Phys2023 Wave Physics February 2009

Overall, most marks were lost for

- omitting parts of a question
- lack of care and rigour
- offering a description in place of a derivation
- failure to read the question, or answering a question different from that set

Section A **mean 14.5/20**

A1 Fermat's principle and refraction **mean 3.6**

Most could state Fermat's theorem and sketch some moderately likely routes, although a few suggestions gave cause for concern. Many explanations were rather sloppy, suggesting for example that the time spent in the air should by itself be maximized or the time in the glass minimized.

A2 Two slit interference **mean 3.3**

This question revealed an astonishing inability to apply Pythagorus' theorem, and a tendency to vagueness about what is meant by interference itself. One or two referred to waves interacting, probably just showing an imprecision of language, and a number used the phrase 'vector sum of amplitudes', which also begged a few questions.

A3 Energy density and intensity **mean 1.5**

Assuming only the most basic knowledge, this question could have been answered successfully simply by following the instructions – at which, as the low scores indicate, most failed. Many took $d^2\xi/dt^2$ to be the same as $(d\xi/dt)^2$; several considered 10^{-14} W m^{-2} to be the energy density, despite its units; and rather too many thought the intensity to be equal to, rather than merely proportional to, the square of the intensity, even though the relationship was defined in the question. Few succeeded with the second part.

A4 Boundary conditions **mean 3.0**

The few who confused boundary conditions with continuity or initial conditions were generally treated leniently, as notation varies in the literature. Most could sketch the modes of the two instruments, though many neglected to offer a physical explanation.

A5 Sinusoidal and complex exponential solutions **mean 3.1**

Generally well answered, with marks lost mainly for omissions.

Section B **mean 23.1/40**

B1 Longitudinal waves **69 attempts mean 13.8**

This textbook question was generally well answered, with few common errors except over-reliance on memory instead of logic, a few dropped signs and confusion of pressure with tension. Some lost marks by omitting to state the wavevector values or giving only the positive root, many calculated the amplitude reflectivity, where the intensity coefficient was sought, and several erred in numerical calculation. Some thoughtful suggestions were offered for the final part.

B2 The Michelson interferometer **69 attempts mean 10.5**

Many answers showed an excess of confidence over revision: forgotten theory, inept geometry and sketches of diffraction patterns rather than interferograms were all responsible for many lost marks. Complex numbers were generally well handled once started correctly, but derivation of the $\cos\vartheta$ factor stumped many.

B3 Dispersion and phase and group velocities **65 attempts mean 10.6**

Another essentially textbook question, which exposed widespread inability with simple partial differentiation – and, indeed, differention per se, with many failing to determine $\mathrm{d}/\mathrm{d}k(k^{\frac{1}{2}})$. Many again thought, as in A3, $\mathrm{d}^2h/\mathrm{d}t^2$ equivalent to $(\mathrm{d}\ h\ /\mathrm{d}t)^2$, and several confused the particle vertical velocity with the horizontal velocity or wave velocity: oh, how an illustration can help! A notable number (I think the majority!) calculated a numerical value that could only be obtained by incorrect use of their calculators…

B4 Fourier analysis **14 attempts score 14.1**

An unpopular but well answered question, with no notable errors beyond failing to attempt some parts. The full width at half maximum proved occasionally testing, and the final calculation exposed a tendency to plug values into the nearest equation.

The overall grades display a rather bi-modal distribution, with students either excelling or scraping a pass, that was notable in the subjective quality of the scripts. Students had either engaged with the course and were able to make perceptive and relatively clearly expressed observations, or they had opted for rote learning at which they were mainly unsuccessful. Happily, the former formed the majority, and these demonstrated an analytical ability that in previous years has been rather rare. If students in this category let themselves down, it was mainly in a lack of rigour and care. Exam technique and literacy seemed better than in previous years, although handwriting and the ability to produce clear diagrams seemed rather worse.

Basic mathematics continues to be a problem for a fair number of students: application of the chain rule for differentiation, and derivation of the derivative itself, were commonly flawed, although complex numbers were usually dealt with competently. Curiously, many seemed unable to use a calculator (…/(2π) being entered as ÷2*π) and mental checking of the result was clearly uncommon. There were many cases of inappropriate precision: too many figures in some cases, too few at intermediate stages in others where the result depended upon differences.