Physics Section 3.1: Medical Applications of Physics

X-rays in Medicine

- That X-rays are EM waves with a wavelength about the same size as the diameter of an atom.
- That X-rays are ionising, which means they can damage or kill cells.
- That X-rays affect photographic film in the same way as visible light.
- That X-rays mostly pass through tissue but are absorbed by metal and bone, so they can be used to take photographs of the body to diagnose things like broken bones and dental problems.
- That a charge-coupled device (CCD) can detect X-rays and produce electronic images.
- That X-rays can be used in CT scans to produce images of tissues, which can be used to diagnose and check-up on a wide range of illnesses.
- That X-rays can be used to treat cancer because they are ionising.
- That precautions must be taken when using X-rays because they are ionising and are a health risk.

Ultrasound

- That ultrasound is sound with a frequency higher than the range of human hearing (which is 20 - 20 000 Hz). It can be produced by electronic systems.
- That ultrasound is partially reflected at a boundary between media, so some is reflected and some is transmitted and refracted. This is the basis of ultrasound scanning.
- How to interpret an oscilloscope trace to measure the time between two reflected ultrasound pulses.
- How to calculate the distance to a boundary or between boundaries using $s = v \times t$ and the time taken for reflected ultrasound pulses to return
- That ultrasound can be used in medicine to remove kidney stones and for pre-natal scanning.

Choosing an Imaging Technique

- That X-rays are ionising but ultrasound is not, and why this means they're used for different reasons.
- The relative health risks of using ultrasound, X-ray photographs and CT scans.
- The relative image quality of images produced by ultrasound, X-ray photographs and CT scans.
- How to evaluate the kind of imaging used in different situations, taking into account the health risks and image quality.

Refractive Index

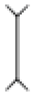
- That the refraction of light is where light changes direction as it crosses a boundary between media of different densities at an angle to the normal.
- That the refractive index of a substance is a measure of how slowly light travels in it and that it is found using the equation, refractive index = $\sin i \div \sin r$ (where i is the angle of incidence and r is the angle of refraction as light crosses the boundary from air into the substance).

Lenses and Images

- That lenses form images by refracting light.
- That a converging or convex lens brings rays travelling parallel to the axis together at the principal focus. Converging lenses bulge outwards.
- That the focal length of a lens is the distance between the centre of the lens and the principal focus.
- That a diverging or concave lens spreads out rays travelling parallel to the axis so that they appear to have come from the principal focus. Diverging lenses curve inwards.
- That an image can be real (when rays from a point on the object all meet at another point) or virtual (when the rays from the object don't meet but appear to have come from the same point).

- That to describe an image you need to talk about its size relative to the object, its orientation and whether it is real or virtual.

Ray Diagrams

- What converging lenses and diverging lenses look like this in ray diagrams.
- Converging 
- Diverging 
- How to construct or complete ray diagrams showing image formation for both converging and diverging lenses.
- How the type of image formed by a converging lens changes depending on the distance between the lens and the object. Be able to describe the image produced each time.
- That diverging lenses always produce virtual images that are upright and smaller than the object.

Magnification

- How a magnifying glass uses a converging lens to produce a magnified, upright, virtual image.
- That magnification can be calculated using the equation:

$$\text{magnification} = \frac{\text{image height}}{\text{object height}}$$

The Eye

- The function of each of the following parts of the eye and can label them on a diagram: the cornea, the iris, the pupil, the lens, the ciliary muscles, the suspensory ligaments and the retina.
- That the shape (and power) of the lens is changed by the ciliary muscles and the suspensory ligaments.
- That the eye can focus on objects that are between the near point and far point.
- That for a healthy adult eye, the near point is 25 cm and the far point is infinity, and that this is the range of human vision.
- How the human eye is similar to a camera — the retina is the equivalent of the camera's film or CCD, the pupil is the equivalent of the camera's aperture and they both have a converging lens.

Correcting Vision

- That short sight is a vision defect in which the far point is closer than infinity, so objects in the distance look blurry. The eye forms a focused image in front of the retina.
- That short sight is caused by the eyeball being too long or the cornea and lens being too powerful.
- That short sight can be corrected with a diverging lens.
- That long sight is a vision defect in which the near point is longer than 25 cm, so nearby objects look blurry. The eye forms a focused image beyond the retina.
- That long sight is caused by the eyeball being too short or the cornea and lens being too weak.
- That long sight can be corrected with a converging lens.

Power and Focal Length

- That the focal length of a lens depends on the refractive index of the material it is made from and how strongly curved the sides of the lens are.

- That the power of a lens is a measure of how strongly it converges or diverges light and it can be found using the equation, power = 1 ÷ focal length.
- That the power of a converging lens is positive and the power of a diverging lens is negative.
- H That the greater the refractive index of the material used to make a lens of a certain power or focal length, the flatter it can be.
- H That lenses can be made thinner by using a material with a higher refractive index.

Medical Uses of Light

- That total internal reflection is when light is completely reflected when meeting the boundary of a less-dense material than the material it is in, and that it only happens when the angle of incidence is greater than the critical angle.
- H That the refractive index of a substance is given by the formula below, where c is the critical angle.
- $\frac{1}{\sin c}$
- That visible light can be sent along optical fibres using total internal reflection.
- That endoscopes use bundles of optical fibres and are used in medicine to see inside the body.
- That lasers are used in medicine for cutting, cauterising, burning and laser eye surgery.