

Feedback to candidates from the examiner: 28th January 2015

Course code: PHYS30101

Course Name: Applications of Quantum Physics

Introduction

Overall a good performance indicating that most of the class has a reasonable understanding of the material covered. However, there was a broad spread in the marks with a long tail at the low end. Looking at the scripts, it seems that the tail is composed of a small number of students who didn't seem to have any recognition of many of the main thread in the course; I suspect that these are students who were absent from the majority of the lectures.

Common misunderstandings

See comments on individual questions below.

Exam technique

Worthwhile reiterating that where there are a number of marks allocated for more qualitative answers, full marks are likely to require a commensurate number of substantive points to be made. In some cases, large volumes of text didn't make many substantive remarks.

A small number of scripts were incredibly difficult to read; if you have bad handwriting it needs working on. If the examiner can't read the answer, it's difficult to mark it.

Specific questions

Q1 was composed of a series of short problems covering a wide range of material. The performance overall was excellent, indicating a good understanding of the basic concepts needed in applying quantum mechanics to real situations. Question (a) on LS coupling was mostly very well done, with only a few odd slips. Answers to (b) about classical and quantum bits were reasonable; a small number of answers had a lot of words, but no clarity, and a few forgot to give examples. Some people confused the ideas of superposition and entanglement. Part (c) was almost universally well done. In (d), it appeared that you either knew how to add angular momentum or you didn't, luckily most did. Full marks for (e) were only obtained if the reasons given contained some definition or explanation of what entanglement was; factorization was only part of this story.

Q2 was a popular choice with most students trying this question. The qualitative descriptions needed for (a) often did not contain enough substantive points for full marks. Some answers did not cover all the points asked for in the question. Part (b) was usually well done, although fudging was done of the minus signs to match the right answer in some cases. A common error was not to use $E=E_F$, as given in the question, to simplify the integrand in the transmission factor. Part (c) was badly done for many reasons. Some did not know how to convert a potential difference into a

field. In many cases units went wildly astray, although most saw that using $\hbar c = 197$ eV.nm would help the arithmetic. Some calculated the percentage change in the current, rather than just I_2/I_1 . A common mistake was to put 4.8 eV into the formula for W but then forget to take the 3rd power. Some tried to use the formula given in Part (a) rather than that in Part (b). All silly errors so perhaps you were all just getting a bit tired of the question, rather than displaying a lack of understanding!

Most people did not choose **Q3** on spin, but those that did achieved a higher average performance than the other optional questions. Parts (a) and (b) were well done; although a common error was to say that the application of a raising operator acting on the eigenstate of the top of the ladder resulted in the eigenstate at the bottom of the ladder, rather than zero (and a similar error for the lowering operator on the bottom eigenstate). There was occasionally sign confusion in Part (c) over whether the charge of the electron was written as e or $-e$; in principle it is a choice, but it needs to be consistently chosen. There was some confusion over S_z and σ_z leading to \hbar 's going astray. Some left spin operators out all together! Verifying that the spin state was a solution of TDSE was the weakest point of this question; the easiest way to do it, substituting the solution into TDSE and showing LHS=RHS, was only spotted by a few people. Most people found the expectation values correctly, albeit to within a sign for some. Some forgot to use the transpose-conjugate ψ^\dagger . A bizarre error that was really difficult to diagnose was that in calculating $\psi^\dagger S_z \psi$, rather than first doing the matrix multiplication $S_z \psi$ followed by a vector product, some people did $\psi^\dagger S_z$ *backwards first* which gives the wrong answer.

Q4 was popular, but attracted the lowest average performance. This was largely a combination of misremembering the energy levels in an infinite square well and revulsion for attempting simple trigonometric integrals. On the former, it is only a couple of lines to actually derive the eigenvalues as a quick check. On the latter many people wrote down the correct integral, but then didn't attempt to do it, or did it wrong for a multitude of different reasons. It **IS** reasonable to assume that third-years can do A-level and first-year integrals in exam conditions! Part (a) was very well done. Other than not remembering, a common error was to assume n_x , n_y and n_z were an integers starting at zero rather than one. In (b) almost everyone could write down the wave function for the lowest state (although some wrote a sum rather than a product of functions of x , y and z) but either the integral was not done or the normalization condition used was $\int \psi dV = 1$ (rather than the integral of the square of the modulus). Most people knew that the change in energy was the expectation of the perturbation but, of those who attempted the integral, some only integrated over z and did not consider integration over x and y .