

# 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  $n^{\text{th}}$  assignment, complete all problems between the  $(n-1)^{\text{th}}$  and  $n^{\text{th}}$  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. Non-abelian gauge invariance. Consider the Lagrangian

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}^a F^{\mu\nu a} + A^{abcd}A_\mu^a A^{\mu a} A_\nu^c A^{\nu c} + B^{abc}\partial_\mu A^{\mu a} A_\nu^b A^{\nu c} + C^{abc}\partial_\mu A_\nu^a A^{\mu b} A^{\nu c} \quad (1)$$

and the gauge transformation

$$A_\mu^a \mapsto A_\mu^a + \frac{1}{g_a}\partial_\mu \alpha^a + T^{ab}A_\mu^b. \quad (2)$$

By  $F_{\mu\nu}^a$ , where we mean the usual thing  $F_{\mu\nu}^a = (\partial_\mu A_\nu^a - \partial_\nu A_\mu^a)$ , 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

$$g_a = g_b =: g \quad \forall a, b \quad T^{ab} = -f^{abc}\alpha^b A_\mu^c \quad C^{abc} = -gf^{abc} \quad A^{abcd} = g^2 f^{kac} f^{kbd} \quad B^{abc} = 0 \quad (3)$$

is the only solution.