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Summer Bridge Program Structured to Cover Most Demanding STEM Topics

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1. Abstract

This evidence-based practice describes a new summer bridge model for increasing STEM retention. Beginning June 2012, Rice University developed the Rice Emerging Scholars Program (RESP), a comprehensive summer bridge and advising program aimed at increasing STEM retention, graduation, and achievement in students who attended under-resourced high schools. RESP is not a remedial program. RESP Scholars are admitted to Rice and are then invited to attend the bridge program in the summer before their freshmen year. A staff member whose sole job is advising the Scholars and overseeing daily program operations supports scholars through graduation.

RESP is not a remedial program. Scholars are admitted to Rice through the same process as Rice students who do not participate in RESP. RESP participation is not a university admission requirement for Scholars. RESP staff partner with the Rice Admissions Office to find incoming students who are intellectually capable of work at a university level but who may not have been sufficiently challenged in K-12 settings. Because Scholars may not have been exposed to high-level STEM courses (e.g., AP Calculus or Physics) or other academic course work as rigorous as what they will encounter at Rice, they may be lacking the skills necessary to excel in a rigorous STEM environment. This is particularly true in comparison to many of their classmates who benefitted from a more demanding high school experience such as that of a rigorous private high school or a strong public high school offering many AP and/or IB courses. RESP aims to help Scholars develop the skills needed to thrive at Rice through essentially a practice round in the summer.

The objective of the summer bridge portion of the program is to prepare Scholars for the pace, rigor, and depth of the STEM curriculum at Rice. All Scholars take first-year Chemistry, Physics, and Calculus as courses, five days a week; homework, quizzes and exams are administered like in the academic year. As stated above, RESP is not a remedial program. Instead, the summer portion of RESP exposes students to the <u>most</u> challenging sections of Chemistry, Physics, and Calculus. Scholars simultaneously receive coaching from instructors, staff, and upperclassmen Fellows in study and learning techniques. This coursework is supplemented by individual Pre-Calculus remediation through ALEKS, an adaptive online learning system. Additionally, students complete modules in engineering design and problem-solving. RESP addresses acculturation through nightly sessions on topics pertinent to the transition from high school to college, promotes interactions with STEM faculty, and develops strong, multi-year cohorts of Scholars from similar backgrounds.

RESP aims to support students *comprehensively* and proactively through the totality of their collegiate experience including and beyond academic support. RESP utilizes an intrusive advising model to provide academic advising and guide students before minor issues create permanent consequences. This model of advising was launched with the 2013 (second) cohort. Currently, students meet with an advisor weekly or bi-weekly through their third semester. Advising frequency after the third semester depends on student needs. Some Scholars continue meeting once a week through graduation while others make appointments as needed. Advising covers academic planning and success strategies, transition issues, and any personal problems that may impact a Scholar's retention in STEM or at Rice. All student performance is actively monitored, enabling advisors to intervene even if students are being seen less frequently. RESP's longitudinal, intrusive advising model proved so successful it has been adapted for other Rice students through the development of the Office of Student Success Initiatives. RESP additionally provides ongoing term-time programming to address common transition issues, training in learning and study technique, and student professional development.

The effectiveness of RESP is tracked through comparison of Scholar performance to that of control group and the ambient background population. Data tracks retention at the University, retention in STEM fields, GPA, STEM GPA, and course selection and completion. Cumulative GPA results for Scholars and control are similar, around 3.0. For 2013 matriculants, 74% of Scholars are declared STEM majors, while only 54% of control group students were retained in STEM fields. Those matriculants completed more than twice as many core STEM credit hours as the control group within three semesters. RESP costs $10,000 per student over the duration of their time at Rice.

2. National Landscape for Bridge Programs

America's leaky STEM pipeline is well documented. Currently, a mere 40% of undergraduates who enter college intending to receive a STEM degree graduate in a STEM field[1]. This issue will be exacerbated as women, underrepresented minorities (URM), and first-generation college students, who traditionally earn fewer STEM degrees than white men, continue to grow as the majority of collegians. A recent report by the President's Council on Science and Technology projects the United States will need one million more engineers in the next decade than we are on track to produce. Increasing STEM graduation rates from 40% to 50% of interested students would create roughly 750,000 of the million-needed engineers.[1]

The percent of underrepresented minorities in engineering and science has historically been dismally low. Based on a widely cited report from the National Academies, underrepresented minority groups comprised 28.5% of our national population in 2006, yet just 9.1% of college-educated Americans in science and engineering occupations.[2] When published, just 2.7% of 24 year-old African Americans, 3.3% of Native Americans, and 2.2% of Hispanics/Latinos had a Bachelor's degree in the natural sciences or engineering. Recent data from the Higher Education Research Institute (HER) at UCLA shows that underrepresented minorities aspire to major in STEM in college at the same rates as their majority peers.[3] Yet, underrepresented minorities have lower four- and five-year completion rates relative to their majority peers. Looking specifically at engineering during the past decade, only 5% of B.S. engineering graduates have been African American and only 7-8% have been Hispanic.[2]

Shoring up the leaky STEM pipeline, particularly for underrepresented groups, is of national importance. The first two years of college are particularly important for STEM retention.[1] One strategy employed by some universities to remedy the gap in retention rates is the creation of summer bridge programs.

3. Research Background

Research suggests this achievement gap does not reflect a difference in student ability but rather structural inequalities in K-12 educational experiences between students from high-performing, well-resourced schools and students from under-performing, low-resource schools.[4] Studies show abilities, attitudes, and college-preparation (e.g., AP courses) are main determinants of successful completion of challenging STEM programs.[5, 6, 7, 8] Students from under-resourced schools often have access to less rigorous college-preparation than their peers and subsequently struggle on campus although they possess all of the inherent intelligence necessary to succeed. Additionally, highly selective institutions often fail to take prior preparation into account when designing support programs, assuming that that because admitted students are all academically capable they will each enter college equally prepared to compete.[9] This compounds the challenge faced by students from under-resourced schools.

Summer bridge programs aim to bridge the gap between K-12 and post-secondary education through an intensive program the summer before a student's freshman year of college. Programs traditionally have three components:

- Academic preparation through coursework and training in study skills
- Institutional acculturation and cohort development
- Improvement of student self-esteem and self-efficacy[10]

Aims, structures and goals of bridge programs vary, and time allotted to each component depends on the goals of the program. Some programs focus on retention and broad degree completion for specific student populations while others focus on retention in a particular program or course of study. Some programs try to 'catch students up' by reviewing critical pre-requisite technical material, whereas others focus entirely on acculturation and study skills. Finally, some programs last one week, whereas others last six to eight weeks.

Though summer bridge programs are a common and recommended strategy for improving student retention, it is difficult to judge the efficacy of this intervention.[1, 10] Much of the existing research focuses on programs aimed at improving undergraduate degree completion rather than retention in STEM fields.[10, 11, 12] For programs that focus on teaching STEM material, it is difficult to measure the rigor of course instruction as few institutions publish their curricula for summer bridge programs. There is currently no standard data collection or reporting, so data collection varies wildly across program and institution. Many universities and bridge programs, including our own, have historically had inadequate assessments, metrics and data tracking. A few programs publish their successes, but many more go unreported.[7, 13, 14] Of those that do publish, few maintain control groups, often relying instead on student satisfaction surveys. There is little consensus around the impact of summer bridge programs on student GPAs.[10, 13, 15, 16, 17] This is likely a result of differences in program structure and data collection.

4. Decision to Start RESP

The decision to start RESP was based on a number of factors, including several different internal reports as well as thoughtful conversations with students, faculty and staff. Here we state data from two of these reports. Results of a 2012 internal review of STEM retention and graduation rates at Rice uncovered a STEM retention and achievement gap for African-American and Mexican-American students similar to the national trend discussed above. Both African-

American and Mexican-American students had lower retention in STEM majors at Rice University (Table 1).

Table 1. Percentage of admitted STEM students persisting through STEM degrees (2004-2006 matriculants, measured in 2012). Percent retained tracks graduating students who upon matriculation indicated a STEM field of interest.

Classification of Student	**% Retained in STEM majors**
All Students	67%
Mexican-American	57%
African-American	38%

A separate 2010 internal review for a different university initiative found African-American and Mexican-American students each accounted for 14% of all students majoring in STEM fields with GPAs below 3.0, a rate of underperformance well beyond their representation in the university's STEM population.

5. Aims and Philosophy of RESP Program

In response to the scenario outlined above, Rice developed RESP to increase STEM retention and graduation rates in highly capable students who attended under-resourced high schools. By bringing students on to campus during the summer and exposing them to the realities of STEM life at Rice, RESP aims to prepare students for the pace, rigor, and depth of a STEM curriculum as well as provide the skills necessary to respond to the challenge and the support needed to process their experience. Note that this program focuses only on first-year matriculants, as Rice University accepts very few STEM transfer students.

RESP aims to be comprehensive in nature, supporting students through the totality of their transition to college including and beyond academic support. Based on research in STEM retention, there are many obstructions to success for students who arrive at college underprepared with respect to the depth and breadth of mathematics and science skills, necessary for success in a competitive environment. These obstacles have been identified in previous studies and include: [6, 14]

(i) lack of academic sophistication [5, 8, 18, 19, 20 , 21, 22]
(ii) lack of deep exposure to and facility with background material
(iii) lack of sophistication in study skills
(iv) alienation from the broader community in the university because of minority status, being the first-in-family to attend college or socio-economic status
(v) alienation in STEM fields because of minority status or gender
(vi) lack of sophistication in accessing available resources
(vii) idiosyncratic episodic financial perils
(viii) a tendency to associate feelings of lack of efficacy with those of struggling (i.e., an approach indicative of a fixed mindset or performance orientation.[19, 20]

RESP addresses each of these obstacles through a number of research based strategies. RESP focuses on students' transition from high school to college and then through second year STEM courses, asserting that if a student can build a strong foundation in introductory coursework, he/she can be successful in upper-level courses. Obstacles (i)-(iii) are addressed directly through the STEM courses in the residential summer program. Students are better prepared if they can make three critical transitions:

- Rote memory to critical thinking
- Straightforward math and science problems to complex word problems
- Single step to multistep problems

Mastery of these methods and skills enables them to meet the demands of a STEM education at Rice University.

The program also recognizes the need to be truly comprehensive in helping students successfully transition to college, especially first generation students and students traditionally underrepresented in STEM fields. As a result, the program attacks obstacles (iv)-(viii) during the summer residential program and term time support. Specifically, RESP supports instruction in learning, study skills, and provides social/emotional support. RESP continues support throughout a student's time at RICE though individual mentorship, advising, and access to tutors. RESP simultaneously develops strong peer bonds through cohort bonding and development activities.

RESP's philosophy that students must master the same rigor and depth in STEM subjects as their peers from highly-resourced high schools was drawn from research on performance and persistence of URM students at research universities.[22, 23] In analogy and as an extension to Treisman's original Mathematics Workshop Program at Berkeley (a subprogram of their Professional Development Program) in the early 1980's, the RESP curriculum aims for the most difficult parts of first-year calculus, chemistry, and physics. In other words, RESP is not remedial.

Put another way, RESP's guiding philosophy is to give students the chance to have a bad semester, if one is coming, without impacting their academic record and with ample support to develop new skills for student's new collegiate setting. Students do not receive course credit, to remove the threat of permanently codifying poor performance on a student's transcript. This differs from models that offer course credit, which carries the risk of permanent academic consequences. During the summer, students build resilience as well as technical skills and enter their fall semester aware of the academic rigor and transition issues they are facing. The combination of rigorous coursework, the freedom to try and fail, and significant peer and staff support allows for the failure and mastery experiences needed to develop self-efficacy and a growth mindset.[19, 24]

Other aspects of RESP were also designed based on a number of best practices in the field. Research demonstrates study groups are a crucial aspect of success in undergraduate STEM programs.[25] Because most students in RESP were among the most capable in their high school, few arrive at Rice having worked extensively in groups of equally capable peers. Additionally, students from groups traditionally underrepresented in STEM fields may resist asking for help so as not to confirm negative stereotypes about themselves or their identity group.[26] By mandating and facilitating daily study groups, RESP allows students to create new narratives around peer-to-peer support (cf. obstacle 3).

6. Targeted Students

RESP targets underprepared STEM students who attended under-resourced high schools. These students are highly capable, but have not been academically challenged. For example, a student may have attended a high school that did not offer calculus or trigonometry. Or, a student may have taken calculus, but it was not taught with high rigor or depth. (In comparison, Rice has many well-prepared STEM students who have attended well-resourced high schools and are prepared academically for the transition to college. These students may have large numbers of AP credits or IB diplomas.)

Offers are extended to incoming STEM freshmen in April and May. All students have accepted Rice's offer and made a financial deposit to begin in the fall. Only students intending to major in STEM fields are invited to participate in the program.

The RESP works with the Admissions Office to evaluate student readiness, aiming to select students who are the least prepared or have the largest gap in their skills and abilities relative to expectations. Currently, the team uses standardized test scores (e.g., SAT, ACT and number and score on AP tests), quality and competitiveness of high school, first generation status, and performance on an in-house diagnosis. The 11-question diagnostic exam was developed with Rice STEM faculty. The test assesses sophistication in word problems using high school science and mathematics that are pre-requisites for the gateway STEM courses at Rice. The average score on this diagnostic is 9/11; RESP targets students who perform 6/11 or below, with 3/11 or below indicating very high risk. Selection is race-, ethnicity-, and gender-blind.

To date, the program has been run for four years. The target cohort size is 25. Each summer, about 50 slots are offered, with a yield of approximately 50%. Since RESP began in 2012 a total of 102 students have participated in the program over four years. In order to complete an assessment, the team has maintained a control group of students who rejected the invitation or who were underprepared but not invited due to limited resources. The control group is typically smaller than the cohort but aims to be well matched with respect to national test scores, diagnostic test scores, and first-generation status.

7. Overall Program Description

Pre-summer program

Before arrival at the RESP summer program, students complete ALEKS, an individualized, online learning environment that covers pre-calculus. This was put into place to respond to the very wide range of competencies in mathematics (pre-trigonometry to calculus) seen in the Scholars. Note that this is the only remedial aspect of the program. Completion of ALEKS through "Limits and Continuity" ensures that students have a strong mathematical foundation. Students earn a $200 stipend for completing either 50 of the approximately 100-150 un-mastered topics or 18 hours in module before the summer residential program.

Summer residential program: Core subjects of Chemistry, Physics, and Calculus

RESP students participate in a six-week residential program on the Rice campus. As shown in Table 2, students take Introductory Chemistry and Physics (level designed for physical science and engineering majors) and Calculus. They attend class every day, with 5 hours of class for each subject each week. Lecture is taught with the same style and pace that as would be experienced during the regular semester. The classes are typically taught by Rice faculty members, some of whom teach the same courses during the academic year.

Table 2. Typical summer week for RESP students

<table>
<tr><th></th><th>Mon</th><th>Tues</th><th>Wed</th><th>Thurs</th><th>Fri</th><th>Sat</th><th>Sun</th></tr>
<tr><td>Morning</td><td colspan="5">Calculus, Chemistry, Physics</td><td colspan="2">Free time, Homework</td></tr>
<tr><td>Afternoon</td><td colspan="5">Mandatory study group (all afternoon)
2 of 5 afternoons include:
• Problem solving lesson
• Engineering design module
• Lab tours</td><td colspan="2">Free time, Homework</td></tr>
<tr><td>Evening</td><td colspan="5">Homework, Review sessions,
Free time, College transition meeting</td><td>Social activity</td><td>College transition meeting, Review sessions</td></tr>
</table>

Students have two and a half hours of classes and approximately seven hours of homework daily. Four hours of homework occur in mandatory study groups, as discussed below. Students have access to support services (e.g., office hours, TA sessions, academic coaching) every day of the week to model resources available during the school year. Each course has two midterms and a final.

<u>Group Work Model</u>

RESP adapts the team-based learning approach to group work, developing diverse groups facilitated by trained upperclassmen.[27] Students begin daily group work sessions by self-generating concepts covered in the morning classes. After the course review to cement learning, students move on to homework, utilizing a structured problem-solving strategy and taking turns teaching each problem until everyone in the group understands.[28, 29] Upperclass STEM students, or Fellows, live with the students and serve as both mentors and academic guides during the program. Many Fellows are program alumni, providing a direct model for successful transition to the new Scholars.

While group work remains mandatory throughout the entirety of the program, upperclassmen facilitation is reduced over the weeks so that, by Week Four, the groups are self-guided. This is intended to serve as a model for successful group work during the academic year.

<u>Summer Residential Program: Supplemental Topics</u>

RESP aims to comprehensively address student needs and provide the strongest possible transition to a highly competitive STEM program. This is achieved through co-curricular programming, including:

- Engineering design module (20 hrs): overview of design process with hands-on prototyping component
- Structured methods to tackle open-ended, technical word problems (6 hrs)

- Peer-to-peer transition mentoring groups: upperclassmen Fellows hold nightly transition meeting to discuss life at Rice and in STEM.
- Academic advising and faculty mentorship: each student is individually academically advised by a faculty member.
- STEM career exploration and research support: lab tours, faculty presentations, and interactions with local STEM professionals from industry
- Cohort building activities (Houston/Rice acculturation).

Details on Curriculum: Chemistry, Physics and Calculus

All concepts covered in the summer residential program are topics in the first two semesters of Chemistry, Physics and Calculus. Both foundational and conceptually difficult topics are selected for the summer. Topics are covered at the same rate in the summer (e.g., 3 hrs on Reaction Stoichiometry) as in the fall (e.g., 3 hrs on Reaction Stoichiometry). Curriculum is also selected that helps students learn and master solving complex word problems. RESP understands "complex word problems" to be multi-step and synthetic, drawing on concepts from multiple points throughout the course. Students are taught material to the level of mastery, meaning that they can apply the material to other contexts. The curricular content for the summer program are listed in the Appendix for Chemistry (Table A1), Calculus (Table A2), and Physics (Table A3).

Term-Time Program

RESP support extends beyond the bridge summer through the entirety of a student's time at Rice. Primary support is offered through ongoing advising provided by a full-time staff member whose sole focus is RESP. The staff member utilizes an intrusive advising model in which first- and second-year students meet weekly or bi-weekly to discuss course selection, study habits, transition issues, and any other challenges that may impact their college experience. This proactive advising model is crucial for supporting at-risk students.[30] Meetings begin during the bridge summer, allowing students to develop a trusting relationship with the staff member. Regular meetings highlight potential issues early and allow for intervention before there are serious consequences. Examples of potential issues include poor time management, financial crises at home, and issues of belonging in STEM. The staff member works closely with other student support services on campus to create a network of support for Scholars.

Students meet weekly or bi-weekly through the first three semesters, after which they transition to as-needed meetings. All students are monitored throughout their tenure at Rice so staff can intervene if necessary.

RESP also offers tutors, ongoing cohort development and navigational programming to all students. In the fall, there is a 2 credit-hour academic course that helps students transition to RICE.[31, 32, 33, 34] The course is available to all first-year students, but RESP students are clustered in a specific section led by the RESP Associate Director.

Costs

All aspects of the RESP program, including the summer program and advising during the semester, are free to all participants. During the summer, RESP pays for room and board, textbooks, and any other costs associated with supplemental activities. To offset the lost income from not working during the summer, participants receive a $2200 stipend (separate from the

$200 ALEKS incentive). This mitigates a potential conflict of a Scholar having to choose between attending RESP or earning money to fund education.

RESP costs approximately $250,000 per year for a cohort of 25 students. The total program cost per student is $6,600 (not including program stipends and incentives, which are $2,400 per student) over the course of their Rice career. This includes expenses listed above as well as program staff salaries (one full-time staff member, summer stipends for program instructors, and $6,000 summer salary for each upperclassmen employee), and the cost of tutoring and limited cohort-building activities during the academic year. Program cost is currently covered through university funding, private donors, and foundation and corporate sponsorship.

8. Assessment of Program

RESP increases retention and persistence, both at the university and in STEM fields. Students at Rice declare a major in spring of their sophomore year, allowing us to track retention in STEM for the first two cohorts of RESP participants. As shown in Table 3, there is no difference between the Year 1 RESP and control groups in terms of STEM retention. This is not surprising, as RESP did not offer formal term time support when the program was launched and substantive curricular changes were implemented after the first summer. In contrast, the retention in the 2013 RESP cohort as compared to the 2013 control is 20 percentage points higher, or 37%. The retention of RESP students in STEM (74%) is approximately the same as for all students (67%, Table 1).

Table 3. Percentage of students who have declared STEM major

	Group	**% Declared STEM**
Year 1	2012 RESP	46%
	2012 control	47%
Year 2	2013 RESP	74%
	2013 control	54%

The team is continuing to track retention for all cohorts (Table 4). While students in the 2014 and 2015 cohorts have not declared a major, evidence from their transcripts informs Table 4. As shown, there are more RESP students than control students in the “likely STEM” group. Also, there are fewer RESP students than control students in the “Unlikely STEM” group. The team will continue to track retention in STEM.

Table 4. Likely STEM outcomes for underclassmen.

	Group	**Likely STEM**	**Unlikely STEM**	**Unsure**
Year 3	2014 RESP	65%	17%	17%
	2014 control	52%	26%	22%
Year 4	2015 RESP	85%	0%	15%
	2015 control	53%	26%	21%

Another way to track early persistence in STEM is to count the number of core STEM courses taken through the fourth semester. (STEM courses are defined as general chemistry, the first four semesters of Mathematics, Physics, Organic Chemistry, Cell Biology, and Engineering Mechanics.) Considering the 2013 cohort, students who participated in the RESP program had taken an average of 60 hours of core STEM credits. In contrast, the 2013 control group had only taken an average of 27 hours of core STEM credits. RESP students are taking more core STEM credits, consistent with a path toward a STEM major.

RESP does not appear to impact GPA. For example, the grades from General Chemistry for the 2013 cohort are shown in Table 5. While the RESP students are not performing quite as well as the overall class, the RESP cohort is doing substantially better than the control group.

Table 5. Percent of students in General Chemistry (2013-2014) who earned at the level of the top two thirds of students (B for Chem121 and B- for Chem122)

	Overall Class	**RESP**	**Control**
CHEM 121 (1st semester)	67%	52%	29%
CHEM 122 (2nd semester)	66%	62%	37%

9. Future Plans

With the first cohort of students on track to graduate in Spring 2016, RESP is transitioning out of the first pilot stage. Immediate plans include expanding cohort from approximately 25 to approximately 45 students for the Summer 2016 cycle and partnering with social scientists to improve program assessment and develop more sophisticated interventions for student self-efficacy and STEM self-concept. RESP will continue to identify obstacles and create programmatic responses to ensure all barriers students face are addressed.

10. Summary

The Rice Emerging Scholars Program is a comprehensive summer bridge that rejects the remedial bridge model to increase student retention. By exposing students to the most challenging parts of the freshman STEM curriculum and providing the tools to respond to that challenge during the summer, RESP overcomes the impact of less-rigorous high school preparation on students of strong potential at a competitive institution. RESP continues this positive development through ongoing, proactive staff support throughout the student’s time at the institution. While RESP does appear to have a positive impact on retention, this model does not significantly impact student GPA. While the core focus of the program remains the same, RESP constantly evolves to better meet student needs.

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Appendix

Table A1. Chemistry topics (summer 2015). ‘Time’ is time spent during RESP in lecture hour equivalents.

Topic	**Time (hr)**	**Learning Outcome**
Atomic Molecular Theory	4	Can explain how the AMT was developed; Develops scientific reasoning skills; interprets data to generate conclusion
Reaction Stoichiometry	3	Can properly generate, interpret, and use chemical reaction equations; Quantitative and proportional reasoning skills
Acid Base Reactions	3	Can predict, interpret, and quantitatively use acid/base reaction equations; Quantitative problem solving (setting up and executing multi-variable algebra)
Precipitation Reactions	2	Can predict, interpret, and quantitatively use precipitation reaction equations; Quantitative problem solving (setting up and executing multi-variable algebra)
Redox Reactions*	2	Can predict, interpret, and quantitatively use redox reaction equations; Quantitative problem solving (setting up and executing multi-variable algebra)
Atomic Structure	3	
Intro Quantum Theory	4	Understands quantum model of atomic structure; can explain how they were developed; Develops scientific reasoning skills; interprets data to generate conclusion

Table A2 Calculus topics (summer 2015). ‘Time’ is time spent during RESP in lecture hour equivalents.

Topic	Time (hr)	Learning Outcome
Vectors	4	Can manipulate vector expressions, use the appropriate type and method in Physics problems; Understand difference between types of quantifiables and their appropriates uses
Sequences	2	
Infinite Series	8	Can apply tests for convergence of infinite series in complete coherent arguments; Formal proofs of quantitative statements
Integration Review	1	Can apply methods of integration in simple problems; Manipulation of algebraic quantities in problem-solving
Power and Taylor Series	5	Apply Power series methods to represent functions and approximate; Understand concept of approximation and error values, correctly using error estimates

Table A3. Physics topics (summer 2015). ‘Time’ is time spent during RESP in lecture hour equivalents.

Topic	Time (hr)	Learning Outcome
Kinematics & Basic Skills	2	Can calculate and describe basic concepts of one dimensional motion
Vectors (2D motion)	3	Can manipulate vector expressions and apply them to two dimensional motion problems
Forces (Newton's Laws) including gravitation	5	Can apply newton's laws of motion to real life situations and solve problems applied to both linear and circular cases
Energy	3	Apply the concept of conservation of energy to a variety of mechanics problems
Linear Momentum	3	Apply the concept of conservation of momentum to a variety of mechanics problems
Angular statics and Dynamics	5	Apply torque and angular quantities to solve mechanics problems
Angular Momentum	4	Apply vector operations to solve angular momentum problems