Strategic Accelerated Review/Proposal

Department of Physics & Astronomy

Overview:

Physics & Astronomy (P&A) has been included in the *programs for strategic accelerated review*. Indeed, P&A is in a unique position to contribute significantly to UW's Land-Grant mission, especially President Seidel's four pillars. Investment should be made to strengthen its programs by increasing the number of research faculty in the growing and marketable fields of astronomical data sciences and quantum materials & devices. Reasons for making this recommendation are abundant.

P&A has enjoyed a 75-100% surge in the number of inquiries and applications by prospective students for the three main undergraduate and graduate programs over the past five years and a 50-120% increase in the number of declared majors. Student demand and employment score a combined 96th percentile for both graduate and undergraduate degrees (Gray's data), indicating that physics graduates have skills sought by the private sector and are well-placed for entrepreneurial ventures. P&A is one of the most productive units on campus in terms of research funding generated per faculty member and citation rate. P&A provides foundational courses across the campus with a high number of student credit hours generated in lower-division, upper-division, professional, and/or graduate level courses (particularly when measured per FTE faculty). Many undergraduates participate in research with faculty, often attending national conferences and earning co-authorship on manuscripts. P&A engages in substantial and structured interdisciplinary collaborations with other programs, such as the concurrent BA degrees in Physics Education, Ph.D.'s in Materials Science and Engineering, multiple joint research projects with faculty in other departments/colleges, collaboration with SER, and 2+2 articulation agreements with the community colleges. P&A's programs reflect what land-grant universities typically consider their critical mission, from STEM-focused core instruction and advanced research to service to Wyoming communities. P&A programs are garnering national recognition, e.g., UW has been named one of the Top 25 Most Affordable Bachelor's in Astronomy for 2020 by Great Value Colleges (ranked 12th). P&A faculty have been leaders in teaching innovation, recipients of teaching awards, and steadfast promoters of outreach/education to Wyoming K-12 students, teachers, & citizens in order to broaden participation and increase access to higher education. As a discipline nationally, Physics has been one of the least diverse faculty & student bodies, but measurable change is already happening nationally and locally. Through a continued commitment to broadening participation we are in a prime position to meaningfully impact the discipline through targeted recruitment and support of faculty, graduate students, and undergraduate students. Faculty hiring has not kept pace with enrollment nor with the emerging opportunities to build upon our strengths in advanced materials and computational sciences.

Background:

Since the near elimination of the Department in 1999, Physics & Astronomy has steadily, if slowly, regenerated to become a highly productive nucleus of 15 faculty members, including 10 active research faculty, two academic professionals (FTRC), plus three serving in upper administration. The Department also operates the Wyoming Infrared Observatory (WIRO) which is a centerpiece of grant-funded research, student education, and outreach, as well as the Harry C. Vaughan Planetarium that served over 9000 attendees last year. P&A offers a PhD in Physics, an MS in Physics, a BS in Physics, a BS in Astronomy, a BA in Physics, and a BA in Physics & Physics Education (Concurrent Major), as well as minors in Physics and in Astronomy.

P&A set its 5-year strategic plan (2018-2023) a few years ago. The strategic plan was developed in line with the University's and College's strategic plans, and our plan focuses on increasing graduate

assistantships and strategically expanding faculty expertise and number, as well as undergraduate student recruiting/retention and outreach.

We are already making headway toward these goals. Over the past five years we have seen a 75-100% increase in the number of inquiries from and applications by students for our three main undergraduate and graduate programs: the BS in Astronomy, the BS in Physics, and PhD in Physics (see Attachment I). For two years in a row (immediately before COVID-19 hit), we had the largest freshman and transfer student enrollment in recent history. P&A has maintained 55-60 astronomy majors and 55 physics majors for the last two years in a row. This is a large increase in the number of majors. For comparison, there were 27 astronomy majors and 36 physics majors in the fall semester of 2016. This is a 50-120% increase in the number of declared majors over the last five years. See Attachment II for data obtained from the Office of Institutional Analysis (OIA). Note, the drop in the numbers for Year 20-21 may have been affected by COVID-19, particularly as a focus of P&A is education through hands-on laboratory work. We currently have 37 full time Ph.D. students. This number is stable and slightly increasing and is roughly dictated by the number of active research faculty.

Physics and Astronomy are fields of *high market demand* that have *huge potential for growth* in Wyoming. For a Ph.D. in Physics, according to Attachment III, student demand and employment are at the 98th and 95th percentiles, respectively (with a combined score of 96). For a bachelor's degree in Physics, they are at the 97th and 95th percentiles, respectively (with a combined score of 96), as shown in Attachment IV. Attachments V-VII show Gray's data on other degrees that P&A offers. Much of the demand is driven by connections to growing, highly technical, industrial applications, such as computer hardware and data science, fields that hunger for the technically trained students produced by Physics and Astronomy degrees.

P&A excels in terms of research support. Over 93% of tenured/tenure-track faculty have active federally funded research projects and many have multiple extramural awards. P&A is one of the most productive departments on campus in terms of research dollars generated per capita (see Attachment VIII). The total amount of external research grants awarded to the Department was $5,061,984 last year, which is $389,383 per faculty FTE. And we have typically kept a total amount of grants in-force of between $7M and $9M over the past few years. It is our strategic goal to maintain high quality scholarly activities and productivity and continue to be a top performer on campus in terms of grants received per capita.

P&A also diligently trains students in research. Our faculty place a high value on undergraduate students gaining practical scientific experience while working in their labs. A large number of undergraduate students (Attachment IX) are involved in research/scholarly/creative work. One of our strategic goals is to increase the opportunity for P&A students to gain internship experience off campus and research experience in faculty's labs. In this regard, we have a policy of encouraging undergraduate student research by providing a 50% match to their research support from the departmental budget. We also host the only NSF Research Experiences for Undergraduates (REU) program on the UW campus.

P&A faculty publish at a high rate and produce high-impact, highly cited papers. More than a third of the research faculty have h-indexes in excess of 40 and are approaching (or have exceeded!) 10,000 citations. This signifies an extremely prolific faculty in areas aligned with UW strategic goals. We have listed the publications by P&A faculty and their students over the past five years in Attachment XI.

P&A provides foundation courses across-campus with a high number of student credit hours generated in lower-division, upper-division, professional, and/or graduate level courses, per FTE faculty. The total number of student credit hours taught by P&A was 8,209 last year (see Attachment X). P&A faculty and lecturers are enthusiastic teachers. We hold frequent "Teaching Chats" to discuss innovative pedagogy as a means to engage students and ensure student success. Faculty and graduate students participate in

Ellbogen and Science Initiative LAMP workshops on best practices in higher education. We currently offer classes in both the traditional lectures-plus-lab/discussion-sections format and in the more innovative "studio" format where lectures, labs and discussions are combined. Faculty teaching "studio" physics classes document >95% attendance, lower D/F/W rates, and higher student satisfaction, all part of a commitment to promoting student success and timely graduation.

P&A is primed to advance President Seidel's **four pillars** of becoming more digital, more entrepreneurial, more interdisciplinary, and more inclusive. In terms of making UW *more digital*, we intend to grow our research and teaching in two relevant directions: 1) condensed matter physics research focused on quantum materials and 2) student training in large data sets and computation.

UW's physics program is focused on condensed matter and materials physics. We have made a collective decision to focus on quantum materials research for quantum computing and spintronics. Our five physics research faculty have been very active in this area and have been successful in securing research grants. For example, faculty member Jifa Tian leads a collaborative project to realize and manipulate Majorana particles at the atomic scale in a simple materials system, topological superconductor 2M tungsten disulfide (WS_2), *because of its potential for creating qubits to build future quantum computers*. In addition, the Department have adopted a strategy of seeking large collaborative grants by combining the expertise of our faculty and other departments in the face of high competitiveness of research grants at the federal level. This strategy has paid off, and most of faculty are known experts in the field.

The department is also well-placed to lead student training in large datasets and computation. For example, our faculty have recently developed two computational courses that have been included as part of the requirements for our majors. These courses prepare students for writing and applying code using modern programming languages, techniques and infrastructure. P&A is an ideal conduit for digital content as astronomy and cosmology have long been at the forefront of computational efforts and digital advances (e.g., see link) and data science is an increasingly common minor in astronomy (e.g., see link). Faculty member Adam Myers is one informative example. Students in Myers' research group regularly use one of the Department of Energy's flagship supercomputers, and they have written a great deal of public software that is publicly released on industry-standard coding repositories such as GitHub.

In terms of *entrepreneurship*, our faculty vigorously pursue grantsmanship at the federal level and with industrial partners. Reaching out to potential donors and securing funds for scholarships and awards are also an important part of such an effort. We spend a significant amount of time communicating and socializing with potential donors. The Department has received a total of $2M in private donations in the past five years. Our lab courses train students in the practical skills of data collection and automation. These are essential ingredients when thinking about how technology interacts with the world in an entrepreneurial fashion. We regularly invite speakers from industry, including our own alumni, to the department's weekly colloquia to discuss their careers and their experiences as innovators. In the future, we plan on holding more entrepreneurship seminars and summer workshops. We intend to invite colleagues from the College of Business to discuss transforming ideas from P&A research into real-world applications.

Interdisciplinary collaborations: Close collaboration between physicists and other stakeholders on campus will strengthen UW's research capability and enhance our chance to secure research grants. As a matter of fact, this is how we already envision our role as physicists in the campus-wide research endeavor. For instance, faculty member Myers is currently Co-PI of a $1M interdisciplinary grant spread across the Colleges of Engineering, Education, and Arts & Sciences focused on introducing coding to teachers across Wyoming. As another example, faculty member Tian's DOE grant includes participants from the Departments of Physics, Chemistry and Chemical Engineering. P&A faculty also have close

collaborations with the School of Energy Resources on projects ranging from rare earths to carbon quantum dot and graphene utilizing Wyoming's coal. Other examples include concurrent BA degrees in Physics Education, the Ph.D. in Materials Science and Engineering, and 2+2 articulation agreements with Wyoming community colleges. Indeed, P&A engages in substantial and structured collaborations with other programs, and there is a culture of interdisciplinary work. We are therefore well-placed to further strengthen and expand interdisciplinary collaborations.

As regards promoting *diversity and inclusion*, P&A are engaged in multiple activities. On the faculty side, we have recently successfully recruited a minority female lecturer. On the student side, our outreach and "in-reach" activities have proven essential to attract and retain female and underrepresented minority students. The Department annually applies for and typically receives Women in Graduate Education and Under Represented Domestic Minority graduate scholarships to support our efforts to diversify our student population. We are also one of a handful of universities outside of the University of California system that participate in the Cal-Bridge program, which creates a pathway for minority students from multiple California State University campuses to doctoral programs in physics and astronomy. Currently, one-half of our astronomy graduate students are women. This is a typical trend for P&A, and some of our most successful recent PhDs in astronomy are women (e.g., Prof. Jessie C. Runnoe at Vanderbilt University). Women make up about 50% of the recipients of the top undergraduate awards since 2017. They are encouraged to and actively attend women focused physics & astronomy conferences. Undergraduate minority students meet regularly to foster belonging and talk to faculty about issues concerning to them. We are also building a strong relationship with the Wind River Indian Reservations. The department participates in the annual Native American Summer Institute in which high school students from the Wind River Indian Reservations are invited to spend a week on the UW campus. Faculty Kobulnicky and Dale have directed a residential middle school STEM camp since 2003, with the goal of making UW more accessible to Wyoming's youth, particularly for underserved rural and low-income families. Grades 6-9 are pivotal ages for creating the pipeline of students into STEM disciplines, particularly for women and students of color who are underrepresented in these fields. Collaborations with UW colleges, secondary science teachers across Wyoming, and partner institutions like the Casper Planetarium have helped over 400 middle-school students experience a free 10-day college-like immersion on the UW campus that promotes STEM careers and fosters access to higher education. Faculty and grad students are regular contributors to UW outreach events such as the Top Tier Science Initiative's Science Roadshow and the on-campus Science Kitchen and the NASA Space Grant Consortium's Women in STEM day.

Recommendations:

Physics & Astronomy is poised to build on its recent successes in the fertile fields of astronomical data sciences and quantum materials and devices. Investment to strengthen our programs, in particular, to increase the number of research faculty in these two areas, is not only essential for the Department to approach national eminence but also advances UW's Land-Grant mission and President Seidel's vision of the four pillars.

We propose to embark on the next phase of making the Department more diverse and more interdisciplinary by completing two faculty hires in astronomy, a physics subfield where half of the recent PhD recipients are female and investments at the national level are succeeding to broaden participation by scientists of color. The searches will target underrepresented faculty with expertise in data mining, computational astrobiology, and numerical astrophysics. Expansion in these areas will complement existing expertise while enhancing the return on UW's investment in the telescope infrastructure that has been responsible for the marked increase we have seen in enrollment and extramural funding. These are current growth areas within astrophysics that will create new channels

for interdisciplinary collaboration with UW faculty in computer science, geoscience, and the life sciences. Expanded faculty expertise will carve new funding opportunities spanning traditional disciplinary boundaries that take advantage of recent cross-cutting initiatives at NSF, NASA, and private foundations. One enduring impact on UW and Wyoming will be producing B.S. and PhD graduates consummately trained in applied computation—purveyors of knowledge, innovation, and wealth for a digital age.

We also propose two faculty hires in quantum physics that build upon recent successes by condensed matter physics faculty in areas crucial to U.S. strategic initiatives in quantum information science. The search will target underrepresented faculty with expertise across the broad areas of quantum information, materials and devices. The new faculty will foster broader interdisciplinary links to chemistry and chemical/electrical engineering faculty and forge new ties to computer science faculty by virtue of the tight linkage between our targeted areas and growth in those subfields. With a critical mass of faculty (from different departments, such as P&A, chemistry, chemical engineering, electrical engineering, computer science and math), postdoctoral researchers, and students at all levels, we plan to establish a Quantum Materials and Devices Center (QMDC) at UW with a focus of designing and fabricating quantum materials and devices for applications in energy and future computational technologies. This center may also be part of a future campus-wide quantum computing school or initiative. We envision that UW QMDC should become a regional center, unique along the Front Range for the confluence of experimental capabilities and potent computational resources. B.S. and PhD students capable of designing and fabricating quantum devices will be at the forefront of entrepreneurial ventures critical to sustaining and diversifying Wyoming's economy while maintaining national preeminence in science and engineering for future generations. Physics students at all levels will be encouraged to pursue coursework in the College of Business, and/or a minor in entrepreneurship, by making our degree programs more flexible.

Metrics and Timeline for Success

1. With the new faculty hires, P&A tenured/tenure-track faculty will exceed either a) the national average of 19% female, or b) 10% Black/Latinx in representation. Ideally, both goals could be attained. Timeline: Fall semester 2028, assuming four faculty hires in seven years.
2. The Department will build on its recruiting initiatives among underrepresented groups so that graduate students will a) exceed the national average of 22% female, or b) exceed the national average of 6% Black/Latinx. Ideally, both would be realized. Timeline: Fall semester, 2026.
3. Half of undergraduate majors would take at least one course or summer workshop in business/entrepreneurship. Timeline: B.S. graduates in May 2025 and afterward, with implementation starting in 2022.
4. Half of graduating PhD & M.S. students would take at least one course or summer workshop in business/entrepreneurship. Timeline: Graduates in May 2025 and afterward, with implementation starting in 2022.
5. At least 40% of extramural grant proposals submitted by faculty would include collaborators from other departments. Timeline: Fall 2026, with implementation beginning at the start of new faculty hires.
6. Physics majors will take at least 2 courses in computational techniques or data mining at the undergraduate level. Timeline: B.S. graduating class of 2023, with implementation already started in fall 2020.
7. Graduating PhD & M.S. students will take at least 2 courses in computational techniques, data mining, or experimental techniques/lab skills. Timeline: Graduates in May 2026, with implementation starting in 2022.

Appendices:

Attachment I. Numbers of inquiries, applications, admissions, confirmation, and enrollment by students for undergraduate and graduate programs

Applicant Academic Program	Year	Prospect Count	Applicant Count	Admit Count	Confirm Count	Enrollment Count
BS in Astronomy	15-16	189	49	37	19	19
	16-17	327	56	43	11	11
	17-18	384	59	50	24	23
	18-19	486	100	64	24	21
	19-20	294	72	55	26	24
	20-21	528	60	50	16	16
BS in Physics	15-16	84	23	20	13	12
	16-17	220	31	28	12	12
	17-18	309	30	25	17	17
	18-19	285	41	28	13	13
	19-20	226	42	33	14	14
	20-21	380	24	17	4	3
BA in Phys Educ	15-16	2	2	2	1	1
	16-17	2	1	1	0	0
	17-18	4	2	2	1	1
	18-19	3	1	1	1	1
	19-20	4	2	2	2	2
	20-21	2	1	1	0	0
PhD in Physics	15-16	56	27	6	5	5
	16-17	49	26	6	5	5
	17-18	48	18	8	8	8
	18-19	67	30	7	7	7
	19-20	93	62	19	9	9
	20-21	104	66	7	6	6
MST in Physics	15-16	9	3	2	2	2
	16-17	29	5	2	2	2
	17-18	15	3	0	0	0
	18-19	12	2	1	1	1
	19-20	10	1	0	0	0
	20-21	8	0	0	0	0

Attachment II. Number of Majors - Including Primary, Second, Third, & Fourth Majors

Program	Fall 2016	Fall 2017	Fall 2018	Fall 2019	Fall 2020
BA in Physics	1	2	3	5	6
BS in Astronomy/Astrophysics	27	38	55	60	52
BS in Physics	36	44	55	55	36
BS in Physics Plus	1	1	0	0	0
MS in Physics	2	2	1	1	1
MST in Physics	2	2	1	1	1
PhD in Physics	28	31	34	36	37
Total Majors	**97**	**120**	**149**	**158**	**133**
Minors in Astronomy/Astrophysics	2	3	4	3	5
Minors in Physics	5	3	8	14	12
Total Minors	**7**	**6**	**12**	**17**	**17**

Program	*Fall 2016*	*Fall 2017*	*Fall 2018*	*Fall 2019*	*Fall 2020*
BA in Physics Education (College of ED)	*1*	*2*	*1*	*2*	*3*
Physics as a secondary to Physics Ed.	*1*	*2*	*1*	*2*	*3*

Note: Headcounts are duplicated since students are counted once for every major declared.

Number of Degrees Awarded - Duplicated by Program

Program	2015-16	2016-17	2017-18	2018-19	2019-20
BA in Physics	0	0	0	0	1
BS in Astronomy/Astrophysics	4	3	4	5	11
BS in Physics	4	7	11	11	10
MS in Physics	5	6	7	6	6
MST in Physics	0	0	1	0	0
PhD in Physics	2	6	1	3	4
Total Degrees	**15**	**22**	**24**	**25**	**32**
Minors in Astronomy/Astrophysics	0	0	0	1	1
Minors in Physics	2	3	2	0	3
Total Minors Awarded with Degrees	**2**	**3**	**2**	**1**	**4**

Attachment III. Gray's data on student demand and employment for PhD in Physics

CIP: 40.0801 Physics, General | Market: National | Modality: All | Award Level: Doctoral

96 Percentile — 40.0801 Physics, General [18 Score]

Student Demand [16 Score]

98 Pctl

Category	Pctl	Criterion	Value	Score
Size	0	Inquiry Volume (12 Months)	0	-2
	99	Int'l Page Views (12 Months)	21,859	NS
	84	Google Search Volume (3 Months)*	416,339	10
	99	On-ground Completions at In-Market Institutions	1,730	NS
	0	Online Completions by In-Market Students	0	NS
	98	Sum of On-ground and Online Completions	1,730	10
Growth	96	Inquiry Volume YoY Change (Units)	0	0
	1	Google Search YoY Change (Units)*	-47,081	-2
	14	Completion Volume YoY Change (Units)	-4	0
		Inquiry Volume YoY Change (%)	NA	NS
	8	Google Search YoY Change (%)*	-10%	0
	47	Completion Volume YoY Change (%)	-0%	0

Competitive Intensity [-7 Score]

1 Pctl

Category	Pctl	Criterion	Value	Score
Volume of Competition	99	Campuses with Graduates**	169	-6
	0	National Online Institutions (Units)**	0	NS
	0	Institutions with Online In-Market Students**	0	NS
	6	Institutions YoY Change (Units)**	-2	0
	92	Average Completions by Local Institution	10	-1
	90	Median Completions by Local Institution	7	0
	68	YoY Median Program Change (Units)	0	0
	68	YoY Median Program Change (%)	0	0
	0	Nat'l Online % of Institutions	0	-1
	0	Nat'l Online % of Completions	0	-1
Market Saturation		Average Cost per Inquiry**	NA	NS
	8	Google Search * Cost per Click**	$2	1
	2	Google Competition Index**	0.03	1

Employment* [5 Score]

95 Pctl

Category	Pctl	Criterion	Value	Score
Size (Direct Prep)	58	Job Postings Total (12 Months)*	2,426	0
	57	BLS Current Employment*	11,470	0
	56	BLS Annual Job Openings*	1,066	0
Size (Generalist)	97	BLS Share of Generalist Employment*	76,964	2
	97	BLS Share of Generalist Openings*	7,300	NS
Growth (Direct Prep)	98	BLS 1-Year Historical Growth*	19%	NS
	97	BLS 3-Year Historic Growth (CAGR)*	9%	1
	64	BLS 10-Year Future Growth (CAGR)*	0.8%	0
Saturation (Direct Prep)	18	Job Postings per Graduate*	0.2	-2
	12	BLS Job Openings per Graduate*	0.1	-2
Wages (Direct Prep)	93	BLS 10th-Percentile Wages*	$58,060	3
	96	BLS Mean Wages*	$104,958	NS
National American Community Survey Bachelor's Degree Outcomes	82	Nat'l ACS Wages (Age < 30)	$52,781	2
	92	Nat'l ACS Wages (Age 30-60)	$132,228	0
	95	Nat'l ACS % with Any Graduate Degree	69%	1
	80	Nat'l ACS % with Masters	35%	NS
	93	Nat'l ACS % with Doct/Prof Degree	34%	NS
	74	Nat'l ACS % Unemp. (Age <30)**	4%	0
	55	Nat'l ACS % Unemp. (Age 30-60)**	2%	0
	53	Nat'l ACS % in Direct Prep Jobs	3%	NS

CIP Description

A general program that focuses on the scientific study of matter and energy, and the formulation and testing of the laws governing the behavior of the matter-energy continuum. Includes instruction in classical and modern physics, electricity and magnetism, thermodynamics, mechanics, wave properties, nuclear processes, relativity and quantum theory, quantitative methods, and laboratory methods.

Attachment IV. Gray's data on student demand and employment for Bachelors in Physics

CIP: 40.0801 Physics, General | Market: National | Modality: All | Award Level: Bachelors

96 Percentile — 40.0801 Physics, General [18 Score]

Student Demand [15 Score]

97 Pctl

Category	Pctl	Criterion	Value	Score
Size	0	Inquiry Volume (12 Months)	0	-2
	97	Int'l Page Views (12 Months)	16,301	NS
	84	Google Search Volume (3 Months)*	416,339	10
	96	On-ground Completions at In-Market Institutions	8,110	NS
	0	Online Completions by In-Market Students	0	NS
	96	Sum of On-ground and Online Completions	8,110	8
Growth	90	Inquiry Volume YoY Change (Units)	0	0
	1	Google Search YoY Change (Units)*	-47,081	-2
	95	Completion Volume YoY Change (Units)	147	1
		Inquiry Volume YoY Change (%)	NA	NS
	8	Google Search YoY Change (%)*	-10%	0
	59	Completion Volume YoY Change (%)	2%	0

Competitive Intensity [-6 Score]

1 Pctl

Category	Pctl	Criterion	Value	Score
Volume of Competition	98	Campuses with Graduates**	687	-6
	0	National Online Institutions (Units)**	0	NS
	0	Institutions with Online In-Market Students**	0	NS
	3	Institutions YoY Change (Units)**	-13	0
	44	Average Completions by Local Institution	12	0
	47	Median Completions by Local Institution	7	0
	66	YoY Median Program Change (Units)	0	0
	66	YoY Median Program Change (%)	0	0
	0	Nat'l Online % of Institutions	0	-1
	0	Nat'l Online % of Completions	0	-1
Market Saturation		Average Cost per Inquiry**	NA	NS
	8	Google Search * Cost per Click**	$2	1
	2	Google Competition Index**	0.03	1

Employment* [5 Score]

95 Pctl

Category	Pctl	Criterion	Value	Score
Size (Direct Prep)	58	Job Postings Total (12 Months)*	2,426	0
	57	BLS Current Employment*	11,470	0
	56	BLS Annual Job Openings*	1,066	0
Size (Generalist)	97	BLS Share of Generalist Employment*	76,964	2
	97	BLS Share of Generalist Openings*	7,300	NS
Growth (Direct Prep)	98	BLS 1-Year Historical Growth*	19%	NS
	97	BLS 3-Year Historic Growth (CAGR)*	9%	1
	64	BLS 10-Year Future Growth (CAGR)*	0.8%	0
Saturation (Direct Prep)	18	Job Postings per Graduate*	0.2	-2
	12	BLS Job Openings per Graduate*	0.1	-2
Wages (Direct Prep)	93	BLS 10th-Percentile Wages*	$58,060	3
	96	BLS Mean Wages*	$104,958	NS
National American Community Survey Bachelor's Degree Outcomes	82	Nat'l ACS Wages (Age < 30)	$52,781	2
	92	Nat'l ACS Wages (Age 30-60)	$132,228	0
	95	Nat'l ACS % with Any Graduate Degree	69%	1
	80	Nat'l ACS % with Masters	35%	NS
	93	Nat'l ACS % with Doct/Prof Degree	34%	NS
	74	Nat'l ACS % Unemp. (Age <30)**	4%	0
	55	Nat'l ACS % Unemp. (Age 30-60)**	2%	0
	53	Nat'l ACS % in Direct Prep Jobs	3%	NS

CIP Description

A general program that focuses on the scientific study of matter and energy, and the formulation and testing of the laws governing the behavior of the matter-energy continuum. Includes instruction in classical and modern physics, electricity and magnetism, thermodynamics, mechanics, wave properties, nuclear processes, relativity and quantum theory, quantitative methods, and laboratory methods.

Attachment V. Gray's data on student demand and employment for Bachelors in Astronomy

CIP: 40.0201 Astronomy | Market: National | Modality: All | Award Level: Bachelors

31 Percentile — 40.0201 Astronomy [-7 Score]

Student Demand [-2 Score]

50 Pctl

Category	Pctl	Criterion	Value	Score
Size	0	Inquiry Volume (12 Months)	0	-2
	94	Int'l Page Views (12 Months)	6,936	NS
		Google Search Volume (3 Months)*	NA	NS
	75	On-ground Completions at In-Market Institutions	421	NS
	0	Online Completions by In-Market Students	0	NS
	73	Sum of On-ground and Online Completions	421	0
Growth	90	Inquiry Volume YoY Change (Units)	0	0
		Google Search YoY Change (Units)*	NA	NS
	88	Completion Volume YoY Change (Units)	40	0
		Inquiry Volume YoY Change (%)	NA	NS
		Google Search YoY Change (%)*	NA	NS
	78	Completion Volume YoY Change (%)	11%	0

Competitive Intensity [-3 Score]

15 Pctl

Category	Pctl	Criterion	Value	Score
Volume of Competition	85	Campuses with Graduates**	56	0
	0	National Online Institutions (Units)**	0	NS
	0	Institutions with Online In-Market Students**	0	NS
	99	Institutions YoY Change (Units)**	6	-1
	30	Average Completions by Local Institution	8	0
	28	Median Completions by Local Institution	4	0
	66	YoY Median Program Change (Units)	0	0
	66	YoY Median Program Change (%)	0	0
	0	Nat'l Online % of Institutions	0	-1
	0	Nat'l Online % of Completions	0	-1
Market Saturation		Average Cost per Inquiry**	NA	NS
		Google Search * Cost per Click**	NA	NS
		Google Competition Index**	NA	NS

Employment* [-6 Score]

19 Pctl

Category	Pctl	Criterion	Value	Score
Size (Direct Prep)	33	Job Postings Total (12 Months)*	360	-2
	20	BLS Current Employment*	559	-2
	19	BLS Annual Job Openings*	47	0
Size (Generalist)	66	BLS Share of Generalist Employment*	1,369	0
	66	BLS Share of Generalist Openings*	130	NS
Growth (Direct Prep)	99	BLS 1-Year Historical Growth*	51%	NS
	88	BLS 3-Year Historic Growth (CAGR)*	5%	0
	31	BLS 10-Year Future Growth (CAGR)*	0.5%	0
Saturation (Direct Prep)	30	Job Postings per Graduate*	0.5	-2
	12	BLS Job Openings per Graduate*	0.1	-2
Wages (Direct Prep)	86	BLS 10th-Percentile Wages*	$52,838	3
	96	BLS Mean Wages*	$103,580	NS
National American Community Survey Bachelor's Degree Outcomes	77	Nat'l ACS Wages (Age < 30)	$48,689	1
	86	Nat'l ACS Wages (Age 30-60)	$114,917	0
	89	Nat'l ACS % with Any Graduate Degree	61%	0
	60	Nat'l ACS % with Masters	30%	NS
	92	Nat'l ACS % with Doct/Prof Degree	31%	NS
	99	Nat'l ACS % Unemp. (Age <30)**	8%	-2
	73	Nat'l ACS % Unemp. (Age 30-60)**	3%	0
	0	Nat'l ACS % in Direct Prep Jobs	0	NS

CIP Description

A general program that focuses on the planetary, galactic, and stellar phenomena occurring in outer space. Includes instruction in celestial mechanics, cosmology, stellar physics, galactic evolution, quasars, stellar distribution and motion, interstellar medium, atomic and molecular constituents of astronomical phenomena, planetary science, solar system evolution, and specific methodologies such as optical astronomy, radioastronomy, and theoretical astronomy.

Attachment VI. Gray's data on student demand and employment for Masters in Physics Teacher Education

CIP: 13.1329 Physics Teacher Education | Market: National | Modality: All | Award Level: Masters

34 Percentile — 13.1329 Physics Teacher Education [-6 Score]

Student Demand [0 Score]

83 Pctl

Category	Pctl	Criterion	Value	Score
Size	85	Inquiry Volume (12 Months)	5	0
	0	Int'l Page Views (12 Months)	0	NS
		Google Search Volume (3 Months)*	NA	NS
	48	On-ground Completions at In-Market Institutions	18	NS
	79	Online Completions by In-Market Students	51	NS
	60	Sum of On-ground and Online Completions	69	0
Growth	9	Inquiry Volume YoY Change (Units)	-4	0
		Google Search YoY Change (Units)*	NA	NS
	85	Completion Volume YoY Change (Units)	15	0
	29	Inquiry Volume YoY Change (%)	-44%	0
		Google Search YoY Change (%)*	NA	NS
	86	Completion Volume YoY Change (%)	28%	0

Competitive Intensity [-5 Score]

2 Pctl

Category	Pctl	Criterion	Value	Score
Volume of Competition	73	Campuses with Graduates**	13	0
	67	National Online Institutions (Units)**	1	NS
	67	Institutions with Online In-Market Students**	1	NS
	83	Institutions YoY Change (Units)**	0	0
	2	Average Completions by Local Institution	1	-2
	9	Median Completions by Local Institution	1	-1
	73	YoY Median Program Change (Units)	0	0
	73	YoY Median Program Change (%)	0	0
	41	Nat'l Online % of Institutions	2%	0
	94	Nat'l Online % of Completions	74%	-2
Market Saturation		Average Cost per Inquiry**	NA	NS
		Google Search * Cost per Click**	NA	NS
		Google Competition Index**	NA	NS

Employment* [-5 Score]

24 Pctl

Category	Pctl	Criterion	Value	Score
Size (Direct Prep)	14	Job Postings Total (12 Months)*	27	-2
	24	BLS Current Employment*	869	-2
	22	BLS Annual Job Openings*	65	0
Size (Generalist)	59	BLS Share of Generalist Employment*	683	0
	59	BLS Share of Generalist Openings*	65	NS
Growth (Direct Prep)	43	BLS 1-Year Historical Growth*	2%	NS
	59	BLS 3-Year Historic Growth (CAGR)*	3%	0
	19	BLS 10-Year Future Growth (CAGR)*	0.3%	0
Saturation (Direct Prep)	19	Job Postings per Graduate*	0.2	-2
	49	BLS Job Openings per Graduate*	0.6	0
Wages (Direct Prep)	62	BLS 10th-Percentile Wages*	$40,512	1
	52	BLS Mean Wages*	$61,367	NS
National American Community Survey Bachelor's Degree Outcomes	48	Nat'l ACS Wages (Age < 30)	$41,726	0
	20	Nat'l ACS Wages (Age 30-60)	$70,041	0
	86	Nat'l ACS % with Any Graduate Degree	56%	0
	95	Nat'l ACS % with Masters	47%	NS
	54	Nat'l ACS % with Doct/Prof Degree	10%	NS
	15	Nat'l ACS % Unemp. (Age <30)**	2%	0
	14	Nat'l ACS % Unemp. (Age 30-60)**	1%	0
	90	Nat'l ACS % in Direct Prep Jobs	24%	NS

CIP Description

A program that prepares individuals to teach physics programs at various educational levels.

Attachment VII. Gray's data on student demand and employment for Bachelors in Physics Teacher Education

CIP: 13.1329 Physics Teacher Education | Market: National | Modality: All | Award Level: Bachelors

61 Percentile — 13.1329 Physics Teacher Education [-2 Score]

Student Demand [0 Score]

82 Pctl

Category	Pctl	Criterion	Value	Score
Size	87	Inquiry Volume (12 Months)	28	0
	0	Int'l Page Views (12 Months)	0	NS
		Google Search Volume (3 Months)*	NA	NS
	45	On-ground Completions at In-Market Institutions	34	NS
	74	Online Completions by In-Market Students	11	NS
	46	Sum of On-ground and Online Completions	45	0
Growth	7	Inquiry Volume YoY Change (Units)	-7	0
		Google Search YoY Change (Units)*	NA	NS
	71	Completion Volume YoY Change (Units)	3	0
	41	Inquiry Volume YoY Change (%)	-20%	0
		Google Search YoY Change (%)*	NA	NS
	72	Completion Volume YoY Change (%)	7%	0

Competitive Intensity [-1 Score]

41 Pctl

Category	Pctl	Criterion	Value	Score
Volume of Competition	71	Campuses with Graduates**	20	0
	76	National Online Institutions (Units)**	1	NS
	76	Institutions with Online In-Market Students**	1	NS
	34	Institutions YoY Change (Units)**	-1	0
	6	Average Completions by Local Institution	2	-2
	0	Median Completions by Local Institution	0	-1
	46	YoY Median Program Change (Units)	-1	0
	3	YoY Median Program Change (%)	-1	0
	55	Nat'l Online % of Institutions	1%	0
	88	Nat'l Online % of Completions	24%	2
Market Saturation		Average Cost per Inquiry**	NA	NS
		Google Search * Cost per Click**	NA	NS
		Google Competition Index**	NA	NS

Employment* [-5 Score]

24 Pctl

Category	Pctl	Criterion	Value	Score
Size (Direct Prep)	14	Job Postings Total (12 Months)*	27	-2
	24	BLS Current Employment*	869	-2
	22	BLS Annual Job Openings*	65	0
Size (Generalist)	59	BLS Share of Generalist Employment*	683	0
	59	BLS Share of Generalist Openings*	65	NS
Growth (Direct Prep)	43	BLS 1-Year Historical Growth*	2%	NS
	59	BLS 3-Year Historic Growth (CAGR)*	3%	0
	19	BLS 10-Year Future Growth (CAGR)*	0.3%	0
Saturation (Direct Prep)	19	Job Postings per Graduate*	0.2	-2
	49	BLS Job Openings per Graduate*	0.6	0
Wages (Direct Prep)	62	BLS 10th-Percentile Wages*	$40,512	1
	52	BLS Mean Wages*	$61,367	NS
National American Community Survey Bachelor's Degree Outcomes	48	Nat'l ACS Wages (Age < 30)	$41,726	0
	20	Nat'l ACS Wages (Age 30-60)	$70,041	0
	86	Nat'l ACS % with Any Graduate Degree	56%	0
	95	Nat'l ACS % with Masters	47%	NS
	54	Nat'l ACS % with Doct/Prof Degree	10%	NS
	15	Nat'l ACS % Unemp. (Age <30)**	2%	0
	14	Nat'l ACS % Unemp. (Age 30-60)**	1%	0
	90	Nat'l ACS % in Direct Prep Jobs	24%	NS

CIP Description

A program that prepares individuals to teach physics programs at various educational levels.

Education

Attachment VIII. External Grants

	2015-16	2016-17	2017-18	2018-19	2019-20
Grants Awarded	**$1,504,130**	**$1,608,571**	**$3,171,415**	**$2,066,329**	**$5,061,984**
Grants Expenditures	NA	NA	$1,952,634	$2,443,195	$2,266,112
Grants Awarded / Faculty FTE	**$107,438**	**$123,736**	**$243,955**	**$158,948**	**$389,383**

Attachment IX. Number of Undergraduate Students Participating in Research

	2015-16	2016-17	2017-18	2018-19	2019-20
Number	**39**	**39**	**41**	**48**	**28**

Attachment X. P&A Student Credit Hours

Level	**2015-16**	**2016-17**	**2017-18**	**2018-19**	**2019-20**
Lower	6,677.0	6,613.0	7,150.0	7,090.0	6,936.0
Upper	251.0	417.0	410.0	667.0	646.0
Grad	466.0	496.0	583.0	599.0	627.0
Total SCH	**7,394.0**	**7,526.0**	**8,143.0**	**8,356.0**	**8,209.0**
Total SCH / Faculty FTE	**0.0**	**0.0**	**626.4**	**642.8**	**631.5**

Attachment XI. Faculty/student publications over the past five years

Brotherton

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