**Stage 1 Physics – Medical Physics Program - Semester 2**

This is a 10-credit program for students intending to study Stage 1 Physics.

The number of lessons is equivalent to approximately 60 hours over 2 semester, including 8 - 10 hours of practical activities.

The unit covers:

* Topic 5 - Waves
* Topic 6 - Nuclear Models
* Topic 2 - Electric Circuits

| **Science Understanding** | **Activities/teaching strategies** | **SIS** | **SHE** | |
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| Week 1 and 2 – The Physics of Sight | | | | |
| Light is the visible part of the electromagnetic spectrum – a spectrum that also includes radio waves, microwaves, infrared, and ultraviolet radiations, x-rays, and gamma rays.  Electromagnetic waves can be modelled as a transverse wave that can travel through a vacuum.  In transverse waves the direction of oscillation is perpendicular to the propagation of the wave.  Represent transverse waves graphically and analyse the graphs.  Describe waves in terms of measurable quantities, including amplitude, wavelength (*λ*), frequency (*f*), period (*T*), and velocity (*v*).  Refraction is the change in direction of propagation of a wave as its speed changes.  Describe reflection and refraction, using the ray model of light.  Explain light-related phenomena of reflection and refraction using the wave model. | Students use a mobile phone app (e.g. Sensor Sense) that measures brightness students will conduct an investigation to determine the effect of brightness of pupil size.  Students research the anatomy of the eye and how the [eye functions.](http://hyperphysics.phy-astr.gsu.edu/hbase/vision/eyescal.html)  Students investigate colour blindness. They discuss how to solve problems of colour blindness in everyday situations. | Students perform an experiment to investigate refractive index of Perspex and glass and thus verify Snell’s Law  Students use ray boxes to investigate refraction and refractive index, convex and concave lenses  Students perform a dissection, extracting the lens from a bull’s eye, determining the focal length, and thus deducing the index of refraction of a bull’s cornea.  Students determine the focal length of prescription glasses. | Student research the development of the bionic eye. |
| Week 3 and 4 – The Physics of Hearing | | | | |
| Sound waves transfer energy through a physical medium.  The natural frequency is the rate at which an object vibrates when it is disturbed by an outside force.  A forced vibration occurs when a wave forces an object to vibrate at the same frequency as the wave.  Resonance is the large amplitude vibration that occurs in the object when the forced vibration is the same as its natural frequency.  Explain a range of wave-related phenomena, including echoes, refraction, and resonance, using the mechanical wave model.  Use the principle of superposition of waves to explain a range of interference phenomena and including standing waves. | Students use a presentation to animate their understanding of the characteristics of waves.  Students discuss how to test the hearing of very young babies. | Students investigate the range of human hearing using a tone generator on their phones or computers.  Students use an app e.g. Frequensee to investigate musical instruments, e.g. test tubes of water, standing waves in air columns etc. For example they might determine the volume of air in a column to its resonant frequency.  Competition between groups to:   * Calculate speed of sound on the day * Use this to place two speakers (playing an in-phase sinusoidal tone) in a way that minimises the volume measured by a fixed microphone.   There is no trial and error for the second part. The speakers are placed first and then turned on once to see how the students did.  Calculations and justifications to be completed by each student on a template provided by the teacher. | Student research the development of the bionic eye. | |
| Week 5 – The Physics of Speech (Science as a Human Endeavour) | | | | |
| [Humans create sounds](http://www.animations.physics.unsw.edu.au/jw/speech.html) using vocal folds which resonate in the mouth and throat. | Demonstration or [YouTube](https://www.youtube.com/watch?v=52UAEQfMTtU)  Helium alters the sound of the human voice, related to *v=f λ* - video of sulfur hexafluoride effect on the voice. | Students use app e.g. Frequensee to investigate the sound spectrum created by human vocal chords or otherwise e.g. whistling, humming etc  **Investigations Folio Task:**  **Students design and perform an investigation using phone or computer apps related to hearing or vision or speech e.g the effectiveness of sunglasses.** | Possibilities for vocal fold [transplants](http://www.dailymail.co.uk/sciencetech/article-3324240/Vocal-cords-voice-grown-US-laboratory.html) | |
| Week 6 – Medical Imaging using Ultrasound (Science as a Human Endeavour) | | | | |
| Ultrasound consists of frequencies above the range of human hearing. Sound waves reflect of structures within the body and they are picked up by a transducer to form an image.  Sound waves are focused on a certain part of your body by a transducer that picks up the sound waves as they bounce back from organs inside the body.  The Doppler effect can be used to determine the direction of blood flow in an ultrasound. | Demo: [Seeing Sound](http://practicalphysics.org/sound-waves.html)  Resource: [The physics of ultrasound](http://www.sonoguide.com/physics.html)  *Activity:*  Low tech: [Measuring distance with sound](http://practicalphysics.org/measuring-speed-sound-using-echoes.html) (modify) or  [Modelling ultrasound with Lego NXT](https://www.teachengineering.org/activities/view/nyu_soundwaves_activity1) or [Arduino Measuring distance with sound](http://www.toptechboy.com/arduino/lesson-20-arduino-lcd-project-for-measuring-distance-with-ultrasonic-sensor/)  [Doppler effect demo](http://www.exploratorium.edu/snacks/doppler-effect)  [Doppler shift explained](https://www.futurelearn.com/courses/ultrasound-imaging/0/steps/10302) |  |  | |
| Week 7 and 8 – Medical Imaging X-rays (Science as a Human Endeavour) | | | | |
| When light hits an object it can be reflected, transmitted or absorbed.  Pulse oximetry is a non-invasive tool that measures changing absorbance at different wavelengths to detect blood oxygen saturation.  Endoscopy and laparoscopy involve using total internal reflection to look inside the body.  Lasers are used cut, vaporize, ablate and photo-coagulate soft tissue.  X-rays are absorbed or transmitted through living tissue.  Fluoroscopy uses a contrast agent and a screen to view x-rays images in real time. Contrast agents contain atoms with high atomic numbers that are opaque to x-rays which are swallowed or introduced into blood vessels. | Activity: [Modelling X-rays](http://www.nuffieldfoundation.org/sites/default/files/04_Investigating_X-rays.pdf)  Activity: Students bring in x-rays and discuss the benefits and risks of x-rays.  **SAT Task:**  **Students create a video of an animation of a medical imaging technique that uses sound or EM waves. They explain the physics behind the technique which links medical conditions that the technique is used to diagnose.** |  | Activity: [Calculating your annual radiation exposure](http://www.iop.org/education/teacher/resources/radioactivity/file_41559.pdf). | |
| Week 9 and 10 – Nuclear Medicine | | | | |
| The structure of the atom.  Atomic nuclei can be described using their chemical symbol (*X*), mass number (*A*), atomic number (*Z*), and number of neutrons (*N*). Describe the structure of an atom, including the relative size and location of the nucleons and electrons.  Isotopes are atoms of the same element that have different mass numbers.  Nucleons are held together by  Describe the properties of the strong nuclear force, including its short range.  Describe the balance between the electrostatic force and strong nuclear force in stable nuclei.  Use the properties of the electrostatic force and strong nuclear force to explain why some isotopes are unstable.  Locate stable and unstable nuclei on an *N* versus *Z* graph.  Unstable nuclei will undergo radioactive decay in which particles and/or electromagnetic radiation are emitted. This property can be used by medicine as a tracer to follow the path of substances within the body. | Activity: [Modelling exponential decay with M&Ms](http://serc.carleton.edu/quantskills/activities/MandMModel.html)  Phet: [Alpha Decay Simulation](https://phet.colorado.edu/en/simulation/alpha-decay)  [Simulation:Inside Story - Radiotherapy](http://insidestory.iop.org/insidestory_flash1.html)  [Radioactive decay Worksheet](http://www.nuclearscienceweek.org/wp-content/uploads/2014/09/Alphas-Betas-Gammas-Oh-My.pdf)  [Radioactive decay Worksheet](http://www.nuclearscienceweek.org/wp-content/uploads/2014/09/Alphas-Betas-Gammas-Oh-My.pdf) |  |  | |
| Week 11 and 12 – Isotopes in Medicine | | | | |
| Alpha decay typically occurs for nuclei with Z > 83. Write equations for the decay of heavy nuclei by alpha decay.  In beta minus decay, an unstable nucleus emits an electron In beta plus decay, an unstable nucleus emits a positron.  Beta plus decay occurs when a nucleus has an excess of protons, and involves the decay of a proton into a neutron, positron, and neutrino.  Describe the structure of unstable nuclei that causes each type of beta decay. Write the equations for the decay of nuclei by beta minus and beta plus decay.  Use the conservation of charge to explain the emission of an electron in the decay of a neutron into a proton.  Use the conservation of charge to explain the emission of a positron in the decay of a proton into a neutron.  In gamma decay, an unstable nucleus emits high-energy gamma rays (*γ*). Gamma decay occurs when a nucleus is left with excess energy after an alpha or beta decay.  Write equations for the decay of unstable nuclei involving the emission of gamma rays.  The type of decay an unstable nucleus will undergo can be predicted based on the number of protons and neutrons within the nucleus.  Use the atomic and mass numbers to predict the type of decay for an unstable nucleus.  Use the location on an *N* versus *Z* graph to predict the type of decay for an unstable nucleus. | Teachers demonstrate with different radioactive sources the types of radioactive decay.  Students [use a simulation](http://splash.abc.net.au/home#!/media/1390049/the-alpha-beta-and-gamma-of-radiation) to investigate different types of radioactive decay. |  | Students discuss the risks and benefits from various incidents involving release of radioactive materials  e.g. Fukushima  Three mile island  Hiroshima  Chernobyl  Bikini Atoll  Maralinga | |
| Week 13 – Radiation and the Human Body | | | | |
| The particles emitted in radioactive decay have sufficient energy to ionise atoms.  The properties of the particles and/or radiation emitted in the different types of radioactive decay result in different penetration of matter.  Describe the effects of ionising radiation on living matter.  Describe methods of minimising exposure to ionising radiation.  Compare and contrast the ionising ability and penetration through matter of alpha, beta, and gamma radiations. |  |  | **SHE Task**  **Students research a radiotracer used in medical imaging and look at key individuals from science and medicine that interact and collaborate in either the development or implementation of the use of radiotracer.** | |
| Week 14 and 15 – Electricity | | | | |
| *Review:*  *Charge is a property of matter. Charge can neither be created nor destroyed, but can be transferred from one place to another.*  *Delocalised electrons are free to move in a conductor, but not in an insulator.*  *Opposite charges attract, like charges repel Water circuits and components are analogous to electrical circuits and components.*  *Symbols and conventions for electronic components (e.g. battery, LED, resistor, capacitor) and circuit diagrams*  Conventional current is in the opposite direction to electron flow.  Electrical current is the rate of flow of charge past a given point.  Define the ampere as 1 coulomb of charge passing a given point in one second. (*1A=1Cs-1* )  SHE: Humans create electricity in their bodies by transporting charges across the cell membrane.  EEGs and ECGs are useful diagnostic tools that measure ionic currents within the brain and heart.  A source of electromotive force (e.g. a battery) gives charges electrical potential energy. Define the volt as *1V=1JC-1*  Define electric potential difference (*V*) (voltage) as the difference in electrical potential per unit charge between two points.  The sum of the voltages (changes in electrical potential energy) around a circuit path equal zero. | Demonstrations with a Van Der Graff generator and a Super Fun Fly stick  Activity: Investigating charge using electroscopes and Perspex and ebonite rods.  Activity: Describe analogous behaviour of water and electricity in behaviour and components (eg battery/pump, wire/pipe, switch/tap)  Students look at normal and abnormal ECGs and EEG’s | Identify circuit components (eg LED, resistors etc) both physically and in circuit diagram.  Students build series circuits and parallel circuits and measure current using a digital multimeter.  Students work out how to design an efficient wiring circuit given a floor plan.  Use a digital multimeter to measure potential difference. | Students investigate devices to reduce the chance of being electrocuted  lightning rods  lightning safety  Grounding  Insulation  RCDs  Students investigate electrical disturbances within the human body such as epilepsy and fibrillation. | |
| Week 16 and 17 – Electricity and the Human Body | | | | |
| Ohms Law  Resistance for ohmic and non-ohmic components is defined as the ratio of potential difference across the component to the current in the component.  The resistance of a conductor depends on its length, area of cross-section, temperature, and the type of the material of which it is composed.  Resistance is constant for ohmic resistors, which conform to Ohm’s law.  Ohm’s Law states that current is directly proportional to the potential difference providing the temperature of the conductor remains constant.  The energy available to charges moving in an electrical circuit is measured using electric potential difference (voltage). This is defined as the change in potential energy per unit charge between two defined points in the circuit and is measured using a voltmeter.  Describe how a voltmeter is used in an electric circuit.  Explain the purpose of measuring potential difference in electric circuit. | Perform calculations involving R=V/I | Perform an experiment to test the relationship between V and I across an ohmic and non-ohmic conductor.  Students perform and investigation on factors affecting electrical resistance. | Possible class discussion:  [The physics of the polygraph](http://ffden-2.phys.uaf.edu/webproj/212_spring_2015/Dillon_Mills/dillon_mills/Sensors.html) - should polygraph tests be admissible in a court?  [The physics of electroconvulsive therapy](http://physicsbuzz.physicscentral.com/2014/07/shockingly-smart-physics-behind-brain.html)- ECT useful medical tool or inhumane practice?  [The physics of TASERS](http://physicsworld.com/cws/article/news/2007/nov/26/taser-is-easy-on-the-heart) - Should our police be equipped with TASERS? | |
| Week 18 | | | | |
| Describe how electrical safety is increased through the use of fuses or circuit breakers residual current devices  When dry, the human body has a high resistance. This drops when wet. | **Skills and Applications Task**  **Test - Students demonstrate Physics knowledge, understanding and application of concepts from the nuclear medicine and electrical sections of the course. The test will include a mini extended response with a SHE focus.** |  |  | |