production2019 production[32] 2021 production 2020 production 2016 risk production[15]2017 production[15] 2018 production[33] (Cannon Lake)[34] 2020 production (Tiger Lake)[35] ^ For 10nm ESF renamed Intel 7, see 7 nm[disputed – discuss] ^ Intel uses this formula:[29] N o . T r a n s i s t o r s / m m 2 = 0.6 · N A N D 2 Tr Count N A N D 2 Cell Area + 0.4 · Scan Flip Flop Tr Count Scan Flip Flop Cell Area {\displaystyle {\rm {No.\ Transistors/mm^{2}=0.6\cdot {\frac {\rm {NAND2\ Tr\ Count}}{\rm {NAND2\ Cell\ Area}}}+0.4\cdot {\frac {\rm {Scan\ Flip\ Flop\ Tr\ Count}}{\rm {Scan\ Flip\ Flop\ Cell\ Area}}}}}} Transistor gate pitch is also referred to as CPP (contacted poly pitch) and interconnect pitch is also referred to as MMP (minimum metal pitch). Samsung reported their "10 nm" process as having a 64 nm transistor gate pitch and 48 nm interconnect pitch. TSMC reported their "10 nm" process as having a 64 nm transistor gate pitch and 42 nm interconnect pitch. Further investigation by Tech Insights revealed even these values to also be false, and they have been updated accordingly. In addition, the transistor fin height of Samsung's "10 nm" process was updated by MSSCORPS CO at SEMICON Taiwan 2017.[36][37][38][39][40] GlobalFoundries decided not to develop a "10 nm" node, because it believed it would be short lived.[41] Samsung's "8 nm" process was at that time the company's last to exclusively use DUV lithography.[42][needs update] Main article: Dynamic random-access memory For the DRAM industry, the term "10 nm-class" is often used and this dimension generally refers to the half-pitch of the active area.[citation needed] The "10 nm" foundry structures are generally much larger.[citation needed] Generally "10 nm class" refers to DRAM with a 10-19 nm feature size, and was first introduced c. 2016. As of 2020, there were three generations of "10 nm class" DRAM : 1x nm (19-17 nm, Gen1); 1y nm (16-14 nm, Gen2); and 1z nm (13-11 nm, Gen3).[43] 3rd Generation "1z" DRAM was first introduced c. 2019 by Samsung, and was initially stated to be produced using ArF lithography without the use of EUV lithography;[44][45] subsequent production did utilise EUV lithography.[46] Beyond 1z Samsung named its next node (fourth generation "10 nm class") DRAM : "D1a" (expected at that time to have been produced in 2021), and beyond that "D1b" (expected at that time to have been produced in 2022)[needs update]; whilst Micron referred[needs update] to succeeding "nodes" as "D1α" and "D1β".[47] Micron announced volume shipment of 1α class DRAM in early 2021.[48] ^ "No More Nanometers – EEJournal". 23 July 2020. ^ Shukla, Priyank. "A Brief History of Process Node Evolution". design-reuse.com. Retrieved 9 July 2019. ^ Hruska, Joel. "14nm, 7nm, 5nm: How low can CMOS go? 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Samsung 10LPE process ^ "10 nm lithography process". wikichip. ^ Jones, Scotten (25 February 2024). "Exclusive - GLOBALFOUNDRIES discloses 7nm process detail". ^ Shilov, Anton. 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View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500)Intel (links | edit) Semiconductor device fabrication (links | edit) Semiconductor (links | edit) Moore's law (links | edit) Flash memory (links | edit) Synchronous dynamic random-access memory (links | edit) Orders of magnitude (length) (links | edit) Tejas and Jayhawk (links | edit) TSMC (links | edit) Semiconductor industry (links | edit) NetBurst (links | edit) Nanoelectromechanical systems (links | edit) 90 nm process (links | edit) Fin field-effect transistor (links | edit) 65 nm process (links | edit) Next-generation lithography (links | edit) 10 nm (links | edit) Intel Core (microarchitecture) (links | edit) Comparison of Intel processors (links | edit) List of Nvidia graphics processing units (links | edit) International Technology Roadmap for Semiconductors (links | edit) 32 nm process (links | edit) Transistor count (links | edit) List of Intel Core processors (links | edit) Intel vPro (links | edit) Nehalem (microarchitecture) (links | edit) Sandy Bridge (links | edit) 22 nm process (links | edit) 130 nm process (links | edit) 180 nm process (links | edit) 14 nm process (links | edit) Nanoelectronics (links | edit) 250 nm process (links | edit) 800 nm process (links | edit) 1 µm process (links | edit) 1.5 µm process (links | edit) 3 µm process (links | edit) 10 µm process (links | edit) 600 nm process (links | edit) 350 nm process (links | edit) Nanocircuitry (links | edit) List of Intel CPU microarchitectures (links | edit) Die shrink (links | edit) Gate oxide (links | edit) Tick–tock model (links | edit) Tegra (links | edit) Haswell (microarchitecture) (links | edit) Random-access memory (links | edit) Kentsfield (microprocessor) (links | edit) Wolfdale (microprocessor) (links | edit) View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500) Retrieved from " WhatLinksHere/10_nm_process" Although light travels incredibly fast, covering a distance of 1000 light-years would take a significant amount of time. Despite its speed, light only travels at a speed of approximately 671 million miles per hour, or approximately 186,000 miles per second.That means that 1000 light-years is equal to about 5,878,499,999,850 miles. To cover that distance would take about 31,597,279,998. 485 seconds, which is equivalent to about 3. 78 years. Therefore, it would take around 3. 78 years to travel 1000 light-years.What is 1,000 light years away?1,000 light years away is a measure of distance that corresponds to 5,878,625,373,183 miles, or 9,460,528,000,000 km. This is a huge distance to cover and it would involve travelling at the highest speed currently achievable by humans, the speed of light.To describe this in further detail, 1 light year is the distance that light travels in a vacuum in one year, which is around 9. 46 trillion km (9. 46 x 1012 km). This is a very long distance and travelling to something 1,000 light years away would take centuries to complete.In terms of our universe, 1,000 light years away is considered a quite close distance, as some galaxies can be millions, or even billions of light years away from us.What is 1 light-year in human years?One light-year is a measure of distance, defined as the distance light travels in one year, or 9. 46 × 10^12 km (5. 88 × 10^12 mi). It is the equivalent of about 10 trillion kilometers (6 trillion miles) or 63,240 astronomical units (AU).In terms of human years, one light-year is roughly equivalent to 19 billion years, or over 1,800 times the current age of the universe. To put this into perspective, it would take a beam of light 8. 3 minutes to travel the length of one light-year.In that time, a person could travel from one side of the world to the other.Is a black hole coming 1000 light-years away?No, a black hole is not coming 1000 light-years away. Black holes are regions of spacetime where gravity is so strong that nothing, not even light, can escape its grasp. A black hole's massive gravitational pull is so strong that nothing—not even light—can escape, meaning that it's impossible for a black hole to travel at any sort of speed.Even if a black hole was 1000 light-years away, it would take 1000 years for the light from the black hole to reach us. Because black holes don't move and can't travel, they won't be coming 1000 light-years away any time soon.How many light-years can we go?It is difficult to provide an exact answer to this question for many reasons. The most significant factor is the speed of light, which is the fastest known speed in the universe. It was determined in 1676 by English scientist Isaac Newton to be approximately 299,792,458 meters per second.Since a light-year is defined as the distance light travels in one year, this equates to approximately 9,460,730,472,580. 8 kilometers per light-year. Therefore, in theory, we are limited only by this speed.In reality, technological advances and principles such as time dilatation mean we can go much farther than a light-year. Time dilatation is a result of Albert Einstein's theories of special relativity, which states that the faster we travel, the slower time passes relative to those not travelling.This means that time effectively slows while travelling at the speed of light. We could theoretically use this principle to travel much further than a light-year in a short amount of time.In conclusion, while we may not be able to go faster than the speed of light, we can certainly travel much farther than one light-year by taking advantage of the principles of special relativity.How many light-years away is the next habitable planet?At this time, it is impossible to say with certainty how many light-years away the next habitable planet is, as we have not yet discovered any other planets with the necessary conditions to support life as we know it here on Earth.Even though we have discovered thousands of exoplanets in recent years, none of them have been deemed to be habitable yet.In addition, scientists estimate that there could be hundreds of billions of potentially habitable planets located within our Milky Way galaxy alone. However, due to the immense distances involved between potential habitable planets and our own, it can be extremely difficult to detect these exoplanets.To make matters worse, the planets that are closest to us are typically too hot or too cold to support life as we know it.Therefore, until more sophisticated detection methods, such as the James Webb Space Telescope, are launched and used in the search for potentially habitable exoplanets, we may never have a definitive answer to this question.How many human years is a light-year?A light-year is a unit of distance and measurement not a unit of time. To calculate the amount of time it takes light to travel one light-year (the distance light travels in one year) we would need to understand the speed of light.The speed of light is 299,792,458 meters/second. Therefore, it would take 315,361,783 seconds for light to travel one light-year, which is equivalent to 31,556,926 minutes or 3,871,564. 27 hours. In terms of human years, the amount of time for light to travel one light-year is equivalent to 46,686.86 human years, as one human year is equivalent to 8766. 812 hours.Is a light-year 365 days?No, a light-year is not 365 days – it is actually much longer. A light-year is a unit of distance, not time, and it is equal to approximately 9,460,730,472,580. 8 km (5,878,625,373,183. 6 miles). A light-year measures the distance that light travels in one year, and is the most commonly used unit of measurement for distances between stars and galaxies.It represents the amount of distance light can travel in one year and is an incredibly large unit of measure – much larger than a year's worth of days! It would actually take about 6 trillion miles, or 10 trillion kilometers, to travel one light-year.Are there seconds in a light-year?No, there are no seconds in a light-year. A light-year is a measure of distance, not time. A light-year is the distance that light travels in one year, which is about 6 trillion miles. To put it into perspective, if you were to travel in a vehicle that averages 60 miles per hour, it would take you 100 million years to travel one light-year.So, no, there are no seconds in a light-year.How far is a black hole from Earth in light years?The exact distance of a black hole from Earth is not known because black holes, by definition, do not emit light. However, the closest known black hole to Earth, V616 Monocerotis, is estimated to be about 3,000 light-years away.This relatively nearby black hole is located in the constellation Monoceros, the Unicorn. It was first detected in 1926 and is believed to have a mass six times larger than our Sun. Numerous other black holes have been detected in other parts of our Milky Way galaxy, though they are much further away, often hundreds or thousands of light-years away, and most are too small to see in detail.Are we in danger of a black hole?No, we are not currently in any danger of a black hole. Black holes are incredibly rare, and even the closest ones to us are still billions of light years away. Additionally, black holes can only form through certain events, such as the collapse of massive stars, which are very unlikely to happen in our immediate vicinity.Even if one did form close to us, the radiation emitted from a black hole would not endanger life as we know it on Earth. In fact, some scientists believe that the central region of our own Milky Way may contain a supermassive black hole and that it may even provide us with beneficial radiation.That being said, it is important to note that attempting to approach a black hole too closely could be dangerous, as they can pull in material near them and destroy it.How long is 1 minute near a black hole?It's incredibly difficult to quantify how long a minute would be near a black hole because it depends upon the observer's frame of reference. According to Einstein's Theory of Relativity, time actually slows for observers located near a black hole.This is because of the immense gravitational pull of the black hole, which slows the passage of time. So, depending upon the observer's point of view, a minute near a black hole could be much longer or shorter than it would be to someone observing from a greater distance.How long would it take for us to get to the closest black hole?Traveling to the closest black hole would take far longer than any of us would be able to experience. The closest black hole is a supermassive black hole, located some 1,600 light-years away from us, in the constellation Sagittarius.Considering that light travels at 186,282 miles per second, it would take a staggering 5,857,294,000,000 miles to travel to the closest black hole. Even if we had some miraculous way of traveling at the speed of light, it would still take us just over 1600 years to make the journey.To put that into perspective, it's 31 billion times the distance from the Earth to the Moon – which we can reach in about 3 days. Any other form of travel would be impossible, given the amount of time it would take us to get there.To us, the closest black hole is simply off limits.