Phys2023 Wave Physics February 2016

Many students this year lost marks for not reading the question, and either answering a different question or omitting parts altogether. Some students clearly tried to rely upon memory rather than understanding; unfortunately, their memories were poor. Vague answers to descriptive sections were scored appropriately.

Section A **mean 10.3/20**

A1 Mountain lee waves **mean 2.7/4**

Students tended to do well on the first part of this question, correctly differentiating the wavefunction and substituting in for x'. Although, some got into a mess with the algebra if they substituted in for x' before differentiating. The second part of the question gave many students problems with many incorrectly stating that the minimum of sin(kx) is 1. This led to negative amplitude in most cases. A not insignificant number of students did not check their mathematics carefully enough with some ending up a factor of 10 out on the final numeric answer as they had not written down the velocities correctly when calculating the amplitude. Others had made small mistakes on their algebra which led to values that were unphysical.

A2 Doppler effect **mean 2.6/4**

Almost all students received full marks for the first part of the question, correctly asserting the Doppler shift accurately. The second part however was often answered by giving examples of how the Doppler effect can be seen in nature or classical physics (e.g. ambulance sirens moving forward and back) rather than describing where it can be theoretically derived from. As such, most only received a single mark for the classical explanation that they gave rather than the full two marks. Some also showed the mathematical derivation of the Doppler effect rather than writing a description for the second part of the question.

A3 Bandwidth theorem **mean 1.2/4**

A lot of students found this question difficult. Many only vaguely answered the first part and explained why there must be different frequency components. Some explained in detail how a laser produces a beam of light with mirrors, but didn't discuss the core physical concepts behind this to answer the actual question. Many stated the bandwidth theorem in some form and usually could work out from there that the minimum bandwidth of the spectrum is inversely proportional to the pulse length. Some mentioned Heisenberg's uncertainty principle although this was not awarded marks. However, this was answered very poorly by most with very few awarded most of the points due to not writing down what was required or by writing everything they knew on a related part of the course which unfortunately did not receive marks. No answer referred to the intensity of the laser, so none received the marks for this.

A4 Boundary conditions **mean 2.0/4**

The cohort answered this question in an irregular way. Some noted that the boundary conditions would be the same at each end but assumed a non-general case of a closed pipe at one end and open at the other, thinking that it was the centre of the receiver that was more important here. Many students forgot to state the length must be an integer number of half-wavelengths, instead jumping to the shortest length of the rod and so didn't gain a mark. The second part of the question was answered well by those who had completed the first part correctly, but some slipped up if they had got the original geometry wrong or had assumed an odd/even number of wavelengths. Mostly this was answered adequately but too many students made incorrect assumptions that hampered their attempts to correctly and fully answer the question.

A5 Travelling & standing waves **mean 1.8/4**

The first part of this question was answered well by almost all students. Any marks lost here were due to vagaries in their answers but this usually only cost half a mark. The second part of the question was mixed. Some students correctly identified the need for showing mathematically how a standing wave could be transformed into a travelling wave. However, many missed the "vice-versa", costing them a mark, or simply stated what superposition meant without any derivation. Some misunderstood that "with example" referred to a mathematical derivation of the interchangeable nature of travelling and standing waves, instead, giving a specific real-world example of that type of wave and so couldn't receive the marks for this part of the question.

Section B **mean 25.0/40**

B1 Electromagnetic waves in a coaxial cable **41 attempts mean 15.2**

Although not particularly popular, this high-scoring question revealed and rewarded those students who had paid attention to lectures and directed reading. Several students skipped parts b and c but, for those who attempted all parts, marks were mainly lost for poor diagrams and missing units. A few cheap marks for number plugging revealed that some students persist in giving answers to a ridiculous precision, or the GCSE habit of arbitrary truncation followed by bracketted 'dp' or 'sf'.

B2 Michelson interferometer **57 attempts mean 9.7**

Often answered after questions that came later on the exam paper, this seemed to be a question of last resort for those who had revised inadequately but thought they could remember the answers from lectures, exercises and past exams. In most cases, they were sadly wrong. Many did not attempt the analytical parts b and c, and there were few complete, correct answers to d. Tatty diagrams suggested that ruler ownership is rare.

B3 Fraunhofer diffraction **33 attempts mean 11.0**

Some surprisingly poor introductory definitions of Fraunhofer diffraction commonly skipped the diffraction aspect and were unclear about which image plane satisfies the Fraunhofer condition. Most preferred to rely upon unreliable memories rather than sketch the diffraction patterns from the expressions given: many resembled the patterns from diffraction gratings, and most omitted sensible axis labelling and values.

B4 Dispersion **117 attempts score 13.4**

This popular and perhaps familiar question elicited some Pavlovian responses, and most marks were dropped for not reading the question: many easy bits were skipped, while time was spent on gratuitous diagrams and oddly placed derivations of phase and group velocities. Answers also revealed a common failure to distinguish between words beginning with 'd'; accounts of diffraction or dissipation did not gain the marks reserved for an explanation of dispersion. Examples of manifestations and applications were often omitted, poor, unclear, bizarre or wrong. Some students confused the longitudinal spreading of a wavepacket with the transverse spreading of ripples propagating in 2 or 3-D.