G-G

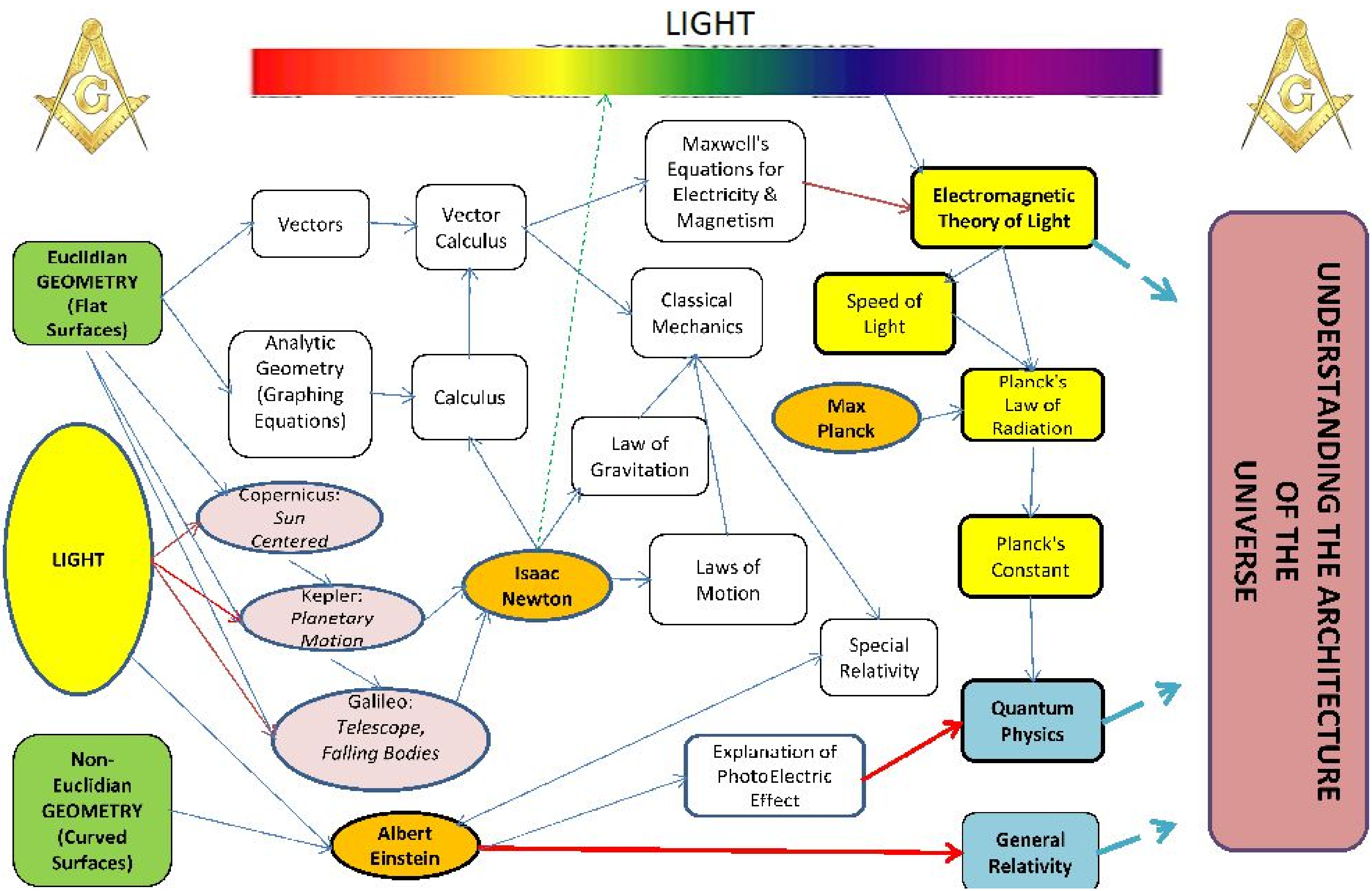
The G's symbolize two essentials of Freemasonry, Geometry (the square and compasses of the emblem above) and God, represented by the "G". The purpose of the hyphen is the purpose of this discourse – connecting the two. This hyphen herein is Light, both physically and hopefully as enlightenment.

We exist in a physical and a spiritual world. The physical world is based upon the laws of nature, which are established by our spiritual Supreme Architect of the Universe. The primary sources of our understanding of nature are Isaac Newton and Albert Einstein Their tool for interpreting nature is geometry, which is defined as "a part of mathematics concerned with questions of size, shape, relative position of figures, and the properties of space." . Max Planck completed our understanding of light and unwittingly laid the foundation for quantum mechanics, by which we understand the composition and much of the fundamental laws of nature and the mechanisms of the universe The following page is a diagram of the processes involved in progressing from geometry through light to approaching an understanding of God's universe, and includes the scientists who discovered the processes.

The text describes the in some detail the processes, and their progression through time; that is, the history of our understanding of God's universe. The text also discusses the religious perspectives of the world's three greatest physicist: Newton, Planck and Einstein.

It is a good study of physics and nature.

NOTE: Advanced concepts cited in the text are described in condensed form in the Appendices.


LIGHT
Euclidian GEOMETRY (Flat Surfaces)
Vectors
Vector Calculus
Maxwell's Equations for Electricity & Magnetism
Electromagnetic Theory of Light
Analytic Geometry (Graphing Equations)
Calculus
Classical Mechanics
Speed of Light
Max Planck
Planck's Law of Radiation
Law of Gravitation
LIGHT
Copernicus: *Sun Centered*
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Galileo: *Telescope, Falling Bodies*
Quantum Physics
Explanation of PhotoElectric Effect
Non-Euclidian GEOMETRY (Curved Surfaces)
Albert Einstein
General Relativity
UNDERSTANDING THE ARCHITECTURE OF THE UNIVERSE

GEOMETRY

The understanding of nature provided by Newton is called "Classical Physics", which is valid for objects larger than the molecular level and moving much slower than the speed of light. To go beyond those limits, respectively, quantum mechanics and relativity must be employed. This is in the realm of Modern Physics.

Vectors

A vector is a contrived geometric device that states quantity and direction. A value expressed in quantity but without direction is called a "scalar". Example: the speed of a car of 60 mph is a scalar, saying that the car is traveling northwest at a speed of 60 mph is the statement of the vector for the car, known as "velocity". Some important scalars are mass and energy. The most important vectors, beside velocity, are acceleration, momentum and force.

A vector can be considered an angle with the length of one side stated. The other leg is a reference to describe the angle from which its adjacent leg exists. Example: a length of ten feet laying at 30 degrees above the horizontal. Although most angles are thought of as having the reference leg as horizontal, any reference leg is permissible.

The exact concept of vectors was developed long after Isaac Newton's time, however he used the equivalent of vectors to established his theories. To develop classical mechanics Newton had to use geometry. He defined force, and demonstrated that the components of a force could be determined using the parallelogram, see Figure 1.

Calculus

To develop his theory of mechanics (motion of objects), Newton needed to be able to mathematically describe the exact values of vectors at any location and time. To do this, he invented the Calculus (which was simultaneously and independently invented by Leibnitz in Germany). The Calculus is an extension of *analytic* ***geometry***. Analytic geometry studies algebraic equations by graphing the dependent variables against the independent variables (in the equation $y = 3x^2$, y is dependent and x is independent variable). When plotted the equation forms the geometric shape of a parabola. Calculus permits the calculation of the slope of the parabola at any point x and y on the parabola by the *derivative* of y (in this case 6x) at point x. Calculus also permits the area under the curve of the parabola between any two points of x, and between the x-axis (y=0) and the parabola curve to be determined as the *integral* of the parabola between the two points of x. See Figure 2.

VECTOR ANALYSIS

A system was contrived to manipulate vectors, known as vector analysis, which includes applying Calculus to vectors. A light treatment of vectors is presented in Appendix A Using vector calculus, J. C. Maxwell was able to describe *all of the laws of electricity and magnetism* in the most elegant and succinct form with four relatively simple equations (See Appendix B). From these equations, a formula for the speed of light was extracted, using only two constants of nature: those defining electrical and magnetic forces. Maxwell's equations, as they are known, meet the rest of Relativity Theory.

Figure 1

Force Parallelogram used by Newton

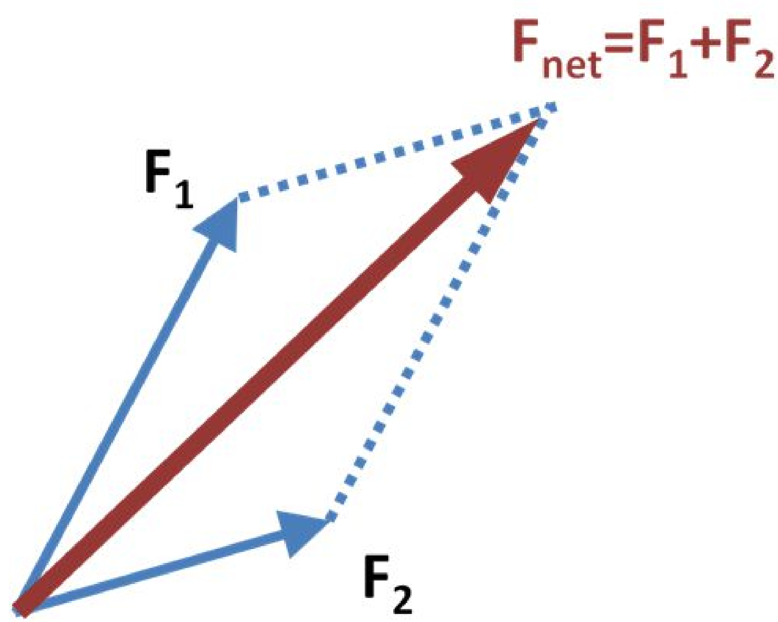
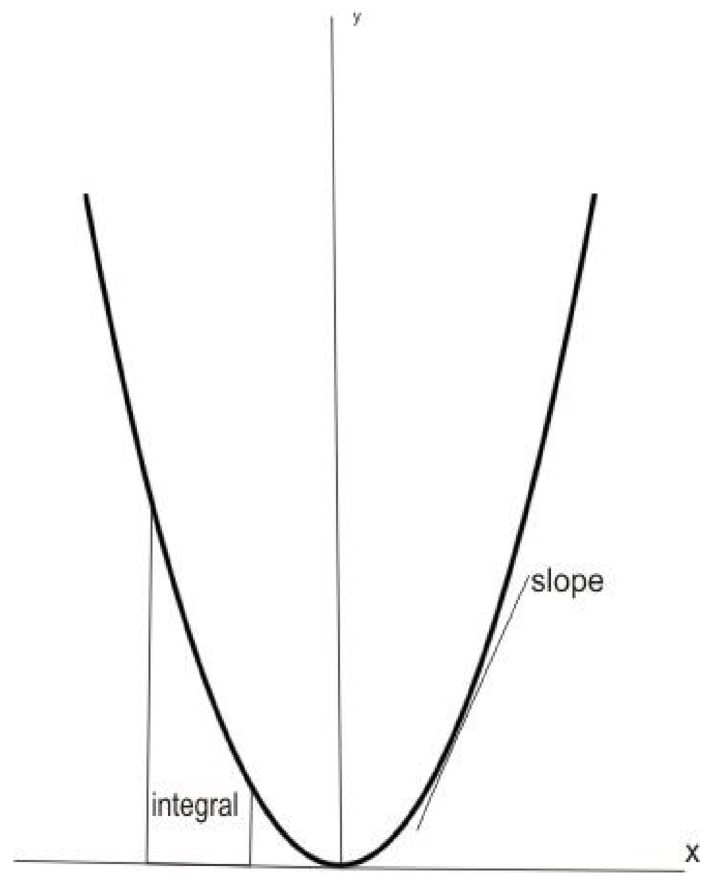
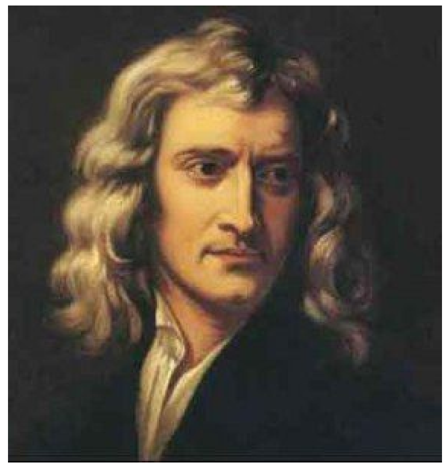


Figure 2

Curve of a Parabola



ISAAC NEWTON 1643 - 1727



Newton's Laws of Motion (Mechanics), the Basis of Classical Physics

First Law: **momentum** (mass x **velocity**) is conserved unless a net external **force** is applied. Remember, velocity is a vector, so is momentum. NOTE: Vector quantities are stated in **bold** lettering.

Second Law: **force** (a vector) is defined as the time rate of change of momentum. For a body whose mass does not change, the familiar equation **F** = m **a**, mass x acceleration applies. Remember, acceleration (a vector) is the time rate of change of velocity. For a body whose mass does change, **Force** = (time rate of change of mass) x (**velocity** of mass lost or gained). This applies, for example, to jets and rockets. Note that the rate of mass loss/gain is a scalar (not a vector), but velocity is a vector.

Third Law: Every action has an equal opposite reaction. This is a perspective of the first law, the conservation of momentum.

Gravity

Newton defined *gravity* as a physical entity that accelerates, and is proportional to the masses of interacting bodies and inversely proportional to the square of the distance between them.

Light

Newton made several contributions to the understanding and use of light:

- He invented the reflective (mirrored) telescope. Up to his time refractive (lensed) telescopes were used, as did Galileo.
- He determined, after studying the refractive effects of prisms, that white light was comprised of various colors, but did not assign the notion of frequency or wavelength
- He considered light to have a dual nature, as tiny bodies (corpuscular) and waves. He thought light waves were like sound waves, which transmit force in the direction they travel. (Actually, the electro-magnetic forces of light act in a direction perpendicular to the direction of travel of light). The corpuscular concept was rejected by science for 200 years until the advent of quantum physics.

Newton the Deist

Newton was very private about his religious beliefs, but certainly was not an orthodox follower of any faith. But he did believe strongly in the Deity. Although the laws of motion and universal gravitation became Newton's best known discoveries, he warned against using them to view the Universe as a mere machine, as if akin to a great clock. He said, *"Gravity explains the motions of the planets, but it cannot explain who set the planets in motion. God governs all things and knows all that is or can be done."* [1] Was Newton a Freemason? "There is no verifiable record of Newton being a Freemason. Despite this lack of evidence, Isaac Newton is still frequently identified as being a member of several early Masonic Lodges including the Grand Lodge of England. There is currently a Freemason Lodge operating at Cambridge University named The Isaac Newton University Lodge, however this does not emphatically mean that Isaac Newton was a founder or even a member, as there are many social and scholastic clubs which bear his name. " [2]

"Considering the secretive nature of early Freemasonry and the belief that the modern structure of the organization was partly established during Newton's lifetime in and around London, there is continued speculation as to the role that Newton may have had in the formation of Masonic Orders in their modern context. Newton's membership in The Royal Society and the fact that many Royal Society members have been identified as early Freemasons has led many to believe Newton was a Mason himself. It is clear that Newton was deeply interested in architecture, sacred geometry, and the structure of the Temple of Solomon, a subject that plays an important role in early Masonic mythology. However, ultimately there is no evidence to directly connect Newton to Freemasonry." [3] Therefore, it is safe to say that if Isaac Newton was not a Mason in fact, he was certainly one in spirit.

LIGHT

The geometric nature of light, as electromagnetic radiation moving through space, can be understood by application of Maxwell's equations, mentioned above (see Appendix B). However, light has another nature, the discovery of which is fascinating and will now be described. The ultimate science explaining it is ironic and will lead us to another fascinating aspect of G-G.

<u>The Nature of Electromagnetic (E-M) Radiation.</u>

Light waves, as do water and sound waves, have velocity, frequency and wavelength. The expression relating these entities is $c = \lambda\nu$, where c is velocity, λ (Greek lower case "lambda") is wavelength and ν (Greek lower case "nu") is frequency, typically in units of "hertz", being per second or sec^{-1}. NOTE: when someone asks you "what's new?" you can answer "nu is c over lambda". You can of course, if you are part nerd.

The *spectrum* of E-M radiation extends from gamma rays to radio waves, in Figure 3.

THERMAL RADIATION

It has been observed for centuries that hot objects emit light. The hotter they are the more light they emit and the color shifts from red to orange to yellow to white. Although only visible radiation from a hot body may be seen, it also emits a lot of radiation in the infrared part of the spectrum, and a small amount in the ultraviolet.

Kirchhoff

A body can absorb as well as emit E-M radiation, being that amount it doesn't reflect. The ability of a body to emit and absorb E-M radiation typically varies with wavelength, unless it is a black body which absorbs 100% of radiation incident upon it and emits 100% of the radiation physically possible at each wavelength. For non "blackbodies" (the common term, conjoining the words) Kirchhoff's law applies, which says at a given wavelength the ability to absorb equals the ability to emit, from a range of 0% to 100% of what a blackbody can do. If the name Kirchhoff sounds familiar, he was the German physicist (Gustav Robert Kirchhoff, 1824-1867) most famous for his law of electric currents, which states that the electric current flowing into a junction equals the current flowing out of the junction, a fundamental law of electricity.

The E-M spectrum of a blackbody was measured and found to have the forms depicted in Figure 4. Note the hotter the body, the more total radiation is emitted, and peaks at shorter wavelengths. Kirchhoff then knew that the amount of energy emitted per unit area of a blackbody, nominally "j" was related to wavelength and absolute temperature, but not how. In 1859 he issued the famous "Kirchhoff Challenge" to find that relationship.

Stefan & Boltzmann

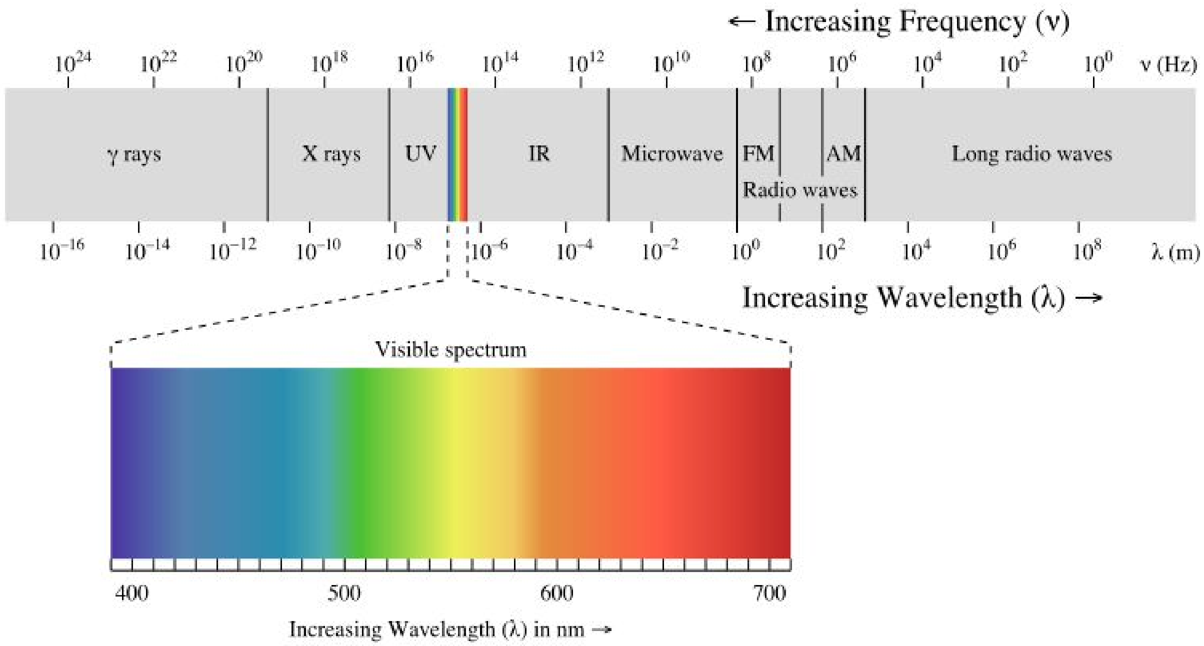
In 1879 physicists J. Stefan and L. Boltzmann derived the following relationship between the light energy emitted by a blackbody and its absolute temperature:

$$j = \sigma T^4$$

where j is the power of light (watts) emitted per unit area of a blackbody, T is the temperature and σ is the Stefan-Boltzmann constant: $\sigma = 5.67\times10^{-8}\ \mathrm{W\ m^{-2}\ K^{-4}}$ (W is watts, m in meters, K is degrees kelvin)

Figure 3

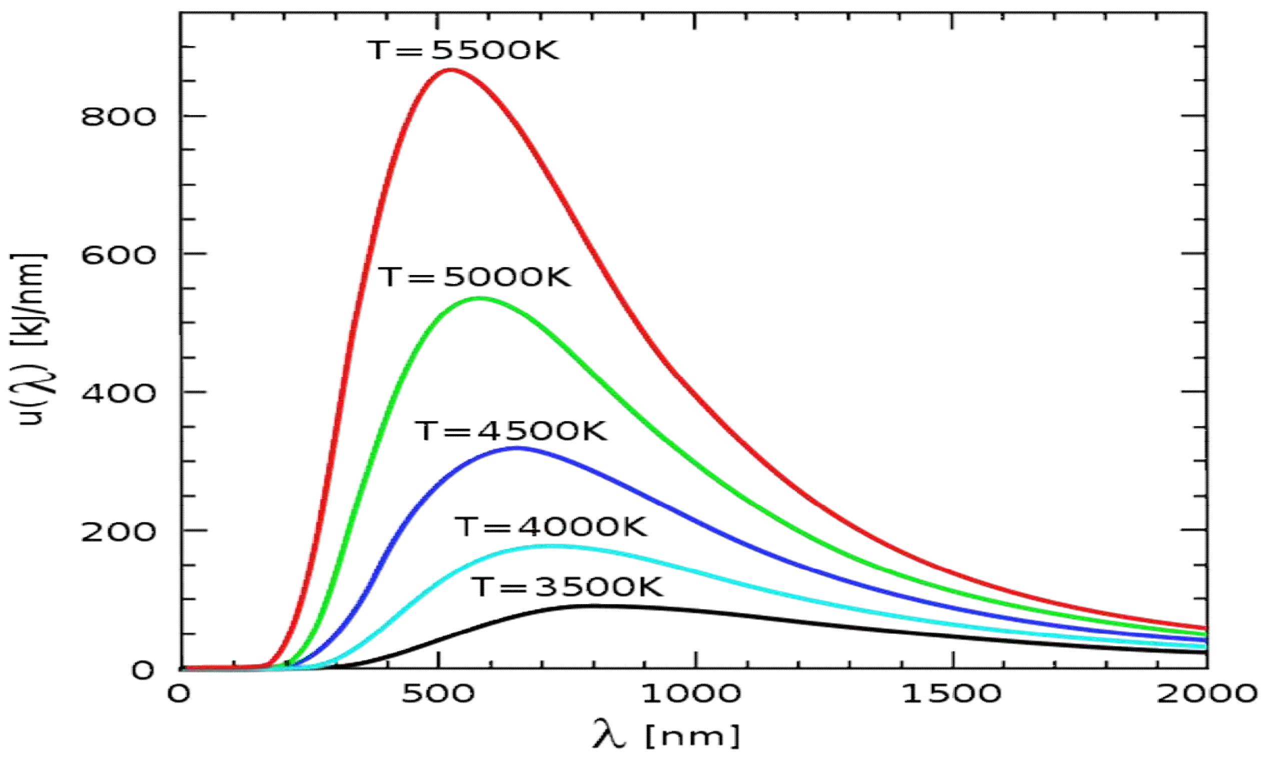
The Electromagnetic Spectrum



"UV" is ultraviolet and "IR" is infrared.

Figure 4

Blackbody Light Spectra at Various Temperatures



Wien

In 1893 another physicist, Wilhelm Wien, studied the shape of the spectrum emitted from a blackbody and formulated the following relationship between the peak wavelength of the spectrum and the blackbody temperature:

$$\lambda = 0.0051 \text{ m-K} / T$$

m = meters (unit of wavelength), K = degrees Kelvin

So here we have a relationship between peak wavelength and temperature and a relationship between total energy emitted and temperature, but no relationship combining the two.

Planck

Then along came Max Planck (1858-1947), a brilliant and persistent German physicist who in 1900 employed intuition, Maxwell's equations of electricity and magnetism, the laws of thermodynamics, and statistics to successfully meet Kirchhoff's challenge. The result is his Quantum Theory of Radiation, for which he won the Nobel Prize in 1918. Planck's equation is:

$$I(\nu, T)d\nu = \left(\frac{2h\nu^3}{c^2}\right)\frac{1}{e^{\frac{h\nu}{kT}} - 1}\,d\nu$$

In this equation, I is the power of light (watts) emitted per unit area of blackbody per steradian solid angle, (remember j was power of light per unit area only). Here is geometry again as steradians. The constant "c" is the speed of light, ν is frequency as before, and k is the Boltzmann constant = 1.38×10^{-23} watt-sec / deg K.

The novel constant in this equation is the Planck Constant "h", being 6.63×10^{-34} watt-sec^2

From this equation both Wien's and Stefan-Boltzmann laws can be derived.

Planck could only develop this relationship by assuming that the little tiny radiators (atoms and electrons) of the blackbody were oscillating in distinct (quantized) amounts, not continuous. (A radio transmitter is an E-M oscillator at a distinct frequency.) Reluctantly, Planck had to postulate that frequencies of these quantized oscillators was not the same at a given temperature, but were *statistically* distributed, something like a bell-curve. Quantization and statistical distribution were means of last resort to Planck, he did not like the idea. "At first Planck considered that quantization was only 'a purely formal assumption ... actually I did not think much about it...'; "nowadays this assumption, incompatible with classical physics, is regarded as the birth of quantum physics and the greatest intellectual accomplishment of Planck's career." [4]

Planck's Faith

Max Planck was not a Freemason, but was certainly religious. "Planck was a devoted and persistent adherent of Christianity from early life to death, but he was very tolerant towards alternative views and religions, and so was discontented with the Nazi church organizations' demands for unquestioning belief.

"The God in which Planck believed was an almighty, all-knowing, benevolent but unintelligible God that permeated everything, manifest by symbols, including physical laws. His view may have been motivated by an opposition like Einstein's and Schrödinger's against the positivist, statistical subjective quantum mechanics universe of Bohr, Heisenberg and others. Planck was interested in truth and the Universe beyond observation, and objected to atheism as an obsession with symbols." [5]

Einstein and Photoelectric Effect

When light of sufficiently short wavelength strikes a surface, electrons are dislodged from that surface. This is the photoelectric effect. It was first observed with metals, which of all substances have the most loosely held, and thus easily dislodged electrons. As long as the wavelength of light is short enough, the amount of electrons discharged from the surface increases with the intensity of light. At wavelengths longer than that threshold, no electrons are discharged no matter how great the intensity of light. It baffled science since first discovered by Hertz in 1887. See Figure 5

It was finally explained by Einstein in 1905 who stated that when light strikes the surface it becomes a particle, which he at the time called a "light quantum" but in 1926 was given the name "photon". Einstein saw its equivalence of quantum of light radiated per Planck's theory: they originated as quanta, moved through space as waves, and interact with matter as quanta. Remember Newton's idea about the dual nature of light?

Einstein ascribed the energy of a quantum of light (photon) as

$E = h\nu$ or $E = hc/\lambda$,

where h is the Planck constant and again ν is the frequency of light and λ is wavelength. This is known as the Planck-Einstein Equation.

Max Planck was astonished at the equivalency of his blackbody quanta and those causing the photoelectric effect. Einstein won his only Nobel Prize for this discovery. Quantum physics was on the move!

Line Spectra and Quanta

It had long been observed, and Kirchhoff stated as such, that excited substances do not emit continuous blackbody spectra but spectra with discrete lines. These excited substances can be metal arcs, sparks, and very hot gases. See Figure 7.

The Bohr Atom

Danish physicist Neils Bohr in 1913 applied the photon concept to atomic spectra, specifically to that of the hydrogen atom. He proposed and proved by a primitive theory that because atoms emitted light in distinct quanta (single frequency) that the electrons in an atom must exist in discrete quantized energy levels, emitting light when falling from a higher level to a lower energy level. His concept was that of a solar system with electrons rotating about the atomic nucleus as planets about the sun. This was a crude representation which the development of quantum mechanics would perfect. See Figure 7.

Figure 5 The Photoelectric Effect

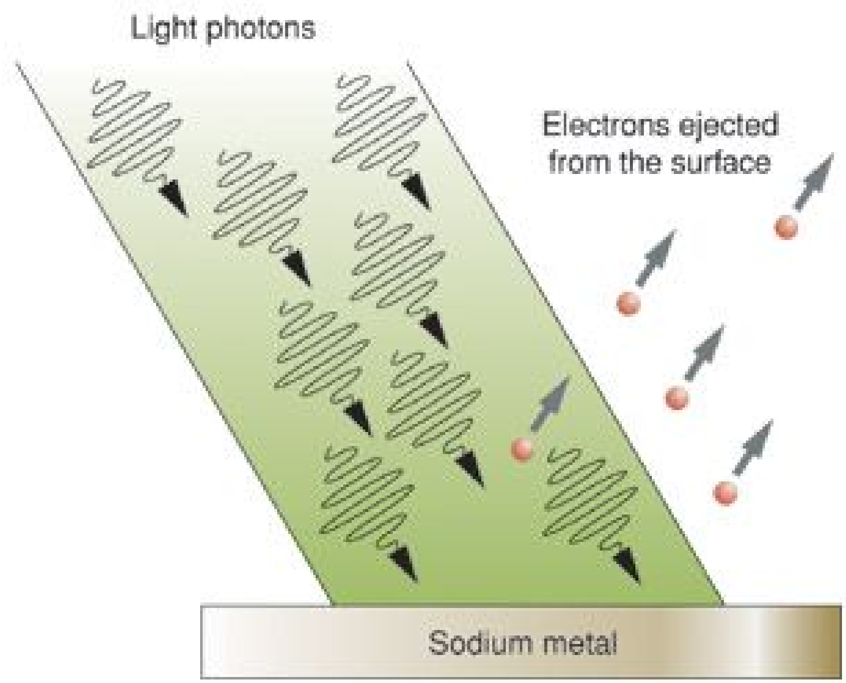


Figure 6

Max Planck and Albert Einstein (Planckeinstein)

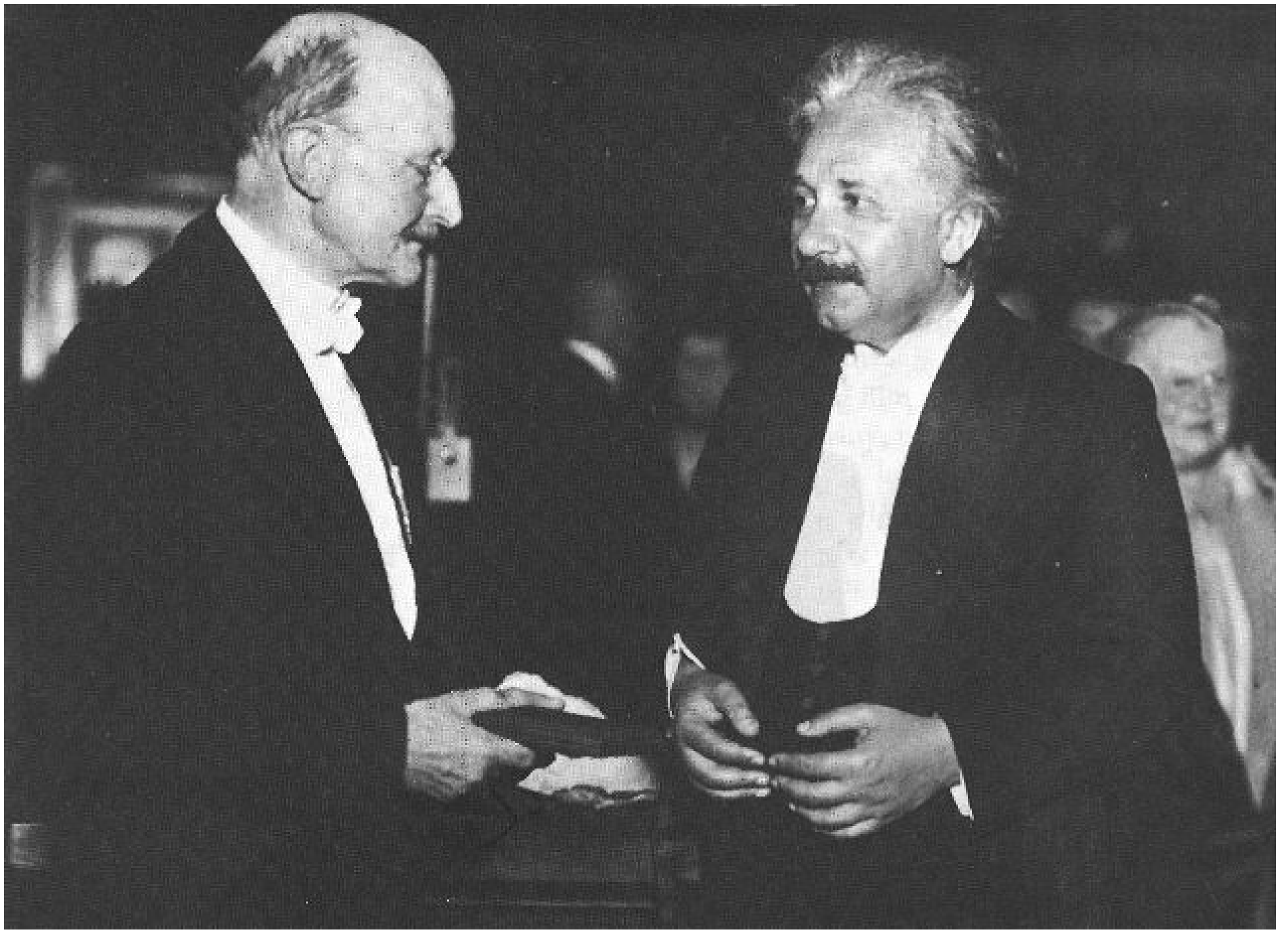
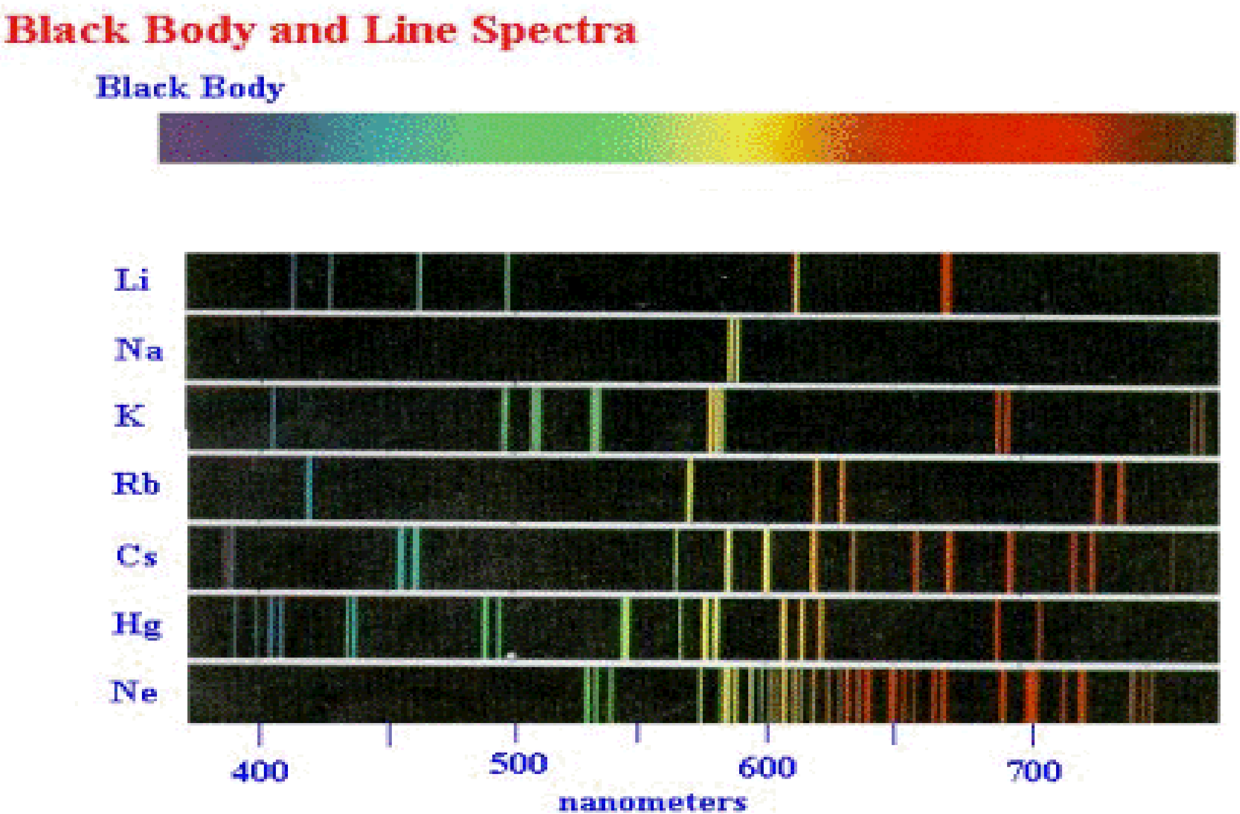


Figure 7


Black Body and Line Spectra
Black Body
Li
Na
K
Rb
Cs
Hg
Ne
400
500
600
700
nanometers

More Paradoxes from Quantum Theory

- Paradox: light can behave as waves and particles, as heretofore described
- New Paradox: a very small particle of matter (e.g. those comprising the atom) can behave as a wave also.
- Another New Paradox: It is impossible to identify the momentum and location of a subatomic particle at the same time. This is known as Heisenberg's Uncertainty Principal (1925):

$$\Delta x \, \Delta p \geq h / 4\pi$$

where Δx = uncertainty of position, Δp = uncertainty of momentum, and h = Planck's constant.

This last paradox, uncertainty, applied to the atom says that you may know the probability of the location of an electron, but never the exact location. Or if you know the exact location, you will never precisely know its momentum (including direction).

This drove Einstein up the wall! He said in effect: *"God does not play dice with the universe!"* This annoying concept that evolved from his own major contributions to quantum mechanics! To prove that there could be certainty, he devoted the rest of his life to "The Theory of Everything"; i.e., a single theory that combines gravitational and electrical and magnetic fields.

After developing Relativity, of course.

GEOMETRY & RELATIVITY

There are two geometries – Euclidian and non-Euclidian, and two relativities – special and general. Special Relativity is a "special" case of General Relativity.

Geometry

Euclidian Geometry is that which we are all familiar, on a plane (flat) surface. Two parallel lines on a flat surface never converge or intersect. The closest distance between two points is a straight line.

Non-Euclidian Geometry is analyzed on non-planar surfaces. Consider the earth, a spherical surface. Lines of longitude at the equator are parallel, but they converge at the poles. The closest distance between two points is not a straight line but an arc.

RELATIVITY

Speed of Light:

In the late 19th century, experiments showed that different from mechanical waves (e.g., sound and water) which required a medium such as air or water to travel through, light waves require no medium. Movement of the media affected the speed of mechanical waves in them, not so for light. From this Einstein recognized that the *speed* of light is constant regardless of the speed of the source or observer, and cannot be exceeded. The *frequency* of light waves do change with the speed of the source or observer – the Doppler effect – but not their speed. This concept is essential to Relativity. The other essential concept of Relativity is that an observed event would be no different if the event were moving and the observer still, or if the observer was moving and the event were still. Event and observer were *related* only by the relative *velocity* between the two.

Special Relativity

Special Relativity applies to observers and events moving at a constant velocity relative to each other. Einstein imagined he was on a train moving at the speed of light and observing a large clock on a tower. If he passed the clock at noon, looking back at anytime afterward he would still see it a noon, because the light coming from the clock after noon – moving at the speed of light – would never catch up to him, who was moving away at the speed of light, although his pocket watch would keep on ticking. Likewise, someone on the clock tower in town trying to view Einstein's pocket watch would see no movement on it, although the clock in his tower would keep on ticking. Einstein thereby surmised that physical processes are *observed* to slow down as the relative speed (or velocity) between process and observer increased, especially as that speed approaches that of light. From this he deduced that the *observed* dimensions of objects would compress, and apparent mass increase, as the relative velocity approached the speed of light. WOW! So, per Special Relativity, the speed of light is constant but time and dimensions change with the relative velocity between event and observer. Einstein also derived from Special Relativity the famous equation: $E = m c^2$.

The concept of *space-time* is extremely important. It says that space and time not independent but are interrelated. In the absence of external forces, the space-time relationship for a process does not change. For a stationary observer viewing a moving object, the time may appear to slow down and the dimensions appear to decrease, but the interrelation between space & time is the same for an observer seated in the moving object. See Appendix C for equations for the slowing of time, and compression of observed objects and the definition of space-time.

Einstein published his Theory of Special Relativity in 1905, the same year he published his theory on the photoelectric effect, and two other important scientific papers. The year 1905 is known as Einstein's "Miracle Year".

General Relativity

Einstein wanted a relativity theory inclusive of all conditions, not just constant velocity. To be all inclusive, he must extend relativity to events and observers accelerating with respect to each other. A body is either at constant velocity or is accelerating. He had several concepts:

- That *mechanical* and *gravitational* acceleration were equivalent. For example, a person in an elevator car in outer space that obvious now but hadn't at that time been established was mechanically accelerated upward at the rate of earth's gravity (32.2 ft/sec/sec) would feel weight on his feet, rather than floating free, but that same feeling would be indistinguishable from the case when the elevator car was at rest on earth. This concept seems.

- The ageold phenomenon that two bodies of differing mass fall (in gravity) at the same rate, hit the ground at the same time. This was finally proved without question on the moon by Apollo 15, where a feather and a rock were dropped from the same height and hit the ground at the same time.
- The laws of physics are the same for all reference frames, regardless of the relative motion.

From these concepts he began to theorize and determined that *gravity bends light*. And since light travels through space, *gravity must warp space in order to bend light*. See Appendix D for a demonstration. Warped space meant *non-Euclidian* geometry. Einstein was a good mathematician but not a great one, so he consulted a friend who was a great mathematician (and geometrician) who showed him the tools to analyze and formulate relationships in warped (non-Euclidian) space. More concisely, although space-time is Euclidian (flat) for systems moving at constant velocity relative to each other, it is non-Euclidian (warped) for all other cases; i.e., acceleration.

Einstein conceived General Relativity in 1907, but after hard work and many disappointments, formulated and published his theory in 1915. His General Theory of Relativity was concise and included both constant velocity and acceleration between event and observer. It further pleased him that at low velocities, the Newtonian physics were valid.

He predicted that the sun, due to its mass, would bend starlight by a small but measurable degree. This was first verified by observations of a star appearing near the sun during a solar eclipse off the Atlantic coasts of South America and Africa in 1919, and again more precisely in Australia in 1922. The entire world celebrated these events, the verification of the General Theory of Relativity.

Whereas Newton stated the existence of gravity and how it acted, Einstein formulated its existence. Einstein elucidated the most fundamental law of the universe to date.

Manifesting geometry, General Relativity shows

- that gravity is the warping of space
- how matter warps space
- how gravity (warped space) acts on matter; i.e., how gravitational fields interact

Einstein's Theology

Einstein was often asked about his theology. Although he expressed himself differently at different times, he was a Deist. He believed in A Supreme Architect of the Universe.

"My religiosity consists of a humble admiration of the infinitely superior spirit that reveals itself in the little that we can comprehend about the knowable world. That deeply emotional conviction of the presence of a superior reasoning power, which is revealed in the incomprehensible universe, forms my idea of God." [6]

"Try and penetrate with our limited means the secrets of nature and you will find that, behind all the discernible laws and connections, there remains something subtle, intangible and inexplicable." [7]

"I'm not an atheist. The problem involved is too vast for our limited minds. We are in the position of a little child entering a huge library filled with books in many languages. The child knows someone must have written those books. It does not know how. It does not understand the languages in which they are written. The child dimly suspects a mysterious order in the arrangement of the books but doesn't know what it is. That, it seems to me, is the attitude of even the most intelligent human being toward God. We see the universe marvelously arranged and obeying certain laws but only dimly understand these laws."[8]

"Everyone who is seriously involved in the pursuit of science becomes convinced that a Spirit is manifest in the laws of the Universe – a Spirit vastly superior to that of man, and one in the face of which we with our modest powers must feel humble. In this way the pursuit of science leads to a religious feeling of a special sort…."[9]

And, of course, his belief that God does not play dice with the Universe.

CONCLUSIONS

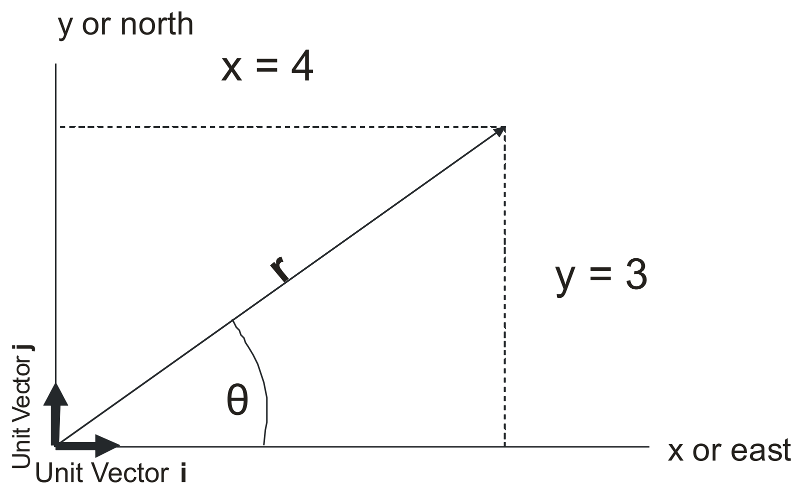
The Universe is explained only by the use of Geometry.

The Universe is observed and its understanding developed by light.

The greatest scientists – Newton, Planck, Einstein – believed in a Supreme Architect of the Universe.

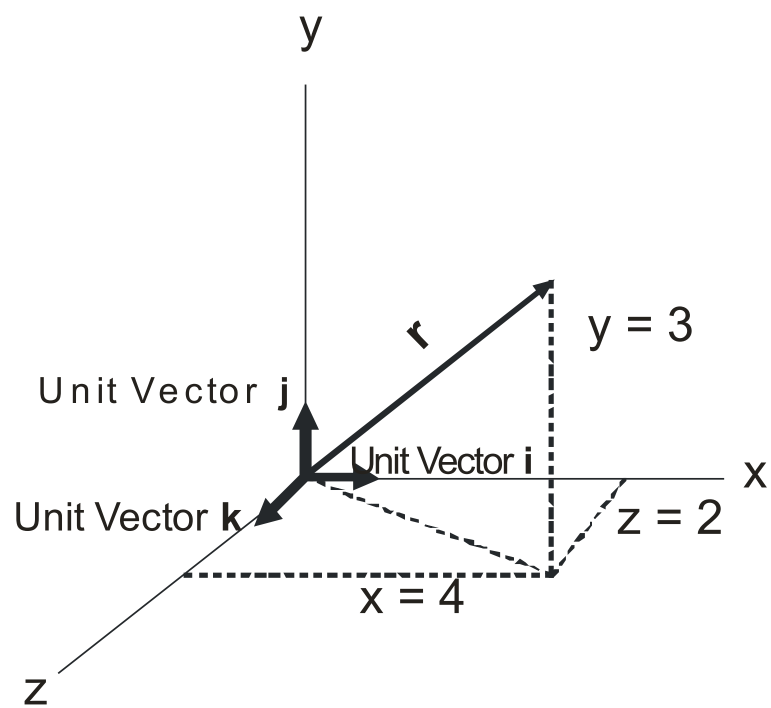
APPENDICES

VECTOR IN 2 DIMENSIONS (x & y)



Vector: **r** = **i** 4 + **j** 3
Scalar: $r = \sqrt{(4^2 + 3^2)} = 5$
$\tan\theta = y / x = 3/4 = 0.75, \theta = 36.9$ degrees
Vector: 5 units, 36.9 degrees north of east

VECTOR IN 3 DIMENSIONS



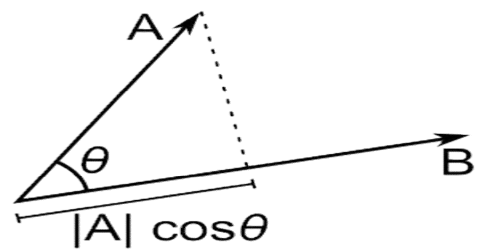
Vector: $\mathbf{r} = \mathbf{i}\,4 + \mathbf{j}\,3 + \mathbf{k}\,2$

Scalar: $r = \sqrt{(4^2 + 3^2 + 2^2)} = 5.385$

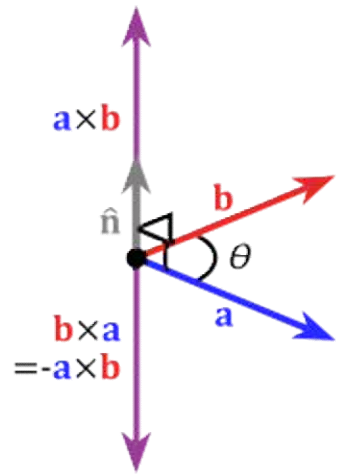
Rotate the 4 fingers of your right hand from x axis to y axis. Notice that your thumb will project forward on the z axis. This coordinate system therefore follows the *right hand rule*.

Vectors may be added and subtracted simply by adding and subtracting the vertical and horizontal components of vectors. The system of multiplication is more complicated. The *scalar or "dot" product* of two vectors yields a scalar as depicted by the diagram below, being the product of the scalar values· of A and B times the cosine of the angle between them.

$$\mathbf{A} \cdot \mathbf{B} = A * B * \cos\theta$$



The *vector or "cross" product* yields a vector as defined by the diagram below, being the product of the scalar values of a and b times the sine of the angle between them, directed perpendicular to the plane defined by vectors a and b, as depicted by the diagram below.



Notice that the cross product of a to b is upward, whereas that of b to a is downward. This follows the "right hand rule", being that moving the four fingers of your right hand from **a** to **b** will yield a vector pointing in direction your thumb moves.

Vector Calculus

The forces of nature – vectors - typically vary through space, therefore a method of analyzing this behavior is necessary. The "del" operator ∇ was contrived to do this, which is demonstrated by the equation

$$\nabla f = \frac{\partial f}{\partial x}\hat{\mathbf{x}} + \frac{\partial f}{\partial y}\hat{\mathbf{y}} + \frac{\partial f}{\partial z}\hat{\mathbf{z}}$$

where f is a scalar function of x, y and z, and $(\hat{\boldsymbol{x}}, \hat{\boldsymbol{y}}, \hat{\boldsymbol{z}})$,are directional unit vectors in mutually perpendicular x, y and z axes, and the δ/dx, δ/dy, and δ/dz are derivatives (slopes of the curve of the function f when projected in three planes) of f along the yz, xz and xy planes, respectively. Note that $\hat{\mathbf{x}}$, $\hat{\mathbf{y}}$ & $\hat{\mathbf{z}}$ unit vectors are the same **as i, j** & **k**.

There are several different applications of the ∇ operator, which are not pertinent to this discussion. What is important is to state that

- vector analysis is a man-made concept
- physical science, mechanics and electromagnetism can be succinctly described and predicted using vector analysis,

APPENDIX B

MAXWELL'S EQUATIONS

Using vector calculus, James Clerk Maxwell was able to describe *all of the laws of electricity and magnetism* in the most elegant and succinct form by the following equations.

$\nabla \cdot (\epsilon \mathbf{E}) = \rho_f$ the net electric field about a closed volume is proportional to the charge contained within the volume

$\nabla \cdot \mathbf{B} = 0$ magnets must always have two poles

$\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$ a varying magnetic field induces an electric field (e.g., transformer)

$\nabla \times (\mathbf{B}/\mu) = \mathbf{J}_f + \epsilon \frac{\partial \mathbf{E}}{\partial t}.$ a magnetic field is produced by an electric current and/or a varying electric field.

E = electric field, B = magnetic field, J = electric current, t = time, ρ_f = density of electric charge, ε_0 = electrostatic constant, μ_0 = magnetic constant,

It is interesting to note that the speed of light c_o in a vacuum is determined by $c_0 = \frac{1}{\sqrt{\mu_0 \varepsilon_0}}.$

The above discussion was intended to demonstrate the necessity of geometry, in this case vectors, to describing nature.

APPENDIX C

EQUATIONS OF SPECIAL RELATIVITY

Dilation of Time:

$t' = t * \sqrt{(1- v^2/c^2)}$, where t' is the time observed to have elapsed in a system moving at velocity v relative to the observer and c is the speed of light.

Note that at low velocity, t' is nearly the same as t, but as velocity approaches the speed of light, t' approaches zero; i.e. time slows to a near halt. Further, the velocity cannot exceed the speed of light, otherwise t' would be come the square root of a negative number, which does not exist.

Compression of Dimension:

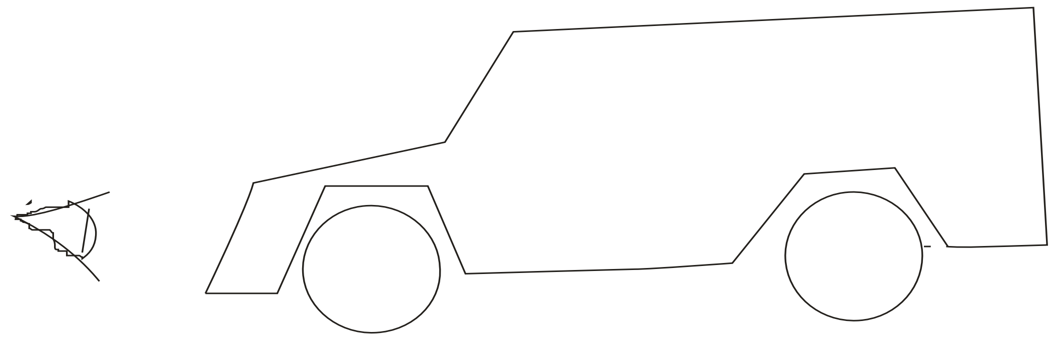
$r' = r * \sqrt{(1- v^2/c^2)}$, where r' is the observed dimension, and t is the observer's time and r the dimension of the observed object as viewed within the object. This applies to a dimension parallel to the direction of travel (v). For dimensions perpendicular to the direction of travel, there is no compression.

Space-Time:

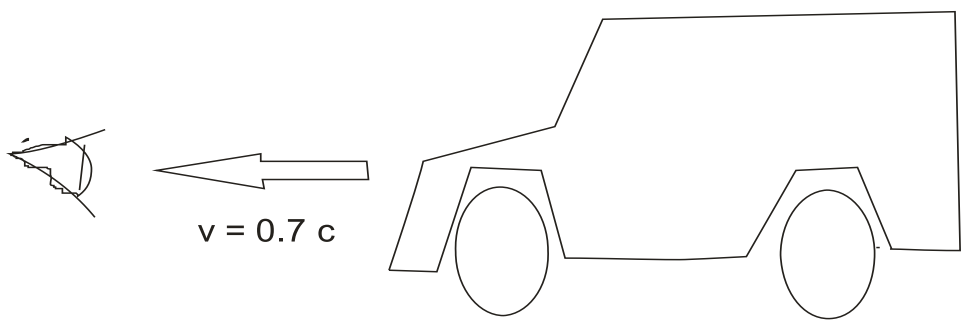
Space-Time is defined by the equation $s = \sqrt{(c^2t^2 - r^2)}$ and is the same for the observer and the object as observed.

$$s = \sqrt{(c^2t^2 - r^2)} = \sqrt{(c^2t'^2 - r'^2)}$$

APPENDIX D DEMONSTRATION OF SPECIAL RELATIVITY



Observing Vehicle at Rest

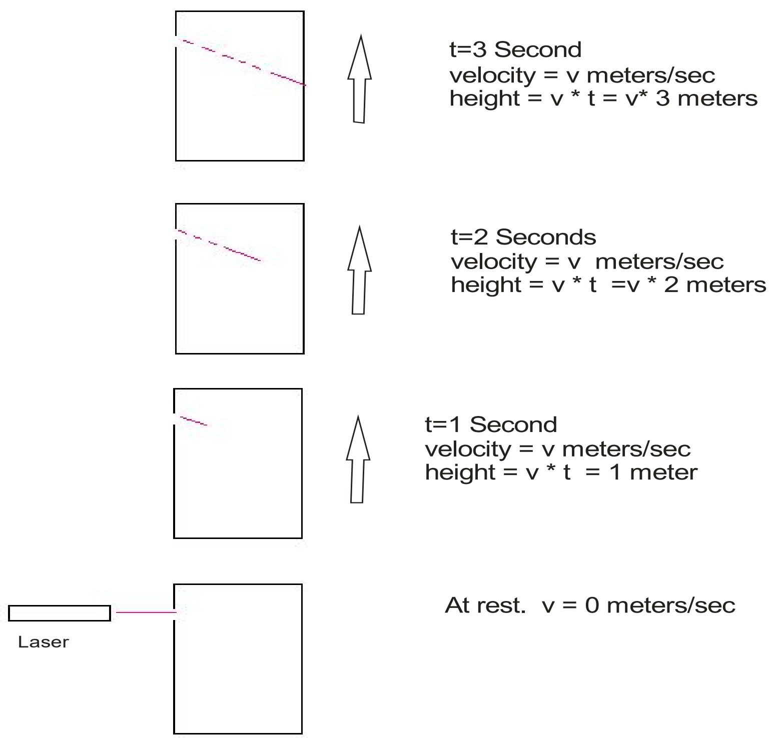


Observing vehicle when moving at 467 million miles per hour = 70% of speed of light (c)
. Notice vertical dimensions do not change.
While you observe it for one hour, someone in the vehicle will have been moving for only 43 minutes (his time). So when he gets back to you after your hour, he will be 17 minutes younger than you.

APPENDIX E

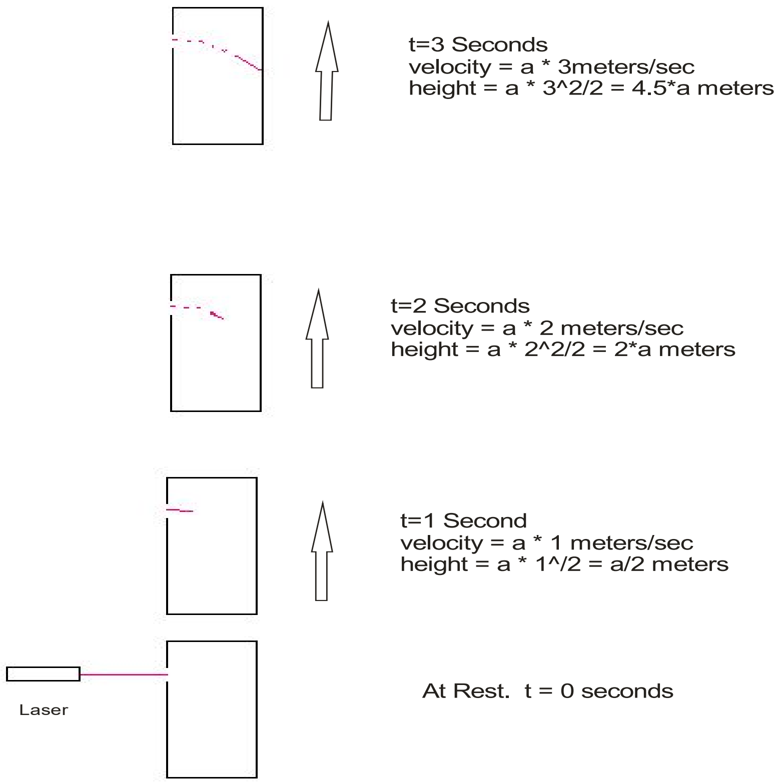
DEMONSTRATION OF GENERAL RELATIVITY

For an elevator rising at constant velocity, the beam makes a straight line downward as it crosses the elevator. At rest, the beam goes across horizontally. Instead of a laser beam, imagine a projectile penetrating and crossing the elevator. The observed trajectories would have the same shape. Start from bottom.



ELEVATOR RISING AT CONSTANT VELOCITY
Beam Crosses forming a straight line downward

When the elevator is accelerated the laser beam takes a curved path as it crosses the elevator, see figure below. Since mechanical acceleration (as in a rocket or an elevator) is the same as the acceleration of gravity, then gravity will bend light!



ACCELERATING ELEVATOR
height = a * t^2/2, a = acceleration
The Path of Laser Beam is Curved
The greater the acceleration a the more the light is bent.

NOTES

1. Tiner, J.H. (1975). *Isaac Newton: Inventor, Scientist and Teacher*. Milford, Michigan, U.S.: Mott Media.
2. "Isaac Newton's Occult Studies," http://en.wikipedia.org/wiki/Isaac_Newton's_occult_studies
3. Ibid
4. "Max Planck," http://en.wikipedia.org/wiki/Max_Planck
5. Ibid
6. Walter Isaacson, *Einstein – His Life and Universe*, (Simon & Schuster, 2007), 384-393
7. Ibid
8. Ibid
9. Ibid

A good reference on relativity for the non-technical student is by Brian Cox & Jeff Forshaw, *Why Does* $E=mc^2$*?*, (Da Capo Press), 2009

An excellent biography of Einstein is by Walter Isaacson, cited above.

G-G

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CONCLUSIONS