HISTORY OF
MATHEMATICS

FRACTXONS

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HISTORY OF Mathematics

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UNIT 1

HISTORY OF MATHEMATICS

FRACTIONS

If the decimal exceeds unity, it is best to change only the decimal part to a common fraction and leave the integral part unchanged.

Example 1. Change 0.0125 to a common fraction. The last decimal, 5 is in the ten-thousandths place, and so the denominator will be 10,000. We have $0.0125 = \frac{125}{10{,}000} = \frac{1}{80}$.

Example 2. $2.75 = 2\frac{75}{100} = 2\frac{3}{4}$, or $2.75 = \frac{275}{100} = \frac{11}{4}$. The former procedure is to be preferred; that is, leave unchanged the 2 to the left of the decimal point and change 0.75 to a common fraction.

In order to change a common fraction to a decimal, divide the numerator by the denominator.

Example 3. change the fraction $\frac{7}{8}$ to a decimal. Divide 7 by 8 we get 0.875.

In the most cases the division process goes on without end. Then the common fraction cannot be changed into a decimal fraction exactly never required practice. The division is terminated when the quotient has as many decimal places as required in a given practical situation.

Example 4. It is required to divide 1 kilogram of coffee into three parts. The weight of each is 1/3 kg. To weigh this quantity, we have to express it in tenths of a kilogram (since there are no weights of one-third of a kilogram). Dividing by 3, we get: 1:3 = 0.333... The division can be continued endlessly with new threes appearing in the quotient. But small weights (say, less than 1 gram) are not indicated by ordinary scale what is more, the coffee beans themselves weigh more than gram each. Only hundredths of a kilogram (10 grams) are practical interest in this case. And so we take $\frac{1}{3}$ kg ≈ 0.33kg.

For greater accuracy, it is accepted usage to mak allowance for the value of the last rejected digit. If it excee 5, the retained digit. If it exceeds 5, the retained digit increased by unity.

Note. Even when a common fraction can be expressed exac as a decimal, this is not done in most cases. The divisi process is terminated as soon as the required degree accuracy is attained.

Example 5. Change the fraction $\frac{7}{32}$ to a decimal. The exa value is 0.21875. Depending on the accuracy required, th division process is terminated with the second, third, etc. dig of the quotient, and we take $\frac{7}{32} \approx 0.22$, $\frac{7}{32} \approx 0.219$, and so o

HISTORICAL SURVEY OF FRACTIONS

The notion of a fraction could develop only after defini conceptions concerning whole numbers had been firm established. Like the concept of the integer, the concept of fraction developed gradually. The idea of "one half" originat much before that of thirds or fourths, and the latter tw appeared much earlier than fractions with other denominato The first notion of a whole number evolved out of the proce of counting, the first conception of fractions, out of the proce of measuring (lengths, areas, weights, and so on). Ma languages have traces of the historical connection betwe fractions and the existing system of measures. For example, the Babylonian system of measures and money, I talent composed of 60 mins, one mina making 60 shekel accordingly Babylonian mathematics made extensive use sexagesimal fractions. In the weight and monetary system ancient Rome, I is consisted of 12 onncess (uncia). The fraction we call $\frac{1}{12}$ was called an "uncia" by the Romans even when it was used for measuring lengths or other quantities. The Romans called $\frac{1}{8}$ one and a half ounces, and so forth.

Our common fraction were widely used by the ancient ...ks and Hindus. The rules for handling fraction given by ... Hindu scholar Brahmagupta (8th century) differ but slightly ... our own rules. Our way of writing fractions coincides with ... Hindu custom. True, the Hindus did not use a fraction bar. ... Greeks wrote the denominator above the numerator, although other form of notation were used more often. For example, they wrote (using other used more often. For example, they wrote (using other symbols, naturally) 35x (three fifths).

The Hindu symbolism for fractions and rules for handling fractions spread into the Muslim world in the 9th century due to al-Khowarizmi and thence to Western Europe in the 13th century, thanks to the Italian merchant and scholar Leonardo of Pisa (also known as Fibonacci).

Besides common fractions, sexagesimal fractions were in use, especially in astronomy. The latter subsequently gave the celebrated samarkand scholar al-Kashi (14th to 15th the Flemish mathematician and engineer (he was also a merchant) Simon Stevin (1548 – 1620).

PERCENTAGE

The expression "per cent" (from the Latin "per centum", "by the hundred") means a hundreth part. Symbolically, 1% stands for 0.01; 27% for 0.27; 100% for 1; 150% for 1.5, etc. (the symbol for percentage, %, is a distortion of the notation cto, which is a contraction of the word "cento"). 1% of a sum means 0.01 of it; to fulfil a plan means to complete 100% of it, whereas fulfillment by 150% would mean that one and a half quotas of the planned amount had been completed, and so forth.

To find the percentage expression of a given number multiply the number by 100 (or, what is the same, move the decimal point two places to the right).

Example. Expressed as a percentage, 2 is 200%; the number 0.357 is 35.7%, the number 1.753 is 175.3%.

To change a percent to a number, divided the percent by 100 (or, what is the same, move the decimal point two places to the left).

Examples. 13.5%% = 0.135, 2.3% = 0.023, 145% = 1.45, $^{2}/_{5}$% = 0.4% = 0.004.

The three principal problems involving percentage are Multiply the number by the percent and divide by 100 (or what is the same, move the decimal point two places to the left; in other words, the given number is multiplied by the fraction expressing the given percent).

Example. A planned quota in coal production is 2860 tons per day. A mine pledges to do 115% of the plan. How many tons of coal will it mine per day?

Solution (1) 2860.115 = 3289 tons

(2) 328,900: 100 = 3289 tons

(which is equivalent to 2860 .1.15 = 3289).

Problem 2. Find a number on the basis of a given percent (cf Rule 2). The given quantity is divided by the percent and then multiplied by 100 (or the decimal point is moved two places to the right, which is to say the given number is divided by the fraction expressing the given percent).

Example. In processing sugar beets, 12.5% of the weight of the beets is granulated sugar. What quantity of beets has to be proceed to produce 3000 centers of granulated sugar?

Solution (1) 3000:12.5 = 240. (2) 210.100 = 24,000 (centners) (which is tantamount to writing 3000:0.125 = 24,000). (Rule 3). Multiply the first number by 100 and divided by the second number.

Example 1. A new burning process for brick manufacture made it possible to increase the output of bricks per cubic metre of furnace from 1200 to 2300 bricks. What was the increase in brick output in percentage?

Solution

(1) 2300 – 1200 = 1100,

(2) 1100.100 = 110,000,

(3) 110.000:1200 ≈ 91.67%

Brick output increased by 91.67%

Example 2. According to the seven-year plan, the petroleum output in the USSR was to reach 161 million tons in 1961. actually, 166 million tons were produced. Give the fulfillment of the 1961 plan to percentage.

Solution

(1) 166.100 = 16,600

(2) 16,600:161 ≈ 103.1

Petroleum output in 1961 was 103.1% of the planned amount.

Note 1. In all three types of problems, the sequence of operations ca be changed (say, in the last problem, we could first divided and then multiply by 100).

Note 2. The example which follows is to serve as a warning against a mistake that is very frequently made.

It is required to find out the price of a metre of cloth prior to a price reduction if after a price reduction of 15% the price is 12 roubles per metre. Sometimes, 15% of 12 roubles is found, that is, 12.0.15 = 1.8. This is followed by the addition 12 + 1.8 = 13.8, and it is taken that the old price was 13.8 roubles per metre. This is not so because the percent of reduction is established with respect to the earlier.

ALGEBRA

The Subject of Algebra

The subject of algebra involves the study of equations and a number of other problems that developed out of the theory of equations. At the present time, when mathematics has split up into a number of specialized areas, the field of algebra includes only equations of a special kind, the so-called *algebraic equations*. On the origin of the name "algebra" see Sec. 66.

Historical Survey of the Development of algebra

Babylonia. The roots of algebra go deep into antiquity. About 4000 years ago, Babtlonian scholars were already solving quadratic equations and systems of two equations, one were used in solving a diversity of problems in land measurement, construction of buildings and in military affairs.

The literal designations which we use today in algebra were unknown to the Babylonians who formulated their equations rhetorically.

Greece. The first syncopated (abridged) notations for unknown quantities are encountered in the writings of the ancient Greek mathematician Diophantus (2nd to 3rd century). For the unknown, Diophantus used the word "arithmos" (number), the second power of the unknown was denoted by "dunamis" (the word had many meanings: power, poverty, degree**). For the third power, Diophantus sued the term 'kubos" (cube), for the fourth power we find (translated into English) square-square, for the fifth. square-cube, for the sixth, cube-cube. He denoted these quantities by the first letters of the corresponding names (we give them in Latin letters): or *ar, du, cu, dcu, ccu*. To distinguish the unknowns from known quantities, the latter were accompanied by the designation "mo" (monads for "units". Addition was not indicated in any way, an abbreviation was used for subtraction, equality was shown by "is" (isos" means equal).

Neither the Babylonians nor the Greeks considered negative numbers. An equation like 3 *ar* 6 *mo* is, 2 *ar* I *mo* ($3x+6 = 2x + 1$) Diaphanous called "inappropriate". When Diophantus transposed terms from one side of the equation to the other, he said that an addend becomes a subtrahend; and a subtrahend becomes an addend.

China. Chinese scholars were solving first degree equations and systems of them and also quadratic equations 2000 years prior to the Christian era. They were acquainted with negative numbers and irrational numbers. Since each symbol in Chinese writing stands for a concept, there could be no syncopations in Chinese algebra.

At later periods, Chinese mathematics was enriched with new attainments. At the end of the 13^{th} century, the **Chinese** were fully acquainted with the law of formation of binomial coefficients which today goes by the name of "**Pascal's** triangle". In Western Europe this law was discovered **by stifle**, 250 year slater.

India. Hindu scholar made extensive use of syncopated notation for unknown quantities and their powers. These notations were the initial letters of the corresponding names (the unknown was called "so - much", the names of various colours - black, blue, yellow, etc, - were used for a second, third, etc. unknown). Hindu scholars made much use of irrational and negative numbers (Greek mathematicians knew how to find approximate values of roots but eschewed irrationalities in algebra). A new addition to the family of numbers was zero, which came in with the negative numbers. Formerly it had been used solely for the absence of a number, as a placeholder.

Arab-language counties. Uzbekistan, Tajikistan. The Hindu authors wrote on algebraic problems in their astronomical works. It was in Arabic writings - the international language of the Muslim world - that algebra emerged as an independent discipline. The founder of algebra as a special branch of learning was the central Asian scholar Mohammed of khorezmi, more generally known as al-khowarizmi (dweller of khorezmi). His algebraic work, composed in the 9^{th} century A.D, bears the name "the science of the reunion and opposition", or more freely, "the science of transposition and cancellation". "Transposition" denoted the transfer of a subtrahend from one side of the equation to the other where it becomes an addend; the "opposition" (or cancellation) was the gathering of unknowns on one side of the equation and the unknowns on the other side. The Arabic for "transposition" is "al-jabr". Whence the name "algebra".

Al-khowarizmi and those that followed him made extensive use of algebra in commercial and monetary computations. Neither he nor any of the other mathematicians introduced at a time when even negative numbers we considered "false". Yet when solving a cubic equation by t Tartaglia rule it turned out that without operations a real roo

Let us go into this in more detail. By Tartaglia's rule root of the equation

$$=x^3 = px + q$$

is given by the expression

$$x = 3\sqrt{u} + 3\sqrt{v}$$

where u and v are solutions of the system

$$u + v = q, \qquad uv = \left(\frac{p}{3}\right)^3$$

For example, for the equation $X^3 = 9x + 28$ ($p = 9$, $q = 28$)

$$U + v = 28, \; uv = 27$$

Whence either $u = 27$, $v = 1$ or $u = 1$, $v = 27$, in the bo cases $3\sqrt{27} + 3\sqrt{7} = 4$

This equation does not have any other real roots.

But, as Cardano had noted, the system (3) may not have a real solutions, where as equation (1) has a real root and , wh is more, a positive root. Thus, the equation $x^3 = 15x+4$ h the root $x = 4$, but the system.

$$U + v = 4, \; uv = 125.$$

has the complex roots: $u = 2+11i$, $v = 2 - 11i$ (or $u=2-11i$, $= 2 +11i$).

Bombelli (1572) was the first to shed light on th mysterious phenomenon. He pointed out that $2 + 11i$ is th cube of $2 + I$, and $2 - 11i$ is the cube of $2 - I$; hence we ca write $\sqrt[3]{2+11I} = 2 + I$, $\sqrt[3]{2-11I} = 2 - I$ and then formula (yields $x = (2 + i) + (2 - I) = 4$.

It was now impossible to ignore complex numbers. Howeve the theory of complex numbers developed slowly. As late a the 18th century, famous mathematicians argued about how t find the logarithms of complex numbers. Although comple numbers helped to obtain a wife range of important fact involving real numbers, their very existence seemed doubtfu Exhortative rules for operating with complex numbers wer given in the middle of the 18th century by Euler, one of th greatest mathematicians in the history of science. At the turn of the 19th century, Wessel of Denmark and Argand of France gave a geometrical representation of complex numbers the first steps in this direction were taken by Walls of England in 1685. But the work of Wessel and Argand was disregarded and ...y in 1831, when this method was developed by the great ...man mathematicians Gauss was it accepted generally.

After solutions had been found for equations of the third ...urth degree, mathematicians strenuously sought the ...r for solving the quintic (fifth degree) equation. ...r, Reffini (Itally) proved, at the turn of the 19th ...y, that the litral fifth-degree equation $X^5 + ax^4 + bx^3 +$ ...x+e = 0 cannot be solved algebraically; more precisely, ... impossible to express any root of it in terms of the literal ...ntities a,b,c,d,e. using the six algebraic operations of addition, subtraction, multiplication, division, involution and evolution (Ruffini's proof was not without fault and in 1824 Abel of Norway gave a flawless proof).

In 1830 Galois (France) demonstrated that no general equation whose degree exceeds 4 can be solved algebraically.

Nevertheless, every nth-degree equation has (if we consider complex numbers as well) n roots, some of which may be 17th century (it stemmed from the analysis of numerous particular cases), but only at the end of the 18th century was the theorem mentioned above proved by Gauss.

The problems that engaged algebraists in the 19th and elementary mathematics. Suffice it to note that in the 19th century many methods were developed for approximate solution of equations. In this direction, important results were obtained by the great Russian mathematicians N.I. Lobachevisky.

Negative Numbers

The first numbers known to man were the natural numbers. But these numbers do not suffice even in the simplest cases. Indeed, in the general case, one natural number.

UNIT 2

SPACE TECHNOLOGY

The Soviet Union took the lead in manned space flight in 1986 and 1987 with its new *Mir space* station and the launch in May 1987 of the massive new Energia booster. Japan and China also made significant strides with their space programs. European and United States space program. Meanwhile, were seriously disrupted because of the January 1986 explosion of the U.S. space shuttle *challenger* and the failure in May 1986 of a European space Agency (ESA) rocket.

Turmoil continued in the U.S. space program as the National Aeronautics and Space Administration (NASA) worked to redesign the flawed solid fuel booster rocket made by Morton Thiokol that caused the *challenger* accident. A leak of hot gases from the right solid-fuel booster rocket led to the explosion of the main fuel tank. In the fiery tragedy all seven crew members died.

The leak occurred because two rubber O-ring seals failed to plug a gap in the joint between two rocket sections. NASA officials in July 1986 announced that the booster rocket would be redesigned with more insulation on the inside of the booster walls to prevent hot gases from reaching the joint and the O-ring seals. NASA said that the addition of a third O-ring seal would provide even greater safety.

Future shuttle missions. NASA set Feb. 18, 1988, as its target date to resume shuttle launches through space officials privately said that no lunch would occur before mid-1998. president Ronald Reagan on Aug. 15, 1986, approved construction of a new $2.8-billon shuttle oribier to replace the challenger. Keeping the number of orbiters in the shuttle fleet at four NASA had determined that a four-orbiter shuttle fleet was necessary to help build and supply the planned U.S. space station and carry out scientific and military space missions.

Return to rockets. The *challengers* accident also causec space officials to place a greater emphasis on the use ol unmanned non-reusable rockets for space launches. Previously, they relied NASA officials in July 1986 an – almost exclusively on the shuttle.

During 1986, the United States was able to recover from serious accidents involving the Titan and Delta rockets which occurred just alter the challenger disaster in 1986. From Late 1986 to mid-1987, the United States launched 1(unmanned missions, starting with two military satellites orbited on Sept. 5, 1986.

On September 17, a National oceanic and Atmospheri(Administration (NOAA) polar-orbit weather satellite was placec in orbit by an Atlas rocket launched from Vandenberg Air Forc Base in California. On November 13, a Scout rocket launchec from Vandenberg place an Air Force scientific satellite int(orbit, and on December 4, an Atlas rocket launched from Cap(Canaveral carried a Navy communications satellite into orbit.

An Air Force Titan rocket was used to launch a secre military payload from Vandenberg on Feb. 11, 1987. It was th(first successful launching of a Titan rocket since a differen type of Titan exploded on liftoff in April 1986. A NASA Delt rocket launched from Cape Canaveral on Feb. 26, 1987 carried a NOAA weather statelite.

On March 20, NASA launched a Delta rocket carrying communications satellite for Indonesia. NASA suffered setback, however, on March 26 when an Altas Centaur rocke carrying a Navy communications satellite was struck b lighting and destroyed.

European troubles. Many commercial satellites whos missions were delayed by the shuttle disaster sought to hav their payloads launched by the ESA's Ariane rocket. But th ESA had suffered a serious failure of its won in May 1986 whe ground controllers had to destroy an Ariane – 2 rocket carryin a communications satellite because the rocket's third stag failed to ingite. Ariane launches were launches were delaye unit at least August 1987 as a result of the accident.

Space station. Plans for a U.S. space station, which would include participation by the ESA, Canada, and Japan, ran into trouble during 1986 and 1987. In mid-1986, concerns of NASA astronauts and managers led to key engineering changes in the station's design. Then, in late 1986, ESA and Japanese space officials complained that they were not being guaranteed a significant role in the space station's design ad operation, though, then contributions to the station's construction were expected to exceed $3 billion. At one point the ESA even threatened to quit the program.

In December 1986, the U.S. Department of Defense revealed that it was increased in using the space station to perform military research. This threatened to jeopardize NASA's preliminary agreements with its foreign partners, which stated that the station would be used only for peaceful purposes. A reaffirmation of the partnership came out of a February 1987 meeting in Washington, D.C., but the defense issue continued to be a problem into mid-1987.

In December 1986, NASA announced that its earlier estimate of $8 billion for the U.S. share of space -station funding was far too low. NASA revised its estimate to $15 billion for the basic station structure and $20 billion for other equipment. As a result, the White House began to reexamine the particularity of the space station. In April, President Reagan announced that he supported a scaled-back version of the space station that would cost $13.5 billion.

The soviet space program continued at the impressive pace, though it too was affected by at least four accidents. The Soviet Union Usually does not announce its failures, but most can be detected by Western satellites.

On Oct. 3, 1986, a Soviet satellite intended to warn against an enemy missile attack failed to achieve the correct attitude and went into a useless orbit. This apparently was caused by a malfunctioning booster rocket. Within 12 days of the failure, however, the soviets used the same type of rocket to launch another missile-warning satellite that succeeded in achieving the proper orbit. Three other Soviet space failures occurred in early 1987. Two of the accidents involved failures with the Proton, the world's largest rocket.

The Soviet failures were minimal, however, compared with their successes. During 1986, for example, the Soviets launched 91 space missions, carrying a total of 114 different satellites, including several satellites a top a single rocket, from January to May 1987, they launched 34 missions.

On of the most important Soviet achievements was the launch on May 15 of the Energia booster, which can carry payloads weighing 100,000 kilograms (220,000 pounds) into orbit and will be used to launch a new Soviet space shuttle.

The soviets also carried out extensive manned operations on the *Mir* space station. Soviet cosmonauts Leonid D. Kizim and Vladimir Solovyov – who were launched to the *Mir* on March 13, 1986 – returned to Earth on July 16 after spending 125 days in orbit.

Cosmonauts Yuri Romanenko and Aleksandr Laveikin docked with the station on Feb. 8, 1987, to begin a mission that mission that was expected to last until August 1987. On April 5, an 18,000-kilogram (40,000-pound) module, carrying West European astrophysics instruments, failed dock properly with the station. The module approached within 180 meters (600 feet) of the *Mir* – then its control system failed. A second attempt failed on April 9, but on April 12, the module successfully docked with the space station after the two cosmonauts made an unscheduled space walk to aid the link-up.

The Japanese space program also matured in late 1986. On August13, 1986, Japan achieved the first successful launch of its new H - 1 rocket.

On Feb. 4, 1987, Japan launched an X-ray astronomy satellite, followed by the launch on February 19 of that nation's first remote-sensing spacecraft, the *Marine Observation Satellite (MOS !)*. *MOS -1* immediately began returning images of Earth comparable to those provided by the U.S. *Landsat* spacecraft in the 1970's.

China's space program. China also made progress in space in 1986, three U.S. Corporation; Dominion Video Satellite, Incorporated; and Teresat, Incorporated, of Houston -- all signed agreements with the Chinese to launch satellites. (Craig P. Covault).

In WORLD BOOK, see SPACE TRAVEL.

A small spacecraft's envounter with Uranus has changed our thinking about this planet- and has raised as many questions as it answered.

VOYAGER'S CLOSE LOOK AT URANUS

BY LAURENCE A. SODERBLOM

A few minutes before before 2 P.M. that Saturday afternoon I joined an anxious group of engineers and scientists watching a bank of television monitors in the Jet Propulsion Laboratory (JPL) of the California Institute of Technology in Pasadena. It was Jan 25, 1986, and we were gathered at the mission control center for the voyager 2 space- craft. Tension was high. The previous day, *voyager 2* had hurtled past Uranus, the seventh planet from the sun.

On this day, *voyager 2* was supposed to come within 28,600 kilometers (17,800 miles) of Miranda, the innermost of five large moons that orbit Uranus. We were worried about the whether the spacecraft's cameras would obtain clear images of Miranda or even if the cameras would be pointed in the right direction. What we had attempt in order to capture images of Miranda verged on the impossible. Just navigating the spacecraft to arrive at precisely the right time and position near Miranda, some 3 billion kilometers (1.9 billion miles) from Earth, was like a golfer trying to make a hole-in-one from Los Angeles to New York City. The smallest error in our calculations of the relative positions of *voyager* 2 and Miranda would result in our not knowing where to point the cameras.

And, ever if *voyager* 2's cameras were properly pointed at the moon, a few other major problems remained. First, Miranda would be moving relative to voyager 2 at a speed of nearly 10 kilometers (6 miles) per second. In addition, Uranus and its moon receive only a small fraction of the sunlight that Earth receives. Photographing Miranda would be like trying to make a picture by moonlight of a lump of coal traveling at about 10 times the speed of a rifle bullet. The exposure time for taking pictures in such dim light was several second, and if *Voyager* 2's television cameras were not tracking Miranda precisely, images would be hopelessly blurred.

We stared silently at the television cameras were not tracking Miranda precisely, the images would be hopeless blurred.

We started silently at the television monitors as the first image began to form. Suddenly, a shout of exhilaration – and relief – reverberated throughout the JPL. The many months of detailed planning, the redesign of *voyager* 2's on-board computer software, and changes to the spacecraft's course down to the last day had all succeeded with uncanny precision. A series of crystal-clear images of Miranda flowed in. It was a technological miracle.

The *voyager* 2 mission in Uranus yielded spectacular images of this giant blue-green planet and its system of rings and moons. *Voyager* 2 discovered two new rings in addition to the nine rings previously known and 10 small moons in addition to the 5 large moons that had been discovered by using telescopes on Earth. the mission gathered a wealth of data about the Uranian system and raised many new puzzles that scientists will ponder for years to come.

Engineering the encounter

Voyager 2 had not even been designed to Uranus. The original mission of the voyager project was to explore Jupiter and Saturn. Two voyager spacecraft, 1 and 2, were launched in the summer of 1977 by the National Aeronautics and Space Administration (NASA). After flying by Jupiter in 1979, the two spacecraft raced onward to Saturn. Voyager 1 reached Saturn in November 1980 and returned dazzling images of Saturn's incredibly complex ring. Then, like a slingshot, the planet's gravitational field hurled voyager 1 on a course that will take it out of our solar system.

Meanwhile, voyager 2 was closing in on Saturn and was due to arrive there is August 1981. The voyager Project team of scientists and engineers decided to make a gamble. They altered voyager 2's course to pass close enough to Saturn so that the planet's gravitational field would send voyager 2 on to Uranus.

The Voyager Project team was able to do this because of a rare alignment in the orbits of Earth, Saturn, Uranus, and Neptune, the eight planet from the sun. the last time the four planets were similarly aligned in their orbits around the sun was in the early 1800's, voyager 2 is expected to reach Neptune in August 1989.

As voyager 2 sped toward, Uranus, the engineering teams began to deal with a major problem. The spacecraft had been designed to operate only as far as Saturn, about 1.5 billion kilometers (930 million miles) from Earth, the trip to Uranus was twice that far with increasing distance, the spacecraft's radio signals were getting continually weaker.

Part of the solution to this problem was to arrange for many large radio antennas on Earth to receive voyager 2's data simultaneously. This, in effect, gave the voyager Project team a bigger set of "radio ears". The other part of the solution was to have the spacecraft's computers transit only the key data needed for scientists to reconstruct images from voyager 2's cameras. Fortunately, voyager's computers could be reprogrammed from Earth, by radio signal.

Earlier discoveries

When Uranus first came into view of the *voyager* 2 cameras in the late spring of 1985, the planet was still so far away that it appeared much as it did to British astronomer Sir William Herschel when he discovered Uranus on March 13, 1781, with his homemade telescope. At first Herschel thought the dull blue-green object he saw might be a comet. He soon realized, however, that a comet so far from the sun could not possibly be detected from Earth, and he concluded that the object must be a planet.

Six years after discovering Uranus, Herschel discovered the two outermost Uranian moons – Oberon and Titania. In 1851, another British astronomer, William Lassell, discovered two other moons- Umbriel and Ariel – orbiting closer to Uranus. Almost 100 years later, in 1948, U.S astronomer Gerard P. Kuiper discovered Miranda, the fifth large moon, which orbits closet to Uranus.

The rings were not discovered until 1977, when several groups of astronomers observed a rare partial eclipse of a relatively bright start by Uranus. To their surprise, they found the star's brightness became less intense in a region outlying Uranus, indicating that something was present there to partially obscure the starlight. They concluded that the variations in brightness were caused by a ring system. Altogether, he astronomers discovered nine narrow rings. Most of the rings were only a few kilometers wide. The outmost ring, known as the Epsilon ring, was the exception, ranging from about 20 to 100 kilometers (12 to 62 miles) in width.

By analyzing the sunlight reflected from Uranus – a technique known as spectroscopy – scientists on Earth had determined by the 1940's some of the chemical elements that make up the planet's upper atmosphere. Astronomers learned that the planet's blue-green colour was due to the presence of a small amount of methane gas in the upper atmosphere. Using spectroscopy, the also determined the presence of hydrogen gas. Other data indicated that helium, too, was probably abundant in the upper atmosphere.

By observing the orbits of Uranus' moons, astronomers determined that Uranus' *axis of rotation* – an imaginary line through its center around which the planet spins – was peculiar. All of the other planets in the solar system have axes that the almost perpendicular to their orbits around the sun, so that their equators point toward the sun. But Uranus' axis is titled so far that it is almost level with its path around the sun. This title means that one or the other polar regions on Uranus points toward the sun and thus receives more sunlight than the region around the equator. It takes 84 years for Uranus complete an orbit. For 42 of these years, the south pole faces the sun directly while the north pole is an perpetual darkness. The positions of the poles are then reversed for the next 42 years.

New findings about Uranus

Voyager 2 furnished much new information about Uranus' atmosphere and interior. Before the *voyager* 2 encounter, one of the major questions scientists had was whether Uranus' atmosphere and interior. Before the *voyager* 2 encounter, one of the major questions scientist had was whether Uranus' atmosphere had any clouds. Clouds could give astronomers dues about wind velocity and atmospheric circulation patterns.

Through careful computer processing of the camera images as *voyager* 2 grew closer to Uranus, the scientists were able to see faint patterns in the planet's atmosphere. The images showed cloud patterns on Uranus organized in bands parallel with the equator. Around the south pole-the only we could see- the atmospheric bands formed concentric circles, giving the planet eerie appearance of a ghoulish eyeball peering out into space. We think the bandlike appearance of the clouds is caused by differences in the depths of the clouds and also by hazes – much like smong-that are produced as sunlight breaks down methane gas.

Scientists measured the positions of individual clouds to estimate the rotation rate of Uranus' atmosphere. They found that clouds 30 degrees (30°) south of the equator rotated around the planet once every 17 hours. Clouds 70° south of the equator, however, made a complete rotation in about 14 hours. This indicated that Uranus has powerful east-west winds that reach maximum velocities of about 650 kilometers (400 miles) per hour.

Astronomers had long been uncertain of the length of a day on Uranus – that is, the time it takes for the planet to spin once on its axis. Earth's rate of rotation, for example, is 23 hours and 56 minutes. Estimates for Uranus had ranged from 16 to 23 hours. Using an instrument on *voyager* 2 called a *magnetometer* – which measures magnetic forces –

astronomers detected a regular variation in the strength o the planet's magnetic that a Uranian day is about 17 hours 1 minutes .

The voyager project team also discovered that th position of Uranus magnetic poleis unlike the position of th magnetic poles on Earth. Jupiter, and Saturn, which ar located in the polar regions, about 70° north and south of the equators. Uranus' magnetic poles are only 30° north and sout of its equator.

The moons and rings

The voyager 2 discoveries involving the moons and ring attracted much attention. The largest of the 10 moons foun by *voyager* 2 was temporarily designated 1985UI (1985 for th year discovered, U for the Uranian system, and I for the firs moon to be discovered there that year). The moon is abou 160 kilometers (100 miles) in diameter and has a dark surfac that reflects little of the sunlight it receives. The other nin new found moons are 15 to 100 kilometers (10 to 62 miles) i diameter and are also dark.

Although most of the new-found moons are scattere between the ring system and the orbit of Miranda, 1986U7 an 1986U8 orbit just inside and outside the Epsilon ring. Voyage Project scientists had thought they might find exactly thi situation. In 1979, planctary scientists Peter Goldreich an Scott D. Tremaine, then of the California institute o Technology, concluded the something had to be holdin Uranus narrow rings rightly confined. Normally, such ring would gradually spread as chunks of rings material bumpe into one another. Goldreic and Tremaine suggested that th gravitational force of pairs of moons orbiting along the inne and outer edges of the rings could hold the ring material i place. The scientists dubbed such moons "shepherds" becaus their gravity herds the just that for the Epsilon ring, confirmin the scientists' prediction. We did not see shepherds around th other rings, but they could easily be too small land dark t have been detected by voyager 2.

Voyager 2 also discovered two new rings as it approached the planet, both of which are too faint and transparent to be detected from Earth. Scientists analysed changes in the spacecraft's radio signals as they passed through the rings from behind. This revealed that the chunks of material in the 11 rings range in size from large boulders to dust-sized particles.

The spacecraft images also confirmed that the rings like the new found moons, are made of extremely dark material. Only a few substances known on earth, such as soot or carbon black, are as dark. Scientists think the rings may be made of ice combined with the dark material.

This finding has intrigued scientists investigating the origin of the solar system. Other such dark objects include the solid cores of comments and the carbon-rich metroites known as carbonaceous chondorites. Such objects are thought to be left over from the formation of the solar system about 4½ billion years ago. Some scientists believe the Uranian rings may be chemically similar and in some way related to these very ancient materials. If so, study of the rings may provide dues about how the solar system formed.

Moons held surprises

Perhaps the greatest surprise in the voyager 2 findings was the tremendous diversity in the geology of the live large moons. Most scientists thought the surfaces of these moons would look alike – covered with large impact craters like those on the moon, Mars, and Mercury. Scientist believe that such craters were created early in the history of the solar system by the impact of large meteorites made up of debris left over from the birth of the solar system.

Planetary scientists thought the interiors of the moons of the moons of Uranus probably were too cold to support the kind of volcanic activity or other geological processes that could have destroyed the craters and created new terrain. On Earth, for example, temperatures within the deepest parts of the planet's outer layer, the crust, may reach 870°C (1600°F.) – hot enough to melt rocks. Early in the Earth's history.

BIBLIOGRAPHY

Ryans, D.G. (1960); Characteristics of Teachers Nashinton: American council on Education.

Ndinechi G.I. (1990) A guide for Effective Typewriters Instruction in Secondary Schools Business Education Journal Volume II No. 2, Nigeria Association of Business Educators.

Adichie R. (1990): Introduction to College Statistics, Ibadan, Oxford University Press Ltd.

Akudolu, I. R. (1995); Effects of Computer Assisted Language Learning on Students Achievement and Interest in French. UNN (Unpublished Ph.D thesis).

Ali A. and Ohuche R. O. (1991): Teaching Senior Secondary School Mathematics Creatively. Onitsha: Summer Educational Pub. Ltd.

Harbor - Peters, V. F. (191); Target Task and Formal Methods of Presenting Secondary School Geometric Concepts. Their Effects on Retention. Josic Vol. 1 March.

James R. Flynn (1978): Humanism and Ideology London, Routledge and Kegan Paul Press.

Ohuche R.O. (1986); "Laboratory Approach to Science Teaching". Nigerian Journal of Education. Vol 3.

Onyejemezi, D.A. (1988):The Principles of Educational Technology. Onitsha Summer Educational Publishers.

Sinclair, L. R. (1990): Computer Science a Concise Instruction. Oxford Heninemann Newness Press.

Fredrick Klemm (1999) A History of Western Technology , London, MR Press Ltd & Books.

Ozofor, N.M. (2000): Effects of Two Modes of Computer Aided Instruction on Students Achievements and Interest in Statistics and probability UNN (Unpublished Ph.D Thesis).

Ernest Nagel (1961): The Structure of Science London Oxford Press.

G. Vygosky (1990) Mathematical Handbook: Moscow, Mins Pub.
Wartofsky, M.W. (1968): Conceptual Foundations of Scientific Thought.
Arthur Danto and Sidney Morgenbesser (1962): Philosophy of Science. Washington DC, Classic Papers Publishers.
John H. Randall, Modern Science (1980) London, Alistar C. Cromob;e Press Ltd.

Huxley T H (1980) Popular Lectures in Science Subjects

Ernest Mach (1990): 20th century delsate in the Philosophy of Science. Boston, Die Mechnik.

Thomas S Kuhn (1970): The Structure of Scientific Revolution . N. Y. Imre Lakatos Press Ltd.
M. Bowden (1991): Science vs Evolution Great Britain, Bath Press, Avon.
Spencer, F. Piltdown: A Scientific Forgery Oxford Press 1990.

Downie, N.M. and Heath, R. W. (1974) Basic Statistical Methods (4th Ed.) Harper and Row Pulishers. N/Y

Edwards, A.L. 9 (1972) Experimental Design in Psychological Research (4th Ed.) Holt, Rinehart and Winston Inc. N/Y.

Guilford, J.P. (1965) Fundamental Statistics in Psychology and Education (4th Ed.) Mc Graw-Hill book company N/Y.

Hays, W.L. 9 (1973) Statistical for the Social Sciences (2nd Ed.) Halt, Rinehart and Winston, Inc. N / Y.

Marascuilo, L.A. (1971) Statistical Methods for Behavioural Science Research. MC Graw – Hill book company. N/Y.

Minimum, E.W. (1978) Statistical Reasoning in Psychology and Education (2nd Ed.) John Wiley and Sons N/Y.

Popham, W. and Sirotnik, K.A. (1973) Educational Statistics: Use and Interpretation (2nd Ed.) Harper and Row Publishers N/Y.

Robinson, P.W. (1981) Fundamentals Experimental Psychology, Prentice hall, Inc. Englewood cliffs.