

Homework Assignment (4)

This assignment is due in on or before Monday March 24th, 2003. Note that late assignments may not receive a mark.

1. In a 15-day period, two cars in the same town, A and B, failed to start on the days marked as 'X'. The temperature is also shown as 'C' for each day it was very cold.

Car A				X	X			X				X	X		
Car B			X	X	X							X			
Temp			C	C	C							C			

- a. Show that car A failing to start is correlated with car B failing to start.
- b. Show that this correlation is likely due to the air temperature as a common cause.

2(a) Explain what is meant by the “wave-particle duality”. You should discuss this question by referring to some realistic set-up in physics- it is probably easiest to do this by looking at the 2-slit interference experiment, and discussing it for something like photons or electrons (or any other system you care to pick). It will be helpful to show what happens in such experiments under different conditions, with the aid of diagrams.

2(b) Now discuss the evidence that shows that one must really assume that when a quantum system propagates through space, the quantum “wave-function”, or quantum state of the system, is actually “feeling out” or sampling all possible paths that it can follow. Consider in particular an experiment like the Aharonov-Bohm experiment for electrons through a pair of slits, in which now one adds a magnetic field localized so that the electron cannot go near the field unless it does sample all these paths. In your description of this experiment you should carefully describe how it is set up, and what is seen under different circumstances.

3. Describe the Hydrogen atom as it is now understood by quantum physics. You should begin at the scale of the atom itself (ie., a scale of roughly 1 Angstrom), and discuss how we now understand the behaviour of the single electron in this atom. Then go on to discuss the nucleus, and also the constituents of the nucleus. You should explain the length scales involved, and also the energy scales. Two other things you should discuss

are (i) what it is that makes this really quantum-mechanical, and why would the whole picture of the Hydrogen atom that we have break down if quantum mechanics was not valid; and (ii) what kinds of experimental evidence we have for the accuracy of this picture, both for the electronic behaviour and for the nuclear behaviour.

YOU WILL BE ABLE TO ANSWER PRETTY MUCH EVERYTHING IN THESE QUESTIONS USING THE COURSE NOTES, BUT YOU MAY ALSO PROFIT BY LOOKING AT THE WEB FOR FURTHER DETAILS ON THE REMARKS MADE IN THE COURSE NOTES.