# Assessment of Undergraduate Physics Program AY2019-20

In AY2014-15 some modifications were made to the assessments reflected in the choices of some assessment tools and the way we interpret data or exclude students who appear to drop midway through the term. These changes persist through this assessment cycle and notes pertaining to them remain near each table or SLO throughout this report for convenient reference.

The incoming cohort during AY2017-18 presented a marked decrease in proficiency and we noted they should be observed as they percolate through the program. Commentary was simple during AY2018's report regarding performance in PHYS 325, but in their third year *and* an opportunity for longitudinal tracking of AY2018's incoming class, there's too much data for tracking in footnotes. To enrich the data tables with cohort-information and make this tracking easier for the reader, the tables have been color-coded. Incoming cohorts' color-codes are assigned in SLO 1's analysis, and subsequent appearances of that color correspond to that cohort as it follows the standard prescription of courses for the program. For example: the cohort of interest were freshman in AY2017 and coded red in tables for PHYS 223 and 224 for AY2017. As sophomores their information appears red in AY2018 for PHYS 325 and PHYS 522, and in AY2019 as juniors. They will also appear red for PHYS 506 as seniors in AY2020's data. Because identifying information is stripped from the data, it's possible the constituencies are not perfectly cross-linked to the original cohorts. To correct for students picked up later (such as those in PHYS325 after recruitment pushes in EP) or those taking the later prescribed courses out of order, we would need to keep detailed profiles on all students. The color-coding tool only provides a rough estimation of the cohort's collective progress and presumes these later courses are majority constituted by the defining incoming students.

- **SLO 1:** Students will demonstrate ability to apply foundational knowledge to the solution of problems in physics. [**K-State SLO:** *Knowledge, Critical Thinking*]

Initially an online assessment was used but very few students actually completed it such that the results were not statistically significant. To adapt we switched to using average exam scores. We feel this is a more reliable way to assess this SLO.

*Proficient* is defined as C-level work at a threshold of >70% while *Exemplary* is A-level at >90%. *Proficient* is inclusive of *Exemplary* students as they are also above the threshold.

| Assessment Instrument: Average Exam Score in PHYS 223 (Physics I) | | | |
|---|---|---|---|
| **Academic Year** | **# of Students** | **Proficient** | **Exemplary** |
| 2013-14 | 18 | 13 (72%) | 3 (17%) |
| 2014-15 | 17 | 14 (82%) | 3 (18%) |
| 2015-16 | 28 | 21 (75%) | 4 (14%) |
| 2016-17 | 22 | 20 (91%) | 6 (27%) |
| 2017-18 | 19 | 12 (63%) | 4 (21%) |
| 2018-19 | 19 | 13 (68%) | 5 (26%) |
| 2019-20 | 9 | 5 (56%) | 2 (22%) |

| Assessment Instrument: Average Exam Score in PHYS 224 (Physics II) | | | |
|---|---|---|---|
| **Academic Year** | **# of Students** | **Proficient** | **Exemplary** |
| 2013-14 | 12 | 12 (100%) | 0 (0%) |
| 2014-15 | 16 | 16 (100%) | 2 (13%) |
| 2015-16 | 25 | 16 (64%) | 2 (8%) |
| 2016-17 | 21 | 14 (67%) | 4 (19%) |
| 2017-18 | 16 | 8 (50%) | 2 (13%) |
| 2018-19 | 12 | 6 (50%) | 1 (8%) |
| 2019-20[†] | 6 | 2 (33%) | 1 (17%) |

[†]Coronavirus pandemic

***Result***: Incoming class sizes has been reduced by half, and retention is falling. With numbers these small, comparisons of proportions are becoming meaningless. Though the data indicate fewer and fewer students are meeting C and A level performance in their examinations, even a change of one student wildly changes the trendline.

The COVID-19 imposed transition to remote-only occurred halfway through Engineering Physics II, and forced one of the original seven (7) students to drop. The transition in these intro level courses was improvised and far from ideal. Students lost all synchronicity in their intimate studio portion for labs, "recitation" and small group back-and-forth instruction. Next year's report will hopefully reflect or reveal a difference from improved and more deliberate strategies that have been learned from experience and implemented in these courses as of this writing.

**SLO 2:** Students will demonstrate skill in collecting, recording and analyzing data. [K-State SLO: Communication, Knowledge, Critical Thinking, Academic & Professional Integrity]

Lab Score distribution in PHYS 325 – Relativity and Quantum Physics: The lab component of this introduction to modern physics course is designed to train students to think through experiments thoroughly and critically; and to acquire, record and analyze data rigorously and in an appropriate way.

*Proficient* is defined as C-level work at a threshold of >70% while *Exemplary* is A-level at >90%. *Proficient* is inclusive of *Exemplary* students as they are also above the threshold.

| Assessment Instrument: Average Lab Score in PHYS 325 (Physics III) | | | |
|---|---|---|---|
| **Academic Year** | **# of Students** | **Proficient** | **Exemplary** |
| 2010-11 | 26 | 23 (88%) | 20 (77%) |
| 2011-12 | 26 | 24 (92%) | 16 (62%) |
| 2012-13 | 28 | 28 (100%) | 28 (100%) |
| 2013-14 | 29 | 22 (81%) | 15 (52%) |
| 2014-15* | 30 → 31 | 30 (100%) → 31 (100%) | 28 (93%) → 29 (94%) |
| 2015-16* | 32 | 27 (84%) | 11 (34%) |
| 2016-17* | 31 | 26 (84%) → 30 (97%) | 20 (65%) → 25 (81%) |
| 2017-18* | 37 | 36 (97%) | 26 (70%) |
| 2018-19* | 30 | 25 (83%) | 9 (30%) |
| 2019-20* | 25 | 21 (84%) | 7 (28%) |

*Students completing fewer than 50% of the lab reports were excluded from analysis. Due to low sample size of completed labs for these students, good (or bad) scores on a single lab may not be representative of the student's proficiency (or deficiency) in SLO 2. A further change of analysis as of AY2017-18 excluded unfinished lab reports from consideration. Previously we computed the "average lab score" as a mean of all points earned compared to all points possible. A missed lab would significantly drop that average score, and it would be unrepresentative of actual work the student turned in. Our new analytic methodology drops any unsubmitted scores (from students completing more than 50% of the coursework) and computes the mean. This report retroactively recomputed all starred years and includes the old → new results under the updated standard.

***Result*:** The larger class size compared to AY2018's EP2 roster's cohort can again be explained away when we consider recruitment pushes at the end of EP2 for students to switch to physics or take on a minor. Also, some of our majors were not able to take the specially designated majors-only section and are hiding in the general EP2 population excluded from this analysis. What is interesting is that the recruitment push appears consistent as the number of extra students pulled in is roughly the same as the previous semester. Generally, performance is holding steady, consistent with a drop at the high end beginning AY2017-18.

- **SLO 3:** Students will demonstrate the ability to effectively communicate information, scientific or otherwise, in both verbal and written form. [K-State SLO: Communication, Knowledge, Critical Thinking, Academic & Professional Integrity]

The assessment for the verbal part was recently switched from using PHYS 636 to using the oral exam in PHYS 506. That report is an oral presentation where clear communication and comprehensive explanation is expected. PHYS 506 is more advantageous in that it is taken across the board by all physics majors whereas PHYS 636 is not.

*Proficient* is defined as C-level work at a threshold of >70% while *Exemplary* is A-level at >90%. *Proficient* is inclusive of *Exemplary* students as they are also above the threshold.

| Assessment Instrument: Capstone Project Scores* for PHYS 636 (Physical Meas. And Instrumentation) | | | |
|---|---|---|---|
| **Academic Year** | **# of Students** | **Proficient** | **Exemplary** |
| 2010-11 | 3 | 3 (100%) | 0 (0%) |
| 2011-12 | 7 | 7 (100%) | 3 (43%) |
| 2012-13 | n/a | n/a | n/a |
| 2013-14 | n/a | n/a | n/a |
| Assessment Instrument: Oral Exam for PHYS 506 (Advanced Physics Lab) | | | |
| 2014-15 | 7 | 7 (100%) | 4 (57%) |
| 2015-16** | 20 | 20 (100%) | 17 (85%) → 19 (95%) |
| 2016-17** | 10 → 9 | 10 (100%) → 9 (100%) | 6 (60%) → 7 (78%) |
| 2017-18** | 9 | 9 (100%) | 7 (78%) |
| 2018-19 | 16 | 16 (100%) | 16 (100%) |
| 2019-20† | 16 | 16 (100%) | 11 (69%) |

* Beginning in Academic Year 2014-15, this instrument (PHYS 636 Capstone Project Scores) was replaced with the Oral Exam Scores from PHYS 506 (Adv. Phys. Lab) for assessing the verbal component of **SLO 3**. This new instrument better assesses the verbal component of scientific communication and is a more reliable and consistent instrument.

** Instead of using a single oral exam, we used the average of any oral instruments available. This year's instructor included more than one presentation, and the benefit of including minor oral presentations as well as a single major presentation seemed obvious.

† Coronavirus shutdown went into effect halfway through this semester.

***Result*:** Students are performing very well in advanced lab in oral presentation of technical and scientific procedures and their interpretations of results.

Lab write-up scores from PHYS 506 – Adv. Physics Lab: Students record all data, activity and analysis in their lab notebooks then produce a formal lab write-up of each experiment. This write-up must provide comprehensive information regarding the experiment and must include sufficient written narrative to be clearly understood by others. The purpose of these write-ups is to teach advanced laboratory students to effectively communicate their scientific work in a clear and acceptable way. The format of this write-up is roughly the same as that used by the physics community in research publications.

*Proficient* is defined as C-level work at a threshold of >70% while *Exemplary* is A-level at >90%. *Proficient* is inclusive of *Exemplary* students as they are also above the threshold.

| Assessment Instrument: Written Lab Scores for PHYS 506 (Advanced Physics Lab) | | | |
|---|---|---|---|
| **Academic Year** | **# of Students** | **Proficient** | **Exemplary** |
| 2010-11 | 10 | 10 (100%) | 5 (50%) |
| 2011-12 | 15 | 14 (93%) | 10 (67%) |
| 2012-13 | 18 | 18 (100%) | 17 (94%) |
| 2013-14 | 17 | 17 (100%) | 9 (53%) |
| 2014-15 | Data Not Available | | |
| 2015-16* | 20 | 20 (100%) | 16 (80%) |
| 2016-17* | 10 → 9 | 9 (90%) → 9 (100%) | 3 (30%) → 3 (33%) |
| 2017-18* | 8 | 8 (100%) | 6 (75%) |
| 2018-19* | 15 | 15 (100%) | 12 (80%) |
| 2019-20* | 16 | 16 (100%) | 14 (88%) |

* These lab scores are following the same exclusion and calculation rules as those applied to PHYS 325, excluding students with less than 50% completion and excluding obvious zeroes on individual reports. These rules are applied retroactively and longitudinal data updated.

***Result*:** All students met minimum standards in the judgment of this professor, and most exceeded them. We believe students are continuing to perform acceptably with written communication of technical thoughts.

**SLO 4:** Students will demonstrate the ability to apply knowledge of physics at the advanced undergraduate level. [K-State SLO: Knowledge, Critical Thinking]

Exam score average in PHYS 522 – Mechanics: The exams contain critical problem solving requirements that must be treated using advanced understanding and techniques. To meet the minimum level of proficiency physics majors must clearly demonstrate mastery of advanced classical mechanics knowledge.

*Proficient* is defined as C-level work at a threshold of >70% while *Exemplary* is A-level at >90%. *Proficient* is inclusive of *Exemplary* students as they are also above the threshold.

| Assessment Instrument: Final Exam Scores* for PHYS 522 (Mechanics) | | | |
|---|---|---|---|
| **Academic Year** | **# of Students** | **% Proficient** | **% Exemplary** |
| 2011-12 | 16 | 12 (75%) | 2 (13%) |
| 2012-13 | 19 | 15 (79%) | 9 (47%) |
| 2013-14 | 15 | 12 (80%) | 1 (7%) |
| 2014-15* | 11 | 8 (73%) | 2 (18%) |
| 2015-16* | 26 | 22 (85%) | 9 (34%) |
| 2016-17* | 21 | 20 (95%) | 3 (14%) |
| 2017-18* | 19 | 18 (95%) | 7 (37%) |
| 2018-19 | Data Not Available: Faculty Severed from University | | |
| 2019-20† | 11 | 18 (95%) | 7 (37%) |

*Changed to average exam scores.
† COVID-19

Exam score average† in PHYS 532 – Electromagnetic Fields I: This course develops electromagnetic theory using analytical tools well beyond the introductory level. The oral and written exams constitute a meaningful assessment of student ability to apply advanced knowledge to theoretical physics.
(† Note: this is a change from previous semesters. There is no longer a final exam regularly given in this course under the current instructor. Instead, the combination of the oral and written exams is a better and timelier indicator of student understanding and application of advanced physics knowledge.)

*Proficient* is defined as C-level work at a threshold of >70% while *Exemplary* is A-level at >90%. *Proficient* is inclusive of *Exemplary* students as they are also above the threshold.

| Assessment Instrument: Final Exam Scores* for PHYS 532 (Electromagnetic Fields I) | | | |
|---|---|---|---|
| **Academic Year** | **# of Students** | **% Proficient** | **% Exemplary** |
| 2011-12 | 13 | 6 (46%) | 0 (0%) |
| 2012-13 | 12 | 8 (67%) | 3 (25%) |

| Assessment Instrument: Final Exam Scores* for PHYS 532 (Electromagnetic Fields I) | | | |
|---|---|---|---|
| 2013-14* | 16 | 15 (94%) | 7 (44%) |
| 2014-15* | 19 | 19 (100%) | 5 (26%) |
| 2015-16* | 20 | 15 (75%) | 4 (20%) |
| 2016-17* | Data Not Available: Faculty on Sabbatical without Access to Data | | |
| 2017-18* | 27 | 8 (30%) | 0 (0%) |
| 2018-19 | Data Not Available | | |
| 2019-20 | Data Not Available | | |

*Changed to average exam scores. If students are close to an A, the final exam is only graded until an A score in the class is reached. For this reason, average exam score is substituted for the assessment tool and the final is not included in the calculation.

Exam score average† in PHYS 662 – Introduction to Quantum Mechanics: Concepts and mathematical models of quantum physics are introduced. Solutions to the time independent Schrödinger equation, descriptions of one-electron and multi-electron atoms, electron spin and magnetic moments are discussed. Students generally find the concepts and the mathematical modeling in this class difficult.

*Proficient* is defined as C-level work at a threshold of >70% while *Exemplary* is A-level at >90%. *Proficient* is inclusive of *Exemplary* students as they are also above the threshold.

| Assessment Instrument: Final Exam Scores* for PHYS 662 (Intro to Quantum Mechanics) | | | |
|---|---|---|---|
| **Academic Year** | **# of Students** | **% Proficient** | **% Exemplary** |
| 2011-12 | 14 | 6 (43%) | 2 (14%) |
| 2012-13 | 12 | 11 (91%) | 4 (36%) |
| 2013-14 | 18 | 10 (56%) | 1 (6%) |
| 2014-15* | 23 | *11 (48%)*** | *2 (9%)*** |
| 2015-16* | 13 | 8 (62%) | 4 (31%) |
| 2016-17* | 19 | 15 (79%) | 6 (32%) |
| 2017-18* | 19 | 18 (95%) | 6 (32%) |
| 2018-19 | 17 | 11 (64%) | 1 (6%) |
| 2019-20† | 13 | 6 (46%) | 2 (15%) |

*Changed to average exam scores. Using only one performance to represent a student's skills is somewhat irresponsible as it will inflate outliers, so it is more logical for us to consider the average exam scores as we have in PHYS 522 and 532.

**Note that the thresholds for *Proficient* and *Exemplary* differ from defaults for this assessment tool. *Proficient* is defined as C-level work at a threshold of >55% while *Exemplary* is A-level at >85% for AY2014-15.

† COVID-19

***Result*:** We failed to capture relevant data for Electromagnetic Fields as of this writing and can draw no conclusions. Quantum Mechanics results are depressed and it's unclear if this is a function of the AY2017 cohort's historical performance or the instructing professor's standards. There's a likelihood the faculty is using the 55/85 scale employed in 2014, and if that's true the results are Proficient 10 (77%) and Exemplary 3 (23%). Mechanics seems to be comparable to historical trends pre-COVID, and we're interested in how they might have done under normal circumstances.

**Assessment Conclusions**

AY19-20 generally is trending either flat or downward. The number of students recruited or retained is continuing to fall, and their performance remains below trends recorded before the dip in enrollment. These two observations are correlated, confirmed, and warrant investigating the cause. To better track students on their academic trajectories—not only chronologically—data tables were color-coded for easy identification of a particular subject group as it moves through the program.

AY18-19 is an unimpressive analysis. Troubling trends within incoming cohorts continue to manifest, and a cohort of concern is showing consistency in its performance as it moves through the program. These initial concerns with problem solving and critical thinking early reflect later as issues of concern in the careful analysis of real non-textbook laboratory cases. A failure to acquire and examine data for the upper-level courses leaves us with very little insight about this semester's performance in those areas.

AY17-18 has been a year of flux. The incoming cohort stumbled on introductory classes. Intermediate courses saw a sudden burst of enrollment and recruitment from other majors. Advanced courses saw instructor changes and personnel turnover. Performance was potentially influenced on both sides of the lectern. We are optimistic about recovery and hope to see positive corrections reflected in AY18-19.

AY16-17 we generally saw a decrease in the number of students in each of our courses. Whether this is a sign of decline overall, an unexpected outlier in an otherwise increasing enrollment, or a correction from last year's surge is unclear. We also identified two trends: proficiency is up, and exemplary performance is down. Sample sizes are large enough to verify our trend toward better proficiency is true; and we take some comfort in knowing the number of students in the exemplary category is so small that any integer change will reflect large proportional shifts and therefore are not necessarily representative. Without larger samples, we expect the exemplary category to suffer from year-to-year "noise" and unfortunately its results (good and bad) will be unreliable.

AY15-16 showed some year-to-year variability in our assessment stemming from differences in grading style and standards with instructor changes, as well as from changes in the course structure and assessment tools (final/no-final, elimination of assignments that once served as assessment tools). To bring some consistency we've changed some of our exam-based assessments to include the average instead of a single final, set a standard procedure of removing from consideration students who've completed fewer than half of lab reports, and those appearing to have dropped the course. These changes appear to have made an impact in ease of analysis and comparability from term-to-term and are overall positive changes to the assessment process.

We proposed last year developing a tool to improve consistency. Whatever tool we develop will need to be an integrated part of the course (so students will participate) and it must be worth enough value for students to take seriously without intruding too much into the course breakdown. For student-learning objectives that don't lend themselves well to standardized testing (e.g. verbal communication), a revolving committee of graders would protect against inconsistency due to style and standards. This development process is very taxing on resources, and executing it will also require a great deal of energy and input. For these reasons progress has stalled.