# Phys2023 Wave Physics February 2015

Amid some excellent papers and individual answers, this exam revealed too widespread an inability to apply general principles to unrehearsed questions, and weakness regarding the year prerequisites, with bizarre statements about the relationships between pressure, force and area, and between energy and power. Second-order differentiation and the chain rule defeated many; too many 'differentiated' by dividing by t, or handled differential equations by treating the 'd' and 'dt' terms as factors. Indeed, while descriptive parts were generally well answered, too few could use mathematics as either a branch of logic or a quantitative representation of a physical situation. Literacy and legibility were generally better than in previous years.

Overall, most marks were lost for

- omitting parts of a question
- lack of care and rigour
- reliance upon memory in place of true derivation
- inability to perform common mathematical operations

**Section A** **mean 14.1/20**

**A1 Travelling and standing waves** **mean 3/4**

Many students understood the difference between standing and travelling waves and wrote good explanations of both. Although many did not derive the phase velocity from the sinusoidal example of a wave that they had just given, most students answered this question well.

**A2 Transverse and longitudinal waves** **mean 4/4**

This question was well answered by almost all students. The physical understanding of differences between transverse and longitudinal waves was clear from the cohort as well as good examples given in most cases.

**A3 Huygens description** **mean 2.5/4**

Most students gave this question a good attempt. The Huygens description generally included the technical terms required to obtain the marks, but several tripped up by being too vague when describing how diffraction could be described using this principle. A small minority wrote about refraction instead of diffraction. Those who drew diagrams showing the process of diffraction often gained marks as this reinforced their descriptions.

**A4 Dispersion** **mean 3.5/4**

A lot of students understood the principle of dispersion even if they could not describe it with clarity; many gained marks in the second section when asked to derive the phase velocity and group velocity of a dispersive system. Once most got the dispersion relation, the rest followed.

**A5 Bandwidth theorem** **mean 1/4**

Students struggled with this question more than the others. Many didn't know where to start when outlining the bandwidth theorem but some did notice the link to Heisenberg's Uncertainty Principle. Again, vagueness in descriptions made it difficult for students to gain full marks.

**Section B** **mean 15.8/40**

**B1 Ocean waves** **105 attempts** **mean 8.6**

This was a popular question amongst those who recognized this as core material about wave propagation, and thought that they could knock up some quick marks. Sadly, they were mostly wrong, although many were remarkably persistent.

The structure of this question proved remarkably successful at identifying whether students had assimilated the prerequisites and learned the new material by rote, understood only at the level of a qualitative description, or could undertake a quantitative explanation and analysis; many scored few marks on the latter.

Many thought hydrostatic pressure to be given by $P = m\,g\,h$. Rather a lot thought that $P = F \times A$. Many took the 'power' or 'intensity' of a tsunami to have a colloquial or figurative meaning, or wrote about the energy increasing with blithe disregard for the principle of energy conservation.

No marks were awarded for painstakingly reproducing the diagrams given on the question sheet.

**B2 Fourier analysis** **87 attempts** **mean 7.3**

Another popular question, which was answered surprisingly well: most attempts were good, except for a failure to read the instructions such as in (c) to integrate equation (1). (e) was answered poorly, with too many wild guesses showing a lack of thought about the physical situation described. More diagrams, and tidier handwriting, would have helped students to stay on track. A surprising number of students made basic mistakes with simple integration and differentiation.

There was a typo in part (b), with rogue modulus marks around what should have remained negative. Most students worked out - and were informed by the invigilators - that these should be ignored.

**B3 Impedance and reflection** **49 attempts** **mean 7.4**

Many confused themselves trying to reproduce reflection and transmission calculations from memory, rather than using the information given, and scored poorly on the first parts of the question. Most obtained good marks for the description of Newton's rings and calculation of the illumination wavelength, though some particularly incoherent descriptions probably let down students who knew better: an astonishing number had difficulty explaining that it was reflections from two surfaces that resulted in the interfering beams. The geometric calculation of the path length difference taxed disappointingly many.

**B4 Doppler effect** **6 attempts** **score 8.7**

This unpopular question seemed for many to have been attempted out of desperation, and revealed confusion with vectors and application of the principle of energy conservation.