

Medical Imaging

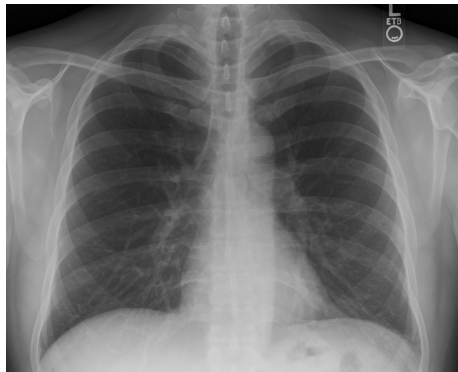
A2 Physics ■ Topic 24

A-Level Physics

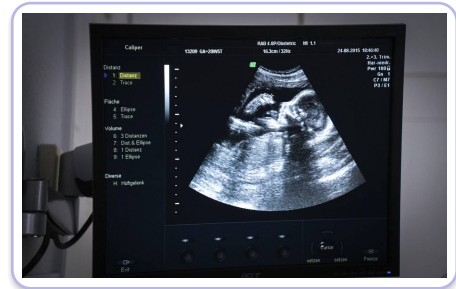
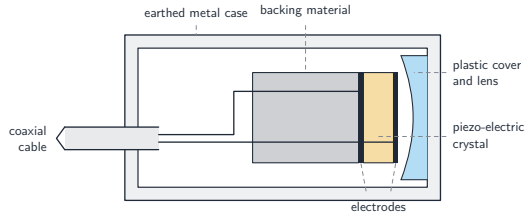


What we will cover

- 1 Ultrasound
- 2 X-rays
- 3 CT scanning
- 4 PET scanning
- 5 Recap



Ultrasound: pulse-echo



ultrasound scan

Worked example – depth from an echo

An ultrasound echo returns after $60\ \mu\text{s}$; the speed in tissue is $1540\ \text{m s}^{-1}$. Find the depth.

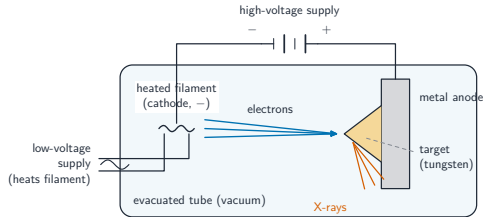
$$d = \frac{vt}{2} = \frac{(1540)(60 \times 10^{-6})}{2}$$
$$\approx 4.6 \times 10^{-2}\ \text{m} = 4.6\ \text{cm}$$

Halve the time because the pulse goes **out and back**.
Forgetting the factor of two doubles every depth.

X-rays: production and attenuation

Electrons accelerated through a high p.d. hit a metal target and emit X-rays. In tissue the beam is **attenuated** 衰减:

$$I = I_0 e^{-\mu x}$$



- bone has a **high** μ – it absorbs more, looks white
- soft tissue absorbs little

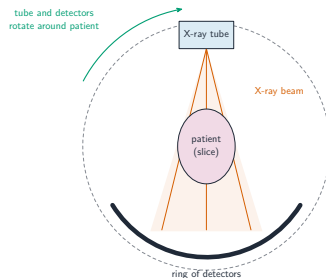
Contrast comes from the **difference** in μ . A contrast medium (barium, iodine) raises μ where the body has none.

CT scanning

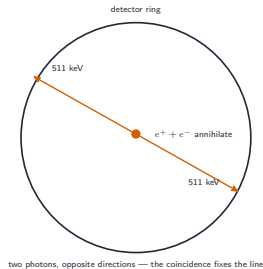
A CT scanner takes X-ray images from **many angles** and a computer reconstructs a 3-D image slice by slice.

- far more detail than a flat X-ray
- at the cost of a **higher** radiation dose

One flat X-ray flattens depth; rotating the source recovers it.



PET scanning



A **positron** 正电子-emitting tracer is injected. Each positron **annihilates** an electron, making two γ -photons back to back:

$$E = mc^2 \Rightarrow 0.51 \text{ MeV each}$$

Detecting both photons fixes the line they came from – and where the tracer, hence the **activity**, is concentrated.

Topic 24 – key takeaways

1 Ultrasound

pulse-echo, $d = vt/2$ – safe, no radiation

2 X-rays

$I = I_0 e^{-\mu x}$ – bone absorbs, looks white

3 CT

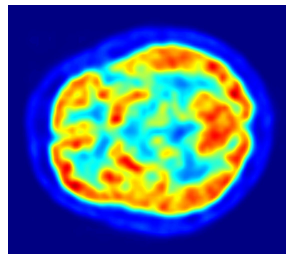
many angles $\rightarrow$ 3-D, higher dose

4 PET

positron annihilation, two γ back to back

Check yourself

- 1 Why the factor of two in $d = vt/2$?
- 2 Why does bone look white on an X-ray?
- 3 What does a CT scan add over a flat X-ray?
- 4 How many photons per annihilation in PET?



Answers 1. out and back 2. high μ , absorbs more 3. 3-D detail 4. two