Archimedes to Hawking

*Archimedes of Syracuse (287-212BC)*

* Greek mathematician and inventor.
* Discovered the principle of buoyancy c. 250BC. The buoyant force an object feels when submerged depends on the density of the liquid and the volume of the object, not the shape of the object or the material it is composed of and is equal to the weight of the displaced liquid.
* He came close to formulating integral calculus and calculated an extremely precise value for pi.
* He was obsessed with mathematics and his servants had to force him to take baths.
* He sometimes sent his colleagues false theorems to trap them when they stole his ideas.

*Johannes Kepler (1571-1630)*

* German astronomer and theologian-cosmologist.
* Discovered three laws of planetary motion.
  1. Law of Orbits (1609). All planets in the solar system move in elliptical orbits with the sun at one focus.
  2. Law of Equal Areas (1618). A planet moves slower as it recedes from the sun and accelerates as it approaches the sun. This means that in equal intervals of time, an imaginary line connecting the sun and the planet sweeps out an equal area.
  3. Law of Periods (1618). The square of the planet’s ‘year’ is a multiple of the cube of the planet’s distance from the sun.
* In 1601, Kepler became imperial mathematician at Prague after Tycho Brahe died.
* His initial vision of the universe resulted in the Platonic Solid model of the solar system. An outer sphere represents heaven. Inside this follows a cube (6 equal faces), a tetrahedron (4 equal faces), a dodecahedron (12 equal faces), an isocahedron (20 equal faces) and an octahedron (8 equal faces). Each planets orbit is represented by a sphere and is interspersed between the polygons.
* He was very religious and actually wanted to become a theologian.
* His mother was accused of being a witch in 1617 but was finally freed in 1621.
* He wrote a science fiction book called *Somnium*.
* He was bow-legged, often afflicted with large boils and suffered from poor vision.

*Willebrord Snell (1580-1626)*

* Dutch astronomer and mathematician.
* In 1621, he formulated the law of refraction. The angle of refraction of light that travels between two media depends on the refractive indices of the media. Some refractive indices include vacuum, 1 and water, 1.333.

*Robert Hooke (1635-1702)*

* English physicist and polymath.
* Discovered the law of elasticity in 1660. The size of a material deformation is directly proportional to the deforming force. So, if an object is elongated by a distance, x, the restoring force exerted by the object is proportional to x.
* Was one of the main proponents of evolution at a time when most people were confused by fossils.
* He was so sick as a child, he wasn’t expected to reach adulthood.
* In 1665, he published *Micrographia*.
* He was a prolific inventor, especially regarding clocks.
* Although he didn’t discover the law of gravitation, it seems that he contributed to Newton’s thinking on the subject.
* He was a physically weak and deformed man.

*Robert Boyle (1626-1691)*

* Irish chemist, physicist and inventor.
* In 1662, he discovered Boyle’s gas law. The relationship between pressure and volume of a quantity of gas is nearly constant. This is most obvious when we breathe. Our diaphragms move downward, increasing the lung volume and reducing the pressure so air flows into the lungs.
* He also conducted research in alchemy.
* He believed that the mechanical universe only proved God’s existence even more and was a devout Christian.

*Isaac Newton (1642-1727)*

* British mathematician and physicist.
* In 1687, he published his laws of motion.
  + Law of Inertia. Bodies do not alter their motions unless forces are applied to them. This demolished the Aristotelian theory that force is required to move an object and the natural state is rest.
  + F = ma or F = dp / dt. Relates the force to the momentum or acceleration.
  + For every action there is an equal and opposite reaction.
* He also published his law of universal gravitation in 1687. Every material object attracts any other material object with a force that varies directly as a product of the masses and inversely as the square of the distance that separates the objects.
* The Principia was published in three volumes.
  + In book 1, he states his three laws and discusses the motions of objects in a vacuum.
  + In book 2, he discusses the motions of fluids and objects in resistive media.
  + In book 3, he discusses gravity and uses it to explain the motions of all objects in outer space.
* In 1701, he also published his law of cooling. The rate of heat loss of a body is proportional to the difference in temperature between the body and its surroundings.
* He published his *Opticks* in 1703, after Robert Hooke died.
* He didn’t know what caused gravity.
* He invented calculus, proved that white light was a mixture of colours, explained the rainbow, built the first reflecting telescope, discovered binomial theorem and much more.
* Amazingly, he spent much more time analysing ancient Biblical texts and writing about religious matters than he did about science. He rejected Trinitarian beliefs and thought that Christianity had gone wrong at the Council of Nicaea.
* At one point, he thought that all the objects in the universe and their motions were the thoughts of God.
* He may have had bipolar disorder and was extremely reticent and humourless. He had more than one mental breakdown in his life. After a breakdown in 1693, he retired from research and a few years later became Warden of the Royal Mint. It was his idea to make coins with ridged edges to prevent criminals from trimming coins to make new ones.
* It was said that he could be entertaining his friends and then leave to get something to drink, or some other matter, and never return, having gotten lost in thought and forgetting all about his guests and the task.
* Another story says that Johann Bernoulli posed a set of mathematical problems in 1696 for mathematicians to ponder in the coming century. Newton got the list and solved one problem after work one night. He gave it to his secretary and told her to send it anonymously to Bernoulli, but Bernoulli immediately recognised Newton as the author.

*Daniel Bernoulli (1700-1782)*

* Dutch born, Swiss mathematician, physicist and medical doctor.
* In 1738, in a book called *Hydrodynamica,* he discovered the law of fluid dynamics. The total energy of fluid pressure, gravitational potential energy and kinetic energy of a moving fluid remain constant. For liquid flowing in a pipe, an increase in velocity occurs simultaneously with a decrease in pressure.
* Bernoulli’s law explains why a shower curtain is pulled inwards when you turn the shower on and why aeroplanes rise. It also gives rise to the *Venturi effect* which occurs when a constricted region in a tube has liquid or air flowing through it and this movement creates a reduction in pressure which sucks something through.
* Daniel’s father, Johann was also a gifted mathematician. His father was also jealous of his son’s work and tried to plagiarise some of his ideas.

*Johann Heinrich Lambert (1728-1777)*

* Swiss-German mathematician and physicist.
* Discovered the law of emission in 1760. The intensity emitted in any direction is proportional to the cosine of the angle between the direction of radiation and the normal (perpendicular) of the surface.
* Lambert was an extreme polymath publishing more than 150 works on extremely varied subjects.

*Johann Elert Bode (1747-1826)*

* German astronomer.
* Discovered the law of planetary distances. The mean distances of the planets from the sun are related by taking the sequence 0, 3, 6, 12, 24..., adding 4 to each number and dividing by 10.
* It turns out Bode didn’t discover the relation. He just read about it in an obscure book in which German astronomer Johann Titius noted it.

*Charles-Augustin de Coulomb (1736-1806)*

* French physicist.
* In 1785 outlined the law of electrostatics. The force of attraction or repulsion between two electric charges is proportional to the magnitude of the charges and inversely proportional to the square of their separation distance. This is very similar to gravity.

*Jacques Charles (1746-1823)*

* French mathematician, physicist and inventor.
* In 1787, he formulated his gas law. At constant pressure, the volume occupied by a fixed amount of gas is directly proportional to its absolute temperature. This basically explains the way that a heated gas will expand.
* He was the first person to ascend in a hydrogen balloon. When he landed in a field the French peasants tore the balloon apart thinking it was some horrible creature.

*John Dalton (1766-1844)*

* English chemist, physicist and meteorologist.
* Discovered the law of partial pressures in 1801. Each gas in a mixture of gases exerts a pressure as if the other gases were not present and the total pressure of the gases is the sum of the pressures created by each gas.
* This law is leads directly to the method of gas collection involving displacing water from a bottle.
* He was colour blind and was the first person to investigate this scientifically.
* Was a leading proponent of the atomic hypothesis and was central to many chemistry advances. He has in fact been called the father of modern chemistry and of the atomic theory.
* He also asserted that it was impossible to create or destroy matter. All we can do is change its form.
* When he died more than 40,000 people filed past his coffin and stores and offices closed for the day out of respect.

*William Henry (1774-1836)*

* British chemist.
* Discovered his gas law in 1802. The amount of gas dissolved in a liquid is proportional to the pressure of the gas above the liquid.
* This law explains the cracking in joints. Gases dissolved in the synovial fluid in joints rapidly come out of the solution as the joint is stretched and pressure is decreased. This sudden formation and collapse of bubbles in liquids produces the crack. It also explains why gas bubbles in a fizzy drink bubble out of the can after it is opened.
* Henry was in constant pain through most of his life and it finally caused him to kill himself in 1836.

*Joseph Louis Gay-Lussac (1778-1850)*

* French chemist and physicist.
* Formulated his law of combining gas volumes in 1808. The volumes of gases that chemically react with each other, or are produced in reactions, are expressed in ratios of small, whole numbers. E.g. 3 volumes hydrogen + 1 volume oxygen => 2 volumes water vapour.

*Amadeo Avogadro (1776-1856)*

* Italian physicist and chemist.
* Discovered his gas law in 1811. Equal volumes of gas contain the same number of molecules.
* Avogadro’s number is 6.0221367 x 1023 and is the number of atoms found in mole of an element and more particularly the number of carbon-12 atoms in 12 grams of carbon-12. A mole is also the amount of an element that has the same number of grams as the value of the atomic weight of the substance.
* He also correctly postulated diatomic gases. (gases whose molecules are composed of two atoms, i.e. O2)

*David Brewster (1781-1868)*

* Scottish physicist and science writer.
* Discovered his law of light polarization in 1815. The amount of polarization of light reflected from a transparent surface is a maximum when the reflected ray is at right-angles to the refracted ray. The *Brewster angle* is the angle at which the reflected and refracted beams are at right angles.
* He created the kaleidoscope (*kalos* (beautiful), *eidos* (form) and *scopos* (watcher)) which rapidly became the most sought after ‘toy’ at the time. Because of a flaw in the patent he acquired, he didn’t receive any money from it though.
* He also invented the lenticular stereoscope, which produced the illusion of a 3D object. This also became very popular.
* He was knighted in 1831.

*Dulong-Petit Law of Specific Heats*

* Discovered in 1819, this law says the specific heats (a measure of how much energy is required to increase the temperature of an element or how well a substance stores heat. A low number means it heats up easily) of elements are in inverse proportion to their atomic weights.

*Jean-Baptiste Biot (1774-1862) and Felix Savart (1791-1841)*

* Discovered the law of magnetic force. Current through a wire causes a magnetic field around the wire, the magnitude of which is inversely proportional to the square of the distance from the wire.
* Biot was a French physicist who convinced scientists that meteorites came from the sky.
* Savart was a French physicist.

*Jean-Baptiste Joseph Fourier (1768-1830)*

* French mathematician and Egyptologist.
* Discovered his law of heat conduction in 1822. The rate of heat flow between two points in a material is proportional to the difference in the temperatures of the points and inversely proportional to the distance between the two points. Heat energy always transfers from high to low temperatures through conduction.
* Accompanied Napoleon to Egypt in 1789.
* He was always cold and never left the house without a coat.
* During his last months, he had to spend most of his time in a large box to support his body which was so weakened by chronic rheumatism.

*Andre-Marie Ampere (1775-1836)*

* French physicist.
* Discovered the circuital law of electromagnetism in 1825. The magnetic circulation in free space is proportional to the electric current.
* Ampere expanded on Danish physicist, Hans Christian Orsted’s discovery in 1819, that a compass needle moves when an electric current is switched on or off in a nearby wire.
* Believed he had proven the existence of the soul and of God.
* Ampere was a genius who was performing arithmetic with pebbles before he could talk.
* He established that two electric currents repel each other when moving in opposite directions and attract each other when moving in the same direction.

*Georg Ohm (1787-1854)*

* German physicist.
* Discovered his law of electricity in 1827. The current flow is proportional to the voltage and inversely proportional to the resistance.
* His work was largely ignored by his contemporaries for many years.

*Thomas Graham (1805-1869)*

* Scottish chemist.
* Discovered his law of effusion in 1829. The rates of effusion of two gases are inversely proportional to square roots of the gases’ densities. At equal pressure and temperature, less massive gases will effuse more rapidly than more massive gases.

*Michael Faraday (1791-1867)*

* British physicist and chemist.
* Discovered his law of induction in 1831. A changing magnetic field produces an electric field. The faster the magnetic field changes the more electricity it produces.
* Discovered his law of electrolysis in 1833. During electrolysis, the amount of chemical change that a current produces is proportional to the amount of electricity used and the amounts of chemical change produced by the same quantity of electricity in different substances is proportional to their equivalent weights. (Note: in electrolysis the electrode attached to the negative node of the battery is called the cathode; the positive end electrode is called the anode)
* Faraday was a handsome man.
* Humphrey Davy, for whom Farady worked, often experimented on gases by inhaling them. This practice was nearly fatal, but did lead to the discovery of nitrous oxide (laughing gas).
* He was born in almost complete poverty and had almost no formal education and may in fact, have had dyslexia.
* As Faraday became more and more famous, Davy became extremely jealous and accused Faraday of stealing ideas from colleagues.
* He was elected to the Royal Society in 1824.
* Later, in the 1860s and 1870s, Maxwell built on Faraday’s foundations to formulate the complete electromagnetic field theory. Faraday had no mathematical background so it was up to Maxwell to take care of that part of the theory.
* In 1839, he suffered a nervous breakdown.
* In 1844, he was suspended as an elder of his Sandemanian church for missing a single Sunday service – the only time he ever missed a service in his life! (Because he was dining with Queen Victoria)
* In 1845, Faraday also discovered diamagnetism, a phenomenon that only manifests when materials are placed in an externally applied magnetic field.

*Carl Friedrich Gauss (1777-1855)*

* German mathematician, astronomer and scientist.
* Discovered the law of electricity in 1835. The electric flux across any closed surface is proportional to the net electric charge enclosed by the surface. (Note: flux is a measure of the number of lines of force that cut through a hypothetical surface in the field)
* In 1835, he also discovered his law of magnetism. The net magnetic flux across any closed surface is zero. This also says that no isolated magnetic poles (monopoles) exist.
* He was one of the most brilliant mathematicians of all time and was a child prodigy. This led to a lot of probably false stories about his childhood, but because his genius was such, they came to be believed. As a teenager, he frequently made discoveries and solved or proved theorems before he found out that they had already been solved or discovered.
* In 1796, when he was still a teenager, he found a means by which to construct a regular 17-gon, using just a ruler and compass. This had been attempted since the time of Euclid. He asked that the 17-gon be placed on his tombstone when he died.
* At one point, the asteroid Ceres disappeared behind the sun and was lost. Gauss used mathematical methods (which he kept secret) to find it again.
* Gauss was extremely secretive about his work. If Gauss published or released all of his discoveries when he made them, mathematics would have been advanced by fifty years. So many novel theories and findings were retrieved from his notes after he died that mathematicians were kept busy for decades.

*Jean Poiseuille (1797-1869)*

* French physician and physiologist.
* Discovered his law of fluid flow in 1840. Flow rate in a tube is determined by the viscosity of the fluid (inversely proportional to the tube length and to the viscosity of the fluid), the change in pressure along the tube (directly proportional to the pressure difference between the ends of the tube) and the radius of the tube (directly proportional to the fourth power of the radius).
* In medicine, this law indicates that a small decrease in the radius of a blood vessel can create a marked decrease (to the power of a fourth) in blood flow. The body can automatically control this sometimes, through vasoconstriction and vasodilation, for example, on cold days when the vessels to the legs and arms are constricted to prevent cold blood from returning to the main part of the body.

*James Joule (1818-1889)*

* British physicist.
* Discovered his law of electric heating in 1840. The amount of heat produced by a steady electric current is proportional to the resistance of the conductor, to the square of the current and to the duration of the current.
* Him and his brother were educated at home for about 4 years by John Dalton.
* His experiments suggested a conservation of energy.

*Gustav Kirchhoff (1824-1887)*

* German mathematician.
* In 1845, he discovered his electrical circuit laws.
  1. Kirchhoff’s current law. The sum of the currents into a circuit junction equals the sum of the currents out of the junction.
  2. Kirchhoff’s voltage law. The sum of the voltage changes around a circuit loop are zero.
* In 1859, he discovered his thermal radiation law. The ratio of absorptive and emissive power for a radiating body is a function of wavelength and temperature. This means that an object radiates a unique spectrum that depends on the object’s temperature and emissivity. (Emissivity is the ratio of an object’s radiant energy compared to the radiant energy of a blackbody with the same temperature as the object) (A blackbody is an object that absorbs all electromagnetic energy incident upon it and emits the maximum possible amount of radiant energy at any given temperature)
* One consequence of this law is that good reflectors are poor emitters. Another is that a material capable of emitting a particular spectral line also absorbs strongly at the same frequency.
* All matter emits radiant energy as thermal energy because all matter has a temperature and a constant motion of its atoms.
* In the early 1860’s, Kirchhoff made three assertions concerning the spectra of objects.
  + A hot, opaque body produces a continuous spectrum.
  + A hot, transparent (i.e. low-density) gas produces an emission line (‘bright-line’) spectrum. I.e. the gas emits mostly at specific wavelengths according to the electron configuration of the atoms in the gas.
  + The combination of a cool, transparent (i.e. low density) gas in front of a source of continuous emission produces an absorption-line spectrum. I.e. a continuous spectrum with dark gaps at the same wavelengths as the emission lines described in the second assertion about spectra.
* Bright lines occur in spectra when electrons jump from higher energy levels down to lower energy levels. The colour of the lines depends on the energy difference between the energy levels. Dark absorption lines occur when an atom absorbs light and the electron jumps to a higher energy level. Kirchhoff was the first person to attribute the dark lines in the sun’s spectrum to the absorption of light as the light passes through gases in the atmosphere of the sun.

*Rudolf Clausius (1822-1888)*

* German mathematical physicist.
* He discovered his law of thermodynamics (the second one) in 1850. Heat always flows spontaneously from a hotter to a colder object. (Clausius’ first formulation) We cannot finish any real process with as much useful energy as we started with because some energy is always wasted. (Lord Kelvin defined it this way) The entropy of the universe tends to a maximum or all matter and energy in the universe tends to evolve to a state of uniformity (lots of entropy and lots of information).[[1]](#footnote-1)
* Carnot developed a formula for measuring thermodynamic efficiency. e = 1 – TL/TH. Where e is the efficiency of the machine, TL, the low operating temperature of the machine and TH, the high operating temperature – both in degrees Kelvin. There must be differences in temperature somewhere in the machine for work to be done.

*George Stokes (1819-1903)*

* Anglo-Irish physicist.
* Discovered his law of viscosity in 1851. The frictional force on a sphere moving through a fluid is proportional to the fluid viscosity and the radius and speed of the sphere.

*August Beer (1825-1863)*

* German mathematician, chemist and physicist.
* Discovered his law of absorption in 1852. The absorbance of a solution is proportional to the concentration of the dissolved solute.

*Gustav Weidemann (1826-1899)*

* German physicist.
* Discovered the Weidemann-Franz law of conductivity in 1853. In a metal, the ratio of thermal conductivity to the electrical conductivity is proportional to the temperature.

*Adolf Fick (1829-1901)*

* German physiologist.
* Discovered his two laws of diffusion in 1855. The steeper the concentration gradient, the greater the net flux of material by diffusion.

*Christoph Hendrik Diedrik Buys Ballot (1817-1890)*

* Dutch meteorologist and physical chemist.
* Discovered his wind and pressure law in 1857. The wind blows at rights angles to the atmospheric pressure gradient.
* This law means that if a person stands with his back to the wind (in the Northern Hemisphere) the low pressure area will be to his left. I.e. the wind travels counterclockwise around low pressure zones. (This is opposite in the Southern Hemisphere)
* In 1845, he performed one of the first experiments to measure the Doppler effect, but refused to believe it could be applied to light.
* In 1854, he founded the Royal Netherlands Meteorological Institute.

*Lorand Eotvos (1848-1919)*

* Hungarian physicist.
* Discovered his law of capillarity in 1866. The surface tension of a liquid depends on the temperature and density of the liquid.
* He was a famous mountain climber and a peak in the Dolomites, in northeast Italy is named after him.

*Friedrich Wilheim Kohlrausch (1840-1910)*

* German physicist.
* Famous for his laws of conductivity.
  1. Kohlrausch’s square root law in 1874. The conductivity of a solution depends on the number of ions in the solution.
  2. Kohlrausch’s law on the independence of migrating ions in 1875. Conductivity of an electrolyte is the sum of the contributions from its individual ions.

*Pierre Curie (1859-1906) and Pierre Weiss (1865-1940)*

* Both were French physicists.
* Curie discovered his magnetism law in 1895. The magnetic susceptibility of paramagnetic materials is inversely proportional to the absolute temperature. A critical temperature exists (the Curie temperature, TC), above which the magnetic properties disappear because thermal motion disrupts the magnetic alignment.
* Weiss refined and generalised the law in 1907.
* Types of materials and their magnetic behaviours:
  + Diamagnetism – no magnetic moment. As external magnetic field increases, magnetisation decreases.
  + Paramagnetism – randomly oriented magnetic moments. As external magnetic field increases, magnetisation increases.
  + Ferromagnetism – aligned magnetic moments facing one direction. As external magnetic field increases, magnetisation increases but quickly reaches a plateau.
  + Antiferromagnetism - aligned magnetic moments. As external magnetic field increases, magnetisation increases.
  + Ferrimagnetism - aligned magnetic moments. As external magnetic field increases, magnetisation increases but quickly reaches a plateau.
* At temperatures above their TC, ferromagnetic, antiferromagnetic and ferromagnetic materials act like paramagnetics.
* Curie considered himself to have a feeble mind. He never went to elementary school.
* Pierre and his brother, Jacques, discovered piezoelectricity, the fact that when certain crystals are compressed, electricity is produced.
* In 1898, the Curies announced their discovery of radium and polonium and conducted landmark studies into the properties of radioactivity and radioactive byproducts.
* Marie Curie was the first person to win two Nobel Prizes, a joint one with her husband in 1903 and one on her own in 1911.
* Marie Curie’s lab assistant suffered radiation poisoning and had to have both legs and one arm amputated.
* Marie died from leukemia in 1934.
* In the mid-1990s, Marie’s writings were sent to a national library in Paris but they were still so highly radioactive, they had to be decontaminated for two years.

*Max Planck (1858-1947)*

* German physicist.
* Discovered his law of radiation in 1900. The amount of energy at a particular wavelength radiated by a blackbody depends on the temperature of the body and its wavelength.
* Notable because it was the first formulation of quanta.

*William Henry Bragg (1862-1942) and son William Lawrence Bragg (1890-1971)*

* British physicists.
* They discovered Bragg’s law of crystal diffraction in 1913. The angles at which radiation produces the most intense reflections from crystals depends on the spacing of atomic planes in the crystals and the wavelength of the incident radiation.
* William Henry Bragg (father) never carried out any original experiments until he was forty.
* William Lawrence Bragg (son) played an important role in the discovery of DNA by offering support to Francis Crick and James Watson.
* William Lawrence also discovered a new kind of cuttlefish, which was named after him.

*Werner Karl Heisenberg (1901-1976)*

* German physicist.
* Formulated his uncertainty principle in 1927. The position and velocity of an object cannot both be known with high precision, at the same time.

*Edwin Hubble (1889-1953)*

* U.S. astronomer.
* Discovered his law of cosmic expansion in 1929. The greater the distance a galaxy is from us, the faster it recedes. The distances between galaxies are continuously increasing and therefore, the universe is expanding. v = H. D (where v is the recessional velocity, H is the Hubble constant and D is the distance of the object from us)
* The Hubble constant is approximately 71 (km/s) per megaparsec. (One megaparsec is 3 million light years) Armed with this value and measurements of the cosmic background radiation we can calculate the age of the universe at 13.7 billion years.
* Hubble was a heavyweight boxer at University and his trainer wanted to train him up but Hubble decided against that.
* He taught for a number of years before attaining his doctorate in astronomy.
* He enlisted in the army in World War 1, before returning to the U.S. in 1919.
* In the 1920s, Hubble discovered that there are other galaxies out there besides this one.
* In 1924, he discovered the Cepheid variable stars that allow us to calculate distances to astronomical bodies.

1. There are actually three laws of thermodynamics. The first law states the energy of the universe is constant and the third says that entropy approaches zero as the temperature approaches absolute zero. To summarise; 1. *You cannot win.* (Matter and energy are conserved so you cannot get something for nothing). 2. *You cannot break even.* (You cannot return to the same energy state because there is always an increase in entropy). 3. *You cannot get out of the game.* (Because absolute zero is unattainable). [↑](#footnote-ref-1)