= James Clerk Maxwell =

James Clerk Maxwell FRS FRSE (13 June 1831 ? 5 November 1879) was a Scottish scientist in the field of mathematical physics . His most notable achievement was to formulate the classical theory of electromagnetic radiation , bringing together for the first time electricity , magnetism , and light as manifestations of the same phenomenon . Maxwell 's equations for electromagnetism have been called the " second great unification in physics " after the first one realised by Isaac Newton .

With the publication of A Dynamical Theory of the Electromagnetic Field in 1865 , Maxwell demonstrated that electric and magnetic fields travel through space as waves moving at the speed of light . Maxwell proposed that light is an undulation in the same medium that is the cause of electric and magnetic phenomena . The unification of light and electrical phenomena led to the prediction of the existence of radio waves .

Maxwell helped develop the Maxwell ? Boltzmann distribution , a statistical means of describing aspects of the kinetic theory of gases . He is also known for presenting the first durable colour photograph in 1861 and for his foundational work on analysing the rigidity of rod @-@ and @-@ joint frameworks (trusses) like those in many bridges .

His discoveries helped usher in the era of modern physics , laying the foundation for such fields as special relativity and quantum mechanics . Many physicists regard Maxwell as the 19th @-@ century scientist having the greatest influence on 20th @-@ century physics . His contributions to the science are considered by many to be of the same magnitude as those of Isaac Newton and Albert Einstein . In the millennium poll ? a survey of the 100 most prominent physicists ? Maxwell was voted the third greatest physicist of all time , behind only Newton and Einstein . On the centenary of Maxwell 's birthday , Einstein described Maxwell 's work as the " most profound and the most fruitful that physics has experienced since the time of Newton " .

= = Life = =

= = = Early life , 1831 ? 39 = = =

James Clerk Maxwell was born on 13 June 1831 at 14 India Street , Edinburgh , to John Clerk Maxwell of Middlebie , an advocate , and Frances Cay daughter of Robert Hodshon Cay and sister of John Cay . His father was a man of comfortable means of the Clerk family of Penicuik , holders of the baronetcy of Clerk of Penicuik . His father 's brother was the 6th Baronet . He had been born " John Clerk " , adding the surname Maxwell to his own after he inherited (as an infant in 1793) the Middlebie country estate near Corsock , Kirkcudbrightshire , from connections to the Maxwell family , themselves members of the peerage . James was the first cousin of the artist Jemima Blackburn and cousin (the son of his mother 's brother) of the civil engineer William Dyce Cay . They were close friends and Cay acted as his best man when Maxwell married .

Maxwell 's parents met and married when they were well into their thirties ; his mother was nearly 40 when he was born . They had had one earlier child , a daughter named Elizabeth , who died in infancy .

When Maxwell was young his family moved to Glenlair House , which his parents had built on the 1 @,@ 500 acres (610 ha) Middlebie estate . All indications suggest that Maxwell had maintained an unquenchable curiosity from an early age . By the age of three , everything that moved , shone , or made a noise drew the question : " what 's the go o ' that ? " In a passage added to a letter from his father to his sister @-@ in @-@ law Jane Cay in 1834 , his mother described this innate sense of inquisitiveness :

He is a very happy man , and has improved much since the weather got moderate ; he has great work with doors , locks , keys , etc . , and " show me how it doos " is never out of his mouth . He also investigates the hidden course of streams and bell @-@ wires , the way the water gets from the pond through the wall ....

= = = Education , 1839 ? 47 = = =

Recognising the potential of the young boy , Maxwell 's mother Frances took responsibility for James 's early education , which in the Victorian era was largely the job of the woman of the house . At eight he could recite long passages of Milton and the whole of the 119th psalm (176 verses) . Indeed , his knowledge of scripture was already very detailed ; he could give chapter and verse for almost any quotation from the psalms . His mother was taken ill with abdominal cancer and , after an unsuccessful operation , died in December 1839 when he was eight years old . James 's education was then overseen by his father and his father 's sister @-@ in @-@ law Jane , both of whom played pivotal roles in his life . His formal schooling began unsuccessfully under the guidance of a sixteen @-@ year @-@ old hired tutor . Little is known about the young man John hired to instruct his son , except that he treated the younger boy harshly , chiding him for being slow and wayward . John dismissed the tutor in November 1841 and , after considerable thought , sent James to the prestigious Edinburgh Academy . He lodged during term times at the house of his aunt Isabella . During this time his passion for drawing was encouraged by his older cousin Jemima .

The ten @-@ year @-@ old Maxwell , having been raised in isolation on his father 's countryside estate , did not fit in well at school . The first year had been full , obliging him to join the second year with classmates a year his senior . His mannerisms and Galloway accent struck the other boys as rustic . Having arrived on his first day of school wearing a pair of homemade shoes and a tunic , he earned the unkind nickname of " Daftie " . He never seemed to resent the epithet , bearing it without complaint for many years . Social isolation at the Academy ended when he met Lewis Campbell and Peter Guthrie Tait , two boys of a similar age who were to become notable scholars later in life . They remained lifelong friends .

Maxwell was fascinated by geometry at an early age , rediscovering the regular polyhedra before he received any formal instruction . Despite winning the school 's scripture biography prize in his second year , his academic work remained unnoticed until , at the age of 13 , he won the school 's mathematical medal and first prize for both English and poetry .

Maxwell 's interests ranged far beyond the school syllabus and he did not pay particular attention to examination performance . He wrote his first scientific paper at the age of 14 . In it he described a mechanical means of drawing mathematical curves with a piece of twine , and the properties of ellipses , Cartesian ovals , and related curves with more than two foci . His work Oval Curves was presented to the Royal Society of Edinburgh by James Forbes , a professor of natural philosophy at Edinburgh University , but Maxwell was deemed too young to present the work himself . The work was not entirely original , since René Descartes had also examined the properties of such multifocal ellipses in the seventeenth century , but he had simplified their construction .

= = = University of Edinburgh , 1847 ? 50 = = =

Maxwell left the Academy in 1847 at age 16 and began attending classes at the University of Edinburgh . He had the opportunity to attend the University of Cambridge , but decided , after his first term , to complete the full course of his undergraduate studies at Edinburgh . The academic staff of Edinburgh University included some highly regarded names ; his first year tutors included Sir William Hamilton , who lectured him on logic and metaphysics , Philip Kelland on mathematics , and James Forbes on natural philosophy . He did not find his classes at Edinburgh University very demanding , and was therefore able to immerse himself in private study during free time at the university and particularly when back home at Glenlair . There he would experiment with improvised chemical , electric , and magnetic apparatus , but his chief concerns regarded the properties of polarised light . He constructed shaped blocks of gelatine , subjected them to various stresses , and with a pair of polarising prisms given to him by William Nicol , viewed the coloured fringes that had developed within the jelly . Through this practice he discovered photoelasticity , which is a means of determining the stress distribution within physical structures .

At age 18 , Maxwell contributed two papers for the Transactions of the Royal Society of Edinburgh . One of these , On the Equilibrium of Elastic Solids , laid the foundation for an important discovery

later in his life , which was the temporary double refraction produced in viscous liquids by shear stress . His other paper was Rolling Curves and , just as with the paper Oval Curves that he had written at the Edinburgh Academy , he was again considered too young to stand at the rostrum to present it himself . The paper was delivered to the Royal Society by his tutor Kelland instead .

= = = University of Cambridge , 1850 ? 56 = = =

In October 1850 , already an accomplished mathematician , Maxwell left Scotland for the University of Cambridge . He initially attended Peterhouse , but before the end of his first term transferred to Trinity , where he believed it would be easier to obtain a fellowship . At Trinity he was elected to the elite secret society known as the Cambridge Apostles . Maxwell 's intellectual understanding of his Christian faith and of science grew rapidly during his Cambridge years . He joined the " Apostles " , an exclusive debating society of the intellectual elite , where through his essays he sought to work out this understanding .

Now my great plan , which was conceived of old , ... is to let nothing be wilfully left unexamined . Nothing is to be holy ground consecrated to Stationary Faith , whether positive or negative . All fallow land is to be ploughed up and a regular system of rotation followed . ... Never hide anything , be it weed or no , nor seem to wish it hidden . ... Again I assert the Right of Trespass on any plot of Holy Ground which any man has set apart . ... Now I am convinced that no one but a Christian can actually purge his land of these holy spots . ... I do not say that no Christians have enclosed places of this sort . Many have a great deal , and every one has some . But there are extensive and important tracts in the territory of the Scoffer , the Pantheist , the Quietist , Formalist , Dogmatist , Sensualist , and the rest , which are openly and solemnly Tabooed . ... "

Christianity ? that is , the religion of the Bible ? is the only scheme or form of belief which disavows any possessions on such a tenure . Here alone all is free . You may fly to the ends of the world and find no God but the Author of Salvation . You may search the Scriptures and not find a text to stop you in your explorations . ...

The Old Testament and the Mosaic Law and Judaism are commonly supposed to be " Tabooed " by the orthodox . Sceptics pretend to have read them , and have found certain witty objections ... which too many of the orthodox unread admit , and shut up the subject as haunted . But a Candle is coming to drive out all Ghosts and Bugbears . Let us follow the light . ' '

The extent to which Maxwell " ploughed up " his Christian beliefs and put them to the intellectual test , can be judged only incompletely from his writings . But there is plenty of evidence , especially from his undergraduate days , that he did deeply examine his faith . Certainly , his knowledge of the Bible was remarkable , so his confidence in the Scriptures was not based on ignorance .

In the summer of his third year , Maxwell spent some time at the Suffolk home of the Rev C.B. Tayler , the uncle of a class @-@ mate , G.W.H. Tayler . The love of God shown by the family impressed Maxwell , particularly after he was nursed back from ill health by the minister and his wife .

On his return to Cambridge , Maxwell writes to his recent host a chatty and affectionate letter including the following testimony ,

... I have the capacity of being more wicked than any example that man could set me , and ... if I escape , it is only by God 's grace helping me to get rid of myself , partially in science , more completely in society , ? but not perfectly except by committing myself to God ...

In November 1851 , Maxwell studied under William Hopkins , whose success in nurturing mathematical genius had earned him the nickname of " senior wrangler @-@ maker " .

In 1854 , Maxwell graduated from Trinity with a degree in mathematics . He scored second highest in the final examination , coming behind Edward Routh and earning himself the title of Second Wrangler . He was later declared equal with Routh in the more exacting ordeal of the Smith 's Prize examination . Immediately after earning his degree , Maxwell read his paper On the Transformation of Surfaces by Bending to the Cambridge Philosophical Society . This is one of the few purely mathematical papers he had written , demonstrating Maxwell 's growing stature as a mathematician . Maxwell decided to remain at Trinity after graduating and applied for a fellowship , which was a

process that he could expect to take a couple of years . Buoyed by his success as a research student , he would be free , apart from some tutoring and examining duties , to pursue scientific interests at his own leisure .

The nature and perception of colour was one such interest which he had begun at Edinburgh University while he was a student of Forbes . With the coloured spinning tops invented by Forbes , Maxwell was able to demonstrate that white light would result from a mixture of red , green , and blue light . His paper Experiments on Colour laid out the principles of colour combination and was presented to the Royal Society of Edinburgh in March 1855 . Maxwell was this time able to deliver it himself .

Maxwell was made a fellow of Trinity on 10 October 1855 , sooner than was the norm , and was asked to prepare lectures on hydrostatics and optics and to set examination papers . The following February he was urged by Forbes to apply for the newly vacant Chair of Natural Philosophy at Marischal College , Aberdeen . His father assisted him in the task of preparing the necessary references , but died on 2 April at Glenlair before either knew the result of Maxwell 's candidacy . Maxwell accepted the professorship at Aberdeen , leaving Cambridge in November 1856 .

= = = Marischal College , Aberdeen , 1856 ? 60 = = =

The 25 @-@ year @-@ old Maxwell was a good fifteen years younger than any other professor at Marischal . He engaged himself with his new responsibilities as head of a department , devising the syllabus and preparing lectures . He committed himself to lecturing 15 hours a week , including a weekly pro bono lecture to the local working men 's college . He lived in Aberdeen during the six months of the academic year and spent the summers at Glenlair , which he had inherited from his father .

He focused his attention on a problem that had eluded scientists for two hundred years : the nature of Saturn 's rings . It was unknown how they could remain stable without breaking up , drifting away or crashing into Saturn . The problem took on a particular resonance at that time because St John 's College , Cambridge had chosen it as the topic for the 1857 Adams Prize . Maxwell devoted two years to studying the problem , proving that a regular solid ring could not be stable , while a fluid ring would be forced by wave action to break up into blobs . Since neither was observed , Maxwell concluded that the rings must be composed of numerous small particles he called " brick @-@ bats " , each independently orbiting Saturn . Maxwell was awarded the £ 130 Adams Prize in 1859 for his essay On the stability of the motion of Saturn 's rings ; he was the only entrant to have made enough headway to submit an entry . His work was so detailed and convincing that when George Biddell Airy read it he commented " It is one of the most remarkable applications of mathematics to physics that I have ever seen . " It was considered the final word on the issue until direct observations by the Voyager flybys of the 1980s confirmed Maxwell 's prediction .

In 1857 Maxwell befriended the Reverend Daniel Dewar , who was then the Principal of Marischal . Through him Maxwell met Dewar 's daughter , Katherine Mary Dewar . They were engaged in February 1858 and married in Aberdeen on 2 June 1858 . On the marriage record , Maxwell is listed as Professor of Natural Philosophy in Marischal College , Aberdeen . Seven years Maxwell 's senior , comparatively little is known of Katherine , although it is known that she helped in his lab and worked on experiments in viscosity . Maxwell 's biographer and friend , Lewis Campbell , adopted an uncharacteristic reticence on the subject of Katherine , though describing their married life as " one of unexampled devotion " .

In 1860 Marischal College merged with the neighbouring King 's College to form the University of Aberdeen . There was no room for two professors of Natural Philosophy , so Maxwell , despite his scientific reputation , found himself laid off . He was unsuccessful in applying for Forbes 's recently vacated chair at Edinburgh , the post instead going to Tait . Maxwell was granted the Chair of Natural Philosophy at King 's College , London , instead . After recovering from a near @-@ fatal bout of smallpox in 1860 , Maxwell moved to London with his wife .

= = = King 's College , London , 1860 ? 65 = = =

Maxwell 's time at King 's was probably the most productive of his career . He was awarded the Royal Society 's Rumford Medal in 1860 for his work on colour and was later elected to the Society in 1861 . This period of his life would see him display the world 's first light @-@ fast colour photograph , further develop his ideas on the viscosity of gases , and propose a system of defining physical quantities ? now known as dimensional analysis . Maxwell would often attend lectures at the Royal Institution , where he came into regular contact with Michael Faraday . The relationship between the two men could not be described as being close , because Faraday was 40 years Maxwell 's senior and showed signs of senility . They nevertheless maintained a strong respect for each other 's talents .

This time is especially noteworthy for the advances Maxwell made in the fields of electricity and magnetism . He examined the nature of both electric and magnetic fields in his two @-@ part paper On physical lines of force , which was published in 1861 . In it he provided a conceptual model for electromagnetic induction , consisting of tiny spinning cells of magnetic flux . Two more parts were later added to and published in that same paper in early 1862 . In the first additional part he discussed the nature of electrostatics and displacement current . In the second additional part , he dealt with the rotation of the plane of the polarisation of light in a magnetic field , a phenomenon that had been discovered by Faraday and is now known as the Faraday effect .

= = = Later years , 1865 ? 1879 = = =

In 1865 Maxwell resigned the chair at King 's College , London , and returned to Glenlair with Katherine . In his paper On reciprocal figures , frames and diagrams of forces (1870) he discussed the rigidity of various designs of lattice . He wrote the textbook Theory of Heat (1871) and the treatise Matter and Motion (1876) . Maxwell was also the first to make explicit use of dimensional analysis , in 1871 .

In 1871 he became the first Cavendish Professor of Physics at Cambridge . Maxwell was put in charge of the development of the Cavendish Laboratory , supervising every step in the progress of the building and of the purchase of the collection of apparatus . One of Maxwell 's last great contributions to science was the editing (with copious original notes) of the research of Henry Cavendish , from which it appeared that Cavendish researched , amongst other things , such questions as the density of the Earth and the composition of water .

Maxwell died in Cambridge of abdominal cancer on 5 November 1879 at the age of 48 . His mother had died at the same age of the same type of cancer . The minister who regularly visited him in his last weeks was astonished at his lucidity and the immense power and scope of his memory , but comments more particularly ,

... his illness drew out the whole heart and soul and spirit of the man : 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 Saviour .

As death approached Maxwell told a Cambridge colleague

I have been thinking how very gently I have always been dealt with . I have never had a violent shove all my life . The only desire which I can have is like David to serve my own generation by the will of God , and then fall asleep .

Maxwell is buried at Parton Kirk , near Castle Douglas in Galloway close to where he grew up . The extended biography The Life of James Clerk Maxwell , by his former schoolfellow and lifelong friend Professor Lewis Campbell , was published in 1882 . His collected works were issued in two volumes by the Cambridge University Press in 1890 .

= = = Personality = = =

As a great lover of Scottish poetry , Maxwell memorised poems and wrote his own . The best

known is Rigid Body Sings , closely based on " Comin ' Through the Rye " by Robert Burns , which he apparently used to sing while accompanying himself on a guitar . It has the opening lines

Gin a body meet a body
Flyin ' through the air .
Gin a body hit a body ,
Will it fly ? And where ?

A collection of his poems was published by his friend Lewis Campbell in 1882 . Descriptions of Maxwell remark upon his remarkable intellectual qualities being matched by social awkwardness .

Maxwell was an evangelical Presbyterian and in his later years became an Elder of the Church of Scotland . Maxwell 's religious beliefs and related activities have been the focus of a number of papers . Attending both Church of Scotland (his father 's denomination) and Episcopalian (his mother 's denomination) services as a child , Maxwell later underwent an evangelical conversion in April 1853 . One facet of this conversion may have aligned him with an antipositivist position .

= = Scientific legacy = =

= = = Electromagnetism = = =

Maxwell had studied and commented on electricity and magnetism as early as 1855 when his paper On Faraday 's lines of force was read to the Cambridge Philosophical Society . The paper presented a simplified model of Faraday 's work and how the two phenomena were related . He reduced all of the current knowledge into a linked set of differential equations with 20 equations in 20 variables . This work was later published as On Physical Lines of Force in March 1861 .

Around 1862 , while lecturing at King 's College , Maxwell calculated that the speed of propagation of an electromagnetic field is approximately that of the speed of light . He considered this to be more than just a coincidence , commenting , " We can scarcely avoid the conclusion that light consists in the transverse undulations of the same medium which is the cause of electric and magnetic phenomena . "

Working on the problem further , Maxwell showed that the equations predict the existence of waves of oscillating electric and magnetic fields that travel through empty space at a speed that could be predicted from simple electrical experiments ; using the data available at the time , Maxwell obtained a velocity of 310 @,@ 740 @,@ 000 metres per second (1 @.@ 0195 × 109 ft / s) . In his 1864 paper A Dynamical Theory of the Electromagnetic Field , Maxwell wrote , " The agreement of the results seems to show that light and magnetism are affections of the same substance , and that light is an electromagnetic disturbance propagated through the field according to electromagnetic laws " .

His famous equations , in their modern form of four partial differential equations , first appeared in fully developed form in his textbook A Treatise on Electricity and Magnetism in 1873 . Most of this work was done by Maxwell at Glenlair during the period between holding his London post and his taking up the Cavendish chair . Maxwell expressed electromagnetism in the algebra of quaternions and made the electromagnetic potential the centrepiece of his theory . In 1881 Oliver Heaviside replaced Maxwell 's electromagnetic potential field by ' force fields ' as the centrepiece of electromagnetic theory . Heaviside reduced the complexity of Maxwell 's theory down to four differential equations , known now collectively as Maxwell 's Laws or Maxwell 's equations . According to Heaviside , the electromagnetic potential field was arbitrary and needed to be " murdered " . The use of scalar and vector potentials is now standard in the solution of Maxwell 's equations .

A few years later there was a debate between Heaviside and Peter Guthrie Tait about the relative merits of vector analysis and quaternions . The result was the realisation that there was no need for the greater physical insights provided by quaternions if the theory was purely local , and vector analysis became commonplace . Maxwell was proven correct , and his quantitative connection between light and electromagnetism is considered one of the great accomplishments of 19th century

mathematical physics .

Maxwell also introduced the concept of the electromagnetic field in comparison to force lines that Faraday described . By understanding the propagation of electromagnetism as a field emitted by active particles , Maxwell could advance his work on light . At that time , Maxwell believed that the propagation of light required a medium for the waves , dubbed the luminiferous aether . Over time , the existence of such a medium , permeating all space and yet apparently undetectable by mechanical means , proved impossible to reconcile with experiments such as the Michelson ? Morley experiment . Moreover , it seemed to require an absolute frame of reference in which the equations were valid , with the distasteful result that the equations changed form for a moving observer . These difficulties inspired Albert Einstein to formulate the theory of special relativity ; in the process Einstein dispensed with the requirement of a stationary luminiferous aether .

= = = Colour vision = = =

As most physicists of the time , Maxwell had a strong interest in psychology . He was particularly interested , following the steps of Isaac Newton and Thomas Young , in the study of colour vision . From 1855 to 1872 , he published at intervals a series of investigations concerning the perception of colour , colour @-@ blindness , and colour theory , and was awarded the Rumford Medal for On the Theory of Colour Vision .

Isaac Newton had demonstrated , using prisms , that white lights , such as sunlight , are composed of a number of monochromatic components which could then be recombined into white light . Newton also showed that an orange paint made of yellow and red could look exactly like a monochromatic orange light , although being composed of two monochromatic yellow and red lights . Hence the paradox that puzzled physicists of the time : two complex lights (composed of more than one monochromatic light) could look alike but be physically different , called metameres . Thomas Young later proposed that this paradox could be explained by colours being perceived through a limited number of channels in the eyes , which he proposed to be threefold , the trichromatic color theory . Maxwell used the recently developed Linear algebra to prove Young 's theory . Any monochromatic light stimulating three receptors should be able to be equally stimulated by a set of three different monochromatic lights (in fact , by any set of three different lights) . He demonstrated that to be the case , inventing color matching experiments and Colorimetry .

Maxwell was also interested in applying his theory of color perception , namely in colour photography . Stemming directly from his psychological work on colour perception : if a sum of any three lights could reproduce any perceivable colour , then colour photographs could be produced with a set of three colored filters . In the course of his 1855 paper , Maxwell proposed that , if three black @-@ and @-@ white photographs of a scene were taken through red , green and blue filters and transparent prints of the images were projected onto a screen using three projectors equipped with similar filters , when superimposed on the screen the result would be perceived by the human eye as a complete reproduction of all the colours in the scene .

During an 1861 Royal Institution lecture on colour theory , Maxwell presented the world 's first demonstration of colour photography by this principle of three @-@ colour analysis and synthesis . Thomas Sutton , inventor of the single @-@ lens reflex camera , took the picture . He photographed a tartan ribbon three times , through red , green , and blue filters , also making a fourth photograph through a yellow filter , which , according to Maxwell 's account , was not used in the demonstration . Because Sutton 's photographic plates were insensitive to red and barely sensitive to green , the results of this pioneering experiment were far from perfect . It was remarked in the published account of the lecture that " if the red and green images had been as fully photographed as the blue , " it " would have been a truly @-@ coloured image of the riband . By finding photographic materials more sensitive to the less refrangible rays , the representation of the colours of objects might be greatly improved . " Researchers in 1961 concluded that the seemingly impossible partial success of the red @-@ filtered exposure was due to ultraviolet light , which is strongly reflected by some red dyes , not entirely blocked by the red filter used , and within the range of sensitivity of the wet collodion process Sutton employed .

= = = Kinetic theory and thermodynamics = = =

Maxwell also investigated the kinetic theory of gases . Originating with Daniel Bernoulli , this theory was advanced by the successive labours of John Herapath , John James Waterston , James Joule , and particularly Rudolf Clausius , to such an extent as to put its general accuracy beyond a doubt ; but it received enormous development from Maxwell , who in this field appeared as an experimenter (on the laws of gaseous friction) as well as a mathematician .

Between 1859 and 1866 , he developed the theory of the distributions of velocities in particles of a gas , work later generalised by Ludwig Boltzmann . The formula , called the Maxwell ? Boltzmann distribution , gives the fraction of gas molecules moving at a specified velocity at any given temperature . In the kinetic theory , temperatures and heat involve only molecular movement . This approach generalised the previously established laws of thermodynamics and explained existing observations and experiments in a better way than had been achieved previously . Maxwell 's work on thermodynamics led him to devise the thought experiment that came to be known as Maxwell 's demon , where the second law of thermodynamics is violated by an imaginary being capable of sorting particles by energy .

In 1871 he established Maxwell 's thermodynamic relations , which are statements of equality among the second derivatives of the thermodynamic potentials with respect to different thermodynamic variables . In 1874 , he constructed a plaster thermodynamic visualisation as a way of exploring phase transitions , based on the American scientist Josiah Willard Gibbs 's graphical thermodynamics papers .

= = = Control theory = = =

Maxwell published a paper On governors in the Proceedings of Royal Society , vol . 16 (1867 ? 1868) . This paper is considered a central paper of the early days of control theory . Here " governors " refers to the governor or the centrifugal governor used to regulate steam engines .

= = Legacy = =

His name is honoured in several ways :

The maxwell (Mx) , a compound derived CGS unit measuring magnetic flux

IEEE Maxwell Award

Maxwell Montes , a mountain range on Venus

The Maxwell Gap in the Rings of Saturn

The James Clerk Maxwell Telescope , the largest submillimetre @-@ wavelength astronomical telescope in the world , with a diameter of 15 metres (49 ft)

The James Clerk Maxwell Building of the University of Edinburgh , housing the schools of mathematics , physics and meteorology

The James Clerk Maxwell building at the Waterloo campus of King 's College London , a chair in Physics , and a society for undergraduate physicists are named after him at the university .

The James Clerk Maxwell Centre of the Edinburgh Academy

The Maxwell Centre at the University of Cambridge , dedicated to academia @-@ industry interactions in Physical Sciences and Technology .

A statue on Edinburgh 's George Street

GPU manufacturer Nvidia has named the architecture of its GeForce 900 series after Maxwell

A proposed sculpture called the Star of Caledonia is to pay tribute to James Clerk Maxwell

ANSYS software for electromagnetic analysis , named Maxwell

= = Publications = =

Maxwell , James Clerk (1873) , A treatise on electricity and magnetism Vol I , Oxford : Clarendon

Press
Maxwell , James Clerk (1873) , A treatise on electricity and magnetism Vol II , Oxford : Clarendon Press
Maxwell , James Clerk (1881) , An Elementary treatise on electricity , Oxford : Clarendon Press
Maxwell , James Clerk (1890) , The scientific papers of James Clerk Maxwell Vol I , Dover Publication
Maxwell , James Clerk (1890) , The scientific papers of James Clerk Maxwell Vol II , Cambridge , University Press
Maxwell , James Clerk (1908) , Theory of heat , Longmans Green Co .
Three of Maxwell 's contributions to Encyclopædia Britannica appeared in the Ninth Edition (1878) : Atom , [1] Attraction , [2] , and Ether [3] ; and three in the Eleventh Edition (1911) : Capillary Action , [4] Diagram , [5] and Faraday , Michael [6] .