Comments on QFT New Year Test 2019

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I will not be providing a dedicated set of answers for this test. However, everything comes from existing material so I have indicated where you can find the relevant material.
The marks are not on an absolute scale. To help you interpret the results I have provide some summary statistics. I had scripts and marks for 28 students.

	Q1/30	Q2/30	Q3/30	Total/90	Percentage
Average	20.5	21.8	17.8	59.4	66%
Median	23	21	18	61	67.8%
1st Quartile	15	19	14.5	49	54.4%
3rd Quartile	25	26	23	69.75	77.5%

1. The use of the equations of motion to derive the classical form of the conserved current for a single complex scalar was given in the lectures and considered in detail in PS3, Q3. The rest of the question was part of PS4 Q6.

(i) Don't forget to show me something, a little working, for any part.

(ii) Many people forgot to use the $\int d^3\boldsymbol{x}$ which is in the definition of $\widehat{Q}$ but not J^0. That is needed to fix the two momenta equal, one from each field. Also don't forget the two fields are at the same space-time point x.

(iii) A typo in the original test has been corrected in the version now online.

2. Wick's theorem in a very general form is a core part of the course. It is covered in covered in lectures, the handout "Notes on Wick's Theorem", on Problem Sheet 5, and in a rapid feedback class.

The contour integration used for the different representations of propagators is also covered in lectures and on the handout "The Feynman Propagator and Cauchy's Theorem".

(i) A lot of the definitions given were not clear or precise enough. I may well use incomplete abbreviations of the definitions in lectures or notes when I'm in the middle of other derivations, but when giving the first definition of these concepts, I and you should be precise (in words or algebraically, either will do). There are precise definitions on the "Operator Ordering" handout. For instance, no good telling me some "field at later time is to the left" Left of what? Of course I know what you mean but I'm giving away a lot of marks here and, for a first definition, it ought to be pretty tight. Similarly, no good giving me $= \phi(x_1)\ldots\phi(x_n)$. What do the dots mean? How are fields ordered there? Something like $\ldots\phi(x_i)\ldots\phi(x_j)\ldots$ for $x_i^{\mu=0} > x_j^{\mu=0}$ is a precise part of one short definition of time-ordering.

(ii) I was looking to see you specify how the energy variables of the two terms combine in $D(x,y)$ calculation.

Show that we have chosen to split here to make sure that $\langle 0|\mathrm{N}\ldots|\,0\rangle = 0$. Then no need for any explicit calculation.

(iii) Poles were often placed wrongly. Explanation for choice of contours sometimes confused. See handout "The Feynman Propagator and Cauchy's Theorem".

3. This question is very similar to the one asked in the QFT summer 2018 exam for which answers are available.

(i) A lot of the definitions given were not clear or precise enough. Again for the large amount of marks given out for straightforward parts at the start of a question I expect to see good answers. So which coordinate labels count when looking for distinct diagrams? (External vertices are the only labelled ones). When you write down a line for a propagator $\Delta_f(x_1 - x_y)$, where do the coordinates come from? (Labels of the vertices at ends). I asked for "scalar Yukawa theory" so I don't give full marks for generic explanations. I asked for the Feynman rules for Green functions so link the coordinates of external vertices to the arguments and fields of the Green function (not those in the S-matrix). We're in four space-time dimensions (implied in the "Useful Definitions" sheet) so don't give me any $\int d^3\boldsymbol{x}$. Define the symmetry factor $\mathcal{S}$ if you refer to it (which you should), the definition is just one line. Why not draw the rules out including all three external vertices? It is not essential but it will help you remember everything you have to mention or provide a second place where you can show me information e.g. coordinates.

I'm not sure anyone got full marks for this section. See the handout "Feynman Rules for SYTh in Coordinate Space".

(ii) Don't forget to give me a line on why $O(g^1)$ terms do not appear.

(iii) Still don't forget to give me a line on why $O(g^1)$ terms do not appear.

(iv) This is just a Taylor expansion in g but you have to give it to me so I can give you the marks.