INKPHYSICS FLASHCARDS

Waves

Year 12 · 37 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 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/flashcards.

DEFINITION

Define: Amplitude.

PROGRESSIVE WAVES

DEFINITION

Define: Wavelength.

PROGRESSIVE WAVES

DEFINITION

Define: Frequency.

PROGRESSIVE WAVES

DEFINITION

Define: Phase difference.

PROGRESSIVE WAVES

EQUATION — NOT ON THE DATA SHEET

Phase difference from path difference d:

phase difference = ?

PROGRESSIVE WAVES

CHECK YOURSELF

A wave on a rope has a period of 0.020 s and a wavelength of 8.0 m. Find (a) its frequency and (b) its speed.

Hint: Which equation links frequency to period? Use its answer in the second equation.

PROGRESSIVE WAVES

SPOT THE ERROR

Say what is wrong with this claim:

The wave carries the water along with it.

PROGRESSIVE WAVES

DEFINITION

Define: Transverse wave.

LONGITUDINAL, TRANSVERSE AND POLARISATION

DEFINITION

The distance between two adjacent points on a wave oscillating in phase, such as crest to crest.

PROGRESSIVE WAVES

DEFINITION

The maximum displacement of a particle from its equilibrium position.

PROGRESSIVE WAVES

DEFINITION

The fraction of a cycle by which one oscillation leads or lags another, in radians or degrees.

PROGRESSIVE WAVES

DEFINITION

The number of complete oscillations per second, in hertz; equivalently the number of complete waves passing a point per second.

PROGRESSIVE WAVES

CHECK YOURSELF

(a) $f = 1/T = 1 / 0.020 = 50$ Hz.

(b) $c = f\lambda = 50 \times 8.0 = 400$ m s^{-1}.

The rope itself never travels at 400 m s^{-1}. That is the speed of the pattern, and of the energy it carries; each piece of rope just oscillates fifty times a second about the place it started.

PROGRESSIVE WAVES

EQUATION — NOT ON THE DATA SHEET

phase difference = $(2\pi d)/(\lambda)$

PROGRESSIVE WAVES

DEFINITION

A wave whose oscillations are perpendicular to the direction of energy transfer.

LONGITUDINAL, TRANSVERSE AND POLARISATION

SPOT THE ERROR

The wave pattern travels; the water does not. Each particle only oscillates about its own equilibrium position — a floating cork bobs on the spot as the wave passes under it. Waves transfer energy, not matter.

PROGRESSIVE WAVES

DEFINITION

Define: Longitudinal wave.

LONGITUDINAL, TRANSVERSE AND POLARISATION

DEFINITION

Define: Polarised wave.

LONGITUDINAL, TRANSVERSE AND POLARISATION

CHECK YOURSELF

Ultrasound is used to image a fetus, and light is used to read a barcode. One of these waves could in principle be polarised. Which one, and why?

Hint: Classify each wave first. Which way does each one oscillate compared with its direction of travel?

LONGITUDINAL, TRANSVERSE AND POLARISATION

SPOT THE ERROR

Say what is wrong with this claim:

Any wave can be polarised if you build the right filter.

LONGITUDINAL, TRANSVERSE AND POLARISATION

DEFINITION

Define: Node.

STATIONARY WAVES

DEFINITION

Define: Antinode.

STATIONARY WAVES

DEFINITION

Define: Stationary wave.

STATIONARY WAVES

EQUATION — NOT ON THE DATA SHEET

Harmonic wavelengths on a string of length L:

λ_n = ?

STATIONARY WAVES

DEFINITION

A transverse wave whose oscillations are confined to a single plane containing the direction of travel.

LONGITUDINAL, TRANSVERSE AND POLARISATION

DEFINITION

A wave whose oscillations are parallel to the direction of energy transfer, as compressions and rarefactions.

LONGITUDINAL, TRANSVERSE AND POLARISATION

SPOT THE ERROR

Polarisation means confining oscillations to one plane perpendicular to travel, so it only makes sense for transverse waves. A longitudinal wave already oscillates along the direction of travel: there is nothing to filter.

LONGITUDINAL, TRANSVERSE AND POLARISATION

CHECK YOURSELF

The light. Light is an electromagnetic wave, so it is transverse, and its oscillations are perpendicular to the ray. A filter can select one oscillation direction, which is what polarisation is.

Ultrasound is sound: a longitudinal wave. Its particles oscillate along the direction of travel, so there are no perpendicular oscillation directions to select between, and no filter orientation can polarise it.

LONGITUDINAL, TRANSVERSE AND POLARISATION

DEFINITION

A point on a stationary wave where the amplitude of oscillation is maximum.

STATIONARY WAVES

DEFINITION

A point on a stationary wave where the displacement is always zero.

STATIONARY WAVES

EQUATION — NOT ON THE DATA SHEET

λ_n = (2L)/(n)

STATIONARY WAVES

DEFINITION

The superposition of two progressive waves of the same frequency travelling in opposite directions, storing energy rather than transferring it.

STATIONARY WAVES

CHECK YOURSELF

A string 1.20 m long is fixed at both ends and vibrates in its third harmonic. (a) What is the wavelength? (b) At the same tension, how does its frequency compare with the first harmonic?

Hint: How many half-wavelengths fit into the 1.20 m?

STATIONARY WAVES

SPOT THE ERROR

Say what is wrong with this claim:

A stationary wave is a wave that has stopped moving.

STATIONARY WAVES

DEFINITION

Define: Refractive index.

REFRACTION AND TOTAL INTERNAL REFLECTION

DEFINITION

Define: Critical angle.

REFRACTION AND TOTAL INTERNAL REFLECTION

DEFINITION

Define: Step-index optical fibre.

REFRACTION AND TOTAL INTERNAL REFLECTION

CHECK YOURSELF

A glass block has a refractive index of 1.50. Calculate the critical angle for light travelling from this glass into air.

Hint: Which refractive index belongs on top of the fraction?

REFRACTION AND TOTAL INTERNAL REFLECTION

SPOT THE ERROR

Say what is wrong with this claim:

Total internal reflection happens at any boundary, as long as you hit it steeply enough.

REFRACTION AND TOTAL INTERNAL REFLECTION

DEFINITION

Define: Diffraction.

DIFFRACTION AND THE SINGLE SLIT

SPOT THE ERROR

Nothing has stopped: two progressive waves are still travelling in opposite directions through each other. Their superposition holds a fixed pattern of nodes and antinodes — the pattern stands still, not the waves.

STATIONARY WAVES

CHECK YOURSELF

(a) The third harmonic has three loops. Each loop is half a wavelength, so $L = 3\lambda/2$, which gives $\lambda = 2L/3 = 2 \times 1.20 / 3 = 0.80$ m.

(b) The wave speed depends only on the tension and the mass per unit length, so it has not changed. In the first harmonic the wavelength is $2L = 2.40$ m. The wavelength has fallen by a factor of three, so by $v = f\lambda$ the frequency has risen by the same factor: the third harmonic is three times the frequency of the first.

Notice what decided the answer. The fixed ends select the wavelengths that can exist, and the fixed wave speed then turns each wavelength into a frequency. The oscillator driving the string does not choose the frequencies; the string does.

STATIONARY WAVES

DEFINITION

The angle of incidence in the denser medium for which the angle of refraction is 90°; beyond it total internal reflection occurs.

REFRACTION AND TOTAL INTERNAL REFLECTION

DEFINITION

The ratio of the speed of light in a vacuum to its speed in the material: $n = c/v$.

REFRACTION AND TOTAL INTERNAL REFLECTION

CHECK YOURSELF

Going from glass ($n_1 = 1.50$) into air ($n_2 = 1.00$), the condition $n_1 > n_2$ holds, so a critical angle exists.

$\sin \theta_c = n_2/n_1 = 1.00 / 1.50 = 0.667$, so $\theta_c = \sin^{-1}(0.667) = 41.8°$.

Any ray inside this glass that meets the surface at more than 41.8° to the normal cannot get out; it is totally internally reflected as if the surface were a mirror.

REFRACTION AND TOTAL INTERNAL REFLECTION

DEFINITION

A thin glass core carrying light by total internal reflection, wrapped in cladding of slightly lower refractive index.

REFRACTION AND TOTAL INTERNAL REFLECTION

DEFINITION

The spreading of a wave as it passes through a gap or past an edge, greatest when the gap is comparable to the wavelength.

DIFFRACTION AND THE SINGLE SLIT

SPOT THE ERROR

Hitting the boundary steeply is not enough. Total internal reflection needs the light to be heading into a lower refractive index AND to meet the boundary beyond the critical angle; going the other way it never happens at any angle.

REFRACTION AND TOTAL INTERNAL REFLECTION

CHECK YOURSELF

A red laser and a blue laser shine in turn through the same narrow slit. Which produces the wider central maximum, and why?

Hint: Which colour has the longer wavelength?

DIFFRACTION AND THE SINGLE SLIT

SPOT THE ERROR

Say what is wrong with this claim:

Waves only diffract when the gap is smaller than the wavelength.

DIFFRACTION AND THE SINGLE SLIT

DEFINITION

Define: Coherent sources.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

DEFINITION

Define: Path difference.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

DEFINITION

Define: Superposition.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

EQUATION — NOT ON THE DATA SHEET

Constructive interference condition:

constructive: path difference = ?

INTERFERENCE AND YOUNG'S DOUBLE SLIT

EQUATION — NOT ON THE DATA SHEET

Destructive interference condition:

destructive: path difference = ?

INTERFERENCE AND YOUNG'S DOUBLE SLIT

CHECK YOURSELF

In a double-slit experiment, light of wavelength 630 nm falls on slits 0.45 mm apart, and the screen is 2.0 m away. Calculate the fringe spacing.

Hint: Put every length into metres before you substitute.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

SPOT THE ERROR

Every gap diffracts every wave; the question is by how much. Spreading is only pronounced when the gap is comparable to the wavelength, which is why you notice sound bending through doors but not light.

DIFFRACTION AND THE SINGLE SLIT

CHECK YOURSELF

The red laser. Red light has a longer wavelength than blue, so the slit width is closer to λ for red light, and the diffraction is stronger.

Stronger diffraction means the light spreads through a larger angle beyond the slit, so every feature of the pattern, including the central maximum, is wider for red than for blue.

DIFFRACTION AND THE SINGLE SLIT

DEFINITION

The difference in the distances from two sources to a point, often expressed in wavelengths.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

DEFINITION

Sources with the same frequency and a constant phase difference.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

EQUATION — NOT ON THE DATA SHEET

constructive: path difference = nλ

INTERFERENCE AND YOUNG'S DOUBLE SLIT

DEFINITION

When two waves meet, the resultant displacement is the vector sum of the individual displacements.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

CHECK YOURSELF

$\lambda = 630 \times 10^{-}$ 9 m, s = $0.45 \times 10^{-}$ 3 m, D = 2.0 m.

w = λD / s = ($630 \times 10^{-}$ 9 $\times$ 2.0) / ($0.45 \times 10^{-}$ 3) = $2.8 \times 10^{-}$ 3 m, so the bright fringes sit 2.8 mm apart.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

EQUATION — NOT ON THE DATA SHEET

destructive: path difference = (n + (1)/(2))λ

INTERFERENCE AND YOUNG'S DOUBLE SLIT

SPOT THE ERROR

Say what is wrong with this claim:

Shine two lights on the same spot and you simply get a brighter spot.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

DEFINITION

Define: Diffraction grating.

DIFFRACTION GRATINGS

EQUATION — NOT ON THE DATA SHEET

Grating spacing from N lines per metre:

d = ?

DIFFRACTION GRATINGS

CHECK YOURSELF

Light of wavelength 550 nm falls on a grating with 300 lines per mm. Find (a) the angle of the first-order maximum and (b) the highest order that can be seen.

Hint: Find d first, and remember that sin θ can never pass 1.

DIFFRACTION GRATINGS

SPOT THE ERROR

Say what is wrong with this claim:

Adding thousands more slits should smear the pattern into a blur.

DIFFRACTION GRATINGS

DEFINITION

A plate ruled with a very large number of equally spaced slits, typically hundreds per millimetre.

DIFFRACTION GRATINGS

SPOT THE ERROR

With two ordinary lamps that is exactly what happens, because their phases wander independently. Make the sources coherent — constant phase difference — and superposition shows: paths differing by a whole number of wavelengths reinforce, an odd half-wavelength cancels, and fringes appear, including dark places either source alone would light.

INTERFERENCE AND YOUNG'S DOUBLE SLIT

CHECK YOURSELF

(a) d = 1/N = (1.0 × 10⁻ 3) / 300 = 3.33 × 10⁻ 6 m. Then sin θ = λ/d = (550 × 10⁻ 9) / (3.33 × 10⁻ 6) = 0.165, so θ = 9.5°.

(b) d/λ = 6.06, so the highest whole n with sin θ ≤ 1 is n = 6, and that sixth order sits out at 81.9°.

DIFFRACTION GRATINGS

EQUATION — NOT ON THE DATA SHEET

$$d = \frac{1}{N}$$

DIFFRACTION GRATINGS

SPOT THE ERROR

More slits sharpen the pattern rather than smearing it: with thousands of slits, even a tiny step away from the exact angle of a maximum leaves the contributions out of step, and they cancel. Light survives only where d sin θ = nλ holds exactly.

DIFFRACTION GRATINGS