

AQA Physics A Level

10.4 Non-ionising imaging

Flashcards

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What are ultrasound waves?



What are ultrasound waves?

Sound waves with a frequency greater than 20,000 Hz (above the range of human hearing).



What happens when an ultrasound wave meets a boundary between 2 different materials?



What happens when an ultrasound wave meets a boundary between 2 different materials?

Some of it is reflected and some is transmitted and will refract when the angle of incidence isn't 0° , the amount of reflection depends on the difference in acoustic impedance (Z) between the materials.



The speed of sound in air is 340ms^{-1} and air's density is 1.2kgm^{-3} , calculate the acoustic impedance of air.



The speed of sound in air is 340ms^{-1} and air's density is 1.20kgm^{-3} , calculate the acoustic impedance of air.

$$Z = 1.2 \times 340 = 408\text{kgm}^{-2}\text{s}^{-1}$$



State the equation used to calculate the fraction of ultrasound wave intensity reflected.



State the equation used to calculate the fraction of ultrasound wave intensity reflected.

$$\frac{I_r}{I_i} = \left(\frac{Z_2 - Z_1}{Z_2 + Z_1} \right)^2$$

I_r = intensity of reflected wave, Wm^{-2}

I_i = intensity of incident wave, Wm^{-2}

Z_2 = acoustic impedance of 2nd material, $\text{kgm}^{-2}\text{s}^{-1}$

Z_1 = acoustic impedance of 1st material, $\text{kgm}^{-2}\text{s}^{-1}$



If 2 materials have the same impedance,
does reflection occur?



If 2 materials have the same impedance, does reflection occur?

If 2 materials have the same impedance then **no** reflection occurs



‘Ultrasound waves are attenuated when they travel through a material’
What is attenuation?



‘Ultrasound waves are attenuated when they travel through a material’ What is attenuation?

When the waves are absorbed and scattered. The higher the frequency of a wave or impedance of a material the more attenuation the wave undergoes.



What is a transducer?



What is a transducer?

A device which converts one form of energy into another.



What do piezoelectric crystals do when they are deformed?



What do piezoelectric crystals do when they are deformed?

Produce a potential difference (the piezoelectric effect), as the change in their structure moves the centres of symmetry of their electric charges.



What happens when you apply a voltage across a piezoelectric crystal?



What happens when you apply a voltage across a piezoelectric crystal?

The crystal deforms, if the voltage is alternating then it vibrates at the same frequency.



True or false: A piezoelectric crystal can only act as a transmitter of ultrasound.



True or false: A piezoelectric crystal can only act as a transmitter of ultrasound

False.

It can act as both a receiver (converting ultrasound to alternating p.d) and a transmitter (converting alternating p.d into ultrasound).



What is the relationship between the thickness of the crystal and the wavelength it produces?



What is the relationship between the thickness of the crystal and the wavelength of the ultrasound it produces?

The crystal thickness is half the wavelength of the ultrasound.



Why is the piezoelectric crystal in ultrasound devices heavily damped?



Why is the piezoelectric crystal in ultrasound devices heavily damped?

To produce short pulses and increase the resolution of the device.



Why is a coupling medium needed between the ultrasound transducer and the body?



Why is a coupling medium needed between the ultrasound transducer and the body?

The acoustic impedance of the body is very different to air so most ultrasound energy is reflected, the coupling medium (oil or gel) has an impedance closer to body tissue (impedance matching) so more ultrasound is transmitted.



How are the uses for amplitude (A) scans and brightness (B) scans different?



How are the uses for amplitude (A) scans and brightness (B) scans different?

Both are ultrasound scans but B scans are used to create images and A scans are used to measure distances e.g. the depth of an eyeball.

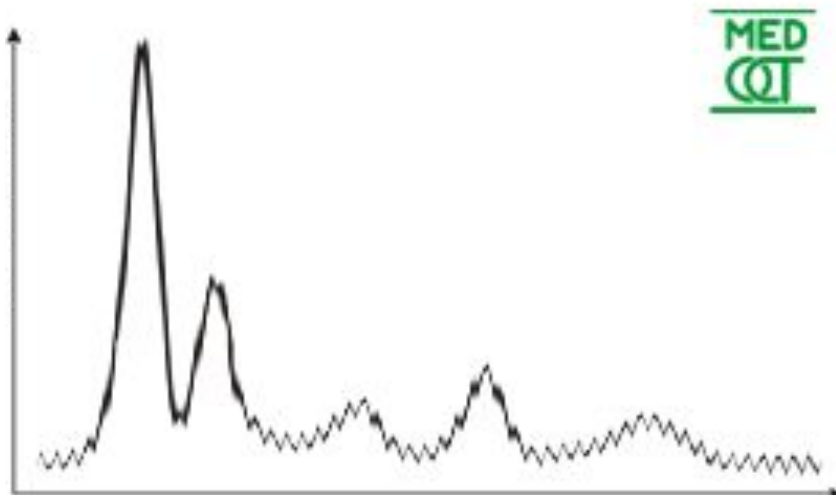


In an A-scan how do reflected ultrasound pulses appear on the cathode ray oscilloscope (CRO) screen?



In an A-scan how do reflected ultrasound pulses appear on the cathode ray oscilloscope screen?

As vertical deflections.



https://upload.wikimedia.org/wikipedia/commons/archive/b/b3/20051211134709%21A-mode_scan.png



What is the process of amplifying weaker pulses that have travelled further called?



What is the process of amplifying weaker pulses that have travelled further called?

Time gain compensation.



What do the horizontal positions of the reflected pulses on the CRO indicate?



What do the horizontal positions of the reflected pulses on the CRO indicate?

The time taken for the reflection to return, this can be used to work out distances as the speed of the ultrasound is known.



In which direction does the electron beam sweep across the CRO screen in an A-scan, what direction is it for a B scan?



In what direction does the electron beam sweep across the CRO screen in an A-scan?

Horizontally for A scans, vertically down for B scans.



State a use of A scans and uses of B scans.



State a use of A scans and uses of B scans.

A: Monitoring a baby's growth in the uterus by measuring its head diameter.

B: Prenatal fetus scanning and echocardiograms to see how the heart is functioning in real time.



How is the amplitude of the reflected pulses displayed in a B scan?



How is the amplitude of the reflected pulses displayed in a B scan?

As the brightness of a spot.



What array of transducers can be used to produce a 2D image in a B scan?



What array of transducers can be used to produce a 2D image in a B scan?

Linear array.



What are five advantages of ultrasound scans?



What are five advantages of ultrasound scans?

- No known hazards or side effects
- No exposure to ionising radiation
- Can obtain real-time images of soft tissues
- Ultrasound devices are portable and cheap
- Scan is quick, non invasive and patient can move



What are three disadvantages of ultrasound scans?



State 3 disadvantages of ultrasound scans

- Ultrasound can't penetrate bone so the brain can't be imaged (skull in the way) and fractures can't be detected.
- Ultrasound can't pass through air spaces in body (mismatched impedance) so can't produce images from behind the lungs.
- Low resolution.



What is meant by a coherent fibre optic bundle?



What is meant by a coherent fibre optic bundle?

The relative positions of the fibres at each end is the same (so the image isn't muddled up).



What property of the optical fibres does the resolution of an image transmitted by optical fibres depend on?



What property of the optical fibres does the resolution of an image transmitted by optical fibres depend on?

The width of the fibres, more detail can be resolved using thinner fibres which are more expensive.



How can an image be magnified by an optical fibre?



How can an image be magnified by an optical fibre?

The diameters of the fibres get bigger along the length of the bundle.



A bundle of optical fibres in which the relative positions of the fibres doesn't stay constant is said to be ...



A bundle of optical fibres in which the relative positions of the fibres doesn't stay constant is said to be ...

Non-coherent, they're cheaper to make and are used to get light to places that are difficult to reach.



What are endoscopes?



What are endoscopes?

A long tube containing two bundles of fibres, a coherent bundle to carry an image to the eyepiece and a non-coherent bundle to light up the area.



Where are the distal end and proximal end of an endoscope located respectively?



Where are the distal end and proximal end of an endoscope located respectively?

Distal - furthest from eye

Proximal - closest to eye



Why does bending an endoscope more increase the likelihood of light escaping?



Why does bending an endoscope more increase the likelihood of light escaping?

Bending reduces the angle of incidence of the light in the optical fibres.



What additional 3 features are found in an medical endoscope used for surgery?



What additional 3 features are found in an medical endoscope used for surgery

- A water channel for cleaning the objective lens.
- A tool aperture for keyhole surgery.
- A CO₂ channel so CO₂ can be pumped in to make more room.



Why is keyhole surgery better than traditional surgery?



Why is keyhole surgery better than traditional surgery?

Lower risk of infection and permanent damage, quicker recovery times which is better for patient and cheaper for hospital.



Where does the patient lie during magnetic resonance imaging?



Where does the patient lie during magnetic resonance imaging?

In the centre of a superconducting magnet that is cooled by liquid helium.



https://commons.wikimedia.org/w/index.php?search=MRI+scanner&title=Special%3ASearch&go=Go&ns0=1&ns6=1&ns12=1&ns14=1&ns100=1&ns106=1#/media/File:An_MRI_scanner.JPG

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What effect does the uniform magnetic field generated have on protons in the body?



What effect does the uniform magnetic field generated have on protons in the body?

They align themselves with the magnetic field lines.



What is the difference between a parallel and antiparallel alignment of protons in a magnetic field?



What is the difference between a parallel and antiparallel alignment of protons in a magnetic field?

Parallel alignment is when the proton's spin axis is parallel to the magnetic field lines and antiparallel is when the spin axis points in the opposite direction to the lines.



What is the effect on protons' when smaller electromagnets (gradient field coils) have their magnetic field superimposed onto the main field?



What is the effect on protons' when smaller electromagnets (gradient field coils) have their magnetic field superimposed onto the main field?

Variations in magnetic field strength are created across the patient so protons will have different precession frequencies depending on their location and will absorb different frequencies of radiation.

Precession frequency is the angular frequency of the protons' wobble about the magnetic field lines, it is proportional to the magnetic field strength.



How does the emission of radio frequency (RF) waves from RF coils lead to an image being formed in an MRI scan?



How does the emission of radio frequency (RF) waves from RF coils lead to an image being formed in an MRI scan?

- Radio waves are absorbed by protons with precession frequency equal to the radio frequency.
- Protons excite and change their spin state (flip their alignment).
- Protons de-excite and re-emit EM energy as RF waves at their precession frequency.
- This wave is detected, its frequency shows the location it came from and other wave properties are used to build a 3D image/ cross section.



How can the contrast of an MRI scan image be controlled?



How can the contrast of an MRI scan image be controlled?

Vary the time between radio wave pulses to enhance the difference in response from each tissue type e.g. rapid pulses enhance the response of fatty tissue.



What are the advantages of MR scanning?



What are the advantages of MR scanning?

- No known side effects.
- Non ionising so won't damage living cells.
- Images can be formed from all orientations.
- High quality images of soft tissue with good resolution.
- Contrast can be adjusted.
- Real time images.



What are the disadvantages of MR scans?



What are the disadvantages of MR scans?

- Poor bone imaging compared to CT.
- Noisy and time consuming.
- Claustrophobic.
- Dangerous with pacemakers/metal implants.
- Cost millions of pounds.

