PHYS 7326: Running Homework and Take-Home Exams

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We are trying something different this semester for the students that wanted more regular homework assignments. Work will still be due biweekly, but problems will be posted on a rolling basis as lectures are developed and given. It is also more natural for me, as assignment ideas come on a rolling basis.

Instructions: Due dates will be listed throughout the document in bold letters. For the first assignment, complete all problems by the first due date. For the n^{th} assignment, complete all problems between the $(n-1)^{\text{th}}$ and n^{th} due date. Two due dates will have the words "TAKE-HOME" on the same line. The first is the take-home midterm, and the second the take-home final. These are your work alone.

I will also organize according to topic.

1 Non-abelian Gauge Theory

- 2 pts. Prove Schwartz equation (25.11).
- 3 pts. Non-abelian gauge invariance. Schwartz problem 25.1.
- 5 pts. Anomaly coefficients. Schwartz problem 25.4.
- 3 points. Peskin 15.1.
- 3 points. Peskin 15.2.

HOMEWORK 1. Due February 1.

- 5 points. Prove Peskin equations 16.48-49 and the second BRST variation of the gauge field discussed in between them.
- 5 pts EXTRA CREDIT. Non-abelian gauge invariance. Consider the Lagrangian

$$\mathcal{L} = -\frac{1}{4}F^a_{\mu\nu}F^{\mu\nu a} + A^{abcd}A^a_\mu A^{\mu b}A^c_\nu A^{\nu d} + B^{abc}\partial_\mu A^{\mu a}A^b_\nu A^{\nu c} + C^{abc}\partial_\mu A^a_\nu A^{\mu b}A^{\nu c} \tag{1}$$

  and the gauge transformation

$$A^a_\mu \mapsto A^a_\mu + \frac{1}{g_a}\partial_\mu\alpha^a + T^{ab}A^b_\mu. \tag{2}$$

  By $F^a_{\mu\nu}$, where we mean the usual thing $F^a_{\mu\nu} = (\partial_\mu A^a_\nu - \partial_\nu A^a_\mu)$, rather than the non-abelian field strength. The latter comes naturally out of this calculation and will involve the interaction terms.

  - Compute the transformation of each term appearing in the Lagrangian.
  - From the transformed Lagrangian, compute conditions that must be satisfied for the Lagrangian to be gauge invariant. Hint: collecting terms with the same number of derivatives and vector fields is useful.
  - Determine whether or not the solution presented in class

$$g_a = g_b =: g \ \forall a,b \qquad T^{ac} = -f^{abc}\alpha^b A^c_\mu \qquad C^{abc} = -gf^{abc} \qquad A^{abcd} = g^2 f^{kac}f^{kbd} \qquad B^{abc} = 0 \tag{3}$$

    is the only solution.