Ultrasound scans

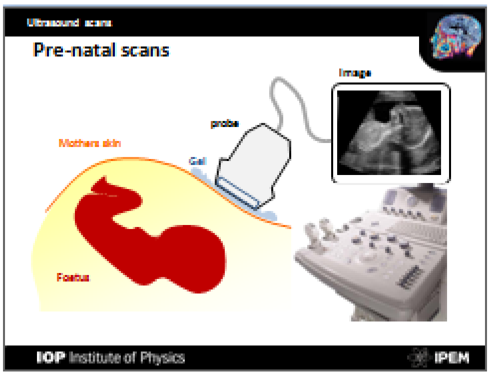
Curriculum links:

- Sound
- Longitudinal waves

Introduction

Ultrasound imaging systems uses piezoelectric transducers as source and detector. Piezoelectric crystals vibrate in response to an alternating voltage, and when placed against a patient's skin and driven at high frequencies produce ultrasound pulses that travel through the body. As they travel outwards and encounter different layers within the body the ultrasound waves are reflected back towards the source. The returning signal drives the crystals in reverse and produces an electronic signal that is processed to construct the image. Compared to MRI, ultrasound has the advantages of low cost and portability. It is also preferred over X-ray imaging for procedures in which ionising radiation poses a significant risk, such as checking foetal development during pre-natal care.

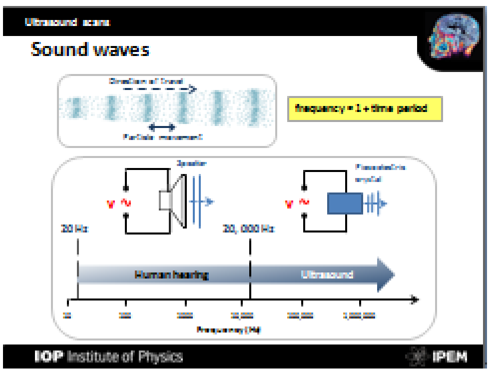
Lesson notes



Pre-natal scans

In order to carry out an ultrasound scan a gel is used to minimise reflections from the patient's skin. The ultrasound waves used to construct an image are produced and detected using a probe connected to the ultrasound machine.

Unlike X-rays, ultrasound is non-ionising and considered safe for pre-natal scans.



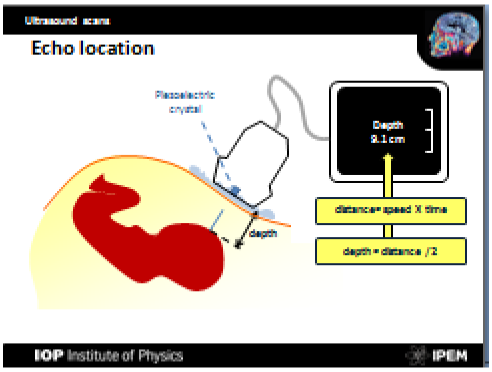
Sound waves

Sound is a longitudinal wave (i.e. one in which the particle vibration is parallel to the direction of travel). Both sound and ultrasound can be produced using (electroacoustic) transducers; sound using a loudspeaker and ultrasound using piezoelectric crystals (crystals that vibrate in response to alternating voltage). The crystals also act as detector when driven in reverse by an incoming ultrasound wave.

frequency = 1/ period

Period is time taken for particle to complete one vibration. Frequency is number of vibrations per second. The audible frequency range is 20 Hz to 20 kHz and sound waves above this frequency are called ultrasound.

Echo location



Echo location is a distance measuring technique which relies on timing the interval between making an sound and detecting the reflected signal. The method used in medical imaging is similar to the ultrasound echo location methods used by submarines, bats and dolphins.

- **CLICK**: *emission, reflection and detection of ultrasound pulse.*

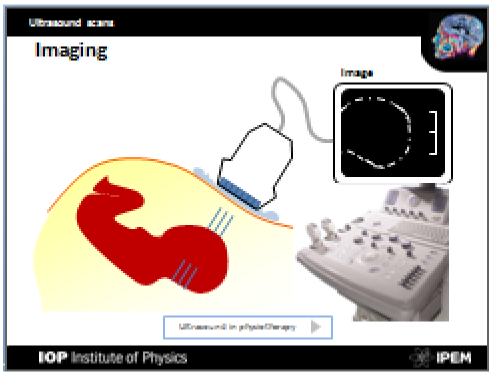
Operation of ultrasound machine:

- Ultrasound machine sends high frequency electronic signal to probe/crystal
- Crystal emits ultrasound pulse
- Pulse reflected from boundary (e.g. edge of an organ)
- Reflected wave drives crystal in reverse to produce signal

Depth calculated using

- distance = speed X time
- depth = distance ÷2

Imaging



When ultrasound pulse reaches a boundary some of it is reflected and some of it continues.

- **CLICK**: *multiple reflection and detection of ultrasound pulse.*

Multiple reflections can be used to determine distances to two (or more) boundaries and so can be used to construct an image.

- ***Ultrasound in physiotherapy:*** *launch video of how ultrasound is used at Wolverhampton Football Club and review of key principles of ultrasound scans.*

Worksheet mark-scheme

1.

(a) to minimise/reduce reflections from the skin ✓

(c) piezoelectric/vibrating crystal(s) ✓

2.

(a) (frequency) above 20,000 Hz/ audible range is 20 Hz to 20 kHz ✓

(b) particle movement/vibration in same direction/parallel to direction of wave ✓

(c) 0.0000002 seconds/ 0.2 μs/ 2 x 10^{-7} s ✓

3.

(a) 30 m ✓

(b) 15 m ✓

(c) *evidence of*
time = speed ÷ distance ✓

(time is) 0.01/0.012 seconds ✓

(d) bats/submarines
[*accept*: SONAR] ✓

TOTAL: 10 Marks