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, the free encyclopedia that anyone can edit. 107,583 active editors 7,025,325 articles in English Sir William Gordon-Cumming (20 July 1848 – 20 May 1930) was a Scottish landowner, soldier and socialite. He was the central figure in the royal baccarat scandal of 1891. He joined the British Army in 1868 and saw service in South Africa, Egypt and the Sudan; he served with distinction and rose to the rank of lieutenant-colonel. An adventurer, he also hunted in the US and India. A friend of Edward, Prince of Wales, for over 20 years, in 1890 he attended a house party at Tranby Croft, where he took part in a game of baccarat at the behest of the prince. During the course of two nights' play he was accused of cheating, which he denied. After news of the affair leaked out, he sued five members of the party for slander; Edward was called as a witness. The case was a public spectacle in the UK and abroad, but the verdict went against Gordon-Cumming and he was ostracised from polite society. After the court case he married an American heiress, but their relationship was unhappy. (Full article...) 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Ongoing: Gaza war Russian invasion of Ukraine timeline Sudanese civil war timeline Recent deaths: Raymond Guiot Felix Baumgartner Fauja Singh Bradley John Murdoch Frank Barrie Ihor Poklad Nominate an article July 20 Forensic experts at the site of the Suruç bombing 1807 – French brothers Claude and Nicéphore Niépce received a patent for their Pyréolophore, one of the world's first internal combustion engines. 1951 – Abdullah I of Jordan was assassinated while visiting the Al-Aqsa Mosque in Jerusalem. 1976 – The Viking 1 lander became the first spacecraft to successfully land on Mars and perform its mission. 1997 – USS Constitution, one of the United States Navy's original six frigates, sailed for the first time in 116 years after a full restoration. 2015 – A suicide attack (aftermath pictured) in Suruç, Turkey, for which Islamic State of Iraq and the Levant (ISIL) claimed responsibility, killed 34 people and injured 104 others. Alexander the Great (b. 356 BC)Amanda Clement (d. 1971)Bruce Lee (d. 1973)Gisele Bündchen (b. 1980) More anniversaries: July 19 July 20 July 21 Archive By email List of days of the year About C/2022 E3 (ZTF) is a non-periodic comet from the Oort cloud that was discovered by the Zwicky Transient Facility (ZTF) in 2022. With a comet nucleus of around 1 kilometre (0.62 mi) in diameter, C/2022 E3 rotates on its axis once every 8.5 to 8.7 hours. Its tails of dust and gas extended for millions of kilometers and, during January 2023, an anti-tail was also visible. The comet reached its most recent perihelion in January 2023, at a distance of 1.11 AU (166 million km; 103 million mi) from the sun, and the closest approach to Earth was a few weeks later, at a distance of 0.28 AU (42 million km; 26 million mi). The comet reached magnitude 5 and was visible with the naked eye under moonless dark skies. This photograph of C/2022 E3 was taken in January 2023 and released by the Italian National Institute for Astrophysics. Photograph credit: Alessandro Bianconi; National Institute for Astrophysics Recently featured: Passion fruit Basilica of St Paul, Rabat Clouded Apollo Archive More featured pictures Community portal – The central hub for editors, with resources, links, tasks, and announcements. Village pump – Forum for discussions about Wikipedia itself, including policies and technical issues. Site news – Sources of news about Wikipedia and the broader Wikimedia movement. Teahouse – Ask basic questions about using or editing Wikipedia. Help desk – Ask questions about using or editing Wikipedia. Reference desk – Ask research questions about encyclopedic topics. Content portals – A unique way to navigate the encyclopedia. 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Many other Wikipedias are available; some of the largest are listed below. 1,000,000+ articles العربية Deutsch Español فارسی Français Italiano Nederlands 日本語 Polski Português Русский Svenska Українська Tiếng Việt 中文 250,000+ articles Bahasa Indonesia Bahasa Melayu Bân-lâm-gú Български Català Čeština Dansk Eesti Ελληνικά Esperanto Euskara עברית Հայերեն Magyar Norsk bokmål Română Simple English Slovenčina Srpski Srpskohrvatski Suomi Türkçe Oʻzbekcha 50,000+ articles Asturianu Azərbaycanca □□□□□ Bosanski کوردی Frysk Gaeilge Galego Hrvatski ქართული Kurdî Latviešu Lietu □□□□□□ Македонски □□□□□□□□□□ Norsk nynorsk □□□□□□ Shqip Slovenščina □□□ □□□□□□ اردو Retrieved from " 2This 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: "1807" – news · newspapers · books · scholar · JSTOR (November 2015) (Learn how and when to remove this message) Calendar year Years Millennium 2nd millennium Centuries 18th century 19th century 20th century Decades 1780s 1790s 1800s 1810s 1820s Years 1804 1805 1806 1807 1808 1809 1810 vte February 7: Napoleon leads French troops into Russia in winter, and fights the Battle of Eylau. June 14: Napoleon triumphs over Russia's General Benningsen, at the Battle of Friedland. 1807 (MDCCCVII) was a common year starting on Thursday of the Gregorian calendar and a common year starting on Tuesday of the Julian calendar, the 1807th year of the Common Era (CE) and Anno Domini (AD) designations, the 807th year of the 2nd millennium, the 7th year of the 19th century, and the 8th year of the 1800s decade. As of the start of 1807, the Gregorian calendar was 12 days ahead of the Julian calendar, which remained in localized use until 1923. Calendar year 1807 by topic Humanities Archaeology Architecture Art Literature Poetry Music By country Australia Brazil Canada Denmark France Germany New Zealand Norway Russia South Africa Sweden United Kingdom United States Other topics Rail transport Science Sports Lists of leaders Sovereign states Sovereign state leaders Territorial governors Religious leaders Law Birth and death categories Births Deaths Establishments and disestablishments categories Establishments Disestablishments Works category Works vte 1807 in various calendarsGregorian calendar1807MDCCCVIIAb urbe condita2560Armenian calendar1256ԹՎ ՌՄԾԶAssyrian calendar6557Balinese saka calendar1728–1729Bengali calendar1213–1214Berber calendar2757British Regnal year47 Geo. 3 – 48 Geo. 3Buddhist calendar2351Burmese calendar1169Byzantine calendar7315–7316Chinese calendar丙寅年 (Fire Tiger)4504 or 4297 — to —丁卯年 (Fire Rabbit)4505 or 4298Coptic calendar1523–1524Discordian calendar2973Ethiopian calendar1799–1800Hebrew calendar5567–5568Hindu calendars - Vikram Samvat1863–1864 - Shaka Samvat1728–1729 - Kali Yuga4907–4908Holocene calendar11807Igbo calendar807–808Iranian calendar1185–1186Islamic calendar1221–1222Japanese calendarBunka 4(文化４年)Javanese calendar1733–1734Julian calendarGregorian minus 12 daysKorean calendar4140Minguo calendar105 before ROC民前105年Nanakshahi calendar339Thai solar calendar2349–2350Tibetan calendar□□□□□□□□□□□□□(male Fire-Tiger)1933 or 1552 or 780 — to —□□□□□□□□□□□□□(female Fire-Hare)1934 or 1553 or 781 Wikimedia Commons has media related to 1807. January 7 – The United Kingdom of Great Britain and Ireland issues an Order in Council prohibiting British ships from trading with France or its allies.[1] January 20 – The Sierra Leone Company, faced with bankruptcy because of the imminent abolition of the slave trade in British colonies, petitions the British government for purchase and transfer of its property to the Crown; Parliament approves the transfer on July 29, and it takes effect on January 1, 1808.[2] February 3 – Napoleonic Wars and Anglo-Spanish War: Battle of Montevideo – The British Army captures Montevideo from the Spanish Empire, as part of the British invasions of the Río de la Plata. February 7 – Napoleon leads the forces of the French Empire in an invasion of the Russian Empire, and begins fighting at the Battle of Eylau against Russian and Prussian forces.[3] February 8 – Battle of Eylau: Napoleon fights a hard but inconclusive battle against the Russians under Bennigsen. February 10 – The Survey of the Coast (renamed the United States Coast Survey in 1836 and the United States Coast and Geodetic Survey in 1878) is established; work begins on August 3, 1816. February 17 – Henry Christopher is elected first President of the State of Haiti, ruling the northern part of the country. February 19 – Burr conspiracy: In Alabama, former Vice President of the United States Aaron Burr is tried for conspiracy, but acquitted. February 23 – The Slave Trade Act is passed in the House of Commons of the United Kingdom by an overwhelming majority.[4] March 2 – The United States Congress passes the Act Prohibiting Importation of Slaves "into any port or place within the jurisdiction of the United States ... from any foreign kingdom, place, or country" (to take effect January 1, 1808). March 25 The United Kingdom Slave Trade Act becomes law abolishing the slave trade in most of the British Empire[5] with effect from 1 May (slavery itself is abolished in British colonies in 1833). The Swansea and Mumbles Railway in South Wales, at this time known as the Oystermouth Railway, becomes the first passenger-carrying railway in the world. March 29 – H. W. Olbers discovers the asteroid Vesta. April 4–12 – Froberg mutiny: The British suppress a mutiny at Fort Ricasoli, Malta, by men of the irregularly-recruited Froberg Regiment. April 14 – African Institution holds its first meeting in London; it is intended to improve social conditions in Sierra Leone. May 22 – A grand jury indicts former Vice President of the United States Aaron Burr for treason.[6] May 24 – Siege of Danzig ends after 6 weeks with Prussian and Russian defenders capitulating to French forces. May 29 – Selim III, Ottoman Emperor since 1789, is deposed in favour of his nephew Mustafa IV. May 31 – Primitive Methodism originates in an All Day of Prayer at Mow Cop, in the north midlands of England.[7] June 9 – The Duke of Portland is chosen as Prime Minister after the United Kingdom general election. June 10 – The Battle of Heilsberg ends in a draw. June 14 – Battle of Friedland: Napoleon decisively defeats Bennigsen's Russian army. June 22 – Chesapeake–Leopard affair: British Royal Navy fourth rate HMS Leopard attacks and boards United States Navy frigate USS Chesapeake off Norfolk, Virginia, seeking deserters. This act of British aggression plays a role in the run-up to the War of 1812. July 5 – A disastrous British attack is mounted against Buenos Aires, during the second failed invasion of the Río de la Plata. July 7–9 – The Treaties of Tilsit are signed between France, Prussia and Russia. Napoleon and Russian Emperor Alexander I ally together against the British. The Prussians are forced to cede more than half their territory, which is formed into the Duchy of Warsaw in their former Polish lands, and the Kingdom of Westphalia in western Germany. The Free City of Danzig is also formed (established September 9 by Napoleon). July 13 – With the death of Henry Benedict Stuart, the last Stuart claimant to the throne of the United Kingdom, Jacobitism comes to an effective end. July 20 – Nicéphore Niépce is awarded a patent by Napoleon Bonaparte for the Pyréolophore, the world's first internal combustion engine, after it successfully powers a boat upstream on the river Saône in France. August 17 – The North River Steamboat, Robert Fulton's first American steamboat, leaves New York City for Albany on the Hudson River, inaugurating the first commercial steamboat service in the world. September 1 – Former U.S. Vice President Aaron Burr is acquitted of treason. He had been accused of plotting to annex parts of Louisiana and Mexico, to become part of an independent republic. September 2–7 – Battle of Copenhagen: The British Royal Navy bombards Copenhagen with fire bombs and phosphorus rockets, to prevent the Dano-Norwegian navy from surrendering to Napoleon; 30% of the city is destroyed, and 2,000 citizens are killed. September 7 – Robert Morrison, the first Protestant missionary to China, arrives in Guangzhou (Canton).[8] September 13 – Beethoven's Mass in C major, Op. 86, is premiered, commissioned by Nikolaus I, Prince Esterházy, and displeasing him.[9] September 27 – Napoleon purchases the Borghese art collection, including the Antinous Mondragone, and brings it to Paris.[10] October 9 – Prussian Reform Movement: Serfdom is abolished by the October edict. October 13 – The Geological Society of London is founded. October 30 – El Escorial Conspiracy: Ferdinand, Prince of Asturias is arrested for conspiring against his father Charles IV of Spain. November 24 – Battle of Abrantes, Portugal: The French under Jean-Andoche Junot take the town. November 29 – Portuguese Queen Maria I and the Court embark at Lisbon, bound for Brazil. Rio de Janeiro becomes the Portuguese capital. December 5–11 – Napoleonic Wars: Raid on Griessie – A British Royal Navy squadron attacks the Dutch port of Griessie on Java in the Dutch East Indies, eliminating the last Dutch naval force in the Pacific and concluding the Java campaign of 1806–1807.[11] December 17 – Napoleonic Wars: France issues the Milan Decree which confirms the Continental System (i.e. no European country is to trade with the United Kingdom). December 22 – The United States Congress passes the Embargo Act, a trade embargo on all foreign nations. Battle of Hingakaka between two factions of Māori people, the largest battle ever fought in New Zealand, and the last fought there without firearms.[12] In 1807 or 1808 is fought the Battle of Moremonui, first of the Musket Wars. Robert E. Lee January 13 – Napoleon Bonaparte Buford, American general, railroad executive (d. 1883) January 19 – Robert E. Lee, American Confederate general (d. 1870) January 28 – Robert McClure, Irish-born Arctic explorer (d. 1873) February 10 – Lajos Batthyány, 1st Prime Minister of Hungary (d. 1849) February 27 – Henry Wadsworth Longfellow, American poet (d. 1882)[13] March 1 – Wilford Woodruff, American religious leader (d. 1898) March 14 – Josephine of Leuchtenberg, Queen of Sweden and Norway (d. 1876) April 2 – William F. Packer, American politician (d. 1870) April 3 – Jane Digby, English adventurer (d. 1881) April 20 – John Milton, Governor of Florida (d. 1865) April 26 – Charles Auguste Frossard, French general (d. 1875) May 28 – Louis Agassiz, Swiss-born zoologist and geologist (d. 1873) June 6 – Adrien-François Servais, Belgian musician (d. 1866) June 16 – John Westcott, American surveyor and politician (d. 1888) Giuseppe Garibaldi July 4 – Giuseppe Garibaldi, Italian patriot (d. 1882) August 11 – David Rice Atchison, American politician (d. 1886) August 15 – Jules Grévy, 4th President of France (d. 1891) August 18 – Charles Francis Adams Sr., American historical editor, politician and diplomat (d. 1886) September 2 – Fredrika Runeberg, Finnish writer (d. 1879)[14] September 7 – Henry Sewell, 1st Premier of New Zealand (d. 1879) September 16 – John Lenthall, American naval architect and shipbuilder (d. 1882) October 8 – Harriet Taylor, English philosophical writer (d. 1858)[15] October 26 – Barbu Catargiu, 1st Prime Minister of Romania (d. 1862) October 29 – Anđeo Kraljević, Herzegovinian Catholic bishop (d. 1879) October 30 – Christopher Wordsworth, Bishop of Lincoln (d. 1885) November 16 – Eduard von Fransecky, Prussian general (d. 1890) December 8 – Friedrich Traugott Kützing, German pharmacist, botanist and phycologist (d. 1893) December 17 – John Greenleaf Whittier, American Quaker poet and abolitionist (d. 1892) Pasquale Paoli February 1 – Sir Thomas Troubridge, 1st Baronet, British admiral (b. c. 1758) February 5 – Pasquale Paoli, Corsican patriot, military leader (b. 1725) February 27 – Louise du Pierry, French astronomer (b.1746) March 10 – Jean Thurel, French soldier (b. 1698) April 4 – Jérôme Lalande, French astronomer (b. 1732) April 10 – Duchess Anna Amalia of Brunswick-Wolfenbüttel, regent of Weimar and Eisenach (b. 1739) May 10 – Jean-Baptiste Donatien de Vimeur, comte de Rochambeau, French soldier (b. 1725) May 13 – Eliphalet Dyer, American statesman, judge (b. 1721) May 17 – John Gunby, Maryland soldier in the American Revolutionary War (b. 1745) May 18 – John Douglas, Scottish Anglican bishop, man of letters (b. 1721) June 9 – Andrew Sterett, American naval officer (b. 1778) Angelica Kauffman July 13 – Henry Benedict Stuart, Italian-born cardinal, Jacobite claimant to the British throne (b. 1725) July 19 – Uriah Tracy, American politician and congressman from Connecticut, 1793 until 1807 (b. 1755) September 14 – George Townshend, 1st Marquess Townshend, British field marshal (b. 1724) October 22 – Jean-François Houbigant, French perfumer (b. 1752) November 2 – Louis Auguste Le Tonnelier de Breteuil, Prime Minister of King Louis XVI of France (b. 1730) November 5 – Angelica Kauffman, Swiss painter (b. 1741) November 8 Darejan Dadiani, Georgian queen consort (b. 1738) Pierre-Alexandre-Laurent Forfait, French engineer, hydrographer, politician, and Minister of the Navy (1799–1801) (b. 1752) November 23 – Jean-François Rewbell, French politician (b. 1747) November 26 – Oliver Ellsworth, American founding father and 3rd Chief Justice of the United States Supreme Court (b. 1745) December 19 – Friedrich Melchior, Baron von Grimm, German writer (b. 1723) December 21 – John Newton, English cleric, hymnist (b. 1725) December 29 – Diogo de Carvalho e Sampayo, Portuguese diplomat, scientist (b. 1750) ^ William S. Dudley, ed. The Naval War of 1812: A Documentary History (Naval Historical Center, 1985) p34 ^ Stephen Tomkins, The Clapham Sect: How Wilberforce's Circle Transformed Britain (Lion Books, 2012) p200 ^ William Hodgson, The Life of Napoleon Bonaparte, Once Emperor of the French, who Died in Exile, at St. Helena, After a Captivity of Six Years' Duration (Orlando Hodgson, 1841) p384 ^ "William Wilberforce (1759–1833)". Retrieved January 18, 2021. ^ "Abolition of the Slave Trade 1807". BBC. Archived from the original on October 11, 2007. Retrieved September 11, 2007. ^ "The Aaron Burr Treason Trial" (PDF). ^ Farndale, W. E. (1950). The Secret of Mow Cop: a new appraisal of the origins of Primitive Methodism. London: Epworth Press. ^ "Sketch of the Canton Protestant Mission", by Rev. John Chalmers, in The Chinese Recorder and Missionary Journal, Volume 7 (American Presbyterian Mission Press, 1876) p174 ^ Marston, Nicholas (2006). Beethoven: Mass in C major, Op. 86 (PDF) (CD). Hyperion Records. CDH55263. Retrieved May 15, 2015. ^ Francis Haskell and Nicholas Penny, Taste and the Antique: The Lure of Classical Sculpture, 1500-1900 (Yale University Press, 1982) p281 ^ Clowes, William Laird (1997) [1900]. The Royal Navy: A History from the Earliest Times to 1900. Vol. V. Chatham Publishing. ISBN 1-86176-014-0. ^ Anderson, Atholl (2022). "War is their principal profession: On the frequency and causes of Maori warfare and migration, 1250–1850 CE". In Clark, Geoffrey; Litster, Mirani (eds.). Archaeological Perspectives on Conflict and Warfare in Australia and the Pacific. Canberra: ANU Press. p. 51. ISBN 978-1-76046-489-9. Retrieved March 29, 2025 – via Google Books. ^ Calhoun, Charles C (2004). Longfellow: A Rediscovered Life. Boston: Beacon Press. p. 5. ISBN 978-0807070260. ^ "Fredrika Runeberg". Svenska Litteratursällskapet i Finland. Archived from the original on May 6, 2014. Retrieved May 14, 2014. ^ Robson, Ann P. "Mill [née Hardy; other married name Taylor], Harriet". Oxford Dictionary of National Biography (online ed.). Oxford University Press. doi:10.1093/ref:odnb/38051. (Subscription or UK public library membership required.) Retrieved from " 3Second-largest asteroid of the main asteroid belt This article is about the asteroid. For the Roman goddess, see Vesta (mythology). For other uses, see Vesta (disambiguation). 4 VestaTrue color image of Vesta taken by Dawn. The massive Rheasilvia Crater dominates Vesta's south pole.DiscoveryDiscovered byHeinrich Wilhelm OlbersDiscovery date29 March 1807DesignationsMPC designation(4) VestaPronunciation/ˈvɛstə/[1]Named afterVestaMinor planet categoryMain belt (Vesta family)AdjectivesVestanVestian[a]Symbol (historically astronomical, now astrological)Orbital characteristics[6]Epoch 13 September 2023(JD 2453300.5)Aphelion2.57 AU (384 million km)Perihelion2.15 AU (322 million km)Semi-major axis2.36 AU (353 million km)Eccentricity0.0894Orbital period (sidereal)3.63 yr (1325.86 d)Average orbital speed19.34 km/sMean anomaly169.4°Inclination7.1422° to ecliptic5.58° to invariable plane[7]Longitude of ascending node103.71°Time of perihelion26 December 2021[8]Argument of perihelion151.66°SatellitesNoneEarth MOID1.14 AU (171 million km)Proper orbital elements[9]Proper semi-major axis2.36151 AUProper eccentricity0.098758Proper inclination6.39234°Proper mean motion99.1888 deg / yrProper orbital period3.62944 yr(1325.654 d)Precession of perihelion36.8729 (2343 years) arcsec / yrPrecession of the ascending node−39.5979 (2182 years) arcsec / yrPhysical characteristicsDimensions572.6 km × 557.2 km × 446.4 km[10]Mean diameter525.4±0.2 km[10]Flattening0.2204Surface area(8.66±0.2)×105 km2[b][11]Volume7.4970×107 km3[10]Mass(2.590271±0.000058)×1020 kg[12]Mean density3.456±0.035 g/cm3[10]Equatorial surface gravity0.22 m/s2 (0.022 g0)Equatorial escape velocity0.36 km/sSynodic rotation period0.2226 d (5.342 h)[6][13]Equatorial rotation velocity93.1 m/s[c]Axial tilt29°North pole right ascension20h 32m[d]North pole declination48°[d]Geometric albedo0.423[15]Temperaturemin: 75 K (−198 °C)max: 250 K (−23 °C)[16]Spectral typeV[6][17]Apparent magnitude5.1[18] to 8.48Absolute magnitude (H)3.20[6][15]Angular diameter0.70″ to 0.22″ Vesta (minor-planet designation: 4 Vesta) is one of the largest objects in the asteroid belt, with a mean diameter of 525 kilometres (326 mi).[10] It was discovered by the German astronomer Heinrich Wilhelm Matthias Olbers on 29 March 1807[6] and is named after Vesta, the virgin goddess of home and hearth from Roman mythology.[19] Vesta is thought to be the second-largest asteroid, both by mass and by volume, after the dwarf planet Ceres.[20][21][22] Measurements give it a nominal volume only slightly larger than that of Pallas (about 5% greater), but it is 25% to 30% more massive. It constitutes an estimated 9% of the mass of the asteroid belt.[23] Vesta is the only known remaining rocky protoplanet of the kind that formed the terrestrial planets.[24] Numerous fragments of Vesta were ejected by collisions one and two billion years ago that left two enormous craters occupying much of Vesta's southern hemisphere.[25][26] Debris from these events has fallen to Earth as howardite–eucrite–diogenite (HED) meteorites, which have been a rich source of information about Vesta.[27][28][29] Vesta is the brightest asteroid visible from Earth. It is regularly as bright as magnitude 5.1,[18] at which times it is faintly visible to the naked eye. Its maximum distance from the Sun is slightly greater than the minimum distance of Ceres from the Sun,[e] although its orbit lies entirely within that of Ceres.[30] NASA's Dawn spacecraft entered orbit around Vesta on 16 July 2011 for a one-year exploration and left the orbit of Vesta on 5 September 2012[31] en route to its final destination, Ceres. Researchers continue to examine data collected by Dawn for additional insights into the formation and history of Vesta.[32][33] Vesta, Ceres, and the Moon with sizes shown to scale Heinrich Olbers discovered Pallas in 1802, the year after the discovery of Ceres. He proposed that the two objects were the remnants of a destroyed planet. He sent a letter with his proposal to the British astronomer William Herschel, suggesting that a search near the locations where the orbits of Ceres and Pallas intersected might reveal more fragments. These orbital intersections were located in the constellations of Cetus and Virgo.[34] Olbers commenced his search in 1802, and on 29 March 1807 he discovered Vesta in the constellation Virgo—a coincidence, because Ceres, Pallas, and Vesta are not fragments of a larger body. Because the asteroid Juno had been discovered in 1804, this made Vesta the fourth object to be identified in the region that is now known as the asteroid belt. The discovery was announced in a letter addressed to German astronomer Johann H. Schröter dated 31 March.[35] Because Olbers already had credit for discovering a planet (Pallas; at the time, the asteroids were considered to be planets), he gave the honor of naming his new discovery to German mathematician Carl Friedrich Gauss, whose orbital calculations had enabled astronomers to confirm the existence of Ceres, the first asteroid, and who had computed the orbit of the new planet in the remarkably short time of 10 hours.[36][37] Gauss decided on the Roman virgin goddess of home and hearth, Vesta.[38] Vesta was the fourth asteroid to be discovered, hence the number 4 in its formal designation. The name Vesta, or national variants thereof, is in international use with two exceptions: Greece and China. In Greek, the name adopted was the Hellenic equivalent of Vesta, Hestia (4 Εστία); in English, that name is used for 46 Hestia (Greeks use the name "Hestia" for both, with the minor-planet numbers used for disambiguation). In Chinese, Vesta is called the 'hearth-god(dess) star', 灶神星 Zàoshénxīng, naming the asteroid for Vesta's role, similar to the Chinese names of Uranus, Neptune, and Pluto.[f] Upon its discovery, Vesta was, like Ceres, Pallas, and Juno before it, classified as a planet and given a planetary symbol. The symbol represented the altar of Vesta with its sacred fire and was designed by Gauss.[39][40] In Gauss's conception, now obsolete, this was drawn . This form is in the pipeline for Unicode 17.0 as U+1F777 .[41][42][g] The asteroid symbols were gradually retired from astronomical use after 1852, but the symbols for the first four asteroids were resurrected for astrology in the 1970s. The abbreviated modern astrological variant of the Vesta symbol is (U+26B6 ⚶).[41][h] After the discovery of Vesta, no further objects were discovered for 38 years, and during this time the Solar System was thought to have eleven planets.[47] However, in 1845, new asteroids started being discovered at a rapid pace, and by 1851 there were fifteen, each with its own symbol, in addition to the eight major planets (Neptune had been discovered in 1846). It soon became clear that it would be impractical to continue inventing new planetary symbols indefinitely, and some of the existing ones proved difficult to draw quickly. That year, the problem was addressed by Benjamin Apthorp Gould, who suggested numbering asteroids in their order of discovery, and placing this number in a disk (circle) as the generic symbol of an asteroid. Thus, the fourth asteroid, Vesta, acquired the generic symbol ④. This was soon coupled with the name into an official number–name designation, ④ Vesta, as the number of minor planets increased. By 1858, the circle had been simplified to parentheses, (4) Vesta, which were easier to typeset. Other punctuation, such as 4) Vesta and 4, Vesta, was also briefly used, but had more or less completely died out by 1949.[48] SPHERE image is shown on the left, with a synthetic view derived from Dawn images shown on the right for comparison.[49] Photometric observations of Vesta were made at the Harvard College Observatory in 1880–1882 and at the Observatoire de Toulouse in 1909. These and other observations allowed the rotation rate of Vesta to be determined by the 1950s. However, the early estimates of the rotation rate came into question because the light curve included variations in both shape and albedo.[50] Early estimates of the diameter of Vesta ranged from 383 kilometres (238 mi) in 1825, to 444 km (276 mi). E.C. Pickering produced an estimated diameter of 513 ± 17 km (319 ± 11 mi) in 1879, which is close to the modern value for the mean diameter, but the subsequent estimates ranged from a low of 390 km (242 mi) up to a high of 602 km (374 mi) during the next century. The measured estimates were based on photometry. In 1989, speckle interferometry was used to measure a dimension that varied between 498 and 548 km (309 and 341 mi) during the rotational period.[51] In 1991, an occultation of the star SAO 93228 by Vesta was observed from multiple locations in the eastern United States and Canada. Based on observations from 14 different sites, the best fit to the data was an elliptical profile with dimensions of about 550 km × 462 km (342 mi × 287 mi).[52] Dawn confirmed this measurement.[i] These measurements will help determine the thermal history, size of the core, role of water in asteroid evolution and what meteorites found on Earth come from these bodies, with the ultimate goal of understanding the conditions and processes present at the solar system's earliest epoch and the role of water content and size in planetary evolution.[53] Vesta became the first asteroid to have its mass determined. Every 18 years, the asteroid 197 Arete approaches within 0.04 AU of Vesta. In 1966, based upon observations of Vesta's gravitational perturbations of Arete, Hans G. Hertz estimated the mass of Vesta at (1.20±0.08)×10−10 M☉ (solar masses).[54] More refined estimates followed, and in 2001 the perturbations of 17 Thetis were used to calculate the mass of Vesta to be (1.31±0.02)×10−10 M☉.[55] Dawn determined it to be 1.3029×10−10 M☉. Vesta orbits the Sun between Mars and Jupiter, within the asteroid belt, with a period of 3.6 Earth years,[6] specifically in the inner asteroid belt, interior to the Kirkwood gap at 2.50 AU. Its orbit is moderately inclined (i = 7.1°, compared to 7° for Mercury and 17° for Pluto) and moderately eccentric (e = 0.09, about the same as for Mars).[6] True orbital resonances between asteroids are considered unlikely. Because of their small masses relative to their large separations, such relationships should be very rare.[56] Nevertheless, Vesta is able to capture other asteroids into temporary 1:1 resonant orbital relationships (for periods up to 2 million years or more) and about forty such objects have been identified.[57] Decameter-sized objects detected in the vicinity of Vesta by Dawn may be such quasi-satellites rather than proper satellites.[57] Olbers Regio (dark area) defines the prime meridian in the IAU coordinate system. It is shown here in a Hubble shot of Vesta, because it is not visible in the more detailed Dawn images.Claudia crater (indicated by the arrow at the bottom of the closeup image at right) defines the prime meridian in the Dawn/NASA coordinate system. Vesta's rotation is relatively fast for an asteroid (5.342 h) and prograde, with the north pole pointing in the direction of right ascension 20 h 32 min, declination +48° (in the constellation Cygnus) with an uncertainty of about 10°. This gives an axial tilt of 29°.[58] Two longitudinal coordinate systems are used for Vesta, with prime meridians separated by 150°. The IAU established a coordinate system in 1997 based on Hubble photos, with the prime meridian running through the center of Olbers Regio, a dark feature 200 km across. When Dawn arrived at Vesta, mission scientists found that the location of the pole assumed by the IAU was off by 10°, so that the IAU coordinate system drifted across the surface of Vesta at 0.06° per year, and also that Olbers Regio was not discernible from up close, and so was not adequate to define the prime meridian with the precision they needed. They corrected the pole, but also established a new prime meridian 4° from the center of Claudia, a sharply defined crater 700 metres across, which they say results in a more logical set of mapping quadrangles.[59] All NASA publications, including images and maps of Vesta, use the Claudian meridian, which is unacceptable to the IAU. The IAU Working Group on Cartographic Coordinates and Rotational Elements recommended a coordinate system, correcting the pole but rotating the Claudian longitude by 150° to coincide with Olbers Regio.[60] It was accepted by the IAU, although it disrupts the maps prepared by the Dawn team, which had been positioned so they would not bisect any major surface features.[59][61] Relative sizes of the four largest asteroids. Vesta is second from left. This graph was using the legacy Graph extension, which is no longer supported. It needs to be converted to the new Chart extension.The mass of 4 Vesta (blue) compared to other large asteroids: 1 Ceres, 2 Pallas, 10 Hygiea, 704 Interamnia, 15 Eunomia and the remainder of the Main Belt. The unit of mass is×1018 kg. Other objects in the Solar system with well-defined masses within a factor of 2 of Vesta's mass are Varda, Gǃkúnǁʼhòmdímà, and Salacia (245, 136, and 492×1018 kg, respectively). No moons are in this range: the closest, Tethys (Saturn III) and Enceladus (Saturn II), are over twice and less than half of Vesta's mass. Vesta is the second most massive body in the asteroid belt, although it is only 28% as massive as Ceres, the most massive body.[62][23] Vesta is, however, the most massive body that formed in the asteroid belt, as Ceres is believed to have formed between Jupiter and Saturn. Vesta's density is lower than those of the four terrestrial planets but is higher than those of most asteroids, as well as all of the moons in the Solar System except Io. Vesta's surface area is about the same as the land area of Pakistan, Venezuela, Tanzania, or Nigeria; slightly under 900,000 km2 (350,000 sq mi; 90 million ha; 220 million acres). It has an only partially differentiated interior.[63] Vesta is only slightly larger (525.4±0.2 km[10]) than 2 Pallas (512±3 km) in mean diameter,[64] but is about 25% more massive. Vesta's shape is close to a gravitationally relaxed oblate spheroid,[58] but the large concavity and protrusion at the southern pole (see 'Surface features' below) combined with a mass less than 5×1020 kg precluded Vesta from automatically being considered a dwarf planet under International Astronomical Union (IAU) Resolution XXVI 5.[65] A 2012 analysis of Vesta's shape[66] and gravity field using data gathered by the Dawn spacecraft has shown that Vesta is currently not in hydrostatic equilibrium.[10][67] Temperatures on the surface have been estimated to lie between about −20 °C (253 K) with the Sun overhead, dropping to about −190 °C (83.1 K) at the winter pole. Typical daytime and nighttime temperatures are −60 °C (213 K) and −130 °C (143 K), respectively. This estimate is for 6 May 1996, very close to perihelion, although details vary somewhat with the seasons.[16] Further information: List of geological features on Vesta Before the arrival of the Dawn spacecraft, some Vestan surface features had already been resolved using the Hubble Space Telescope and ground-based telescopes (e.g., the Keck Observatory).[68] The arrival of Dawn in July 2011 revealed the complex surface of Vesta in detail.[69] Geologic map of Vesta (Mollweide projection).[70] The most ancient and heavily cratered regions are brown; areas modified by the Veneneia and Rheasilvia impacts are purple (the Saturnalia Fossae Formation, in the north)[71] and light cyan (the Divalia Fossae Formation, equatorial),[70] respectively; the Rheasilvia impact basin interior (in the south) is dark blue, and neighboring areas of Rheasilvia ejecta (including an area within Veneneia) are light purple-blue;[72][73] areas modified by more recent impacts or mass wasting are yellow/orange or green, respectively. Main articles: Rheasilvia and Veneneia Northern (left) and southern (right) hemispheres. The "Snowman" craters are at the top of the left image; Rheasilvia and Veneneia (green and blue) dominate the right. Parallel troughs are seen in both. Colors of the two hemispheres are not to scale,[j] and the equatorial region is not shown. South pole of Vesta, showing the extent of Rheasilvia crater. The most prominent of these surface features are two enormous impact basins, the 500-kilometre-wide (311 mi) Rheasilvia, centered near the south pole; and the 400-kilometre-wide (249 mi) Veneneia. The Rheasilvia impact basin is younger and overlies the Veneneia.[74] The Dawn science team named the younger, more prominent crater Rheasilvia, after the mother of Romulus and Remus and a mythical vestal virgin.[75] Its width is 95% of the mean diameter of Vesta. The crater is about 19 km (12 mi) deep. A central peak rises 23 km (14 mi) above the lowest measured part of the crater floor and the highest measured part of the crater rim is 31 km (19 mi) above the crater floor low point. It is estimated that the impact responsible excavated about 1% of the volume of Vesta, and it is likely that the Vesta family and V-type asteroids are the products of this collision. If this is the case, then the fact that 10 km (6 mi) fragments have survived bombardment until the present indicates that the crater is at most only about 1 billion years old.[76] It would also be the site of origin of the HED meteorites. All the known V-type asteroids taken together account for only about 6% of the ejected volume, with the rest presumably either in small fragments, ejected by approaching the 3:1 Kirkwood gap, or perturbed away by the Yarkovsky effect or radiation pressure. Spectroscopic analyses of the Hubble images have shown that this crater has penetrated deep through several distinct layers of the crust, and possibly into the mantle, as indicated by spectral signatures of olivine.[58] Subsequent analysis of data from the Dawn mission provided much greater detail on Rheasilvia's structure and composition, confirming it as one of the largest impact structures known relative to its parent body size.[74] The impact clearly modified the pre-existing very large, Veneneia structure, indicating Rheasilvia's younger age.[74] Rheasilvia's size makes Vesta's southern topography unique, creating a flattened southern hemisphere and contributing significantly to the asteroid's overall oblate shape.[69] Rheasilvia's ~22 km (14 mi) central peak stands as one of the tallest mountains identified in the Solar System.[74] Its base width of roughly 180 km (110 mi) and complex morphology distinguishes it from the simpler central peaks seen in smaller craters.[77] Numerical modeling indicates that such a large central structure within a ~505 km (314 mi) diameter basin requires formation on a differentiated body with significant gravity. Scaling laws for craters on smaller asteroids fail to predict such a feature; instead, impact dynamics involving transient crater collapse and rebound of the underlying material (potentially upper mantle) are needed to explain its formation.[77] Hydrocode simulations suggest the impactor responsible was likely 60–70 km (37–43 mi) across, impacting at roughly 5.4 km/s.[78] Models of impact angle (around 30-45 degrees from vertical) better match the detailed morphology of the basin and its prominent peak.[77] Crater density measurements on Rheasilvia's relatively unmodified floor materials and surrounding ejecta deposits, calibrated using standard lunar chronology functions adapted for Vesta's location, place the impact event at approximately 1 billion years ago.[79][70] This age makes Rheasilvia a relatively young feature on a protoplanetary body formed early in Solar System history. The estimated excavation of ~1% of Vesta's volume[74] provides a direct link to the Vesta family of asteroids (Vestoids) and the HED meteorites. Since Vesta's spectral signature matches that of the Vestoids and HEDs, this strongly indicates they are fragments ejected from Vesta most likely during the Rheasilvia impact.[27][79] The Dawn mission's VIR instrument helped to confirm the basin's deep excavation and compositional diversity. VIR mapping revealed spectral variations across the basin consistent with the mixing of different crustal layers expected in the HED meteorites. Signatures matching eucrites (shallow crustal basalts) and diogenites (deeper crustal orthopyroxenites) were identified, which usually correlate with specific morphological features like crater walls or slump blocks.[80][27] The confirmed signature of olivine-rich material, which were first hinted at by Hubble observations is strongest on the flanks of the central peak and in specific patches along the basin rim and walls, suggesting it is not uniformly distributed but rather exposed in distinct outcrops.[81][80] As the dominant mineral expected in Vesta's mantle beneath the HED-like crust,[10] the presence of olivine indicates the Rheasilvia impact penetrated Vesta's entire crust (~20–40 km (12–25 mi) thick in the region) and excavated material from the upper mantle.[81] Furthermore, the global stresses resulting from this massive impact are considered the likely trigger for the formation of the large trough systems, like Divalia Fossa, that encircle Vesta's equatorial regions.[82][69] The crater Aelia Feralia Planitia, an old, degraded impact basin or impact basin complex near Vesta's equator (green and blue). It is 270 km (168 mi) across and predates Rheasilvia (green at bottom) Several old, degraded craters approach Rheasilvia and Veneneia in size, although none are quite so large. They include Feralia Planitia, shown at right, which is 270 km (168 mi) across.[83] More-recent, sharper craters range up to 158 km (98 mi) Varronilla and 196 km (122 mi) Postumia.[84] Dust fills up some craters, creating so-called dust ponds. They are a phenomenon where pockets of dust are seen in celestial bodies without a significant atmosphere. These are smooth deposits of dust accumulated in depressions on the surface of the body (like craters), contrasting from the Rocky terrain around them.[85] On the surface of Vesta, we have identified both type 1 (formed from impact melt) and type 2 (electrostatically made) dust ponds within 0˚–30°N/S, that is, Equatorial region. 10 craters have been identified with such formations.[86] The "snowman craters" are a group of three adjacent craters in Vesta's northern hemisphere. Their official names, from largest to smallest (west to east), are Marcia, Calpurnia, and Minucia. Marcia is the youngest and cross-cuts Calpurnia. Minucia is the oldest.[70] "Snowman" craters by Dawn from 5,200 km (3,200 mi) in 2011Detailed image of the "Snowman" craters The majority of the equatorial region of Vesta is sculpted by a series of parallel troughs designated Divalia Fossae; its longest trough is 10–20 kilometres (6.2–12.4 mi) wide and 465 kilometres (289 mi) long. Despite the fact that Vesta is a one-seventh the size of the Moon, Divalia Fossae dwarfs the Grand Canyon. A second series, inclined to the equator, is found further north. This northern trough system is named Saturnalia Fossae, with its largest trough being roughly 40 km (25 mi) wide and over 370 km (230 mi) long. These troughs are thought to be large-scale graben resulting from the impacts that created Rheasilvia and Veneneia craters, respectively. They are some of the longest chasms in the Solar System, nearly as long as Ithaca Chasma on Tethys. The troughs may be graben that formed after another asteroid collided with Vesta, a process that can happen only in a body that is differentiated,[82] which Vesta may not fully be. Alternatively, it is proposed that the troughs may be radial sculptures created by secondary cratering from Rheasilvia.[87] A section of Divalia Fossae, with parallel troughs to the north and southA computer-generated view of a portion of Divalia Fossae Compositional information from the visible and infrared spectrometer (VIR), gamma-ray and neutron detector (GRaND), and framing camera (FC), all indicate that the majority of the surface composition of Vesta is consistent with the composition of the howardite, eucrite, and diogenite meteorites.[88][89][90] The Rheasilvia region is richest in diogenite, consistent with the Rheasilvia-forming impact excavating material from deeper within Vesta. The presence of olivine within the Rheasilvia region would also be consistent with excavation of mantle material. However, olivine has only been detected in localized regions of the northern hemisphere, not within Rheasilvia.[32] The origin of this olivine is currently unclear. Though olivine was expected by astronomers to have originated from Vesta's mantle prior to the arrival of the Dawn orbiter, the lack of olivine within the Rheasilvia and Veneneia impact basins complicates this view. Both impact basins excavated Vestian material down to 60–100 km, far deeper than the expected thickness of ~30–40 km for Vesta's crust. Vesta's crust may be far thicker than expected or the violent impact events that created Rheasilvia and Veneneia may have mixed material enough to obscure olivine from observations. Alternatively, Dawn observations of olivine could instead be due to delivery by olivine-rich impactors, unrelated to Vesta's internal structure.[91] Pitted terrain has been observed in four craters on Vesta: Marcia, Cornelia, Numisia and Licinia.[92] The formation of the pitted terrain is proposed to be degassing of impact-heated volatile-bearing material. Along with the pitted terrain, curvilinear gullies are found in Marcia and Cornelia craters. The curvilinear gullies end in lobate deposits, which are sometimes covered by pitted terrain, and are proposed to form by the transient flow of liquid water after buried deposits of ice were melted by the heat of the impacts.[71] Hydrated materials have also been detected, many of which are associated with areas of dark material.[93] Consequently, dark material is thought to be largely composed of carbonaceous chondrite, which was deposited on the surface by impacts. Carbonaceous chondrites are comparatively rich in mineralogically bound OH.[90] Cut-away schematic of Vestan core, mantle, and crust Eucrite meteorite A large collection of potential samples from Vesta is accessible to scientists, in the form of over 1200 HED meteorites (Vestan achondrites), giving insight into Vesta's geologic history and structure. NASA Infrared Telescope Facility (NASA IRTF) studies of asteroid (237442) 1999 TA10 suggest that it originated from deeper within Vesta than the HED meteorites.[94] Vesta is thought to consist of a metallic iron–nickel core, variously estimated to be 90 km (56 mi)[63] to 220 km (140 mi)[10] in diameter, an overlying rocky olivine mantle, with a surface crust of similar composition to HED meteorites. From the first appearance of calcium–aluminium-rich inclusions (the first solid matter in the Solar System, forming about 4.567 billion years ago), a likely time line is as follows:[95][96][97][98][99] Timeline of the evolution of Vesta 2–3 million years Accretion completed 4–5 million years Complete or almost complete melting due to radioactive decay of 26Al, leading to separation of the metal core 6–7 million years Progressive crystallization of a convecting molten mantle. Convection stopped when about 80% of the material had crystallized Extrusion of the remaining molten material to form the crust, either as basaltic lavas in progressive eruptions, or possibly forming a short-lived magma ocean. The deeper layers of the crust crystallize to form plutonic rocks, whereas older basalts are metamorphosed due to the pressure of newer surface layers. Slow cooling of the interior Vesta is the only known intact asteroid that has been resurfaced in this manner. Because of this, some scientists refer to Vesta as a protoplanet.[100] Composition of the Vestan crust (by depth)[101] A lithified regolith, the source of howardites and brecciated eucrites. Basaltic lava flows, a source of non-cumulate eucrites. Plutonic rocks consisting of pyroxene, pigeonite and plagioclase, the source of cumulate eucrites. Plutonic rocks rich in orthopyroxene with large grain sizes, the source of diogenites. On the basis of the sizes of V-type asteroids (thought to be pieces of Vesta's crust ejected during large impacts), and the depth of Rheasilvia crater (see below), the crust is thought to be roughly 10 kilometres (6 mi) thick.[102] Findings from the Dawn spacecraft have found evidence that the troughs that wrap around Vesta could be graben formed by impact-induced faulting (see Troughs section above), meaning that Vesta has more complex geology than other asteroids. The impacts that created the Rheasilvia and Veneneia craters occurred when Vesta was no longer warm and plastic enough to return to an equilibrium shape, distorting its once rounded shape and prohibiting it from being classified as a dwarf planet today.[citation needed] Vesta's surface is covered by regolith distinct from that found on the Moon or asteroids such as Itokawa. This is because space weathering acts differently. Vesta's surface shows no significant trace of nanophase iron because the impact speeds on Vesta are too low to make rock melting and vaporization an appreciable process. Instead, regolith evolution is dominated by brecciation and subsequent mixing of bright and dark components.[103] The dark component is probably due to the infall of carbonaceous material, whereas the bright component is the original Vesta basaltic soil.[104] Some small Solar System bodies are suspected to be fragments of Vesta caused by impacts. The Vestian asteroids and HED meteorites are examples. The V-type asteroid 1929 Kollaa has been determined to have a composition akin to cumulate eucrite meteorites, indicating its origin deep within Vesta's crust.[28] Vesta is currently one of only eight identified Solar System bodies of which we have physical samples, coming from a number of meteorites suspected to be Vestan fragments. It is estimated that 1 out of 16 meteorites originated from Vesta.[105] The other identified Solar System samples are from Earth itself, meteorites from Mars, meteorites from the Moon, and samples returned from the Moon, the comet Wild 2, and the asteroids 25143 Itokawa, 162173 Ryugu, and 101955 Bennu.[29][k] Animation of Dawn's trajectory from 27 September 2007 to 5 October 2018 Dawn · Earth · Mars · 4 Vesta · 1 Ceres First image of asteroids (Ceres and Vesta) taken from Mars. The image was made by the Curiosity rover on 20 April 2014. Animation of Dawn's trajectory around 4 Vesta from 15 July 2011 to 10 September 2012 Dawn · 4 Vesta In 1981, a proposal for an asteroid mission was submitted to the European Space Agency (ESA). Named the Asteroidal Gravity Optical and Radar Analysis (AGORA), this spacecraft was to launch some time in 1990–1994 and perform two flybys of large asteroids. The preferred target for this mission was Vesta. AGORA would reach the asteroid belt either by a gravitational slingshot trajectory past Mars or by means of a small ion engine. However, the proposal was refused by the ESA. A joint NASA–ESA asteroid mission was then drawn up for a Multiple Asteroid Orbiter with Solar Electric Propulsion (MAOSEP), with one of the mission profiles including an orbit of Vesta. NASA indicated they were not interested in an asteroid mission. Instead, the ESA set up a technological study of a spacecraft with an ion drive. Other missions to the asteroid belt were proposed in the 1980s by France, Germany, Italy and the United States, but none were approved.[106] Exploration of Vesta by fly-by and impacting penetrator was the second main target of the first plan of the multi-aimed Soviet Vesta mission, developed in cooperation with European countries for realisation in 1991–1994 but canceled due to the dissolution of the Soviet Union. Artist's conception of Dawn orbiting Vesta In the early 1990s, NASA initiated the Discovery Program, which was intended to be a series of low-cost scientific missions. In 1996, the program's study team recommended a mission to explore the asteroid belt using a spacecraft with an ion engine as a high priority. Funding for this program remained problematic for several years, but by 2004 the Dawn vehicle had passed its critical design review[107] and construction proceeded.[citation needed] It launched on 27 September 2007 as the first space mission to Vesta. On 3 May 2011, Dawn acquired its first targeting image 1.2 million kilometres (0.75×10^6 mi) from Vesta.[108] On 16 July 2011, NASA confirmed that it received telemetry from Dawn indicating that the spacecraft successfully entered Vesta's orbit.[109] It was scheduled to orbit Vesta for one year, until July 2012.[110] Dawn's arrival coincided with late summer in the southern hemisphere of Vesta, with the large crater at Vesta's south pole (Rheasilvia) in sunlight. Because a season on Vesta lasts eleven months, the northern hemisphere, including anticipated compression fractures opposite the crater, would become visible to Dawn's cameras before it left orbit.[111] Dawn left orbit around Vesta on 4 September 2012 11:26 p.m. PDT to travel to Ceres.[112] NASA/DLR released imagery and summary information from a survey orbit, two high-altitude orbits (60–70 m/pixel) and a low-altitude mapping orbit (20 m/pixel), including digital terrain models, videos and atlases.[113][114][115][116][117][118] Scientists also used Dawn to calculate Vesta's precise mass and gravity field. The subsequent determination of the J2 component yielded a core diameter estimate of about 220 km (140 mi) assuming a crustal density similar to that of the HED.[113] Dawn data can be accessed by the public at the UCLA website.[119] Albedo and spectral maps of 4 Vesta, as determined from Hubble Space Telescope images from November 1994 Elevation map of 4 Vesta, as determined from Hubble Space Telescope images of May 1996 Elevation diagram of 4 Vesta (as determined from Hubble Space Telescope images of May 1996) viewed from the south-east, showing Rheasilvia crater at the south pole and Feralia Planitia near the equator Vesta seen by the Hubble Space Telescope in May 2007 The 2006 IAU draft proposal on the definition of a planet listed Vesta as a candidate.[120] Vesta is shown fourth from the left along the bottom row. Vesta comes into view as the Dawn spacecraft approaches and enters orbit: Vesta from 100,000 km(1 July 2011) Vesta from 41,000 km(9 July 2011) In orbit at 16,000 km(17 July 2011) In orbit from 10,500 km(18 July 2011) The northern hemisphere from 5,200 km(23 July 2011) In orbit from 5,200 km(24 July 2011) In orbit from 3,700 km(31 July 2011) Full rotation(1 August 2011) Composite greyscale image Cratered terrain with hills and ridges(6 August 2011) Densely cratered terrain near terminator(6 August 2011) Vestan craters in various states of degradation, with troughs at bottom(6 August 2011) Hill shaded central mound at the south pole of Vesta(2 February 2015) Detailed images retrieved during the high-altitude (60–70 m/pixel) and low-altitude (~20 m/pixel) mapping orbits are available on the Dawn Mission website of JPL/NASA.[121] Annotated image from Earth's surface in June 2007 with (4) Vesta Its size and unusually bright surface make Vesta the brightest asteroid, and it is occasionally visible to the naked eye from dark skies (without light pollution). In May and June 2007, Vesta reached a peak magnitude of +5.4, the brightest since 1989.[122] At that time, opposition and perihelion were only a few weeks apart.[123] It was brighter still at its 22 June 2018 opposition, reaching a magnitude of +5.3.[124] Less favorable oppositions during late autumn 2008 in the Northern Hemisphere still had Vesta at a magnitude of from +6.5 to +7.3.[125] Even when in conjunction with the Sun, Vesta will have a magnitude around +8.5; thus from a pollution-free sky it can be observed with binoculars even at elongations much smaller than near opposition.[125] In 2010, Vesta reached opposition in the constellation of Leo on the night of 17–18 February, at about magnitude 6.1,[126] a brightness that makes it visible in binocular range but generally not for the naked eye. Under perfect dark sky conditions where all light pollution is absent it might be visible to an experienced observer without the use of a telescope or binoculars. Vesta came to opposition again on 5 August 2011, in the constellation of Capricornus at about magnitude 5.6.[126][127] Vesta was at opposition again on 9 December 2012.[128] According to Sky and Telescope magazine, this year Vesta came within about 6 degrees of 1 Ceres during the winter of 2012 and spring 2013.[129] Vesta orbits the Sun in 3.63 years and Ceres in 4.6 years, so every 17.4 years Vesta overtakes Ceres (the previous overtaking was in April 1996).[129] On 1 December 2012, Vesta had a magnitude of 6.6, but it had decreased to 8.4 by 1 May 2013.[129] Conjunction of Ceres and Vesta near the star Gamma Virginis on 5 July 2014 in the Constellation of Virgo. Ceres and Vesta came within one degree of each other in the night sky in July 2014.[129] 3103 Eger 3551 Verenia 3908 Nyx 4055 Magellan Asteroids in fiction Diogenite Eucrite List of former planets Howardite Vesta family (vestoids) List of tallest mountains in the Solar System ^ Marc Rayman of the JPL Dawn team used "Vestian" (analogous to the Greek cognate Hestian) a few times in 2010 and early 2011 in his Dawn Journal, and the Planetary Society continued to use that form for a few more years.[2] The word had been used elsewhere, e.g. in Tsiolkovsky (1960) The call of the cosmos. However, otherwise the shorter form "Vestan" has been used by JPL.[3] Most modern print sources also use "Vestan".[4][5]Note that the related word "Vestalian" refers to people or things associated with Vesta, such as the vestal virgins, not to Vesta herself. ^ Calculated using the known dimensions assuming an ellipsoid. ^ Calculated using (1) the known rotation period (5.342 h)[6] and (2) the equatorial radius Req (285 km)[10] of the best-fit biaxial ellipsoid to Asteroid 4 Vesta. ^ a b topocentric coordinates computed for the selected location: Greenwich, United Kingdom[14] ^ On 10 February 2009, during Ceres perihelion, Ceres was closer to the Sun than Vesta, because Vesta has an aphelion distance greater than Ceres's perihelion distance. (10 February 2009: Vesta 2.56 AU; Ceres 2.54 AU) ^ 維斯塔 wéisītǎ is the closest Chinese approximation of the Latin pronunciation westa. ^ Some sources contemporaneous to Gauss invented more elaborate forms, such as and .[43][44] A simplification of the latter from c. 1930, ,[45] never caught on. ^ This symbol can be seen in the top of the most elaborate of the earlier forms, . It dates from 1973, at the beginning of astrological interest in asteroids.[46] ^ The data returned will include, for both asteroids, full surface imagery, full surface spectrometric mapping, elemental abundances, topographic profiles, gravity fields, and mapping of remnant magnetism, if any.[53] ^ that is, blue in the north does not mean the same thing as blue in the south. ^ Note that 6 Hebe may be the parent body for H chondrites, one of the most common meteorite types. ^ "Vesta". Dictionary.com Unabridged (Online). n.d. ^ "Search Results". Planetary Society. Archived from the original on 27 July 2020. Retrieved 31 August 2012. ^ "Search – Dawn Mission". JPL. Archived from the original on 5 March 2016. ^ Meteoritics & planetary science, Volume 42, Issues 6–8, 2007; Origin and evolution of Earth, National Research Council et al., 2008 ^ E.g in Meteoritics & planetary science (volume 42, issues 6–8, 2007) and Origin and evolution of Earth (National Research Council et al., 2008). ^ a b c d e f g h "JPL Small-Body Database Browser: 4 Vesta". Archived from the original on 26 September 2021. Retrieved 1 June 2008. ^ Souami, D.; Souchay, J. (July 2012). "The solar system's invariable plane". Astronomy & Astrophysics. 543: 11. Bibcode:2012A&A...543A.133S. doi:10.1051/0004-6361/201219011. A133. ^ "Horizons Batch for 4 Vesta on 2021-Dec-26" (Perihelion occurs when rdot flips from negative to positive). JPL Horizons. Retrieved 26 September 2021. (Epoch 2021-Jul-01/Soln.date: 2021-Apr-13) ^ "AstDyS-2 Vesta Synthetic Proper Orbital Elements". Department of Mathematics, University of Pisa, Italy. Retrieved 1 October 2011. ^ a b c d e f g h i j Russell, C. T.; et al. (2012). "Dawn at Vesta: Testing the Protoplanetary Paradigm" (PDF). Science. 336 (6082): 684–686. Bibcode:2012Sci...336..684R. doi:10.1126/science.1219381. PMID 22582253. S2CID 206540168. ^ "surface ellipsoid 286.3x278.6x223.2". Wolfram-Alpha: Computational Knowledge Engine. ^ Konopliv, A. S.; et al. (2014). "The Vesta gravity field, spin pole and rotation period, landmark positions, and ephemeris from the Dawn tracking and optical data". Icarus. 240: 118–132. Bibcode:2014Icar..240..103K. doi:10.1016/j.icarus.2013.09.005. PDF copy ^ Harris, A. W. (2006). Warner, B. D.; Pravec, P. (eds.). "Asteroid Lightcurve Derived Data. EAR-A-5-DDR-DERIVED-LIGHTCURVE-V8.0". NASA Planetary Data System. Archived from the original on 9 April 2009. Retrieved 26 December 2013. ^ "Asteroid 4 Vesta". TheSkyLive. Retrieved 13 December 2022. ^ a b Tedesco, E. F.; Noah, P. V.; Noah, M.; Price, S. D. (2004). "Infra-Red Astronomy Satellite (IRAS) Minor Planet Survey. IRAS-A-FPA-3-RDR-IMPS-V6.0". NASA Planetary Data System. Archived from the original on 9 April 2009. Retrieved 15 March 2007. ^ a b Mueller, T. G.; Metcalfe, L. (2001). "ISO and Asteroids" (PDF). ESA Bulletin. 108: 38. Bibcode:2001ESABu.108...39M. Archived (PDF) from the original on 11 September 2005. ^ Neese, C.; Ed. (2005). "Asteroid Taxonomy EAR-A-5-DDR-TAXONOMY-V5.0". NASA Planetary Data System. Archived from the original on 10 March 2007. Retrieved 25 December 2013. ^ a b Menzel, Donald H. & Pasachoff, Jay M. (1983). A Field Guide to the Stars and Planets (2nd ed.). Boston, MA: Houghton Mifflin. p. 391. ISBN 978-0-395-34835-2. ^ "In Depth - 4 Vesta". NASA Solar System Exploration. 10 November 2017. Retrieved 13 December 2022. ^ "Dawn Mission Overview". NASA. Archived from the original on 16 October 2011. Retrieved 14 August 2011. ^ Lang, Kenneth (2011). The Cambridge Guide to the Solar System. Cambridge University Press. pp. 372, 442. ISBN 9780521198578. ^ Russell, C. T.; et al. (2011). "Exploring the smallest terrestrial planet: Dawn at Vesta" (PDF). EPSC Abstracts. 2011 EPSC-DPS Joint Meeting. Vol. 6. EPSC-DPS2011-97-3. Archived (PDF) from the original on 20 March 2012. ^ a b Pitjeva, E. V. (2005). "High-Precision Ephemerides of Planets—EPM and Determination of Some Astronomical Constants" (PDF). Solar System Research. 39 (3): 176–186. Bibcode:2005SoSyR..39..176P. doi:10.1007/s11208-005-0033-2. S2CID 120467483. Archived from the original (PDF) on 31 October 2008. ^ Amos, Jonathan (11 May 2012). "Asteroid Vesta is 'last of a kind' rock". BBC News. ^ Jutzi, M.; E. Asphaug; P. Gillet; J.-A. Barrat; W. Benz (14 February 2013). "The structure of the asteroid 4 Vesta as revealed by models of planet-scale". Nature. 494 (7436): 207–210. Bibcode:2013Natur.494..207J. doi:10.1038/nature11892. PMID 23407535. S2CID 4410838. ^ Cook, Jia-Rui. "Dawn Reality-Checks Telescope Studies of Asteroids". Archived from the original on 2 May 2014. Retrieved 30 April 2014. ^ a b c McSween, H. Y.; R. P. Binzel; M. C. De Sanctis; et al. (27 November 2013). "Dawn; the Vesta-HED connection; and the geologic context for eucrite, diogenites, and howardites". Meteoritics & Planetary Science. 48 (11): 2090–21–4. Bibcode:2013M&PS...48.2090M. doi:10.1111/maps.12108. S2CID 131100157. ^ a b Kelley, M. S.; et al. (2003). "Quantified mineralogical evidence for a common origin of 1929 Kollaa with 4 Vesta and the HED meteorites". Icarus. 165 (1): 215–218. Bibcode:2003Icar..165..215K. doi:10.1016/S0019-1035(03)00149-0. ^ a b "Vesta". NASA/JPL. 12 July 2011. Archived from the original on 29 June 2011. Retrieved 30 July 2011. ^ "Ceres, Pallas, Vesta, and Hygiea". Gravity Simulator. Archived from the original on 17 June 2008. Retrieved 31 May 2008. ^ "Mission > Mission Status – Dawn Mission". JPL. Archived from the original on 11 May 2013. Retrieved 6 September 2012. ^ a b Ammannito, E.; M. C. De Sanctis; E. Palomba; et al. (2013). "Olivine in an unexpected location on Vesta's surface". Nature. 504 (7478): 122–125. Bibcode:2013Natur.504..122A. doi:10.1038/nature12665. PMID 24196707. S2CID 4464889. ^ Cook, Jia-Rui. "It's Complicated: Dawn Spurs Rewrite of Vesta's Story". Archived from the original on 2 May 2014. Retrieved 30 April 2014. ^ Littmann, Mark (2004). Planets Beyond: Discovering the Outer Solar System. Dover Books on Astronomy. Courier Dover Publications. p. 21. ISBN 978-0-486-43602-9. ^ Lynn, W. T. (February 1907). "The discovery of Vesta". The Observatory. 30: 103–105. Bibcode:1907Obs....30..103L. ^ Dunnington, Guy Waldo; Gray, Jeremy; Dohse, Fritz-Egbert (2004). Carl Friedrich Gauss: Titan of Science. The Mathematical Association of America. p. 76. ISBN 978-0-88385-547-8. ^ Rao, K. S.; Berghe, G. V. (2003). "Gauss, Ramanujan and Hypergeometric Series Revisited". Historia Scientiarum. 13 (2): 123–133. ^ Schmadel, Lutz D. (2003). Dictionary of Minor Planet Names: Prepared on Behalf of Commission 20 Under the Auspices of the International Astronomical Union. Springer. p. 15. ISBN 978-3-540-00238-3. ^ von Zach, Franz Xaver (1807). Monatliche correspondenz zur beförderung der erd- und himmels-kunde. Vol. 15. p. 507. ^ Carlini, Francesco (1808). Effemeridi astronomiche di Milano per l'anno 1809. ^ a b Bala, Gavin Jared; Miller, Kirk (18 September 2023). Unicode request for historical asteroid symbols (PDF) (Report). Unicode Consortium. Retrieved 26 September 2023 – via unicode.org. ^ "Proposed new characters". unicode.org. The Pipeline. Unicode Consortium. Retrieved 6 November 2023. ^ Bureau des longitudes (1807). Annuaire pour l'an 1808. p. 5. ^ Canovai, Stanislao; del-Ricco, Gaetano (1810). Elementi di fisica matematica. p. 149. ^ Koch, Rudolf (1955) [1930]. The Book of Signs (reprint ed.). Dover. ^ Bach, Eleanor (1973). Ephemerides of the asteroids: Ceres, Pallas, Juno, Vesta, 1900–2000. Celestial Communications. Bibcode:1973eacp.book.....B. ^ Wells, David A. (1851). Bliss, George Jr. (ed.). "The Planet Hygiea". Annual of Scientific Discovery for the year 1850, quoted by spaceweather.com archives, 2006-09-13. Retrieved 1 June 2008. ^ Hilton, James L. When Did the Asteroids Become Minor Planets? (Report). Archived from the original on 24 March 2008 – via U.S. Naval Observatory website, particularly the discussion of Gould, B. A. (1852). "On the Symbolic Notation of the Asteroids". Astronomical Journal. 2: 80. Bibcode:1852AJ......2...80G. doi:10.1086/100212. and immediate subsequent history. Also, the discussion of C. J. Cunningham (1988) Introduction to Asteroids explains the parenthetical part. ^ "New SPHERE view of Vesta". www.eso.org. Retrieved 25 June 2018. ^ McFadden, L.

A.; Emerson, G.; Warner, E. M.; Onukwubiti, U.; Li, J.-Y. "Photometry of 4 Vesta from its 2007 Apparition". Proceedings, 39th Lunar and Planetary Science Conference. League City, Texas. Bibcode:2008LPI....39.2546M. 10–14 March 2008 ^ Hughes, D. W. (September 1994). "The Historical Unravelling of the Diameters of the First Four Asteroids". Quarterly Journal of the Royal Astronomical Society. 35 (3): 331. Bibcode:1994QJRAS..35..331H. ^ Povenmire, H. (September 2001). "The January 4, 1991 Occultation of SAO 93228 by Asteroid (4) Vesta". Meteoritics & Planetary Science. 36 (Supplement): A165. Bibcode:2001M&PSA..36Q.165P. doi:10.1111/j.1945-5100.2001.tb01534.x. ^ a b "Dawn-NASA-NSSDCA-Spacecraft-Details". Archived from the original on 23 May 2022. Retrieved 16 December 2022. ^ Hertz, Hans G. (19 April 1968). "Mass of Vesta". Science. 160 (3825): 299–300. Bibcode:1968Sci...160..299H. doi:10.1126/science.160.3825.299. PMID 17788233. S2CID 2555834. ^ Kovačević, A. (January 2005). "Determination of the mass of (4) Vesta based on new close approaches". Astronomy and Astrophysics. 430 (1): 319–325. Bibcode:2005A&A...430..319K. doi:10.1051/0004-6361:20035872. ^ Christou, A. A. (2000). "Co-orbital objects in the main asteroid belt". Astronomy and Astrophysics. 356: L71 – L74. Bibcode:2000A&A...356L..71C. ^ a b Christou, A. A.; Wiegert, P. (January 2012). "A population of Main Belt Asteroids co-orbiting with Ceres and Vesta". Icarus. 217 (1): 27–42. arXiv:1110.4810. Bibcode:2012Icar..217...27C. doi:10.1016/j.icarus.2011.10.016. ISSN 0019-1035. S2CID 59474402. ^ a b c Thomas, P. C.; et al. (1997). "Vesta: Spin Pole, Size, and Shape from HST Images". Icarus. 128 (1): 88–94. Bibcode:1997Icar..128...88T. doi:10.1006/icar.1997.5736. ^ a b Hand, Eric (2012). "Space missions trigger map wars". Nature. 488 (7412): 442–443. Bibcode:2012Natur.488..442H. doi:10.1038/488442a. PMID 22914145. ^ "IAU WGCCRE Coordinate System for Vesta | USGS Astrogeology Science Center". Astrogeology.usgs.gov. 15 November 2013. Retrieved 25 June 2014. ^ Li, Jian-Yang; Mafi, Joseph N. "Body-Fixed Coordinate Systems for Asteroid (4) Vesta" (PDF). Planetary Data System. Archived (PDF) from the original on 6 November 2015. ^ Baer, James; Chesley, Steven R. (2008). "Astrometric masses of 21 asteroids, and an integrated asteroid ephemeris". Celestial Mechanics and Dynamical Astronomy. 100 (1): 27–42. Bibcode:2008CeMDA.100...27B. doi:10.1007/s10569-007-9103-8. ^ a b Park, R. S.; Ermakov, A. I.; Konopliv, A. S.; Vaughan, A. T.; Rambaux, N.; Bills, B. G.; Castillo-Rogez, J. C.; Fu, R. R.; Jacobson, S. A.; Stewart, S. T.; Toplis, M. J. (23 April 2025). "A small core in Vesta inferred from Dawn's observations". Nature Astronomy: 1–11. doi:10.1038/s41550-025-02533-7. ISSN 2397-3366. ^ Carry, B.; et al. (2009). "Physical properties of (2) Pallas". Icarus. 205 (2): 460–472. arXiv:0912.3626v1. Bibcode:2010Icar..205..460C. doi:10.1016/j.icarus.2009.08.007. S2CID 119194526. ^ "The IAU draft definition of "planet" and "plutons"". IAU. August 2006. Archived from the original on 9 January 2010. Retrieved 16 December 2009. (XXVI) ^ Fu, R. R.; Hager, B. H.; Ermakov, A.I.; Zuber, M.T. (2013). "Early Viscous Relaxation of Asteroid Vesta and Implications for Late Impact-Driven Despinning" (PDF). 44th Lunar and Planetary Science Conference (1719): 2115. Bibcode:2013LPI....44.2115F. Archived (PDF) from the original on 26 July 2014. ^ Asmar, S. W.; Konopliv, A. S.; Park, R. S.; et al. (2012). "The Gravity Field of Vesta and Implications for Interior Structure" (PDF). 43rd Lunar and Planetary Science Conference (1659): 2600. Bibcode:2012LPI....43.2600A. Archived (PDF) from the original on 20 October 2013. ^ Zellner, N. E. B.; Gibbard, S.; de Pater, I.; et al. (2005). "Near-IR imaging of Asteroid 4 Vesta" (PDF). Icarus. 177 (1): 190–195. Bibcode:2005Icar..177..190Z. doi:10.1016/j.icarus.2005.03.024. Archived from the original (PDF) on 23 November 2008. ^ a b c Jaumann, R.; et al. (2012). "Vesta's Shape and Morphology". Science. 336 (6082): 687–690. Bibcode:2012Sci...336..687J. doi:10.1126/science.1219122. PMID 22582254. S2CID 206540010. ^ a b c d Williams, D. A.; Yingst, R. A.; Garry, W. B. (December 2014). "Introduction: The geologic mapping of Vesta". Icarus. 244: 1–12. Bibcode:2014Icar..244....1W. doi:10.1016/j.icarus.2014.03.001. hdl:2286/R.I.28071. —Williams, D. A.; et al. (December 2014). "The geology of the Marcia quadrangle of asteroid Vesta: Assessing the effects of large, young craters". Icarus. 244: 74–88. Bibcode:2014Icar..244...74W. doi:10.1016/j.icarus.2014.01.033. hdl:2286/R.I.28061. S2CID 5505009. ^ a b Scully, J. E. C.; Yin, A.; Russell, C. T.; et al. (December 2014). "Geomorphology and structural geology of Saturnalia Fossae and adjacent structures in the northern hemisphere of Vesta". Icarus. 244: 23–40. Bibcode:2014Icar..244...23S. doi:10.1016/j.icarus.2014.01.013. hdl:2286/R.I.28070. Archived (PDF) from the original on 21 July 2018.—Scully, J. E. C.; et al. (2014). "Sub-curvilinear gullies interpreted as evidence for transient water flow on Vesta" (PDF). 45th Lunar and Planetary Science Conference (1777): 1796. Bibcode:2014LPI....45.1796S. ^ Schäfer, M.; Nathues, A.; Williams, D. A.; et al. (December 2014). "Imprint of the Rheasilvia impact on Vesta – Geologic mapping of quadrangles Gegania and Lucaria" (PDF). Icarus. 244: 60–73. Bibcode:2014Icar..244...60S. doi:10.1016/j.icarus.2014.06.026. hdl:2286/R.I.28060. Archived from the original (PDF) on 28 April 2019. Retrieved 24 September 2019. ^ Kneissl, T.; Schmedemann, N.; Reddy, V.; et al. (December 2014). "Morphology and formation ages of mid-sized post-Rheasilvia craters – Geology of quadrangle Tuccia, Vesta". Icarus. 244: 133–157. Bibcode:2014Icar..244..133K. doi:10.1016/j.icarus.2014.02.012. hdl:2286/R.I.28058. ^ a b c d e Schenk, P.; et al. (2012). "The Geologically Recent Giant Impact Basins at Vesta's South Pole". Science. 336 (6082): 694–697. Bibcode:2012Sci...336..694S. doi:10.1126/science.1223272. PMID 22582256. S2CID 206541950. ^ "Rheasilvia – Super Mysterious South Pole Basin at Vesta is Named after Romulus and Remus Roman Mother". Universe Today. 21 September 2011. Retrieved 23 September 2011. ^ Binzel, R. P.; et al. (1997). "Geologic Mapping of Vesta from 1994 Hubble Space Telescope Images". Icarus. 128 (1): 95–103. Bibcode:1997Icar..128...95B. doi:10.1006/icar.1997.5734. ^ a b c Ivanov, B. A.; Melosh, H. J. (2013). "Rheasilvia impact basin on Vesta: Constraints on formation models from the central peak topography". Journal of Geophysical Research: Planets. 118 (7): 1545–1555. Bibcode:2013JGRE..118.1545I. doi:10.1002/jgre.20108. ^ Bowling, T. J.; Richard, G.; Melosh, H. J. (2013). "Numerical simulations of the Rheasilvia impact basin on Vesta". Journal of Geophysical Research: Planets. 118 (8): 1622–1639. Bibcode:2013JGRE..118.1622B. doi:10.1002/jgre.20113. ^ a b Marchi, S.; McSween, H. Y.; O'Brien, D. P. (2012). "The Violent Collisional History of Vesta". Science. 336 (6082): 690–694. Bibcode:2012Sci...336..690M. doi:10.1126/science.1218405. ^ a b De Sanctis, M. C.; Combe, J.-P.; Ammannito, E. (2012). "Spectroscopic Characterization of Mineralogy and Its Diversity on Vesta". Science. 336 (6082): 697–700. Bibcode:2012Sci...336..697D. doi:10.1126/science.1219270. ^ a b Clénet, H.; Jutzi, M.; Barrat, J.-A. (2014). "Constraints on Vesta's crustal structure and evolution from VIR/Dawn data: Olivine detection and analysis". Icarus. 244: 146–157. Bibcode:2014Icar..244..146C. doi:10.1016/j.icarus.2014.04.010. ^ a b Buczkowski, D.L.; Raymond, C.A.; Williams, D.A.; et al. (2012). "Large-scale troughs on Vesta: A signature of planetary tectonics". Geophysical Research Letters. 39 (18): L18205. Bibcode:2012GeoRL..3918205B. doi:10.1029/2012GL052959. ^ Garry, W.B.; Sykes, M.; Buczkowski, D.L.; et al. (March 2012). Geologic Mapping of Av-10 Oppia Quadrangle of Asteroid 4 Vesta (PDF). 43rd Lunar and Planetary Science Conference, held 19–23 March 2012 at The Woodlands, Texas. id.2315. Bibcode:2012LPI....43.2315G. LPI Contribution No. 1659. Archived (PDF) from the original on 24 April 2014. —Garry, W.B.; Sykes, M.; Buczkowski, D.L.; et al. (April 2012). "Geologic Mapping of Av-10 Oppia Quadrangle of Asteroid 4 Vesta" (PDF). Geophysical Research Abstracts. EGU General Assembly 2012, held 22–27 April 2012 in Vienna, Austria. Vol. 14. p. 5711. Bibcode:2012EGUGA..14.5711G. EGU2012-5711-1. Archived (PDF) from the original on 8 April 2014. ^ "Nomenclature Search Results / Target: VESTA / Feature Type: Crater, craters". Gazetteer of Planetary Nomenclature. IAU. ^ Beatty, J. Kelly (25 June 2004). "Eros's puzzling surface". Sky and Telescope. Retrieved 18 October 2023 – via skyandtelescope.org. To geologists' surprise, the asteroid Eros has more than 250 'ponds' thought to contain compacted deposits of finely ground dust. ^ Parekh, R.; Otto, K.A.; Matz, K.D.; Jaumann, R.; Krohn, K.; Roatsch, T.; et al. (28 February 2022) [1 November 2021]. "Formation of ejecta and dust pond deposits on asteroid Vesta". Journal of Geophysical Research: Planets. 126 (11): e2021JE006873. doi:10.1029/2021JE006873. ^ Hirata, N. (2023). "Secondary Cratering From Rheasilvia as the Possible Origin of Vesta's Equatorial Troughs". Journal of Geophysical Research: Planets. 128 (3). arXiv:2303.14955. Bibcode:2023JGRE..12807473H. doi:10.1029/2022JE007473. hdl:20.500.14094/0100482053. Retrieved 4 March 2024. ^ De Sanctis, M. C.; et al. (2012). "Spectroscopic Characterization of Mineralogy and Its Diversity Across Vesta". Science. 336 (6082): 697–700. Bibcode:2012Sci...336..697D. doi:10.1126/science.1219270. PMID 22582257. S2CID 11645621. ^ Prettyman, T. H.; et al. (2012). "Elemental Mapping by Dawn Reveals Exogenic H in Vesta's Regolith". Science. 338 (6104): 242–246. Bibcode:2012Sci...338..242P. doi:10.1126/science.1225354. PMID 22997135. S2CID 206542798. ^ a b Reddy, V.; et al. (2012). "Color and Albedo Heterogeneity of Vesta from Dawn". Science. 336 (6082): 700–704. Bibcode:2012Sci...336..700R. doi:10.1126/science.1219088. PMID 22582258. S2CID 1326996. ^ Palomba, E.; Longobardo, A.; De Sanctis, M. C.; et al. (September 2015). "Detection of new olivine-rich locations on Vesta". Icarus. 258: 120–134. Bibcode:2015Icar..258..120P. doi:10.1016/j.icarus.2015.06.011. ^ Denevi, B. W.; et al. (2012). "Pitted Terrain on Vesta and Implications for the Presence of Volatiles". Science. 338 (6104): 246–249. Bibcode:2012Sci...338..246D. CiteSeerX 10.1.1.656.1476. doi:10.1126/science.1225374. PMID 22997131. S2CID 22892716. ^ De Sanctis, M. C.; et al. (2012). "Detection of Widespread Hydrated Materials on Vesta by the vir Imaging Spectrometer on Board Thedawnmission". The Astrophysical Journal Letters. 758 (2): L36. Bibcode:2012ApJ...758L..36D. doi:10.1088/2041-8205/758/2/L36. ^ "A look into Vesta's interior". Max-Planck-Gesellschaft. 6 January 2011. ^ Ghosh, A.; McSween, H. Y. (1998). "A Thermal Model for the Differentiation of Asteroid 4 Vesta, Based on Radiogenic Heating". Icarus. 134 (2): 187–206. Bibcode:1998Icar..134..187G. doi:10.1006/icar.1998.5956. ^ Righter, K.; Drake, M. J. (1997). "A magma ocean on Vesta: Core formation and petrogenesis of eucrites and diogenites". Meteoritics & Planetary Science. 32 (6): 929–944. Bibcode:1997M&PS...32..929R. doi:10.1111/j.1945-5100.1997.tb01582.x. S2CID 128684062. ^ Drake, M. J. (2001). "The eucrite/Vesta story". Meteoritics & Planetary Science. 36 (4): 501–513. Bibcode:2001M&PS...36..501D. doi:10.1111/j.1945-5100.2001.tb01892.x. S2CID 128394153. ^ Sahijpal, S.; Soni, P.; Gagan, G. (2007). "Numerical simulations of the differentiation of accreting planetesimals with 26Al and 60Fe as the heat sources". Meteoritics & Planetary Science. 42 (9): 1529–1548. Bibcode:2007M&PS...42.1529S. doi:10.1111/j.1945-5100.2007.tb00589.x. S2CID 55463404. ^ Gupta, G.; Sahijpal, S. (2010). "Differentiation of Vesta and the parent bodies of other achondrites". J. Geophys. Res. Planets. 115 (E8): E08001. Bibcode:2010JGRE..115.8001G. doi:10.1029/2009JE003525. S2CID 129905814. ^ Cook, Jia-Rui C. (29 March 2011). "When Is an Asteroid Not an Asteroid?". NASA/JPL. Archived from the original on 29 June 2011. Retrieved 30 July 2011. ^ Takeda, H. (1997). "Mineralogical records of early planetary processes on the HED parent body with reference to Vesta". Meteoritics & Planetary Science. 32 (6): 841–853. Bibcode:1997M&PS...32..841T. doi:10.1111/j.1945-5100.1997.tb01574.x. ^ Yamaguchi, A.; Taylor, G. J.; Keil, K. (1995). "Metamorphic History of the Eucritic Crust of 4 Vesta". Meteoritical Society. 30 (5): 603. Bibcode:1995Metic..30..603Y. ^ Pieters, C. M.; Ammannito, E.; Blewett, D. T.; et al. (2012). "Distinctive space weathering on Vesta from regolith mixing processes". Nature. 491 (7422): 79–82. Bibcode:2012Natur.491...79P. doi:10.1038/nature11534. PMID 23128227. S2CID 4407636. ^ McCord, T. B.; Li, J. -Y.; Combe, J. -P.; et al. (2012). "Dark material on Vesta from the infall of carbonaceous volatile-rich material". Nature. 491 (7422): 83–86. Bibcode:2012Natur.491...83M. doi:10.1038/nature11561. PMID 23128228. S2CID 2058249. ^ Rayman, Marc (8 April 2015). Now Appearing At a Dwarf Planet Near You: NASA's Dawn Mission to the Asteroid Belt (Speech). Silicon Valley Astronomy Lectures. Foothill College, Los Altos, CA. Archived from the original on 14 November 2021. Retrieved 7 July 2018. ^ Ulivi, Paolo; Harland, David (2008). Robotic Exploration of the Solar System: Hiatus and Renewal, 1983–1996. Springer Praxis Books in Space Exploration. Springer. pp. 117–125. ISBN 978-0-387-78904-0. ^ Russell, C. T.; Capaccioni, F.; Coradini, A.; et al. (October 2007). "Dawn Mission to Vesta and Ceres" (PDF). Earth, Moon, and Planets. 101 (1–2): 65–91. Bibcode:2007EM&P..101...65R. doi:10.1007/s11038-007-9151-9. S2CID 46423305. Archived (PDF) from the original on 27 September 2011. Retrieved 13 June 2011. ^ Cook, Jia-Rui C.; Brown, Dwayne C. (11 May 2011). "NASA's Dawn Captures First Image of Nearing Asteroid". NASA/JPL. Archived from the original on 29 January 2012. Retrieved 14 May 2011. ^ Vega, Priscilla; Brown, Dwayne (16 July 2011). "NASA's Dawn Spacecraft Enters Orbit Around Asteroid Vesta". NASA. Archived from the original on 19 June 2012. Retrieved 17 July 2011. ^ Dawn mission timeline Archived 19 October 2013 at the Wayback Machine ^ Mid-continent Research for Education and Learning: McREL (27 September 2010). "Dawn Mission: Mission". Dawn Journal. Retrieved 29 March 2011. ^ "Dawn has Departed the Giant Asteroid Vesta". NASA JPL. NASA. 5 September 2012. Retrieved 5 September 2012. ^ a b Russell, C. T.; et al. (2013). "Dawn completes its mission at 4 Vesta". Meteoritics & Planetary Science. 48 (11): 2076–2089. Bibcode:2013M&PS...48.2076R. doi:10.1111/maps.12091. ^ Roatsch, Thomas; et al. (2012). "High resolution Vesta High Altitude Mapping Orbit (HAMO) Atlas derived from Dawn framing camera images". Planetary and Space Science. 73 (1): 283–286. Bibcode:2012P&SS...73..283R. doi:10.1016/j.pss.2012.08.021. ^ Roatsch, Thomas; et al. (2013). "High-resolution Vesta Low Altitude Mapping Orbit Atlas derived from Dawn Framing Camera images". Planetary and Space Science. 85: 293–298. Bibcode:2013P&SS...85..293R. doi:10.1016/j.pss.2013.06.024. ^ "NASA's Journey Above Vesta". DLR Institute of Planetary Research video with NASA JPL imagery. NASA. 16 September 2011. Archived from the original on 22 April 2021. Retrieved 18 September 2011. ^ "DLR public Dawn products site". Archived from the original on 16 October 2015. ^ "NASA Dawn". ^ "Dawn Public Data". Dawn [website]. Univ. California, Los Angeles. Retrieved 6 March 2015. ^ Gingerich, Owen (2006). "The Path to Defining Planets" (PDF). Dissertatio cum Nuncio Sidereo Ill. Tertia. Vol. VIII, no. 16. pp. 4–5. Archived (PDF) from the original on 15 March 2015. Retrieved 13 March 2007. ^ "Dawn Mission website of JPL/NASA". 22 October 2018. ^ Bryant, Greg (2007). "Sky & Telescope: See Vesta at Its Brightest!". Retrieved 7 May 2007. ^ "Vesta Finder". Sky & Telescope. Archived from the original on 12 June 2007. Retrieved 7 May 2007. ^ Harrington, Philip S. (21 October 2010). Cosmic Challenge: The Ultimate Observing List for Amateurs. Cambridge University Press. p. 75. ISBN 9781139493680. ^ a b James, Andrew (2008). "Vesta". Southern Astronomical Delights. Retrieved 6 November 2008. ^ a b Yeomans, Donald K.; Chamberlin, Alan B. "Horizons Ephemeris". JPL Solar System Dynamics. Retrieved 9 January 2010. ^ "Elements and Ephemeris for (4) Vesta". Minor Planet Center. Archived from the original on 4 March 2016. ^ "2012 Astronomy Special". Nightskyonline.info. Archived from the original on 20 April 2012. Retrieved 23 November 2012. ^ a b c d T. Flanders – Ceres and Vesta: July 2012 – April 2013 – Sky & Telescope. The Dawn Mission to Minor Planets 4 Vesta and 1 Ceres, Christopher T. Russell and Carol A. Raymond (Editors), Springer (2011), ISBN 978-1-4614-4903-4 Keil, K.; Geological History of Asteroid 4 Vesta: The Smallest Terrestrial Planet in Asteroids III, William Bottke, Alberto Cellino, Paolo Paolicchi, and Richard P. Binzel (editors), University of Arizona Press (2002), ISBN 0-8165-2281-2 Wikimedia Commons has media related to Vesta (asteroid). This video explores Vesta's landscape, history and planet-like characteristics. Interactive 3D gravity simulation of the Dawn spacecraft in orbit around Vesta Archived 11 June 2020 at the Wayback Machine Vesta Trek – An integrated map browser of datasets and maps for 4 Vesta JPL Ephemeris Views of the Solar System: Vesta HubbleSite: Hubble Maps the Asteroid Vesta Encyclopædia Britannica, Vesta – full article HubbleSite: short movie composed from Hubble Space Telescope images from November 1994. Adaptive optics views of Vesta from Keck Observatory 4 Vesta images at ESA/Hubble Archived 22 January 2009 at the Wayback Machine Dawn at Vesta (NASA press kit on Dawn's operations at Vesta) NASA video Archived 22 April 2021 at the Wayback Machine Vesta atlas 4 Vesta at AstDyS-2, Asteroids—Dynamic Site Ephemeris · Observation prediction · Orbital info · Proper elements · Observational info 4 Vesta at the JPL Small-Body Database Close approach · Discovery · Ephemeris · Orbit viewer · Orbit parameters · Physical parameters Portals: Stars Spaceflight Outer space Science Retrieved from " 4 The following pages link to 4 Vesta External tools (link count transclusion count sorted list) · See help page for transcluding these entries Showing 50 items. View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500)Asteroid (links | edit) Apparent magnitude (links | edit) Comet (links | edit) Classical Kuiper belt object (links | edit) Deep Space 1 (links | edit) Earth (links | edit) Erosion (links | edit) Geology (links | edit) Galilean moons (links | edit) Giant planet (links | edit) Galileo project (links | edit) Interplanetary spaceflight (links | edit) Kuiper belt (links | edit) Human spaceflight (links | edit) Moon (links | edit) Mercury (planet) (links | edit) Meteorite (links | edit) Near-Earth object (links | edit) Oort cloud (links | edit) Olympus Mons (links | edit) Planet (links | edit) Planets beyond Neptune (links | edit) Plutino (links | edit) Planetary nomenclature (links | edit) Ring system (links | edit) Plate tectonics (links | edit) Ruthenium (links | edit) Sun (links | edit) Solar System (links | edit) Space exploration (links | edit) Space colonization (links | edit) Trans-Neptunian object (links | edit) Jupiter trojan (links | edit) Tau Ceti (links | edit) Venus (links | edit) Zodiacal light (links | edit) 1800s (decade) (links | edit) 1807 (links | edit) 433 Eros (links | edit) NEAR Shoemaker (links | edit) Ion thruster (links | edit) Jupiter (links | edit) Geochemistry (links | edit) Callisto (moon) (links | edit) Europa (moon) (links | edit) List of hypothetical Solar System objects (links | edit) Basalt (links | edit) Vulcan (hypothetical planet) (links | edit) Triton (moon) (links | edit) Pluto (links | edit) View (previous 50 | next 50) (20 | 50 | 100 | 250 | 500) Retrieved from " WhatLinksHere/4_Vesta" These free volume of a cylinder worksheets help students practice finding the volume of a cylinder in a variety of ways. Each worksheet provides the basic formula for the volume of a cylinder. Some worksheets will provide the radius of each object, while another set will feature the diameter of the cylinder. Some worksheets offer a mixture of radii and diameters. You can also have your students calculate the volume in terms of Pi, or use 3.14 in place of Pi. Each worksheet is printable and available in a variety of formats. Answers are also provided for each free volume worksheet. Let me know what you think! Page 2 These free volume of a cylinder worksheets will help your students practice calculating the volume of a cylinder by using a formula. This set of problems features a graphic of a cylinder and the length of the radius of the cylinder is given. All of the radii are whole numbers. Students are asked to round the volume to the nearest tenth. These free volume of a cylinder worksheets are printable and available in a variety of formats. Of course, answer keys are provided as well. Volume of a Cylinder (Radius Given) Worksheet 1 – This worksheet features images of 12 cylinders. The radius of each cylinder is provided, and you must round the volume to the nearest tenth. Volume of a Cylinder (Radius Given) Worksheet 1 RTF Volume of a Cylinder (Radius Given) Worksheet 1 PDF Preview Volume of a Cylinder (Radius Given) Worksheet 1 In Your Web Browser View Answers Volume of a Cylinder (Radius Given) Worksheet 2 – This worksheet features images of 12 cylinders. The radius of each cylinder is provided, and you must round the volume to the nearest tenth. Volume of a Cylinder (Radius Given) Worksheet 2 RTF Volume of a Cylinder (Radius Given) Worksheet 2 PDF Preview Volume of a Cylinder (Radius Given) Worksheet 2 In Your Web Browser View Answers Volume of a Cylinder (Radius Given) Worksheet 3 – This worksheet features images of 12 cylinders. The radius of each cylinder is provided, and you must round the volume to the nearest tenth. Volume of a Cylinder (Radius Given) Worksheet 3 RTF Volume of a Cylinder (Radius Given) Worksheet 3 PDF Preview Volume of a Cylinder (Radius Given) Worksheet 3 In Your Web Browser View Answers Go back to Calculators page Volume calculator will determine the volume of the most common geometric solids.What is Volume?Volume is the amount of total space on the interior of the solid. Knowing the definition of volume, we can now focus on the formulas for volume of common geometric solids. Using these formulas manually won’t be difficult, but for fast, accurate results every time, use the volume calculator.Formulas for volume:Cone = \((\frac{1}{3})\pi r^{2}h\), where r is the radius and h is the height.Cube = \(s^{2}\), where s is the length of the side.Cylinder = \(\pi r^{2}h\), where r is the radius and h is the height.Rectangular prism= \(l\times w\times h\), where l is the length, w is the width and h is the height.Sphere = \((\frac{4}{3})\pi r^{3}\), where r is the radius.Simply enter the dimensions into the calculator to find the volume. The units for volume will always be cubed, as compared to square units for surface area.@mometrixNeed a volume calculator? Link in bio. ##pi ##piday ##volume ##sphere ##math ##mathhelp ##mometrix ##fyp♬ original sound – Mometrix Test PreparationCalculating the Volume of a Cube ExampleHere’s an example for calculating the volume of a cube.For this example, suppose the side length of the cube is 5 cm. Then the volume is simply \(5\times 5\times 5=125\) cubic centimeters.Let’s take a look at another example. Suppose you want the volume of a cone with a height of 4 cm and radius of 3 cm.Volume = \((\frac{1}{3})\pi(3)^{2}(4)=12\pi\) cubic centimetersOne might wonder where this calculator will be useful in a real-life setting. It’s very important in terms of architecture and constructionRelated Topics of InterestThere are many applications in real life where the volume calculator is useful. One such instance is in road or pavement construction where slabs of concrete must be built. Generally concrete slabs are rectangular solids, so the rectangular prism calculator can be used.Sticking with the construction theme, surface area is important when determining the amount of tile to put on a rectangular floor, of wallpaper on a wall or the amount of paint needed to cover the total surface of a building.All of these calculations can be done manually, but in the real world, time is of the essence when completing a project. Therefore, a calculator that will solve these problems are volume and surface area are essential. Try ours today!@mometrixNeed a volume calculator? Link in bio! ##pi ##piday ##volume ##cone ##formula ##math ##mathhelp ##mometrix ##geometry ##fyp ##stepbystep♬ original sound – Mometrix Test Preparation@mometrixHere’s the formula for volume of a cylinder! Link in bio for more. ##pi ##piday ##formula ##math ##mathhelp ##mometrix ##fyp ##stepbystep ##cylinder♬ original sound – Mometrix Test Preparation Looking for a comprehensive resource to master cylinder volume calculations? Our worksheets offer a variety of problems, from basic calculations to complex word problems, perfect for students of all levels. Each worksheet is available in PDF format and includes answer keys for easy grading. Understanding Cylinder Volume Grasping the concept of cylinder volume is crucial in geometry and various real-world applications. Cylinder volume represents the three-dimensional space enclosed within a cylinder, determined by its base area and height. Understanding this concept involves recognizing the relationship between the radius of the circular base, the height of the cylinder, and the resulting volume. Worksheets provide visual diagrams and step-by-step problems to aid in comprehension, allowing students to practice calculating volume using the formula. By exploring these resources, learners can build a strong foundation and apply their knowledge to practical situations. Formula for Volume of a Cylinder The volume of a cylinder is calculated using a simple formula: $V = \pi r^2h$. This formula multiplies the area of the circular base (πr^2) by the cylinder’s height (h), providing a straightforward way to determine its volume. $V = \pi r^2h$ The formula $V = \pi r^2h$ is the cornerstone for calculating the volume of any cylinder. ‘V’ represents the volume, ‘π’ (pi) is approximately 3.14159, ‘r’ denotes the radius of the circular base, and ‘h’ signifies the height of the cylinder. Understanding and applying this formula correctly is crucial for solving cylinder volume problems. Our worksheets provide ample practice in using this formula with various values for radius and height, ensuring a solid understanding of the concept. Remember to always use consistent units for accurate results. Worksheet Problem Types Our worksheets feature diverse problem types. These encompass calculating volume given radius and height, determining dimensions from volume, and solving real-world applications. Each problem type reinforces understanding and builds problem-solving skills for cylinder volume calculations. Calculating Volume Given Radius and Height These problems provide the radius and height of various cylinders. Students must apply the formula $V = \pi r^2h$ to find the volume. The worksheets include diagrams of cylinders with clearly labeled dimensions, allowing students to visualize the problem. These exercises reinforce the basic understanding of the cylinder volume formula. By working through these problems, learners enhance their ability to apply the formula accurately. They develop essential skills in identifying the radius and height from diagrams. These skills are crucial for solving more complex problems. It helps them to build a solid foundation in geometry and measurement. Finding Radius/Diameter/Height Given Volume These problems challenge students to work backwards. They are given the volume of a cylinder and must calculate the missing radius, diameter, or height. This requires rearranging the formula $V = \pi r^2h$. These questions encourage critical thinking and problem-solving skills. They also enhance algebraic manipulation skills. Students will learn to isolate variables and apply inverse operations. Worksheets include problems with varying levels of difficulty. They provide practice in applying the formula in different scenarios. This is essential for a deeper understanding of cylinder volume. It enables students to tackle real-world problems effectively. Word Problems Involving Cylinder Volume These word problems apply the concept of cylinder volume to real-life scenarios. Students must interpret the problem, identify relevant information, and apply the formula $V = \pi r^2h$ to find the solution. These problems often involve practical situations. Examples include calculating the volume of a cylindrical tank, determining the amount of liquid a can holds, or finding the volume of a cylindrical pipe. These problems enhance critical thinking and problem-solving skills. They require students to translate words into mathematical expressions. Worksheets include various scenarios with increasing complexity. This helps students develop a deeper understanding of cylinder volume. Worksheet Content Our worksheets feature clear diagrams of cylinders with labeled dimensions, ensuring students can easily visualize the problems. Problems include varying units of measurement, such as cm, inches, meters, and feet, providing a comprehensive practice experience. Diagrams of Cylinders with Labeled Dimensions Visual learning is key to understanding geometric concepts. That’s why our worksheets prominently feature clear and precise diagrams of cylinders. Each diagram is meticulously labeled with the necessary dimensions, including the radius or diameter of the base and the height of the cylinder. These labeled dimensions provide students with all the information they need to apply the volume formula effectively. The diagrams help students to visualize the three-dimensional shape and understand how the radius and height contribute to the overall volume calculation, aiding in comprehension and problem-solving skills. Problems with Varying Units of Measurement (cm, inches, meters, feet) To ensure a thorough understanding of cylinder volume, our worksheets incorporate problems with varying units of measurement. Students will encounter dimensions expressed in centimeters (cm), inches, meters (m), and feet (ft). This variety challenges them to pay close attention to units and perform necessary conversions when required. Working with different units reinforces the importance of dimensional analysis and helps students develop a deeper understanding of how units affect volume calculations. By practicing with mixed units, students become more versatile problem solvers, prepared for real-world applications where measurements are not always uniform. Answer Keys Our worksheets come complete with answer keys. This feature allows for easy grading and self-assessment. Answer keys enable educators to efficiently assess student understanding and allow students to check their work. Availability of Answer Keys for Easy Grading Each volume of cylinder worksheet comes equipped with a comprehensive answer key. This invaluable tool allows for efficient and accurate grading, saving educators valuable time. Students can also use the answer keys for self-assessment, identifying areas where they need additional practice. Detailed solutions are provided. This promotes a deeper understanding of the concepts. The inclusion of answer keys ensures that learning is reinforced and that students can confidently tackle cylinder volume problems. They are perfect for both classroom and home use, supporting independent learning. Target Audience Our cylinder volume worksheets cater to a broad spectrum of learners. This includes students from K-12, particularly those in 8th grade. These worksheets provide tailored content that is grade appropriate. Worksheets for Various Grade Levels (K-12, 8th Grade) Our collection of cylinder volume worksheets is designed to accommodate students across various grade levels, specifically targeting K-12 education. We offer resources tailored for 8th-grade students, ensuring alignment with curriculum standards. These worksheets cover fundamental concepts. As well as more advanced problem-solving techniques. The difficulty is appropriately scaled. This helps to reinforce their understanding of volume calculations. They can also help students develop critical mathematical skills. The accessible format and step-by-step instructions promote student success across all learning stages. We also provide additional support materials. Online Resources Explore our online resources for printable PDF worksheets to practice volume calculations. Interactive worksheets provide dynamic learning and immediate feedback. These resources cater to various learning styles and levels of understanding. Availability of Printable PDF Worksheets Our website offers a wide array of printable PDF worksheets designed to help students master the concept of cylinder volume; These worksheets are easily accessible and can be downloaded for classroom or home use. Each worksheet includes a variety of problems, ranging from simple calculations to more complex scenarios, ensuring a comprehensive learning experience. The PDF format allows for easy printing and distribution, making them a valuable tool for teachers and parents alike. These resources provide ample opportunity for practice and reinforcement of cylinder volume concepts. Interactive Online Worksheets Enhance your learning experience with our interactive online worksheets focused on cylinder volume. These worksheets provide an engaging and dynamic way to practice calculating the volume of cylinders. Students can input their answers directly on the screen and receive immediate feedback, promoting self-assessment and understanding. Interactive elements such as drag-and-drop activities and visual aids make learning more enjoyable and effective. Our online worksheets are accessible on various devices, allowing for flexible learning anytime, anywhere. They are designed to reinforce concepts and provide a stimulating alternative to traditional paper-based exercises. Applications of Cylinder Volume Explore the real-world applications of cylinder volume through practical word problems. These problems demonstrate how understanding cylinder volume is essential in various fields, from engineering to everyday life, making learning relevant. Real-World Applications in Word Problems Our worksheets bring cylinder volume to life with real-world applications embedded in engaging word problems. Students will calculate the volume of oil tanks, water pipes, and various cylindrical containers, connecting mathematical concepts to practical scenarios; These problems enhance critical thinking and problem-solving skills, illustrating the relevance of cylinder volume in everyday contexts. By tackling these challenges, learners gain a deeper understanding of how geometric principles apply to engineering, construction, and other fields. These applications solidify comprehension and make learning more meaningful and applicable for practical use. Additional Resources Enhance your understanding of cylinder volume with our curated collection of lessons and educational opportunities. Supplement your learning with videos explaining the concepts and providing step-by-step solutions to various problems. Lessons and Educational Opportunities Expand your knowledge of cylinder volume through various educational resources. Access virtual learning resources for comprehensive lessons and educational opportunities. Explore complete lesson packs that include lesson plans, PowerPoint presentations, guided notes, and practice worksheets with answer keys for easy grading. These resources are designed to support both teachers and students in mastering the concepts related to cylinder volume. Find a variety of materials to enhance understanding and skills in this area, catering to different learning styles and needs. Take advantage of the available lessons to improve your comprehension. Videos explaining cylinder volume Enhance your understanding of cylinder volume with instructional videos. These videos offer visual explanations of the concepts, formulas, and problem-solving techniques related to calculating the volume of cylinders. Perfect for visual learners, the videos provide step-by-step guidance and real-world examples to help clarify any confusion. Many complete lesson packs also include links to YouTube videos that further explain the volume and surface area of cylinders; Use these video resources to supplement your learning and gain a deeper insight into the topic, improving your ability to solve problems effectively. Related posts: Quantity of three-dimensional space For other uses, see Volume (disambiguation). VolumeA measuring cup can be used to measure volumes of liquids. This cup measures volume in units of cups, fluid ounces, and millilitres.Common symbolsVSI unitcubic metreOther unitsLitre, fluid ounce, gallon, quart, pint, tsp, fluid dram, in3, yd3, barrelIn SI base unitsm3Extensive?yesIntensive?noConserved?yes for solids and liquids, no for gases, and plasma[a]Behaviour undercoord transformationconservedDimensionL3 Volume is a measure of regions in three-dimensional space.[1] It is often quantified numerically using SI derived units (such as the cubic metre and litre) or by various imperial or US customary units (such as the gallon, quart, cubic inch). The definition of length and height (cubed) is interrelated with volume. The volume of a container is generally understood to be the capacity of the container; i.e., the amount of fluid (gas or liquid) that the container could hold, rather than the amount of space the container itself displaces. By metonymy, the term "volume" sometimes is used to refer to the corresponding region (e.g., bounding volume).[2][3] In ancient times, volume was measured using similar-shaped natural containers. Later on, standardized containers were used. Some simple three-dimensional shapes can have their volume easily calculated using arithmetic formulas. Volumes of more complicated shapes can be calculated with integral calculus if a formula exists for the shape's boundary. Zero-, one- and two-dimensional objects have no volume; in four and higher dimensions, an analogous concept to the normal volume is the hypervolume. 6 volumetric measures from the mens ponderia in Pompeii, an ancient municipal institution for the control of weights and measures The precision of volume measurements in the ancient period usually ranges between 10–50 mL (0.3–2 US fl oz; 0.4–2 imp fl oz).[4]: 8 The earliest evidence of volume calculation came from ancient Egypt and Mesopotamia as mathematical problems, approximating volume of simple shapes such as cuboids, cylinders, frustum and cones. These math problems have been written in the Moscow Mathematical Papyrus (c. 1820 BCE). In the Reisner Papyrus, ancient Egyptians have written concrete units of volume for grain and liquids, as well as a table of length, width, depth, and volume for blocks of material.[4]: 116 The Egyptians use their units of length (the cubit, palm, digit) to devise their units of volume, such as the volume cubit[4]: 117 or deny (1 cubit × 1 cubit × 1 cubit), volume palm (1 cubit × 1 cubit × 1 palm), and volume digit (1 cubit × 1 cubit × 1 digit).[4]: 117 The last three books of Euclid's Elements, written in around 300 BCE, detailed the exact formulas for calculating the volume of parallelepipeds, cones, pyramids, cylinders, and spheres. The formula were determined by prior mathematicians by using a primitive form of integration, by breaking the shapes into smaller and simpler pieces. A century later, Archimedes (c. 287 – 212 BCE) devised approximate volume formula of several shapes using the method of exhaustion approach, meaning to derive solutions from previous known formulas from similar shapes. Primitive integration of shapes was also discovered independently by Liu Hui in the 3rd century CE, Zu Chongzhi in the 5th century CE, the Middle East and India. Archimedes also devised a way to calculate the volume of an irregular object, by submerging it underwater and measure the difference between the initial and final water volume. The water volume difference is the volume of the object. Though highly popularized, Archimedes probably does not submerge the golden crown to find its volume, and thus its density and purity, due to the extreme precision involved.[5] Instead, he likely have devised a primitive form of a hydrostatic balance. Here, the crown and a chunk of pure gold with a similar weight are put on both ends of a weighing scale submerged underwater, which will tip accordingly due to the Archimedes' principle.[6] Further information: History of calculus and Apothecaries' system Diagram showing how to measure volume using a graduated cylinder with fluid dram markings, 1926 In the Middle Ages, many units for measuring volume were made, such as the sester, amber, coomb, and seam. The sheer quantity of such units motivated British kings to standardize them, culminated in the Assize of Bread and Ale statute in 1258 by Henry III of England. The statute standardized weight, length and volume as well as introduced the peny, ounce, pound, gallon and bushel.[4]: 73–74 In 1618, the London Pharmacopoeia (medicine compound catalog) adopted the Roman gallon[7] or congius[8] as a basic unit of volume and gave a conversion table to the apothecaries' units of weight.[7] Around this time, volume measurements are becoming more precise and the uncertainty is narrowed to between 1–5 mL (0.03–0.2 US fl oz; 0.04–0.2 imp fl oz).[4]: 8 Around the early 17th century, Bonaventura Cavalieri applied the philosophy of modern integral calculus to calculate the volume of any object. He devised Cavalieri's principle, which said that using thinner and thinner slices of the shape would make the resulting volume more and more accurate. This idea would then be later expanded by Pierre de Fermat, John Wallis, Isaac Barrow, James Gregory, Isaac Newton, Gottfried Wilhelm Leibniz and Maria Gaetana Agnesi in the 17th and 18th centuries to form the modern integral calculus, which remains in use in the 21st century. Further information: History of the metric system On 7 April 1795, the metric system was formally defined in French law using six units. Three of these are related to volume: the stère (1 m3) for volume of firewood; the litre (1 dm3) for volumes of liquid; and the gramme, for mass—defined as the mass of one cubic centimetre of water at the temperature of melting ice.[9] Thirty years later in 1824, the imperial gallon was defined to be the volume occupied by ten pounds of water at 17 °C (62 °F). This definition was further refined until the United Kingdom's Weights and Measures Act 1985, which makes 1 imperial gallon precisely equal to 4.54609 litres with no use of water.[10] The 1960 redefinition of the metre from the International Prototype Metre to the orange-red emission line of krypton-86 atoms unbounded the metre, cubic metre, and litre from physical objects. This also make the metre and metre-derived units of volume resilient to changes to the International Prototype Metre.[11] The definition of the metre was redefined again in 1983 to use the speed of light and second (which is derived from the caesium standard) and reworded for clarity in 2019.[12] Further information: Volume element and Volume form As a measure of the Euclidean three-dimensional space, volume cannot be physically measured as a negative value, similar to length and area. Like all continuous monotonic (order-preserving) measures, volumes of bodies can be compared against each other and thus can be ordered. Volume can also be added together and be decomposed indefinitely; the latter property is integral to Cavalieri's principle and to the infinitesimal calculus of three-dimensional bodies.[13] A 'unit' of infinitesimally small volume in integral calculus is the volume element; this formulation is useful when working with different coordinate systems, spaces and manifolds. The oldest way to roughly measure a volume of an object is using the human body, such as using hand size and pinches. However, the human body's variations make it extremely unreliable. A better way to measure volume is to use roughly consistent and durable containers found in nature, such as gourds, sheep or pig stomachs, and bladders. Later on, as metallurgy and glass production improved, small volumes nowadays are usually measured using standardized human-made containers. This method is common for measuring small volume of fluids or granular materials, by using a multiple or fraction of the container. For granular materials, the container is shaken or leveled off to form a roughly flat surface. This method is not the most accurate way to measure volume but is often used to measure cooking ingredients. Air displacement pipette is used in biology and biochemistry to measure volume of fluids at the microscopic scale.[14] Calibrated measuring cups and spoons are adequate for cooking and daily life applications, however, they are not precise enough for laboratories. There, volume of liquids is measured using graduated cylinders, pipettes and volumetric flasks. The largest of such calibrated containers are petroleum storage tanks, some can hold up to 1,000,000 bbl (160,000,000 L) of fluids. Even at this scale, by knowing petroleum's density and temperature, very precise volume measurement in these tanks can still be made. For even larger volumes such as in a reservoir, the container's volume is modeled by shapes and calculated using mathematics. Main articles: Unit of volume and Orders of magnitude (volume) Some SI units of volume to scale and approximate corresponding mass of water To ease calculations, a unit of volume is equal to the volume occupied by a unit cube (with a side length of one). Because the volume occupies three dimensions, if the metre (m) is chosen as a unit of length, the corresponding unit of volume is the cubic metre (m3). The cubic metre is also a SI derived unit.[15] Therefore, volume has a unit dimension of L3.[16] The metric units of volume uses metric prefixes, strictly in powers of ten. When applying prefixes to units of volume, which are expressed in units of length cubed, the cube operators are applied to the unit of length including the prefix. An example of converting cubic centimetre to cubic metre is: 2.3 cm3 = 2.3 (cm)3 = 2.3 (0.01 m)3 = 0.0000023 m3 (five zeros).[17]: 143 Commonly used prefixes for cubed length units are the cubic millimetre (mm3), cubic centimetre (cm3), cubic decimetre (dm3), cubic metre (m3) and the cubic kilometre (km3). The conversion between the prefix units are as follows: 1000 mm3 = 1 cm3, 1000 cm3 = 1 dm3, and 1000 dm3 = 1 m3.[1] The metric system also includes the litre (L) as a unit of volume, where 1 L = 1 dm3 = 1000 cm3 = 0.001 m3.[17]: 145 For the litre unit, the commonly used prefixes are the millilitre (mL), centilitre (cL), and the litre (L), with 1000 mL = 1 L, 10 mL = 1 cL, 10 cL = 1 dL, and 10 dL = 1 L.[1] Various other imperial or U.S. customary units of volume are also in use, including: cubic inch, cubic foot, cubic yard, acre-foot, cubic mile; minim, drachm, fluid ounce, pint; teaspoon, tablespoon; gill, quart, gallon, barrel; cord, peck, bushel, hogshead. Capacity is the maximum amount of material that a container can hold, measured in volume or weight. However, the contained volume does not need to fill towards the container's capacity, or vice versa. Containers can only hold a specific amount of physical volume, not weight (excluding practical concerns). For example, a 50,000 bbl (7,900,000 L) tank that can just hold 7,200 t (15,900,000 lb) of fuel oil will not be able to contain the same 7,200 t (15,900,000 lb) of naphtha, due to naphtha's lower density and thus larger volume.[18]: 390–391 Proof without words that the volume of a cone is a third of a cylinder of equal diameter and height See also: List of formulas in elementary geometryFor many shapes such as the cube, cuboid and cylinder, they have an essentially the same volume calculation formula as one for the prism: the base of the shape multiplied by its height. Further information: Volume integralIllustration of a solid of revolution, which the volume of rotated g(x) subtracts the volume of rotated f(x). The calculation of volume is a vital part of integral calculus. One of which is calculating the volume of solids of revolution, by rotating a plane curve around a line on the same plane. The washer or disc integration method is used when integrating by an axis parallel to the axis of rotation. The general equation can be written as: V = π ∫ a b | f (x) 2 − g (x) 2 | d x {\displaystyle V=\pi \int _{a}^{b}\left|f(x)^{2}-g(x)^{2}\right|\,dx} where f (x) {\textstyle f(x)} and g (x) {\textstyle g(x)} are the plane curve boundaries.[19]: 1, 3 The shell integration method is used when integrating by an axis perpendicular to the axis of rotation. The equation can be written as:[19]: 6 V = 2 π ∫ a b x | f (x) − g (x) | d x {\displaystyle V=2\pi \int _{a}^{b}x|f(x)-g(x)|\,dx} The volume of a region D in three-dimensional space is given by the triple or volume integral of the constant function f (x , y , z) = 1 {\displaystyle f(x,y,z)=1} over the region. It is usually written as:[20]: Section 14.4 ∭ D 1 d x d y d z . {\displaystyle \iiint _{D}1\,dx\,dy\,dz.} In cylindrical coordinates, the volume integral is ∭ D r d r d θ d z , {\displaystyle \iiint _{D}r\,dr\,d\theta \,dz,} In spherical coordinates (using the convention for angles with θ {\displaystyle \theta } as the azimuth and φ {\displaystyle \varphi } measured from the polar axis; see more on conventions), the volume integral is ∭ D ρ 2 sin φ d ρ d θ d φ . {\displaystyle \iiint _{D}\rho ^{2}\sin \varphi \,d\rho \,d\theta \,d\varphi .} Low poly triangle mesh of a dolphin A polygon mesh is a representation of the object's surface, using polygons. The volume mesh explicitly define its volume and surface properties. See also: List of physical quantities Density is the substance's mass per unit volume, or total mass divided by total volume.[21] Specific volume is total volume divided by mass, or the inverse of density.[22] The volumetric flow rate or discharge is the volume of fluid which passes through a given surface per unit time. The volumetric heat capacity is the heat capacity of the substance divided by its volume. Banach–Tarski paradox Dimensional weight Dimensioning ^ At constant temperature and pressure, ignoring other states of matter for brevity ^ a b c "SI Units - Volume". National Institute of Standards and Technology. April 13, 2022. Archived from the original on August 7, 2022. Retrieved August 7, 2022. ^ "IEC 60050 — Details for IEV number 102-04-40: "volume"". International Electrotechnical Vocabulary (in Japanese). Retrieved 2023-09-19. ^ "IEC 60050 — Details for IEV number 102-04-39: "three-dimensional domain"". International Electrotechnical Vocabulary (in Japanese). Retrieved 2023-09-19. ^ a b c d e f Imhausen, Annette (2016). Mathematics in Ancient Egypt: A Contextual History. Princeton University Press. ISBN 978-1-4008-7430-9. OCLC 934433864. ^ Rorres, Chris. "The Golden Crown". Drexel University. Archived from the original on 11 March 2009. Retrieved 24 March 2009. ^ Graf, E. H. (2004). "Just what did Archimedes say about buoyancy?". The Physics Teacher. 42 (5): 296–299. Bibcode:2004PhTea..42..296G. doi:10.1119/1.1737965. Archived from the original on 2021-04-14. Retrieved 2022-08-07. ^ a b "Balances, Weights and Measures" (PDF). Royal Pharmaceutical Society. 4 Feb 2020. p. 1. Archived (PDF) from the original on 20 May 2022. Retrieved 13 August 2022. ^ Cardarelli, François (6 Dec 2012). Scientific Unit Conversion: A Practical Guide to Metrication (2nd ed.). London: Springer Science+Business Media. p. 151. ISBN 978-1-4471-0805-4. OCLC 828776235. ^ Cox, Edward Franklin (1958). A History of the Metric System of Weights and Measures, with Emphasis on Campaigns for its Adoption in Great Britain, and in The United States Prior to 1914 (PhD thesis). Indiana University. pp. 99–100. ProQuest 301905667. ^ Cook, James L. (1991). Conversion Factors. Oxford [England]: Oxford University Press. pp. xvi. ISBN 0-19-856349-3. OCLC 22861139. ^ Marion, Jerry B. (1982). Physics For Science and Engineering. CBS College Publishing. p. 3. ISBN 978-4-8337-0098-6. ^ "Mise en pratique for the definition of the metre in the SI" (PDF). International Bureau of Weights and Measures. Consultative Committee for Length. 20 May 2019. p. 1. Archived (PDF) from the original on 13 August 2022. Retrieved 13 August 2022. ^ "Volume - Encyclopedia of Mathematics". encyclopediaofmath.org. Retrieved 2023-05-27. ^ "Use of Micropipettes" (PDF). Buffalo State College. Archived from the original (PDF) on 4 August 2016. Retrieved 19 June 2016. ^ "Area and Volume". National Institute of Standards and Technology. February 25, 2022. Archived from the original on August 7, 2022. Retrieved August 7, 2022. ^ Lemons, Don S. (16 March 2017). A Student's Guide to Dimensional Analysis. New York: Cambridge University Press. p. 38. ISBN 978-1-107-16115-3. OCLC 959922612. ^ a b The International System of Units (PDF) (9th ed.). International Bureau of Weights and Measures. Dec 2022. ISBN 978-92-822-2272-0. ^ Treese, Steven A. (2018). History and Measurement of the Base and Derived Units. Cham, Switzerland: Springer Science+Business Media. ISBN 978-3-319-77577-7. LCCN 2018940415. OCLC 1036766223. ^ a b "Volumes by Integration" (PDF). Rochester Institute of Technology. 22 September 2014. Archived (PDF) from the original on 2 February 2022. Retrieved 12 August 2022. ^ Stewart, James (2008). Calculus: Early Transcendentals (6th ed.). Brooks Cole Cengage Learning. ISBN 978-0-495-01166-8. ^ Benson, Tom (7 May 2021). "Gas Density". Glenn Research Center. Archived from the original on 2022-08-09. Retrieved 2022-08-13. ^ Cengel, Yunus A.; Boles, Michael A. (2002). Thermodynamics: an engineering approach. Boston: McGraw-Hill. p. 11. ISBN 0-07-238332-1. Wikimedia Commons has media related to Volumes. Perimeters, Areas, Volumes at Wikibooks Volume at Wikibooks Retrieved from " 0 ratings0% found this document useful (0 votes)9 views2 pagesThe document provides calculations for the volume of cylinders using the formula $\pi \times r^2$, with various radii and corresponding volumes calculated for different levels. 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For example, other rights such as publicity, privacy, or moral rights may limit how you use the material. Volume of a Cylinder | Integers - Easy Explain the volume of a cylinder formula and assist students in applying it to solve mathematical and real-life word problems. The height and radius of the cylinders are expressed as integers. Volume of a Cylinder | Integers - Moderate The height and diameter (or radius) of each cylindrical object are provided. Divide the diameter by 2 to determine the radius. Use the formula V = πr2h to compute the volume. Volume of a Cylinder | Integers - Difficult Intensify practice with this batch of pdf volume of a cylinder worksheets for grade 8. The dimensions are expressed in different units of measurement. Convert the units to the one specified and then find the volume. Volume of a Cylinder | Decimals - Easy Each dimension of the cylinder is presented as a decimal measure. Figure out the volume of each cylinder by plugging in the dimensions in the volume formula. Solve real-life word problems too. Volume of a Cylinder | Decimals - Moderate Determine the radius from the diameter. Apply the volume of a cylinder formula V = πr2h, substitute the value of the radius and height in the formula and compute the volume of each cylinder. Volume of a Cylinder | Decimals - Difficult Augment your practice in finding the volume of cylinders involving unit conversions. Direct students to convert the units in the dimensions to the indicated unit and then determine the volume. Missing Parameter | Level 1 Walk through this batch of high school pdf worksheets with volume presented in terms of pi. Rearrange the formula, making the missing parameter the subject, substitute the known values and solve for the missing dimension. Missing Parameter | Level 2 Assign the values of the volume and the radius or height and also the value of pi in the rearranged volume formula. Compute and find the missing height or radius in these printable volume of a cylinder worksheets. Enjoy sharper detail, more accurate color, lifelike lighting, believable backgrounds, and more with our new model update. Your generated images will be more polished than ever.See What's NewExplore how consumers want to see climate stories told today, and what that means for your visuals.Download Our Latest VisualGPS ReportData-backed trends. Generative AI demos. Answers to your usage rights questions. Our original video podcast covers it all—now on demand.Watch NowEnjoy sharper detail, more accurate color, lifelike lighting, believable backgrounds, and more with our new model update. Your generated images will be more polished than ever.See What's NewExplore how consumers want to see climate stories told today, and what that means for your visuals.Download Our Latest VisualGPS ReportData-backed trends. Generative AI demos. Answers to your usage rights questions. 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To calculate the surface area, find the area of the circular base (πr^2), multiply by 2 (because there are 2 of them) and add that to the area of the curved side ($2\pi r \bullet h$).Here’s the formula for the surface area of a cylinder:Surface Area = $2\pi r^2 + 2\pi r \bullet h$ Check out our other Geometry worksheets, too! Expand How to Calculate the Volume and Surface Area of a Cylinder The volume of a 3D shape is the amount of fillable space on the inside. Volume is measured in cubic units (units ^{3}). The surface area of a 3D shape is the amount of coverable space on the outside. Surface Area is measured in square units (units ^{2}). Here’s how to calculate the volume and surface area of a cylinder: EXAMPLE: Find the volume and surface area of the cylinder below. VOLUME: The formula for the volume of a cylinder is: Volume = πr^2h r is the radius of the circle h is the height of the cylinder. In our figure, the height is 10 cm. We need the radius, but we’re given the diameter (7 cm). To calculate the radius, just cut the diameter in half. So, r = 3.5 cm All we need to do now is substitute the values into our formula. $V= \pi r^2h$ $V = \pi(3.5\text{ cm})^2(10\text{ cm})$ $V = \pi(12.25\text{ cm}^2)(10\text{ cm})$ $V = \pi(122.5\text{ cm}^3)$ $V = 122.5\pi\text{ cm}^3$ OR $V \approx 384.9\text{ cm}^3$ SURFACE AREA: To find the surface area of the entire figure, find the area of each face. Note: The two bases are both circles, so we’ll use $A = \pi r^2$ for those. To find the area of the side, imagine cutting straight up the side of the cylinder and laying it flat. You would end up with a rectangle. The height of the rectangle would be 10 cm, and the length of the rectangle would be equal to the circumference of the circular base. That means that the area of the curved side of the cylinder would be length times height, or in this case : ($2\pi r$) times height. Area of bottom = $\pi r^2 = \pi(3.5\text{ cm})^2 = \pi(12.25\text{ cm}^2) = 12.25\pi\text{ cm}^2$ Area of the top = $\pi r^2 = \pi(3.5\text{ cm})^2 = \pi(12.25\text{ cm}^2) = 12.25\pi\text{ cm}^2$ Area of the curved side = $2\pi rh = 2\pi(3.5\text{ cm})(10\text{ cm}) = 2\pi(35\text{ cm}^2) = 70\pi\text{cm}^2$ Surface area = The sum of the areas of all 3 faces $SA = 12.25\pi\text{ cm}^2 + 12.25\pi\text{ cm}^2 + 70\pi\text{cm}^2$ $SA = 24.5\pi\text{ cm}^2 + 70\pi\text{ cm}^2$ $SA = 94.5\pi\text{ cm}^2$ OR $SA \approx 296.9\text{ cm}^2$ This guide provides a collection of printable worksheets focusing on calculating the volume of cylinders. These resources include various difficulty levels, from basic problems to advanced exercises involving unit conversions. PDF versions with answers are available for convenient self-assessment. Formulas and Key Concepts The foundational formula for calculating the volume (V) of a cylinder is $V = \pi r^2h$, where ‘r’ represents the radius of the circular base and ‘h’ denotes the height of the cylinder. Understanding this formula is paramount. Remember that the radius is half the diameter. The constant π (pi), approximately 3.14159, represents the ratio of a circle’s circumference to its diameter. Accurate measurement of ‘r’ and ‘h’ is crucial for precise volume calculations. Worksheets often present problems with varying units (centimeters, meters, yards, etc.), requiring careful attention to unit consistency throughout the calculation. Sometimes, the volume might be given, and you’ll need to solve for either the radius or height using algebraic manipulation of the formula. This involves isolating the unknown variable. For instance, to find the radius, rearrange the formula to $r = \sqrt{(V/(\pi h))}$. Similarly, to find the height, use $h = V/(\pi r^2)$. A strong grasp of these fundamental concepts and the ability to manipulate the formula are essential for successfully completing the provided worksheets and mastering cylinder volume calculations. Practice and attention to detail are key to accuracy. Practice Worksheets: Basic Problems Begin your journey into cylinder volume calculations with our introductory worksheets. These exercises focus on straightforward problems, providing a solid foundation for understanding the core concept. Each problem presents a cylinder with clearly stated radius and height values, usually whole numbers to simplify calculations. The goal is to familiarize yourself with the formula ($V = \pi r^2h$) and its application. These worksheets are designed to build confidence and reinforce the fundamental steps involved. Expect problems where you substitute the given radius and height directly into the formula and calculate the volume. This initial practice helps solidify your understanding before progressing to more complex scenarios. Pay close attention to the units of measurement (e.g., centimeters, meters) and ensure consistency in your calculations. The provided answer keys allow you to check your work and identify any areas needing further review. Mastering these basic exercises will provide a strong base for tackling more challenging problems in subsequent worksheets. Practice Worksheets: Intermediate Problems Progress to our intermediate-level worksheets designed to challenge your understanding of cylinder volume calculations. These problems introduce slightly more complex scenarios, building upon the foundational knowledge gained from the basic exercises. Expect to encounter problems involving decimal values for radius and height, requiring more precise calculations and attention to detail. You might also find problems presenting the diameter instead of the radius, requiring an extra step to calculate the radius before applying the volume formula. Some problems may present the volume and one dimension (radius or height), requiring you to solve for the missing dimension. This step encourages a deeper understanding of the formula’s manipulation and algebraic skills. The use of π (pi) might be presented in its symbolic form or using approximations such as 3.14, offering opportunities to practice both exact and approximate calculations. Remember to maintain consistent units throughout your calculations and always double-check your work using the provided answer key to ensure accuracy and identify areas needing further attention. These exercises are crucial for developing proficiency and confidence before tackling advanced problems. Practice Worksheets: Advanced Problems (Including Unit Conversions) This section presents advanced-level problems designed to comprehensively test your understanding of cylinder volume calculations. These worksheets incorporate unit conversions, demanding a deeper understanding of measurement systems and the ability to seamlessly convert between units such as centimeters, meters, inches, and feet. Problems may present dimensions in mixed units, requiring conversion before calculating the volume. This necessitates a strong grasp of conversion factors and the ability to apply them accurately within the volume formula. Expect to encounter more complex scenarios, such as multi-step problems involving multiple cylinders or those requiring the calculation of volume to solve real-world application problems. Some problems might involve calculating the volume of a cylinder given its surface area or other related properties, thereby promoting problem-solving skills and critical thinking. Remember to always clearly show your working, highlighting each step of the conversion process and the application of the volume formula. These advanced problems are designed to prepare you for more complex mathematical applications involving cylinders. Resources for Volume of Cylinder Worksheets This section offers access to free printable worksheets and PDF versions complete with answers, facilitating independent practice and self-assessment of cylinder volume calculations. Convenient online calculators are also linked. Free Printable Worksheets Access a wide array of free printable worksheets designed to enhance your understanding and skills in calculating the volume of cylinders. These worksheets cater to various skill levels, from foundational exercises suitable for middle school students to more challenging problems incorporating unit conversions and decimal values, ideal for high school learners. Each worksheet typically features multiple problems, allowing for ample practice and reinforcement of the formula $V = \pi r^2h$. The problems are carefully structured to progress in difficulty, building confidence and competence. These readily available resources provide a flexible and convenient way to supplement classroom learning or independent study, allowing students to work at their own pace and focus on areas requiring extra attention. The clear and concise presentation of problems ensures that students can easily grasp the concepts and apply the formula effectively. Regular practice with these worksheets will undoubtedly improve problem-solving abilities and deepen understanding of cylinder volume calculations. Worksheets with Answers (PDF Format) Enhance your learning experience with our readily downloadable PDF worksheets, complete with comprehensive answer keys. These resources offer a convenient and efficient way to practice calculating the volume of cylinders. The inclusion of answers allows for immediate self-assessment, enabling students to identify areas where they excel and pinpoint concepts requiring further attention. This self-directed approach promotes independent learning and fosters a deeper understanding of the subject matter. The PDF format ensures easy accessibility and compatibility across various devices. Whether you are a student looking to bolster your skills, a teacher seeking supplementary materials, or a parent aiming to support your child’s education, these worksheets provide a valuable tool. The structured format and clear instructions make them user-friendly for all skill levels. The detailed solutions provided not only reveal the correct answers but also offer insights into the problem-solving process, aiding in comprehension and skill development. Online Volume Calculators and Interactive Tools Supplement your worksheet practice with dynamic online resources designed to enhance your understanding of cylinder volume calculations. Numerous websites offer free online volume calculators, allowing for quick verification of your answers and immediate feedback on your problem-solving approach. These tools are invaluable for checking your work and reinforcing your understanding of the formulas involved. Beyond simple calculators, interactive simulations and tutorials provide a visual and engaging learning experience. These interactive tools often allow you to manipulate the dimensions of a cylinder and observe the resulting changes in volume in real-time. This dynamic approach helps solidify your understanding of the relationship between a cylinder’s dimensions and its volume. Explore these resources to gain a deeper, more intuitive grasp of the concepts presented in your worksheets. The combination of hands-on practice with interactive digital tools creates a comprehensive and effective learning strategy. Applications and Real-World Examples Explore practical applications of cylinder volume calculations. From calculating the capacity of storage tanks to determining the amount of liquid in a cylindrical container, these worksheets bridge the gap between theory and practical scenarios. Word Problems Involving Cylinders This section delves into the practical application of cylinder volume calculations through a series of engaging word problems. These problems present real-world scenarios where understanding cylinder volume is crucial for problem-solving. For instance, students might be tasked with calculating the amount of water a cylindrical tank can hold, given its dimensions. Another example could involve determining the volume of grain stored in a cylindrical silo, requiring them to apply the formula $V = \pi r^2h$ and potentially perform unit conversions. The problems gradually increase in complexity, introducing challenges such as calculating the volume of partially filled cylinders or those with unusual shapes. These word problems encourage critical thinking and problem-solving skills by requiring students to interpret information, identify relevant formulas, and apply their mathematical knowledge to real-world contexts. By successfully tackling these word problems, students enhance their understanding of cylinder volume and its significance in various fields. The inclusion of answers allows for self-assessment and reinforcement of learned concepts. This approach ensures that students not only master the formula but also develop practical problem-solving abilities. Using Volume Calculations in Different Fields The ability to calculate the volume of cylinders extends far beyond the classroom, proving invaluable across numerous fields. In engineering, precise volume calculations are essential for designing pipelines, storage tanks, and other cylindrical structures. Architects utilize these calculations to determine the capacity of cylindrical components in buildings or to estimate material requirements. Manufacturing processes often rely on accurate volume measurements for efficient production and quality control, particularly in industries involving cylindrical containers or parts. The medical field uses volume calculations for tasks such as determining the appropriate dosage of medication delivered through cylindrical syringes or analyzing the capacity of cylindrical medical equipment. Even in everyday life, understanding cylinder volume can help in tasks like determining the amount of paint needed to cover a cylindrical column or calculating the storage capacity of a cylindrical container. The application of these skills underscores the practical relevance of mastering cylinder volume calculations, showcasing their utility in diverse professional and everyday scenarios. Further Exploration of Cylinder Properties Beyond calculating volume, a deeper understanding of cylinder properties opens doors to more complex mathematical and scientific concepts. Investigating the relationship between a cylinder’s volume, surface area, and its dimensions (radius and height) provides valuable insights into geometric principles and problem-solving strategies. Exploring the concept of similar cylinders and how scaling affects both volume and surface area strengthens proportional reasoning skills. Advanced studies might involve calculating the volume of truncated cylinders or cylinders with varying cross-sections, demanding a more nuanced understanding of integral calculus. Furthermore, delving into the applications of cylinder properties in physics, such as fluid dynamics or pressure calculations within cylindrical vessels, provides a practical context for theoretical concepts. Connecting the mathematical calculations to real-world scenarios enhances comprehension and cultivates a more holistic understanding of the properties of cylinders and their significance in various scientific and engineering disciplines. This deeper exploration fosters critical thinking and problem-solving skills applicable beyond the realm of geometry. Pi Day is celebrated on March 14th (3/14) around the world. Pi (Greek letter “π”) is the symbol used in mathematics to represent a constant — the ratio of the circumference of a circle to its diameter — which is approximately 3.14159. Pi Day is an annual opportunity for math enthusiasts to recite the infinite digits of Pi, talk to their friends about math, and eat pie. Pi has been calculated to over 50 trillion digits beyond its decimal point. As an irrational and transcendental number, it will continue infinitely without repetition or pattern. While only a handful of digits are needed for typical calculations, pi’s infinite nature makes it a fun challenge to memorize, and to computationally calculate more and more digits. Learn More About Pi – What is Pi?Who is the official sponsor of Pi Day? Mometrix is a test preparation company that has created and curated the world’s largest collection of educational materials for helping individuals pass high-stakes standardized tests. They pride themselves on producing the very best content for exams and certifications across the country. What they care about even more, however, is empowering individuals across the nation to achieve their dreams.Mometrix’s goal is for their study materials, coupled with diligent effort, to empower a test-taker to attain the highest score within their ability to achieve. Mometrix prepares people to achieve their dreams by helping them overcome the testing hurdles necessary for them to get where they want to be. Volume of a Cylinder (Basic)The top of this page is an explanation of how to find the volume of a cylinder. Beneath that are six problems for students to solve.7th and 8th GradesVolumes of Rectangular PrismsFrom this page you can download a collection of worksheets on calculating the volumes of rectangular prisms. Tackle mixed shapes in our free volume worksheets with answer keys! Guide students from basic to advanced volume calculation, with prisms, spheres, pyramids, cones, and cylinders competing for space. Dimensions progress from smaller integers to larger values and decimal measurements, building skills step-by-step for real-world applications.

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