Phys2023 Wave Physics February 2018

Many scripts this year suggested a patchy grasp of wave physics, but what caused one student to founder another had mastered, and few parts were done consistently well or poorly. Descriptive answers and definitions were generally better than mathematical analysis: many stumblings seemed rooted in discomfort with prerequisite mathematics, and there was more trouble than in previous years with basic differentiation and binomial expansion. Logical layout, numerical precision and diagrams, however, were somewhat improved.

Many marks were lost when students omitted parts of the question through either oversight or weak heartedness, or answered a different question from that posed; and too many tried to rely upon a dodgy memory where with thoughtful consideration they would have spotted simple steps and obvious errors. Exam technique and weak mathematics seemed the principal problems overall.

Section A **mean 9.1/20**

This section revealed a wide range of abilities: some students did well and gave reasonable answers to all questions, but too many could not recall the basics of the module or apply them properly. Written answers (e.g. A2, A3a, A5) tended to be better than mathematical ones (e.g. A1b, A3b, A4). Overall, the ability to apply maths to wave forms seemed lacking, with a number of students unable to use trigonometry rules and confusing imaginary numbers.

A1 Travelling and standing waves **mean 2.0/4**

Most students made a good attempt at the first part of this question, and answered well. However, many were stumped by the second part of the question: a number mistook standing wave superpositions from beats, and those who answered correctly often only showed how a standing wave could be superposed from two travelling waves but not the other way around.

A2 Michelson interferometer **mean 2.5/4**

This question was generally answered well by all. It was clear a lot of the students knew exactly what the Michelson interferometer was and what its original purpose was (e.g. to test the aether hypothesis). However, very few seemed to know what it is used for now, beyond that a similar concept is used in LIGO experiments.

A3 Impedance and reflectivity **mean 1.0/4**

Few students could explain the concept of impedance. Consequently, the formula for the reflectivity was often poorly written or confused with other formulae. Very few of those who attempted full answers discussed what the reflectivity or impedance meant in terms of how much of the wave was reflected given two characteristic impedances.

A4 Energy density and intensity **mean 1.5/4**

About half the class answered the first part of this question correctly, but many confused $(\partial\psi/\partial x)^2$ for $\partial^2\psi/\partial x^2$ and consequently were unable to remove a sine or cosine dependence from the mean energy density in the second part of the question. Those who performed the derivation of part (a) correctly often made a good stab at part (b).

A5 Operators **mean 2.0/4**

Despite generally vague answers to the first part of this question, students were often able to give the $\hat{k}$ or $\hat{\omega}$ operators and work out the final part correctly, though unchecked guesses resulted in many errors. Unfortunately, some students slipped up with their use of notation, for example, the use of complex numbers or mixing ∂x with ∂t.

Section B **mean 21.4/40**

B1 Thermal diffusion waves **87 attempts mean 9.5**

There was great variation in which bits students could answer correctly, with (d) the only part to be found consistently difficult. A number omitted the simple opening part, or had not revised conduction and heat capacity, and few said much about their assumptions. (b) and (c) were usually fine, though many seemed unsure of $\sqrt{i}$. Few could describe the variations in (e), even though this example was covered explicitly in lectures: many forgot that the heating followed a square wave, or missed this part's connection to the rest of the question. The propagation speed was found correctly by those who calculated $v_p = \omega/k_0$, but a tendency to guess rather than deduce was rarely successful.

B2 Guitar strings and Fourier transforms **138 attempts mean 12.1**

There were also some excellent answers to the early parts of this question, but some surprisingly poor derivations of the much-practiced string wave equation and much confusion over the Fourier combinations of x, t, ω and k. In the later parts, too many thought a guitar string would vibrate at an overtone, signals were often plotted as intensities, 'spectra' were plotted as functions of time, and some tried to plot frequency against time.

B3 Doppler effect and atomic linewidth **22 attempts mean 8.0**

With its small steps and many prompts, this question (shortened at the external examiner's suggestion) offered quick marks for students with a sense of direction rather than a broad knowledge or love of maths. Unfortunately, many decided to answer the questions they'd have liked, rather than those set. The vector nature of the geometry was commonly neglected, and later results quoted where derivations were sought. This question was disproportionately chosen by weaker students, with an average 'other question' mark lower by 1.4.

B4 Fraunhofer diffraction and convolution **38 attempts score 10.6**

This straightforward question, fully covered in lectures and exercises, produced a very wide range of answers from textbook perfection to blind guesswork. Over-reliance upon memory meant that few diffraction patterns (e) were shown with an appropriate axis (θ, $\sin\theta$, distance), and multiplication and convolution seemed to be used at random in the combination of functions.