James Clerk Maxwell

June 13, 1831 - November 5, 1879

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"Maxwell can be justifiably placed with Einstein and Newton in a triad of the greatest physicists known to history"[1]

"From a long view of the history of mankind – seen from, say, ten thousand years from now – there can be little doubt that the most significant event of the 19th century will be judged as Maxwell's discovery of the laws of electrodynamics."
– Richard P. Feynman

"One scientific epoch ended and another began with James Clerk Maxwell"
– Albert Einstein

A quote about Maxwell from 1931 by J J Thomson seems to speak of the future internet:.
"The discovery of electrical waves has not merely scientific interest though that alone inspired it ... it has had a profound influence on civilization; it has been instrumental in providing the methods which may bring all inhabitants of the world within hearing distance of each other and has potentialities social, educational and political which we are only beginning to realize."

"...many think that Maxwell's study of the particles of Saturn's rings led him directly and inevitably into the realm of kinetic theory of gases, in which so much of his life was spent. However this may be, when he crossed the bridge from Astronomy to Physics he left behind him for ever the prospect of becoming a great astronomer - but only to become the greatest mathematical physicist the world has seen since Newton."
– Sir James Jeans 1931[2]

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[1]Graves, Dan. Scientists of Faith. Grand Rapids, MI: Kregel, 1996. pg 151.

[2]O'Connor, J.J. and Robertson, E.F. "A visit to James Clerk Maxwell's house." Scottish Index. Nov 1997. School of Mathematics and Statistics, University of St. Andrews, Scotland. 16 March 2002 <http://www-groups.dcs.st-and.ac.uk/%7Ehistory/HistTopics/ Maxwell_House.html>.

"I believe, with the Westminster Divines and their predecessors ad Infinitum that

'Man's chief end is to glorify God and to enjoy him for ever.'"[3]

James Clerk Maxwell gave this as the basis, or foundation, of all intellectual pursuits. In answer to how to enjoy the Lord, Maxwell states, "That happiness is indissolubly connected with the full exercise of these powers in the *intended* direction... In order to advance, the soul must converse with things external to itself." In this same address he wrote regarding mathematics and other disciplines,

> I am also persuaded that the study of *x* and *y* is to men an essential preparation for the intelligent study of the material universe. That the idea of Beauty is propagated by communication, and that in order thereto human language must be studied ... In every branch of knowledge the progress is proportional to the amount of facts on which to build, and therefore to the facility of obtaining data. In the Mathematics this is easy. Do you want a quantity? Take *x*; there it is!—got without trouble, and as good a quantity as one would wish to have. And so in other sciences,—the more abstract the subject, the better it is known. Space, time, and force come first in certainty. These are the subjects in Mechanics. Then the active powers, Light, Heat, Electricity, etc.=Physics.[4]

A contemporary of Boltzman, Gibbs, Kelvin, Hamilton, Stokes, Faraday, and his good friend Tait, this Scottish Mathematician has been my favorite for some time. A few years ago I had some students of mine paint a mural in my classroom of the triad of the greatest physicists of all time: Newton, Maxwell, and Einstein. After doing this additional research into his life and thoughts for this paper I have become even more impressed with his successful integration of the Christian faith and scientific/mathematical pursuits. I think I was first impressed with him on one of my college visits. The book store at M.I.T. had a t-shirt with the writing "And God said," followed by Maxwell's equations, "and there was light."[5] Maxwell would actually have us be a little more careful with our exegesis. Consider the admonition he gave to the Bishop of Gloucester and Bristol in 1876, just a few years before his death:

> there is a statement printed in most commentaries that the fact of light being created before the sun is in

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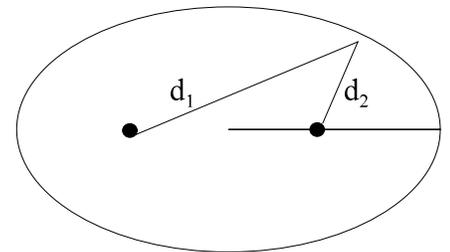[3]Campbell, Lewis and Garnet, William. <u>The Life and Times of James Clerk Maxwell</u>. London: Macmillan and Company, 1882. pg 158. Available online <http://www.sonnetusa.com/bio/maxbio.pdf>.

[4]Ibid, pg 158-159.

[5]A variation of this is available at http://www.scienceteecher.com/physics.html

striking agreement with the last results of science (I quote from memory). I have often wished to ascertain the date of the original appearance of this statement, as this would be the only way of finding what "last result of science" it referred to. It is certainly older than the time when any notions of the undulatory theory became prevalent among men of science or commentators. If it were necessary to provide an interpretation of the text in accordance with the science of 1876 (which may not agree with that of 1896), it would be very tempting to say that the light of the first day means the all-embracing æther, the vehicle of radiation, and not actual light, whether from the sun or from any other source. But I cannot suppose that this was the very idea meant to be conveyed by the original author of the book to those for whom he was writing... I should be very sorry if an interpretation founded on a most conjectural scientific hypothesis were to get fastened to the text in Genesis, even if by so doing it got rid of the old statement of the commentators which has long ceased to be intelligible. The rate of change of scientific hypothesis is naturally much more rapid than that of Biblical interpretations, so that if an interpretation is founded on such an hypothesis, it may help to keep the hypothesis above ground long after it ought to be buried and forgotten."[6]

Again Maxwell goes on to explain and gives a motivation for the study of the works of God, "I think that each individual man should do all he can to impress his own mind with the extent, the order, and the unity of the universe, and should carry these ideas with him as he reads such passages as the 1st Chap. of the Ep. to Colossians (see Lightfoot on Colossians, p. 182), just as enlarged conceptions of the extent and unity of the world of life may be of service to us in reading Psalm viii.; Heb. ii. 6, etc."[7]

Over the course of his life James Clerk Maxwell did impress his mind with the order and unity of the universe. While still a young boy, in 1846 at the age of 14 he wrote a paper on ovals. Here he generalized the famous definition of an ellipse (seen in the figure to the right) by defining an oval as $md_1 + nd_2 = k$, where k is a constant. Ovals are therefore egg shaped, but if *m* and *n* are equal to 1 then the curve is an ellipse. He presented this, his first paper, *On the description of oval curves, and those having a plurality of loci*, to the

[6]Campbell, Lewis and Garnet, William. The Life and Times of James Clerk Maxwell. London: Macmillan and Company, 1882. pg 393-394. Available online <http://www.sonnetusa.com/bio/maxbio.pdf>.

[7]Ibid, pg 395.

Royal Society of Edinburgh on 6 April 1846.[8]

He went on to explain the composition of Saturn's rings (1855-1857), the kinetic molecular theory of gas (1859-1878), color photography (1861), the perception of color (1849-1870), and thermodynamics (1870). Maxwell had begun thinking about the question of Saturn's rings with Peter Tait[9] in 1847 while they were students together at Edinburgh Academy. Maxwell mathematically showed in 1857 in *The Motion of Saturn's Rings*, one of the approximately 100 papers he produced in his life, that Saturn's rings cannot be solid, or shearing stress due to differences in gravitational force would cause it to break apart. Maxwell described the rings as being "something like the siege of Sebastopol conducted from a forest of guns 100 miles away, and 30,000 miles from the other, and the shot never to stop, but go spinning away round a circle, radius 170,000 miles."[10] For his essay he won the Adam's prize and it was commented by the President of the Royal Astronomical Society and British Association that this "is one of the most remarkable applications of mathematics to physics that I have ever seen." But "stability can only be achieved if the rings consisted of numerous small solid particles."[11] His work with Saturn's rings directly lead to the development of the kinetic theory of gases.

James married Katherine Mary Dewar, the daughter of the Principal of Marishal College where Maxwell taught, after a year and a half engagement in 1859. In this, Maxwell's 28th year, at a meeting of the British Association for the Advancement of Science he presented some results of the kinetic theory. "He concluded that gas viscosities are independent of pressure, and that

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[8]O'Connor, J.J. and Robertson, E.F. "James Clerk Maxwell." <u>History Index</u>. Nov 1997. School of Mathematics and Statistics, University of St. Andrews, Scotland. 16 March 2002 <http://www-groups.dcs.st-and.ac.uk/%7Ehistory/Mathematicians/Maxwell_House.html>. Descartes had done some similar work earlier.

[9]A testimony to their friendship and sense of humor is witnessed from the result of when in a mathematical work produced by P.G. Tait, J.C. Maxwell's initials coincidently appeared: JCM=dp/dt (from Newton's 2nd law, force is equal to this differential change in momentum with respect to time). From then on in their correspondence Maxwell would sign off with dp/dt. See the postcard in Figure 8 of Ian Hutchinson's "James Clerk Maxwell and the Christian Proposition." http://silas.psfc.mit.edu/Maxwell/maxwell.html

[10]O'Connor, J.J. and Robertson, E.F. "James Clerk Maxwell." <u>History Index</u>. Nov 1997. School of Mathematics and Statistics, University of St. Andrews, Scotland. 16 March 2002 <http://www-groups.dcs.st-and.ac.uk/%7Ehistory/Mathematicians/Maxwell_House.html>.

[11]Ibid.

they increase approximately with the square root of the absolute temperature."[12] In 1860, Maxwell was appointed to the chair of Natural Philosophy at King's College in London. Here he worked with his wife in their attic doing experiments measuring the viscosities of gases.

The next year Maxwell gave a demonstration of color photoimaging, in which he was probably the first person in history to produce a colored image of an object. (Herschel and Becqueral had taken photographs of the spectrum in 1842 and 1843, respectively.) Maxwell made this accomplishment in a way that reminds me of the way big screen televisions used to work. He projected red, green, and blue light using three black and white positive transparencies. This process is the basis of our modern color photos, but it took 90 years for this to become commercially viable. It was Maxwell who showed red, green and blue are the primary colors of light, and using color blind individuals, he showed that these colors are the three our eyes perceive.[13]

One of Professor Maxwell's four books was published in 1870. His *Theory of Heat* was a lucid and popular book, seeing 11 editions. It gave a clear explanation of thermodynamics and included some basic equations which have hence been referred to as "Maxwell relations."[14]

Although Maxwell was involved in many fields of mathematics and physics, he is most known for his electromagnetic theory and its application to light. "In the course of his mathematical work Maxwell found that the velocity of electromagnetic waves is 186,000 miles per second." This relationship to the calculated speed of light by Roemer provided great evidence of the success of the mathematics he had discovered.[15]

James Clerk Maxwell's equations for electromagnetism have revolutionized the world of physics (and the world in general, for that matter). He presented these in *Treatise on Electricity and Magnetism* in 1873. They have hence "enabled scientist to accomplish wonders with

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[12]Laidler, Keith J. "The Genius of James Clerk Maxwell Part 2. Colour, Saturn's Rings, a Demon, and a Radiometer." University of Ottawa. 6 April 2002 <http://www.science.uwaterloo.ca/physics/p13news/maxwell.html>.

[13]Ibid.

[14]Ibid.

[15]Kline, Morris. Mathematics and the Search for Knowledge. New York: Oxford U Press, 1985. pg 140.

electrical and magnetic phenomena. Not only are these equations profound [summarizing the work of all who have gone before him], comprehensive, and effective, they are also extremely beautiful and symmetric."[16] It has been said that they demonstrate "the marvellous power of pure thought, aiming only at the satisfaction of intellectual desires (e.g. beauty, order, symmetry), to control the external world."[17] These equations are "possibly the most beautiful equations until then formulated in theoretical physics."[18]

$\vec{E}$ and $\vec{B}$ are the electric and magnetic fields, respectively. The first and third equations in the box below[19] are dot product, leaving the other two involving cross products with vector solutions. $\nabla = \frac{\partial}{\partial x}\vec{i} + \frac{\partial}{\partial y}\vec{j} + \frac{\partial}{\partial z}\vec{k}$. The permittivity of free

$$\nabla \cdot \varepsilon_o \vec{E} = \rho$$
$$\nabla \times \frac{\vec{B}}{\mu_o} - \frac{\partial}{\partial t}\varepsilon_o \vec{E} = \vec{J}$$
$$\nabla \cdot \vec{B} = 0$$
$$\nabla \times \vec{E} = -\frac{\partial}{\partial t}\vec{B}$$

space $\varepsilon_o = \frac{1}{c^2 \mu_o} = 8.854\times10^{-12}$ C^2/N·m^2, and the permeability of free space is the constant $\mu_o = 4\pi\times10^{-7}$ T·m/A.[20] ρ is the charge density and $\vec{J}$ is the current density with dimensions of current per unit area.[21]

$$\vec{J} = \sum_i N_i q_i \vec{v}_i$$

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[16]Nickel, James. <u>Mathematics: Is God Silent?</u> Vallecito, CA: Ross House, 2001. pg 219.

[17]Campbell, Lewis and Garnett, William. <u>The Life and Times of James Clerk Maxwell</u>. London: Macmillan and Company, 1882. pg 156. Cited in James Nickel's <u>Mathematics: Is God Silent?</u>, pg 219-220.

[18]Jaki, Stankly L. <u>Cosmos and Creator</u>. Edinburgh: Scottish Academic Press, 1980. pg 31-32. Cited in James Nickel's <u>Mathematics: Is God Silent?</u>, pg 220.

[19]Martin, Larry. "Maxwell's equations in usual (differential) form." <u>Physics 3410 E&M Lecture Notes</u>. 30 Aug 2000. North Park University. 8 April 2002 <http://campus.northpark.edu/ physics/phys3410/day2.html>.

[20]Giancoli, Douglas C. <u>Physics: Principles with Applications</u>. 5th ed. Upper Saddle River, NJ: Prentice Hall, 1998. front inside cover.

[21]Reitz, John R., Milford, Frederick J. and Christy, Robert W. <u>Foundations of Electromagnetic Theory</u>. 4th ed. Reading, MA: Addison-Wesley, 1993. pg 166.

Maxwell, being an advocate of quaternion notion in physics, wrote many of his theorems quaternion form, using the vector operator gradient, or grad,[22] where ∇, read *del*, is the partial derivative in each of the three components as shown above. It was Sir William Hamilton who first discovered vectors and quaternions. Yet Maxwell's application of them standardized their use and "today nearly all branches of classical and modern physics are represented using the language of vectors. Vectors are also used with increasing frequency in the social and biological sciences."[23] Another amazing discovery in mathematics that found its application after Maxwell's death was his proposal of a way of generating radio waves, which he termed 'displacement current.' Many mathematical physicists of his time scoffed at both the use of vectors and Maxwell's science-fiction-like waves.[24] James Clerk Maxwell, with his Biblical Worldview and purpose for life of glorifying God and enjoying Him, would have found delight in discovering the works of God in mathematics long before his eyes could see a fruitful application of his mathematical discoveries. Knowing that he was created in God's image he knew that this was a means by which he was being used by God in fulfilling the cultural mandate of taking dominion for the glory of God (see Gen 1:28-30; Psalm 111:2).

I can also relate to Maxwell's eclectic interests. Besides the major advancement he contributed in multiple fields, he was a poet who wrote on both mathematical and literary topics. For example, in his last year at Cambridge he wrote,
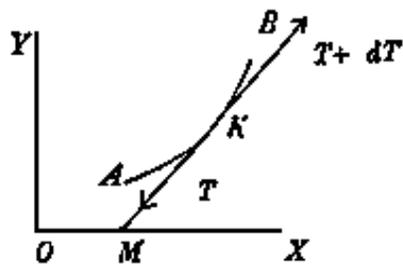
An inextensible heavy chain
Lies on a smooth horizontal plane,
An impulsive force is applied at *A*,
Required the initial motion of *K*.
Let *ds* be the infinitesimal link,

Of which for the present we've only to think;
Let *T* be the tension, and *T + dT*
The same for the end that is nearest to *B*.
Let *a* be put, by common convention,

For the angle at *M* 'twixt *OX* and the tension

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[22]Katz, Victor J. A History of Mathematics: An Introduction. 2nd ed. Reading, MA: Addison-Wesley, 1998. pg 752.

[23]Grossman, Stanley I. Calculus. New York: Academic Press, 1977. pg 658. Cited in Truth and the Transcendent: The Origin, Nature, and Purpose of Mathematic by Larry Zimmerman, 2000. pg 22.

[24]Wilder, R.H. "Mathematics and its Relations to Other Disciplines," The Mathematics Teacher, Dec. 1973, pgs 680,681. Cited in Truth and the Transcendent: The Origin, Nature, and Purpose of Mathematic by Larry Zimmerman, 2000. pg 22.

He has even inspired others with their poetry. Hanging on a wall in the home of his birth place is the following poem written in the same style as Maxwell's:[25]

Energies through the ether flow,
Waves travel to and fro,
And with a ratio
Their speed you measure.
Colours yield their secret hue,
And Saturn's rings subdued by you
Suggest that gases
Might be measured too.
Science you freed
From cramping mechanistic creed,
And by your theory brought
The elastic solid ether to naught,
And changed the axiomatic basis
Of scientific thought.
Oh Maxwell! How can I declaim

On such a genius, such a fame,

And speak of one so very wise
Who saw the world through splendid eyes,
And though of such a subtle mind
Was yet so humorous and kind?
Yours was a mind unique and rare
That, nurtured in a northern air,
Struck out new paths in many ways
Through all too short, yet fruitful days.
How can one capture in a line
Something so great, so pure, so fine?

Give thanks,
That such a man drew breath,
And lament with all the world
His early death.

Furthermore, I was impressed by Maxwell's knowledge of Scripture, at the age of eight he had memorized large sections of Milton and the entire 119th Psalm. He could give the chapter and verse for nearly any quotation from the Psalms. "A devout Christian faith and demanding mental discipline were, for Maxwell, part of the same experience."[26] As he grew into manhood his faith in Christ deepened, and his conviction in the Word of God as the standard for godly teaching and living increased. In a letter to an old friend, Rev. C.B.Taylor, on February 2, 1866, Clerk Maxwell wrote,[27]

Many people's minds seem to be shut up with solemn charms, so that though they seem Christians, and know what they mean to speak about, they can say nothing. At Cambridge I heard several sermons from

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[25]O'Connor, J.J. and Robertson, E.F. "A visit to James Clerk Maxwell's house." Scottish Index. Nov 1997. School of Mathematics and Statistics, University of St. Andrews, Scotland. 16 March 2002 <http://www-groups.dcs.st-and.ac.uk/%7Ehistory/HistTopics/ Maxwell_House.html>.

[26]Hutchinson, Ian. "James Clerk Maxwell and the Christian Proposition." MIT IAP Seminar: The Faith of Great Scientists. Jan 1998. Massachusetts Institute of Technology. 6 April 2002 <http://silas.psfc.mit.edu/Maxwell/ maxwell.html>.

[27]Campbell, Lewis and Garnet, William. The Life and Times of James Clerk Maxwell. London: Macmillan and Company, 1882. pg 345. Available online <http://www.sonnetusa.com/bio/maxbio.pdf>. pg 170.

excellent texts, but all either on other subjects or else right against the text. There is a Mr. Offord in this street, a Baptist who knows his Bible, and preaches as near it as he can, and does what he can to let the statements in the Bible be understood by his hearers. We generally go to him when in London, though we believe ourselves baptized already.

His biographer comments that while Mr. And Mrs. Maxwell were in London they would sometimes attend what was known as a "Nonconformist" church due to its simple style of worship. Here I see in Maxwell the Protestant conviction for purity in worship and doctrine. Christ's Church should not have a lot of ritual; it should be simple and regulated from Scripture alone. Also I note in Maxwell a spirit of unity of believers, in that he was willing to go wherever that gospel is preached correctly even if the pastor did not realize the Biblical basis for infant baptism.[28] "The tone of Maxwell's remarks leaves little doubt that his only awkwardness about attending the chapel arose from the doctrinal differences concerning the validity of infant baptism."[29]

Maxwell was definitely a Sabbath keeper. I can relate to his love for the writings of great thinkers who had gone before him which he would enjoy in the afternoon on the Lord's Day. I sometimes think that if someone were to come up with a truly novel theological thought, it would surely be heresy. Campbell writes, "On Sundays, after returning from the kirk [church], he would bury himself in the works of the old divines... He preferred resting on the great thoughts of other ages, though no man knew better wherein they (and scientific theories likewise) fell short of certainty; and while he was anything rather than a formalist or a dogmatist, and still clung to the belief that love remains while knowledge vanishes away, he was the enemy of indefiniteness and indifferentism, as well as of a style of preaching which, as he used to say, 'dings ye wi' mere morality.'"[30]

[28]To understand this position better see John Murray's book Christian Baptism or for a brief article on the subject see "The Biblical Basis for Infant Baptism" by James Scott from July-August 2000 issue of New Horizon. Available online <http://www.opc.org/new_horizons/NH00/0007c.html>.

[29]Hutchinson, Ian. "James Clerk Maxwell and the Christian Proposition." MIT IAP Seminar: The Faith of Great Scientists. Jan 1998. Massachusetts Institute of Technology. 6 April 2002 <http://silas.psfc.mit.edu/Maxwell/maxwell.html>.

[30]Campbell, Lewis and Garnet, William. The Life and Times of James Clerk Maxwell. London: Macmillan and Company, 1882. pg 321-322. Available online <http://www.sonnetusa.com/bio/maxbio.pdf>. pg 160.

I learnt much from his life: from his witty sense of humor to his perseverance in overcoming adversity. In their rustic home he was educated by his mother who instructed him to "look up through Nature to Nature's God"[31] until her death to cancer at the age of 48. Having spent so much time with his mother for those first 8 years of his life, her death was particularly difficult for him, although he rejoiced even in this circumstance that she was no longer in pain. Added to this injury was the insult of having a tutor whose harshness tormented young James. He grew quite close to his father who was a member of the Royal Society[32] and taught him much about how things work, giving some satisfaction to his son's inquisitive mind. But then when James was 25, while still in school, his father grew ill and died. J.C. Maxwell suffered personal illness when he fought off smallpox with the assistance of Katherine; he in turn nursed her during her frequent illnesses. At 48, in 1879, when his abdominal cancer was getting extremely painful, the minister who visited him was amazed by Maxwell's clarity and memory. Maxwell never complained and his kindness did not subside. The minister remarked how the illness had a profound effect on his whole being, yet[33]

> his firm and undoubting faith in the Incarnation and all its results; in the full sufficiency of the Atonement; in the work of the Holy Spirit. He had gauged and fathomed all the schemes and systems of philosophy, and had found them utterly empty and unsatisfying - "unworkable" was his own word about them - and he turned with simple faith to the Gospel of the Savior.

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[31] Ibid. pg 33. online pg 15.

[32] The Royal Society was an outgrowth of the Protestant Reformation's advance to Britain. Its original membership was largely Puritan despite the fact that Puritans were never more than 4% of the population. Of the inaugural membership of 1663, 42 of the 68 were definitely Puritan, and for many of the rest it is difficult to ascertain religious information. Robert Hooke wrote a memorandum in 1663 explaining the purpose of the organization; it concludes with, "All to advance the glory of God, the honour of the King, ... and the generall good of mankind." Four tenants of Puritanism promoted scientific progress.
i) Absolute authority of Scripture; reason and science are tools of dominion.
ii) God is Creator and Lawgiver, so humans have the ability, yea the duty to study His creation and laws.
iii) God has called men to a particular task in this life–vocation; Biblical principles are applicable to all activities.
iv) Optimistic eschatology- they had a positive outlook concerning progress of society based on Scriptural promises.
Nickel, James. Mathematics: Is God Silent? Vallecito, CA: Ross House, 2001. pg 130-131, 136-138.

[33] Hutchinson, Ian. "James Clerk Maxwell and the Christian Proposition." MIT IAP Seminar: The Faith of Great Scientists. Jan 1998. Massachusetts Institute of Technology. 6 April 2002 <http://silas.psfc.mit.edu/Maxwell/maxwell.html>.

About this time, Maxwell told a colleague, "The only desire which I can have is like David to serve my own generation by the will of God, and then fall asleep."[34]

I would like to not only follow his example in death, but also in life. He loved children and would upon occasion injure himself while trying to amuse them with physical comedy. He also deeply loved his wife. Beginning before their marriage he would write her and, as Scripture says, "wash her with the water of the Word"(Eph 5:26). And with nearly his dying breath he prayed for her "God help my poor wife."[35]

But overall I would like to do everything for the glory of God alone, as he conveyed in the few prayers we have recorded by him. Between 1865 and 1869, one who frequently visited Glenlair, the Maxwell estate, was "struck with the manner in which the daily prayers were conducted by the master of the household. The prayer, which seemed *extempore*, was most impressive and full of meaning."[36] They were reflections of a mind that had been transformed by being saturated with the truth of the Word of God. I see Genesis chapter 1, Psalm 8 and Hebrews 2 echoed in his following prayers:[37]

> "Almighty God, who hast created man in Thine own image, and made him a living soul that he might seek after Thee and have dominion over Thy creatures, teach us to study the works of Thy hands that we may subdue the earth to our use, and strengthen our reason for Thy service; and so to receive Thy blessed Word, that we may believe on Him whom Thou hast sent to give us the knowledge of salvation and the remission of our sins. All which we ask in the name of the same Jesus Christ our Lord."
>
> "O Lord, our Lord, how excellent is Thy name in all the earth, who hast set Thy glory above the heavens, and out of the mouths of babes and sucklings hast perfected praise. When we consider Thy heavens, the work of Thy fingers, the moon and the stars which Thou hast ordained, teach us to know that Thou art mindful of us, and visitest us, making us rulers over the works of Thy hands, showing us the wisdom of Thy laws, and crowning us with honour and glory in our earthly life; and looking higher than the heavens, may we see Jesus, made a little lower than the angels for the suffering of death, crowned with glory and honour, that He, by the grace of God, should taste death for every man. O Lord, fulfil Thy promise, and put all things in subjection under His feet. Let sin be rooted out of the earth, and let the wicked be no more. Bless Thou the Lord, O my soul, praise the Lord."

[34]Ibid.

[35]Graves, Dan. Scientists of Faith. Grand Rapids, MI: Kregel, 1996. pg 152.

[36]Campbell, Lewis and Garnet, William. The Life and Times of James Clerk Maxwell. London: Macmillan and Company, 1882. pg 323. Available online <http://www.sonnetusa.com/bio/maxbio.pdf>. pg 160.

[37]Ibid.

Bibliography

Campbell, Lewis and Garnet, William. <u>The Life and Times of James Clerk Maxwell</u>. London: Macmillan and Company, 1882. Available online <http://www.sonnetusa.com/bio/maxbio.pdf>.

Giancoli, Douglas C. <u>Physics: Principles with Applications</u>. 5th ed. Upper Saddle River, NJ: Prentice Hall, 1998.

Graves, Dan. <u>Scientists of Faith</u>. Grand Rapids, MI: Kregel, 1996.

Hutchinson, Ian. "James Clerk Maxwell and the Christian Proposition." <u>MIT IAP Seminar: The Faith of Great Scientists</u>. Jan 1998. Massachusetts Institute of Technology. 6 April 2002 <http://silas.psfc.mit.edu/Maxwell/maxwell.html>.

Jaki, Stankly L. <u>Cosmos and Creator</u>. Edinburgh: Scottish Academic Press, 1980.

Katz, Victor J. <u>A History of Mathematics: An Introduction</u>. 2nd ed. Reading, MA: Addison-Wesley, 1998.

Kline, Morris. <u>Mathematics and the Search for Knowledge</u>. New York: Oxford U Press, 1985.

Laidler, Keith J. "The Genius of James Clerk Maxwell Part 2. Colour, Saturn's Rings, a Demon, and a Radiometer." 6 April 2002 <http://www.science.uwaterloo.ca/physics/p13news/ maxwell.html>.

Martin, Larry. "Maxwell's equations in usual (differential) form." <u>Physics 3410 E&M Lecture Notes</u>. 30 Aug 2000. North Park University. 8 April 2002 <http://campus.northpark.edu/physics/phys3410/ day2.html>.

Nickel, James. <u>Mathematics: Is God Silent?</u> Vallecito, CA: Ross House, 2001.

O'Connor, J.J. and Robertson, E.F. "A visit to James Clerk Maxwell's house." <u>Scottish Index</u>. Nov 1997. School of Mathematics and Statistics, University of St. Andrews, Scotland. 16 March 2002 <http://www-groups.dcs.st-and.ac.uk/%7Ehistory/HistTopics/ Maxwell_House.html>.

- - -. "James Clerk Maxwell." <u>History Index</u>. Nov 1997. School of Mathematics and Statistics, University of St. Andrews, Scotland. 16 March 2002 <http://www-groups.dcs.st-and.ac.uk/%7Ehistory/ Mathematicians/Maxwell_House.html>.

Reitz, John R., Milford, Frederick J. and Christy, Robert W. <u>Foundations of Electromagnetic Theory</u>. 4th ed. Reading, MA: Addison-Wesley, 1993.

Zimmerman, Larry. <u>Truth & the Transcendent: The Origin, Nature, & Purpose of Mathematics</u>. 2000.