

# Chapter -1

## Preface

The preparation of these notes began in 2008 when my colleague Laurence Yaffe taught the first offering of the newly designed class entitled *Particles and Symmetries*. This class was created to give undergraduate physics students, early in their studies, an introduction to the fundamental constituents of matter and the symmetries which characterize their interactions. The presentation begins with an overview of special relativity, and then moves into an examination of the building blocks of the current Standard Model of particle physics. The material, by design, takes advantage of the fact that a remarkable amount of particle physics may be understood quantitatively using relatively few basic concepts. Students are assumed to have had introductory physics and at least one quarter of quantum mechanics introducing state vectors (bars and kets), quantum time evolution, observables and expectation values, spin-1/2 and related two-state systems, quantized angular momentum, and quantized harmonic oscillators. Facility with calculus, linear algebra, and basic mathematical methods is also assumed. Prior exposure to special relativity, or particle physics, is not required.

The autumn 2014 version of these notes incorporates or adapts a number of subsequent changes to the original notes from both myself (I have taught *Particles and Symmetries* several times starting in 2011) and Professor Yaffe. His contributions are gratefully acknowledged. Note, in particular, that starting last spring there are Chapters (1 and 5) explicitly reviewing the most relevant concepts from Physics 227 and 225 (respectively). Note also that there is no required textbook for this course, only some suggestions of books that you may find useful. On the other hand, it is essential that you read the notes according to the reading assignments on the class webpage and come to class prepared to discuss the covered topics, especially those that you might find confusing. It would be an efficient use of class time if we could focus on the issues you find especially challenging, rather than on those that I “think” are the most challenging. We will have frequent in-class “clicker quizzes” to encourage you to do the reading and also help me identify those concepts that are causing difficulty. The point here is - DO THE ASSIGNED READING BEFORE CLASS!

Next, here are some comments regarding conventions. Arrows are used to indicate three-dimensional spatial vectors, such as  $\vec{x}$ . Components of spatial vectors are written as  $x^j$ , with a Latin index (such as  $j$ ), which runs from 1 to 3 (corresponding to  $x$  to  $z$ ). Four-dimensional spacetime vectors, which are introduced in chapter 3, will not be marked with a vector sign, but their meaning should be clear from context. Components of a spacetime vector are written as  $x^\mu$ , with a Greek index (such as  $\mu$ ) running from 0 to 3. Sadly, there are two different conventions in common use in the physics community for defining the dot product of spacetime vectors, differing by an overall minus sign. These notes use the so-called West Coast metric (+,-,-,-) that renders time-like invariants positive,

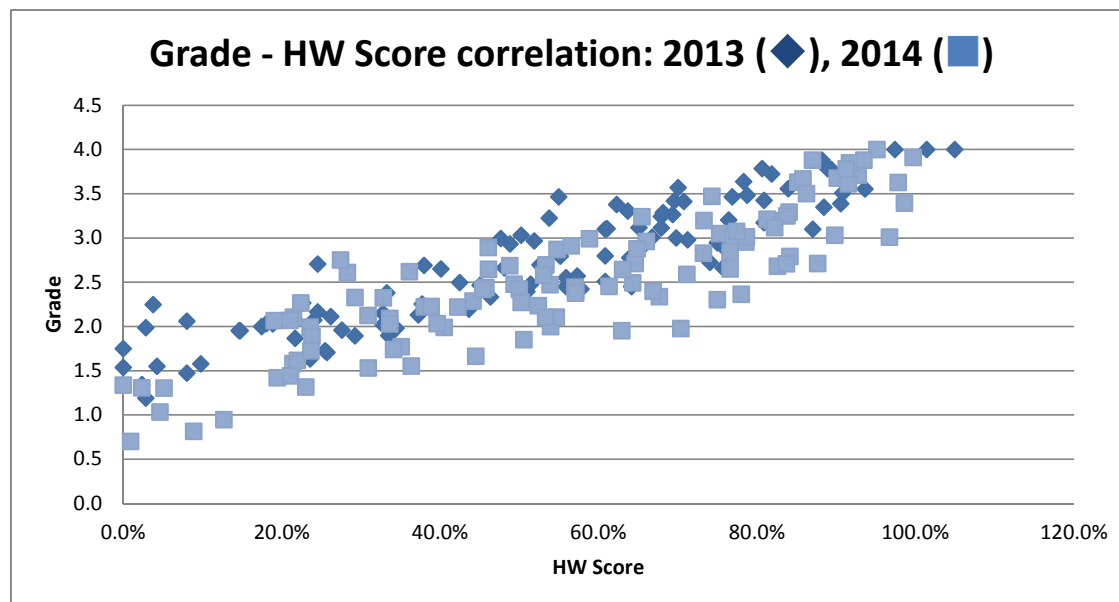


Figure 1: Correlation between HW scores and Final Grades for spring 2013 and 2014.

but the dot product of spacetime vectors having vanishing time components the negative of the usual three-dimensional dot product. The notes from Prof. Yaffe use the so-called East Coast metric  $(-,+,+,+)$  (that he labels "the only sensible choice", but I disagree), which makes the dot product of spacetime vectors having vanishing time components the same as the usual three-dimensional dot product, but time-like quantities are negative.

Finally we include a few words concerning the role of the Homework (HW) assignments. Since this is a physics course with a focus on learning to quantitatively analyze the properties of physical systems, the HW provides the core of this course. It is essential that you do the HW in order to achieve command of the various concept and techniques covered in this course. This connection is confirmed by the fact that the HW and the exams, for which you should consider the HW as practice, constitute the basis of the course grade.

An illustration of the correlation between HW scores and Final Grade for the classes of the last two springs is provided in Fig. 1, which clearly indicates a fairly direct correlation between performance on the HW and in the class. In particular, students who put little effort into the HW, invariably received a poor grade in the course. There is, in fact, an important further dimension to the question of learning from the HW in this class. Solutions to all HW exercises are posted on the web (Catalyst) as soon as the HW is turned in. It is important to look through these solutions, especially if you had difficulty solving a particular exercise (or all of them), in order to identify and remedy any misunderstandings that may be causing you difficulty. As part of the "postmortem" of Phys 226 in spring 2013, I looked through the "not-picked-up" HW papers still in my office at the end of the quarter. Again there was a strong correlation between the fraction of HW (turned-in but) not-picked-up and the final grade, as illustrated in Fig. 2. Several students turned in most (or all) of the HW but never picked it up. In many such cases, these students were apparently unaware of the mistakes they made on the HW and repeated these mistakes on the exams (and received poor final grades). You are encouraged to make the HW a central part of your study process. Do the HW (or at least attempt it), then study the solutions to identify the issues that are causing you trouble and

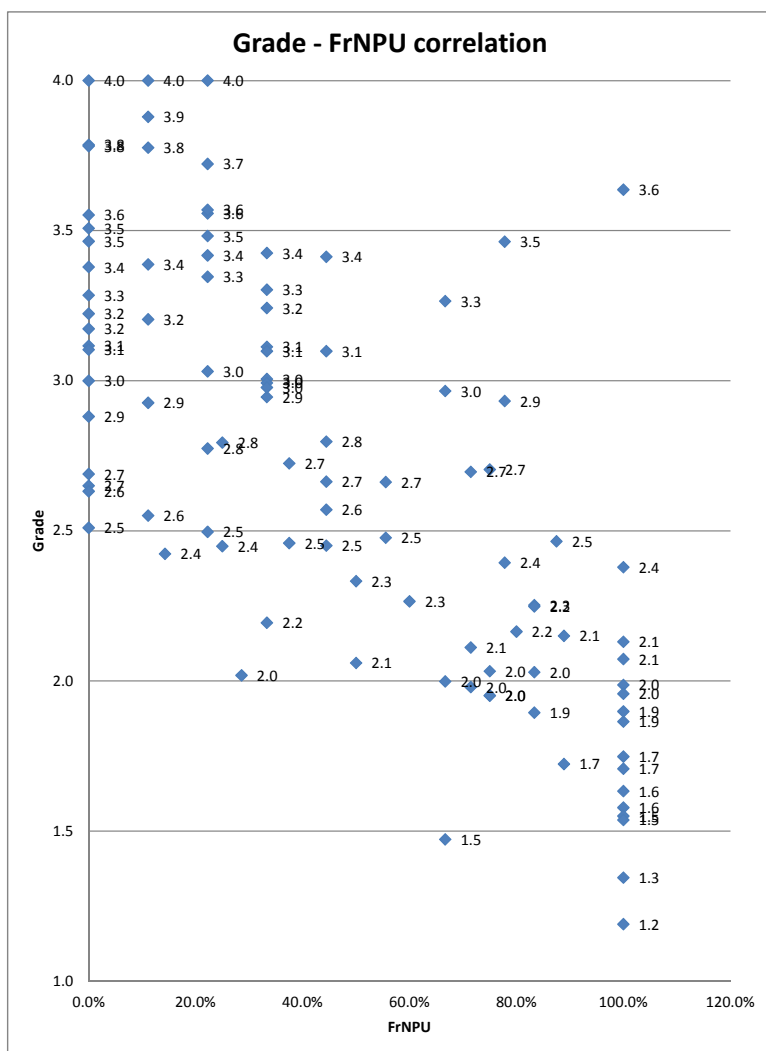


Figure 2: Correlation between Final Grade and the fraction of HW not picked up for spring 2013

then rectify any misunderstanding.

Note that there is a late HW option (after solutions are posted) for partial credit. I am also hoping to have sufficient TA resources to allow a re-submittal option, as occurred last spring, so that you can correct your HW and turn it in again for more credit.

So the second essential point is - DO THE HW and CHECK THE SOLUTIONS!!

Stephen D. Ellis

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