INKPHYSICS FLASHCARDS

Medical physics

Year 13 · 73 cards · fronts and backs

Print double-sided, flipping on the long edge, and each answer lands behind its question. Cut along the card borders.

Definitions in mark-scheme wording, the equations that are not on the AQA data sheet, each lesson's check question, and the misconceptions that lose marks. The same cards run on the website with spaced-repetition scheduling, at inkphysics.co.uk/physics/flashcards.

DEFINITION

Define: Acoustic impedance.

ULTRASOUND IMAGING

RECALL

State what determines the fraction of a pulse reflected at a boundary.

ULTRASOUND IMAGING

DEFINITION

Define: Coupling gel.

ULTRASOUND IMAGING

RECALL

State how to find the depth of a boundary from a pulse-echo time.

ULTRASOUND IMAGING

DEFINITION

Define: Piezoelectric effect.

ULTRASOUND IMAGING

RECALL

State the unit of acoustic impedance.

ULTRASOUND IMAGING

RECALL

Explain the frequency trade-off in ultrasound.

ULTRASOUND IMAGING

RECALL

State the attenuation law for ultrasound in tissue.

ULTRASOUND IMAGING

RECALL

The fraction of an ultrasound pulse reflected at a boundary grows with the mismatch in acoustic impedance across it.

ULTRASOUND IMAGING

DEFINITION

The product of a material's density and the speed of sound in it: $Z = \rho c$.

ULTRASOUND IMAGING

RECALL

$d = ct/2$, the factor of two because the pulse travels to the boundary and back.

ULTRASOUND IMAGING

DEFINITION

The gel between transducer and skin that displaces the air, so the impedances are matched and the pulse enters the body.

ULTRASOUND IMAGING

RECALL

kg m^{-2} s^{-1}, from the product of density and speed.

ULTRASOUND IMAGING

DEFINITION

A pd applied across the crystal deforms it, and deforming the crystal produces a pd.

ULTRASOUND IMAGING

RECALL

Intensity falls exponentially with the distance travelled through the tissue: $I = I_0 e^{-\mu x}$, where μ is the attenuation coefficient. CIE prints the radioactive-decay exponential on its formula sheet and does not print this one, so it has to be recalled. (CIE only.)

ULTRASOUND IMAGING

RECALL

Higher frequency resolves finer detail but is attenuated more strongly, so it cannot reach deep structures.

ULTRASOUND IMAGING

RECALL

Explain why the Doppler shift from flowing blood is doubled.

ULTRASOUND IMAGING

RECALL

State what the angle θ is measured between in Doppler ultrasound.

ULTRASOUND IMAGING

RECALL

State the two limits on the detail a pulse-echo scan can resolve.

ULTRASOUND IMAGING

EQUATION · NOT ON THE AQA DATA SHEET

Depth of a boundary from its echo time:

d = ?

ULTRASOUND IMAGING

SPOT THE ERROR

Say what is wrong with this claim:

Ultrasound scans photograph the inside of the body with sound.

ULTRASOUND IMAGING

DEFINITION

Define: Attenuation coefficient.

X-RAYS AND CT SCANNING

RECALL

Explain the X-ray contrast of bone.

X-RAYS AND CT SCANNING

RECALL

State the maximum X-ray photon energy.

X-RAYS AND CT SCANNING

RECALL

In $\Delta f/f = 2v \cos \theta/c$, θ is the angle between the ultrasound beam and the direction of blood flow, and c is the speed of ultrasound in tissue. A beam square across the vessel has $\theta = 90°$, so $\cos \theta$ is zero and no shift is measured however fast the blood is going. (OCR A only.)

ULTRASOUND IMAGING

RECALL

The blood is moving relative to the transmitter, so it meets an already shifted frequency; it then re-radiates that wave while still moving relative to the receiver, so the frequency shifts a second time. (OCR A only.)

ULTRASOUND IMAGING

EQUATION · NOT ON THE AQA DATA SHEET

$$d = \frac{ct}{2}$$

ULTRASOUND IMAGING

RECALL

Two boundaries closer than about half the length of the pulse return echoes that overlap into one, and no pulse can be shorter than about one cycle, so the resolution stops near the wavelength of the radiation used.

ULTRASOUND IMAGING

DEFINITION

The constant μ in $I = I_0 e^{-\mu x}$, measuring how strongly a material absorbs and scatters X-rays.

X-RAYS AND CT SCANNING

SPOT THE ERROR

An ultrasound image is built from echo timings, not captured like a photograph: each boundary in the body reflects a pulse, and $d = ct/2$ converts each echo's return time into a depth.

ULTRASOUND IMAGING

RECALL

One accelerated electron caps one photon: $E_{max} = eV$ for tube pd V.

X-RAYS AND CT SCANNING

RECALL

Bone's larger attenuation coefficient means it absorbs X-rays more strongly, so it shows clearly against soft tissue.

X-RAYS AND CT SCANNING

RECALL

Explain the different effects of tube voltage and tube current.

X-RAYS AND CT SCANNING

DEFINITION

Define: Half-value thickness.

X-RAYS AND CT SCANNING

RECALL

Explain pair production as an attenuation mechanism.

X-RAYS AND CT SCANNING

EQUATION · NOT ON THE AQA DATA SHEET

Maximum photon energy from the tube voltage:

E_{max} = ?

X-RAYS AND CT SCANNING

SPOT THE ERROR

Say what is wrong with this claim:

A CT scanner is just a sharper X-ray photograph.

X-RAYS AND CT SCANNING

DEFINITION

Define: Tracer.

RADIONUCLIDE IMAGING AND PET

RECALL

State what radionuclide imaging shows.

RADIONUCLIDE IMAGING AND PET

DEFINITION

Define: Coincidence detection.

RADIONUCLIDE IMAGING AND PET

DEFINITION

The thickness that halves the beam intensity: $x = \ln 2/\mu$.

X-RAYS AND CT SCANNING

RECALL

Raising the voltage raises the photon energies; raising the current only makes more photons.

X-RAYS AND CT SCANNING

EQUATION · NOT ON THE AQA DATA SHEET

$$E_{max} = eV$$

X-RAYS AND CT SCANNING

RECALL

Above 1.022 MeV a photon can convert into an electron-positron pair near a nucleus; it matters for high-energy beams, not diagnostic X-rays.

X-RAYS AND CT SCANNING

DEFINITION

A radionuclide attached to a molecule the body processes, so detectors outside the body can map where it is taken up. A gamma camera uses a gamma emitter; PET uses a positron emitter, whose annihilation photons are what escape.

RADIONUCLIDE IMAGING AND PET

SPOT THE ERROR

A CT scan is not a single sharper image: the scanner records many X-ray projections from different angles and reconstructs a cross-sectional slice, locating structures in depth as one shadow image cannot.

X-RAYS AND CT SCANNING

DEFINITION

Registering two 511 keV photons arriving at opposite detectors at effectively the same instant.

RADIONUCLIDE IMAGING AND PET

RECALL

Radionuclide imaging maps function, where the body's chemistry takes the tracer, rather than anatomical structure.

RADIONUCLIDE IMAGING AND PET

RECALL

State what a coincidence pair locates.

RADIONUCLIDE IMAGING AND PET

RECALL

State the energy of each PET annihilation photon.

RADIONUCLIDE IMAGING AND PET

RECALL

Explain why annihilation photons leave back to back.

RADIONUCLIDE IMAGING AND PET

RECALL

State the half-life of technetium-99m.

RADIONUCLIDE IMAGING AND PET

RECALL

State how to find the effective half-life of a tracer.

RADIONUCLIDE IMAGING AND PET

RECALL

State what PET scanning is used to diagnose.

RADIONUCLIDE IMAGING AND PET

RECALL

Explain why a PET scanner is combined with a CT scanner.

RADIONUCLIDE IMAGING AND PET

SPOT THE ERROR

Say what is wrong with this claim:

A PET scanner works by sending radiation into the body.

RADIONUCLIDE IMAGING AND PET

RECALL

511 keV, the rest energy of one electron through $E = mc^2$.

RADIONUCLIDE IMAGING AND PET

RECALL

The annihilation that produced the pair lies on the straight line between the two detectors that fired.

RADIONUCLIDE IMAGING AND PET

RECALL

Six hours, long enough to prepare and image but short enough to spare the patient a lasting dose.

RADIONUCLIDE IMAGING AND PET

RECALL

The electron-positron pair is nearly at rest, so momentum conservation demands equal and opposite photon momenta.

RADIONUCLIDE IMAGING AND PET

RECALL

Fluorine-18 on a glucose analogue maps how fast tissue is burning sugar. Tumours burn it fastest and show as bright spots, so PET finds and stages cancers; reduced uptake in regions of cortex marks dementia, an over-active patch locates the origin of epileptic seizures, and heart muscle still taking up the tracer after a heart attack is muscle still alive.

RADIONUCLIDE IMAGING AND PET

RECALL

$1/T_E = 1/T_B + 1/T_P$, always shorter than either half-life alone.

RADIONUCLIDE IMAGING AND PET

SPOT THE ERROR

PET sends no radiation in: a positron-emitting tracer inside the body is the source, and the scanner detects the back-to-back 511 keV photons produced when positrons annihilate with electrons.

RADIONUCLIDE IMAGING AND PET

RECALL

PET measures function but shows anatomy poorly, so a bright spot alone does not say which organ it is in. CT gives the structure and no function, so the two images are overlaid: one says what is happening, the other says where.

RADIONUCLIDE IMAGING AND PET

DEFINITION

Define: Accommodation.

THE PHYSICS OF THE EYE

DEFINITION

Define: Near point.

THE PHYSICS OF THE EYE

DEFINITION

Define: Far point.

THE PHYSICS OF THE EYE

RECALL

State the nature of the image on the retina.

THE PHYSICS OF THE EYE

DEFINITION

Define: Myopia.

THE PHYSICS OF THE EYE

DEFINITION

Define: Hypermetropia.

THE PHYSICS OF THE EYE

DEFINITION

Define: Astigmatism.

THE PHYSICS OF THE EYE

RECALL

State the three parts of a prescription for astigmatism.

THE PHYSICS OF THE EYE

DEFINITION

The closest object an eye can bring into sharp focus, taken as 0.25 m for a normal adult eye; also called the least distance of distinct vision.

THE PHYSICS OF THE EYE

DEFINITION

The eye changing the power of its lens, by changing the lens shape, so that objects at different distances all form sharp images on a retina that cannot move.

THE PHYSICS OF THE EYE

RECALL

Real, inverted and diminished.

THE PHYSICS OF THE EYE

DEFINITION

The furthest object an eye can bring into sharp focus, at infinity for a normal eye, and the distance the relaxed eye is focused on.

THE PHYSICS OF THE EYE

DEFINITION

Long sight: the eye has too little power for its length, so rays from a near object would focus behind the retina and the near point is further away than 0.25 m.

THE PHYSICS OF THE EYE

DEFINITION

Short sight: the eye is too powerful for its length, so parallel rays focus in front of the retina and the far point is at a finite distance instead of infinity.

THE PHYSICS OF THE EYE

RECALL

The spherical power SPH in dioptres, the additional cylindrical power CYL in dioptres, and the AXIS in degrees from 0 to 180 giving the orientation at which the cylinder is set.

THE PHYSICS OF THE EYE

DEFINITION

A cornea or lens whose curvature differs between two perpendicular directions, so its power is not the same along both and a point object cannot be focused to a point.

THE PHYSICS OF THE EYE

RECALL

State the power of the lens that corrects myopia.

THE PHYSICS OF THE EYE

RECALL

Explain why cones resolve finer detail than rods.

THE PHYSICS OF THE EYE

RECALL

State the wavelength the eye is most sensitive to in bright light.

THE PHYSICS OF THE EYE

DEFINITION

Define: Fovea.

THE PHYSICS OF THE EYE

SPOT THE ERROR

Say what is wrong with this claim:

The eye focuses on near and far objects by moving its lens, the way a camera does.

THE PHYSICS OF THE EYE

DEFINITION

Define: Intensity.

THE PHYSICS OF THE EAR

DEFINITION

Define: Threshold of hearing.

THE PHYSICS OF THE EAR

DEFINITION

Define: Intensity level.

THE PHYSICS OF THE EAR

RECALL

Each cone in the fovea has effectively its own nerve fibre, so neighbouring cones stay separate signals, while many rods share one fibre and their signals are combined.

THE PHYSICS OF THE EYE

RECALL

The lens must image an object at infinity at the far point, so P = −1/(far point in metres): negative, and therefore diverging.

THE PHYSICS OF THE EYE

DEFINITION

The small patch of retina on the axis of the eye, packed with cones and carrying no rods, where the sharpest vision is formed.

THE PHYSICS OF THE EYE

RECALL

About 555 nm, in the yellow-green; the rods peak nearer 500 nm, and the response has gone by roughly 400 nm and 700 nm.

THE PHYSICS OF THE EYE

DEFINITION

The power carried by a wave through unit area at right angles to its direction of travel: $I = P/A$, in W m^{-2}.

THE PHYSICS OF THE EAR

SPOT THE ERROR

The lens does not move: the retina is a fixed distance behind it, so v cannot change. Ciliary muscles change the shape of the lens instead, altering its focal length and so its power, and that change of power is accommodation.

THE PHYSICS OF THE EYE

DEFINITION

A logarithmic measure of a sound against the threshold of hearing, $10 \log(I/I_0)$, quoted in decibels.

THE PHYSICS OF THE EAR

DEFINITION

The minimum intensity a normal ear can detect at a frequency of 1 kHz, taken as 1.0×10^{-12} W m^{-2}.

THE PHYSICS OF THE EAR

RECALL

Explain why sound is measured on a logarithmic scale.

THE PHYSICS OF THE EAR

RECALL

State the change in intensity level when the intensity is multiplied by ten.

THE PHYSICS OF THE EAR

DEFINITION

Define: Equal loudness curve.

THE PHYSICS OF THE EAR

RECALL

Explain how an equal loudness curve is produced.

THE PHYSICS OF THE EAR

RECALL

State where the ear is most sensitive.

THE PHYSICS OF THE EAR

RECALL

State what the dBA scale is for.

THE PHYSICS OF THE EAR

RECALL

Explain how the middle ear raises the pressure.

THE PHYSICS OF THE EAR

RECALL

State why the middle ear must raise the pressure.

THE PHYSICS OF THE EAR

RECALL

The intensity level rises by 10 dB, because 10 log 10 = 10; doubling the intensity is a rise of about 3 dB.

THE PHYSICS OF THE EAR

RECALL

The audible range spans about twelve powers of ten of intensity, and the ear judges by ratio, so equal multiples of intensity are heard as equal steps of loudness.

THE PHYSICS OF THE EAR

RECALL

A 1 kHz reference tone is set to a chosen intensity level, and at each other frequency a test tone is adjusted until the listener judges the two equally loud.

THE PHYSICS OF THE EAR

DEFINITION

A curve joining the combinations of frequency and intensity level that a listener judges equally loud, labelled by its own intensity level at the 1 kHz reference tone.

THE PHYSICS OF THE EAR

RECALL

It passes the sound through a standard A-weighting curve, which approximates the ear's response at moderate levels, before the level is computed, so the reading counts the frequencies the ear is sensitive to most heavily rather than treating all of them alike. It is an exposure metric, not a measurement of perceived loudness.

THE PHYSICS OF THE EAR

RECALL

Between about 2 kHz and 5 kHz, where every equal loudness curve dips lowest; sensitivity falls at both ends of the 20 Hz to 20 kHz range and worst at the bass end.

THE PHYSICS OF THE EAR

RECALL

The cochlea beyond the oval window is fluid-filled, and without the gain almost all of the sound would reflect at the air-to-fluid boundary instead of entering.

THE PHYSICS OF THE EAR

RECALL

The ossicles act as a lever, and the eardrum has roughly twenty times the area of the oval window, so the same force acts over a much smaller area.

THE PHYSICS OF THE EAR

RECALL

Explain what noise damage or age does to the equal loudness curves.

THE PHYSICS OF THE EAR

EQUATION · NOT ON THE AQA DATA SHEET

Intensity of a wave from its power and area:

I = ?

THE PHYSICS OF THE EAR

EQUATION · NOT ON THE AQA DATA SHEET

Relative intensity level of two sounds:

relative intensity level = ?

THE PHYSICS OF THE EAR

SPOT THE ERROR

Say what is wrong with this claim:

A sound at 80 dB carries twice the power of one at 40 dB.

THE PHYSICS OF THE EAR

DEFINITION

Define: Resting potential.

BIOLOGICAL MEASUREMENT

DEFINITION

Define: Action potential.

BIOLOGICAL MEASUREMENT

DEFINITION

Define: Depolarisation.

BIOLOGICAL MEASUREMENT

RECALL

Explain where the p.d. an ECG measures comes from.

BIOLOGICAL MEASUREMENT

EQUATION · NOT ON THE AQA DATA SHEET

$I = \frac{P}{A}$

THE PHYSICS OF THE EAR

RECALL

The threshold curve lifts, most at the high-frequency end, so a greater intensity is needed to hear anything and the top of the range is lost first.

THE PHYSICS OF THE EAR

SPOT THE ERROR

80 dB is 40 dB more, which is four factors of ten, so the intensity ratio is 10^4. Ten thousand times the power, not twice: the decibel scale is logarithmic precisely because the ear judges by ratio rather than by difference.

THE PHYSICS OF THE EAR

EQUATION · NOT ON THE AQA DATA SHEET

relative intensity level $= 10 \log\frac{I_2}{I_1}$

THE PHYSICS OF THE EAR

DEFINITION

The brief pulse in which a triggered cell depolarises, its membrane p.d. reversing, and then repolarises as the resting state is restored.

BIOLOGICAL MEASUREMENT

DEFINITION

The potential difference held across the membrane of a resting muscle or nerve cell by the unequal distribution of ions, about 90 mV with the inside negative.

BIOLOGICAL MEASUREMENT

RECALL

Part of the heart is depolarised and part is not, so the heart acts as a changing electric dipole, and the conducting body fluids carry a p.d. of about 1 mV to the skin.

BIOLOGICAL MEASUREMENT

DEFINITION

The collapse and reversal of the p.d. across a cell membrane as ions cross it, which sweeps across the heart muscle as a wave and triggers contraction.

BIOLOGICAL MEASUREMENT

RECALL

State the three requirements of an ECG amplifier.

BIOLOGICAL MEASUREMENT

RECALL

State why conducting gel is used under an ECG electrode.

BIOLOGICAL MEASUREMENT

RECALL

State what the P wave represents.

BIOLOGICAL MEASUREMENT

RECALL

State what the QRS complex represents.

BIOLOGICAL MEASUREMENT

RECALL

State what the T wave represents.

BIOLOGICAL MEASUREMENT

RECALL

Explain why the QRS complex is the largest deflection.

BIOLOGICAL MEASUREMENT

RECALL

Explain why the T wave is broader and lower than the QRS complex.

BIOLOGICAL MEASUREMENT

RECALL

State how a heart rate is read from an ECG trace.

BIOLOGICAL MEASUREMENT

RECALL

Dry skin makes a contact of tens of kilohms, and the gel lowers that resistance and keeps the reading steady as the patient moves.

BIOLOGICAL MEASUREMENT

RECALL

High gain, to lift a millivolt to a usable size; high input impedance, so the large skin contact resistance does not swallow the signal; and low noise, to reject 50 Hz mains hum.

BIOLOGICAL MEASUREMENT

RECALL

The depolarisation of the ventricles, which then contract.

BIOLOGICAL MEASUREMENT

RECALL

The depolarisation of the atria, which then contract.

BIOLOGICAL MEASUREMENT

RECALL

The ventricles carry far more muscle than the atria, so far more charge moves at once and the p.d. at the skin is several times larger than during the P wave.

BIOLOGICAL MEASUREMENT

RECALL

The repolarisation of the ventricles as they recover and relax.

BIOLOGICAL MEASUREMENT

RECALL

Measure the interval T between two successive R spikes; the rate is 60/T beats per minute.

BIOLOGICAL MEASUREMENT

RECALL

Repolarisation is slower than depolarisation and less well synchronised across the muscle, so the same recovery is spread over more time.

BIOLOGICAL MEASUREMENT

SPOT THE ERROR

Say what is wrong with this claim:

An ECG is a recording of the heart moving, so the trace is a picture of the muscle contracting.

BIOLOGICAL MEASUREMENT

SPOT THE ERROR

The trace plots potential difference at the skin against time, not movement. What it records is the wave of depolarisation crossing the heart muscle, and the mechanical contraction of each chamber follows the electrical event that caused it.

BIOLOGICAL MEASUREMENT