Report on Spring 2017 Sabbatical:
Upper-Division and Graduate Coursework in Atmospheric Science

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Overview

During Spring 2017, I was granted sabbatical from my usual duties as a full-time physics instructor at ECC. I used this opportunity to take upper-division and graduate courses in UCLA's Atmospheric and Oceanic Sciences Department during UCLA's Winter and Spring Quarters, enrolling through the Concurrent Enrollment office of UCLA Extension.

Between the two quarters, I took four graduate courses, for a total of eighteen quarter units, and two upper-division courses, for a total of six quarter units. A table listing the courses taken is given below.

Course Number	**Quarter Taken**	**Units (Grad/ Undergrad)**	**Course Title**
AOS 202	Winter	4 (G)	Introduction to Ocean Science
AOS 222	Winter	4 (G)	Atmospheric Boundary Layer
AOS 227	Winter	6 (G)	Advanced Dynamic and Synoptic Meteorology
AOS 180	Spring	4 (U)	Numerical Methods in Atmospheric Sciences
AOS 186	Spring	2 (U)	Operational Meteorology
AOS 201C	Spring	4 (G)	Atmospheric and Oceanic Turbulence

My decision to take courses with UCLA's AOS department was an outgrowth of my longstanding fascination with atmospheric processes in general and weather in particular. Nearly all subject areas in the atmospheric sciences are deeply rooted in ideas from physics. The areas of physics most foundational to the atmospheric sciences are fluid mechanics, and thermodynamics, including in particular phase transitions, thermal transfer, and related topics. All of these topics are covered in some depth in Physics 1B. Thus, in the remainder of this report, I will describe the courses I took, as well as possible applications of what I leared to teaching Physics 1B.

AOS 202 – Ocean Science (Winter 2017)

This course was a graduate-level overview of oceanography. The emphasis was on physical oceanography, although chemical and biological topics, such as alkalinization due to dissolved inorganic carbon, and plankton blooms, were included. As my primary interest is in atmospheric science, I found especially interesting and useful the discussions of atmosphere-ocean interactions, such as the subtropical gyre circulations, in which anticyclonic (i.e. clockwise) ocean circulation is driven by shifts in prevailing wind direction with latitude. Another, closely related, example is the El Nino/ Southern Oscillation (ENSO), which is a consequence of variation in the tropical easterlies in the South Pacific. Most of the examples of ocean science I have mentioned here have some connection to oceanic thermal stratification (i.e. warmer, less dense water is found at the top of the ocean) which may be a good illustration of topics such as density and buoyancy in Physics 1B.

AOS 222 – Boundary Layer Meteorology (Winter 2017)

This course was a study of the atmospheric boundary layer (ABL). Typically the ABL is the lowest layer of the atmosphere, typically about 500 ~ 1500 m, lying between earth's surface and a capping inversion, where the air temperature increases sharply with height.

Heating of the earth's surface results in convectively-driven turbulence, which transports various physical properties such as heat, momentum, and materials (water vapor, dust, etc.) upward from the ground. Much of my workload in this course went into the production of a term paper on marine stratocumulus clouds, a well-known example of which are the "June Gloom" clouds regularly observed in coastal Los Angeles during late spring and early summer. This course improved my understanding of turbulence and convective heat transport, which are a somewhat minor, but still regularly covered topic in Physics 1B. Also, the physics responsible for the positive correlation between cold ocean temperatures and marine stratocumulus clouds will be readily accessible to Physics 1B students and could even motivate a homework problem.

AOS 227 – Advanced Dynamic and Synoptic Meteorology (Winter 2017)

Synoptic meteorology studies large-scale atmospheric processes, typically defined as those occuring at length scales of ~1000 km or greater. The most important synoptic processes typically occur in the upper troposphere, where large scale divergence (blobs of air moving away from each other) may drive large scale convergence (blobs of air moving towards each other) and therefore ascent (upward motion) near the surface. Conversely, large-scale convergence in the upper troposphere may drive large-scale divergence, and therefore subsidence (downward motion), near the surface. Among the topics studied in this course was the interpretation of soundings, which are vertical profiles of thermodynamic properties, typically dew point and temperature, most often measured by radiosondes (i.e. "weather balloons"). The principles needed to analyze soundings are likely accessible to Physics 1B students, and this topic might make for interesting extra credit projects.

AOS 180 – Numerical Methods in Atmospheric Sciences (Spring 2017)

This course was an introduction to techniques used in numerical simulation of atmospheric processes. Initially I had not intended to take this course, as I already have a broad familiarity with numerical methods. However, I did learn quite a bit about numerical methods for fluid mechanics generally and atmospheric sciences in particular that I did not already know. My final project was a simulation of the Rayleigh-Taylor instability, in which a denser fluid initially sits atop a lighter fluid. This was great fun to code and to execute. In regards to my work at ECC, we currently have essentially no component of scientific coding in our courses, although it might make sense to incorporate that topic, at least mildly, into our Physics 1 Series. Also, I have been wanting to produce animations of thermal transfer processes to show in class for some time. The material learned in this course would be relevant to that.

AOS 186 – Operational Meteorology (Spring 2017)

This course consisted of thrice-weekly meetings with an expert forecaster to discuss current weather charts, with the goal of explaining current weather and forecasting future weather. The data most frequently used included soundings (discussed earlier), constant pressure charts, and radar and satellite imagery. As much as I like the idea of including an element of weather forecasting in Physics 1B, it would really be too far afield from the main subject matter. In the future it might make sense to incorporate some aspects of weather forecasting as extra credit. This would be a long-term project, however.

AOS 201C – Atmospheric and Oceanic Turbulence (Spring 2017)

This course was a high-level survey of a variety of topics related to turbulence. Most, but not all of the topics were applications to the atmospheric and oceanic contexts, such as boundary layer turbulence or geostrophic turbulence. As there were neither exams nor collected homework, the great bulk of my workload for the course was the preparation of a literature review on turbulent entrainment in cumulus clouds, with a particular focus on the interaction between the turbulent forward cascade (the process by which the entrained parcel is spun into ever-smaller fragments by the turbulence) and the distribution of cloud droplet sizes. The product of this work was a twenty-page single-spaced paper (including references and figures) and a fifteen-minute presentation. Although turbulence is not a major topic in Physics 1B, it does come up in relation to the drag force acting on objects moving through a fluid, and I have a better understanding of the topic now than I did prior to taking AOS 201C.