THE GRADUATE STUDENT

WHAT DOES HE STUDY?

A varied program of coursework, research, major examinations and language requirements awaits the prospective physics graduate student when he has fulfilled the equally varied entrance standards.

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DIVERSITY AND QUALITY of academic programs offered by a university as well as the undergraduate physics prerequisites that a prospective graduate student must satisfy are two of the most important criteria that determine selection of a graduate school. Students are attracted to a particular university by the research specialities available, the quality of the faculty and the size of the department.

The would-be graduate student should have mastered certain textbooks and will have his grade-point average and Graduate Record Examination scores evaluated. The student will simultaneously examine the school's language requirements, the number of major examinations throughout the PhD program, teaching duties and geographic location.

A few statistics

In September 1968 the American Institute of Physics published *Graduate Programs in Physics and Astronomy,*[1] which describes in detail the doctoral programs in separate and joint physics–astronomy departments throughout the US and Puerto Rico. The book also includes brief entries on master's degree programs in both disciplines. At present there are 169 PhD programs in physics and 277 master's degree programs. According to an earlier AIP publication[2] only 145 departments offered a PhD in 1965. The new book gives information about 163 PhD programs, and six new departments have come into existence since the data for the book were compiled in the spring of 1968.

Although most students who obtain bachelor's degrees in physics continue in physics at the graduate level, there is a growing variety of interdisciplinary programs that broaden the choice of the prospective graduate student. The respondents to the AIP survey provided the names of 124 physics-related programs given in other departments at their institutions. Examples of such programs are chemical physics, planetary science, radiology, molecular biology and celestial mechanics.

UNDERGRADUATE PREPARATION

Some 5800 students, 95% of whom are male, will soon be awarded bachelor's degrees with a major in physics; of that number two thirds are planning to enter graduate school. The PhD in physics will be the goal of about 1300 students, and approximately 2500 will set their immediate sights on completion of a master's degree in physics. A small number, some 900, will veer off into physics-related or interdisciplinary graduate programs.

Every graduate department seeks students who will fit in well with both the style and level of its program. Admissions committees evaluate two major requisites: the amount of physics and related subjects the student has completed and the quality of his academic work. Data on the extent of expected preparation were supplied for the AIP book primarily by a listing of undergraduate course textbooks that should be mastered before graduate-school entry. Table 1 provides a summary of this information; not shown on table 1 is information related to texts on mathematical physics, elec-

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tronics, wave motion, astronomy, acoustics, solid-state physics and general physics, which were mentioned a total of 23 times.

GPA's and the GRE

Academic excellence is usually measured in terms of grade-point average (GPA). The graduate-department chairmen who volunteered information on their minimal grade requirements quoted letter grades rather than precise GPA's. Minimal averages of "B+" were mentioned 18 times, a "B" average was specified 53 times and lower grades only five times. 88 departments did not commit themselves explicitly on grade requirements.

A great problem that arises when undergraduate grades are used to assess graduate potential is that a given grade often represents different standards at different institutions, and graduate departments find it impossible to learn all the formulas. A partial answer lies in the utilization of the Graduate Record Examination (GRE) score to compare the ability of students from different schools. It is not surprising, therefore, that 69 graduate departments require applicants to submit GRE results and 43 other departments say they prefer to receive them. 40 departments failed to mention the GRE, and only 12 specifically stated that the exam is not required.

Only 30% of the departments surveyed volunteered the GRE scores that they accept. Of that percentage, scores on the mathematical aptitude test range from a low of 520 to a high of 780; scores on the advanced physics exam ranged from 490 to 850. These wide ranges suggest that most undergraduate physics majors could find schools with entrance requirements that correspond to the student's qualifications.

28 PhD-granting astronomy departments supplied information that differs little from the data provided by physics departments and combined physics–astronomy departments. The ten astronomy departments that reported minimal grade-average requirements specified "B" or "B+" grades. GRE scores of entering graduate students for ten astronomy departments encompass a range from 650 to 750 on the mathematical aptitude test and from 590 to 840 on the advanced astronomy exam.

THE DOCTORAL PROGRAM

Requirements for the PhD can be classified into three categories: coursework, examinations and thesis. In the first category the trend in recent years has been to specify fewer and fewer courses as absolute requirements. Nevertheless somewhat more than one quarter of the physics departments in the US still require for the PhD one or more courses in analytical mechanics, statistical mechanics, electrodynamics and quantum mechanics. Just under one fifth of the departments require a theoretical or mathematical physics course and 10 to 15 departments specify nuclear physics and solid-state physics among their PhD requirements. In addition a scattering of other courses such as modern physics, optics and advanced laboratory are required by a few schools, and from one to five departments indicate that any particular one of these courses is strongly recommended though not absolutely required. Two of the astronomy departments listed required courses and these were basic physics courses.

59 departments specified a minimal number of semester hours (or the quarter-hour equivalent) for a PhD. The number mentioned most often was 48, but a spectrum of other numbers ranging from 8 to 90 was mentioned occasionally. Astronomy departments exhibited a similar spread in requirements, bunched around 45 hours.

Examinations for the PhD

Required examinations, other than course examinations, are in one sense the most important requirement of all. More often than not students who terminate their efforts to earn a PhD for academic reasons do so because they run afoul of an early qualifying exam or an oral preliminary.

In recent years many graduate departments have reviewed their examination structure and have made significant modifications in the traditional pattern. It is, therefore, particularly interesting to survey the situation at this time. Table 2 lists most of the departments that offer a PhD degree in either physics or astronomy in the US. (An additional 22 departments that are known to offer PhD's in physics or astronomy are not listed because we have no detailed information about their degree requirements.) The table lists information about required examinations in three categories: basic, advanced and foreign language. The first two categories correspond roughly to what are called at many institutions qualifying and preliminary exams, but as the chart shows, there is significant variation in the way different institutions administer the exams. Of course each student is required to take a final examination, though this exam is not indicated on table 2. In the foreign-language category of table 2 the num-

Table 1. Textbooks

	Mechanics	*Electricity and magnetism*	*Thermodynamics and statistical physics*	*Optics*	*Atomic and nuclear physics*	*Quantum mechanics*
Text mentioned most frequently	K. R. Symon	J. R. Reitz and F. J. Milford	F. W. Sears	F. A. Jenkins and H. F. White	R. M. Eisberg	R. H. Dicke and J. P. Wittke
Other texts mentioned five or more times	J. Marion R. A. Becker H. Goldstein	D. R. Corson and P. Lorrain	M. W. Zemansky F. Reif P. M. Morse	B. B. Rossi	D. Halliday W. Kaplan R. B. Leighton E. G. Segré	D. A. Park
The number of other texts mentioned	8	13	6	6	16	10
The total number of times texts on this subject were mentioned	86	80	66	54	101	40

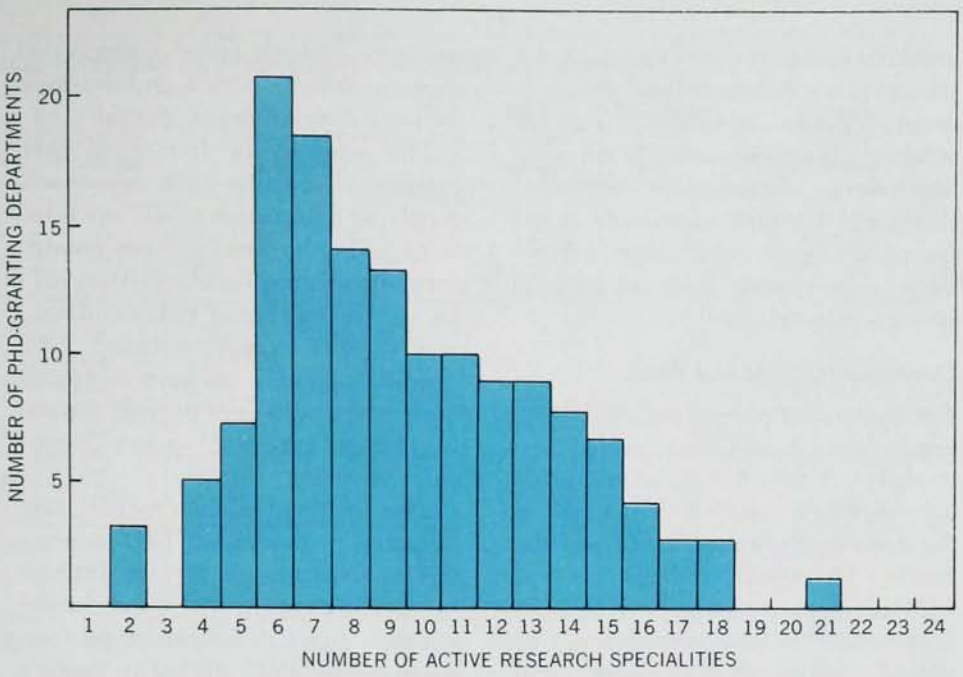
ber of languages in which proficiency must be demonstrated is indicated as well as the language choices available. Blanks in the table do not necessarily mean that no requirement exists within a given category; rather, a blank may indicate that no information on the item was supplied to AIP.

A survey of the table documents several generalizations. About two thirds of the physics departments do give a basic exam during the first or second year to PhD hopefuls; usually these exams are written and cover material studied in advanced undergraduate or beginning graduate courses. Almost every department gives some kind of advanced exam usually after most graduate courses are completed. About two thirds of these exams involve both written and oral phases; the remainder are more often oral than written. About 60% of the responding departments still require PhD candidates to exhibit knowledge of two foreign languages, while 30% of the departments have reduced their requirement to one language. The remaining departments offer the student a choice between passing reading exams in two languages or exhibiting greater competency in a single language. The choice of languages offered is most often German, French and Russian. Occasionally other choices are included such as Italian, Spanish and Chinese. 14 departments now permit students to substitute skill in a computer language or some other "tool of the trade" for a foreign language.

Every graduate department requires a thesis describing original research, and most schools arrange an oral defense of the thesis as a final hurdle. This final oral is not taken too seriously by most PhD candidates, but the research that precedes it is at once the most demanding and the most interesting requirement.

Subfields of physics

Questions that prospective graduate students frequently ask are "What schools are strong in (*subfield of physics*)?" and "How many different research fields are active at (*university*)?" Answers to both questions are summarized in table 3 and figure 1. We see that the most popular subfields among the universities are atomic and molecular physics, elementary particles and fields, nuclear physics and solid-state physics. Figure 1 shows that most departments are active in from six to nine subfields and the full range extends from two to 21 subfields. In evaluating these data one should know that each department was required to describe its research in the 24 categories chosen by AIP, and the categories are clearly not equally broad or mutually exclusive.



SUBFIELDS IN GRADUATE STUDIES. The most probable number of research subfields at graduate schools is six. These data were collected by AIP for the five-year period prior to 1968. —FIG. 1

Another question asked by prospective graduate students is "How long does it take to get a PhD?" Over 100 PhD-granting institutions supplied this information. Ranging from 3.9 years at Louisiana State University to 6.5 years at Oregon State University the overall average for physics is just under five years. 18 astronomy departments averaged 4.5 years for a PhD. Many schools listed residence requirements, and a minimum of three years in residence between baccalaureate

Table 3. Departments Active in Each Subfield

Subfield	*Active theoretically*	*Active experimentally*
Acoustics	22	15
Applied physics	21	7
Astronomy	43	28
Astrophysics	42	55
Atmospheric physics	35	19
Atomic and molecular physics	91	71
Biological physics	31	10
Cosmic radiation	33	8
Cosmology and general relativity	18	60
Crystallography	31	7
Elementary particles and fields	70	106
Geophysics	15	11
History and philosophy of physics	0	10
Low-temperature physics	86	40
Magnetic resonance	79	18
Mathematical physics	1	78
Nuclear physics	111	95
Optics	58	28
Physical chemistry	16	7
Physics of fluids	14	11
Plasma physics	69	53
Solid-state physics	129	113
Space physics	38	26
Statistical and thermal physics	14	59

and PhD degree is characteristic. Some schools place an upper limit of five to seven full-time equivalent years in residence, but this practice is not common. Seven departments mentioned that some teaching experience is required of all graduate students and two other departments said teaching is strongly recommended.

Departments large and small

Two features of physics and astronomy departments, in addition to curriculum, strongly influence the nature of a graduate student's experience: the size of the department and the quality of the faculty. The quality is hard to assess with the data we have. Perhaps the best that can be done is to observe that virtually all faculty members listed among PhD-granting departments have PhDs themselves, and most of them are actively engaged in directing research. The size of the department can be measured in three ways: the number of faculty members, the number of graduate students and the number of degrees awarded, PhD and master's, during a recent five-year period.

The numbers of faculty of each professorial rank for each department supplying information to AIP are listed in table 2. Also listed are the number of full-time graduates enrolled in 1967–68 and the number of PhD's and master's degrees granted between 1962 and 1967. Finally we have computed the average number of degrees granted per year per professor – a sort of productivity index.

Scanning these columns we find huge variations in the size of PhD-granting physics departments. At one extreme we have Bryn Mawr where four faculty members direct to completion an average of one PhD and one or two master's degrees per year. At the other extreme 47 physicists with professorial rank produced 120 PhD and 224 master's degrees in five years at Wisconsin, and a staff of similar size at Berkeley turned out 276 PhD's between 1962 and 1967. This productivity index also shows large variations from below 0.1 degree per year per professor for schools that are still establishing new programs to 1.5 at Rice, Chicago and Wisconsin where the output of both PhD and master's degrees is large. A very large number of the indexes falls between 0.3 and 0.9, and part of the apparent variation results from lack of information about the master's degrees awarded by some departments.

Clearly the graduate physics departments offer great variety on a number of items. The only problem is to match each capable graduate with an institution that can serve his needs.

References

1. *Graduate Programs in Physics and Astronomy: A Handbook for Advisors of Prospective Doctoral and Master's Students* (AIP Pub. No. R-205) American Institute of Physics, New York (1968).
2. *Physics Manpower 1966* (AIP Pub. No. R-196) Susanne Ellis, ed., American Institute of Physics, New York (1966).

TABLE 2. GRADUATE PROGRAMS IN PHYSICS AND ASTRONOMY

PHYSICS		Faculty: Professors	Faculty: Associate professors	Faculty: Assistant professors	Faculty: Total	Graduate students	Degrees granted 1962-1967: PhD's	Degrees granted 1962-1967: MS's	Degrees granted 1962-1967: Degrees per year per professor	Basic examination: Year	Basic examination: Written or oral or both	Advanced examination: Year	Advanced examination: Written or oral or both	Foreign language examination: Number of exams	Foreign language examination: Language choices
ALA.	U. of Alabama	5	4	2	11	24	20	37	1.0					2	
	Auburn U.	3	8	2	13	48	New	20	0.3			2 or 3		2	G,F,R
ALASKA	U. of Alaska	6	10	4	20									1 or 2	
ARIZ.	Arizona State U.	8	4	3	15	45	New	40	0.5	1	W	2	W	2	G,F,R
	U. of Arizona	18	7	6	31	98	19	68	0.6	1			W/O	2	G,F,R
ARK.	U. of Arkansas	3	3	5	11	27	10	28	0.7	2	W		W/O	1	G,R
CAL.	Cal Tech	24	7	6	37	118	99		0.5	0 2					
	UC Berkeley	27	10	9	46	340	276		1.2	0		3		*	
	UC Davis	5	7	4	16	41	5	23	0.4	2	W	3	O	2	G,F,R,T
	UC Irvine	8	3	10	21	35	New					2	W/O	1	G,F,R
	UCLA	26	9	11	46	175	72	234	1.3	1	W	2 & 3	O, O	1	G,F,R
	UC Riverside	6	5	6	17	103	28		0.3	2	W		O	1	G,F,R
	UC La Jolla	21	6	12	39	152	37		0.2	1 2	W O	0		1 or 2	G,F,R,I,S
	UC Santa Barbara	9	4	8	21	48	6		0.06			2 or 3	W/O	1	G,F,R
	Naval Post-Graduate Sch.	14	11	5	30	10	8	138	1.0	1		2		2	G,F,R
	U. of Southern Cal.	7	7	8	22	65	15	48	0.6	1	W/O	2	W/O	2	
	Stanford U. (Applied)	7	3	0	10	65	New			1	W	2	O	1	G,F,R
	Stanford U.	10	5	8	23	146	131		1.1	1	W		O	1	G,F,R,I
COL.	Colorado State U.	5	3	5	13	29	3	22	0.4			2			
	U. of Colorado	35	14	12	61	145	83		0.3	0	W	2	W/O	2	G,F,R
	U. of Denver	7	5	4	16	23	New					2		2	G,F,R

TABLE 2. GRADUATE PROGRAMS IN PHYSICS AND ASTRONOMY (continued)

PHYSICS		Faculty				Graduate students	Degrees granted 1962-1967			Basic examination		Advanced examination		Foreign language examination	
		Prof.	Assoc.	Assist.	Total		PhD's	MS's	Ratio	Year	W/O	Year	W/O	Number	Choices
CONN.	U. of Connecticut	6	5	7	18	62	18	70	1.0			2	W/O	2	G,F,R,T
	Wesleyan U.	2	2	5	9	14	New	15	0.3	(1)		2		1	G,R
	Yale U.	20	7	12	39	164	103		0.5	2				2	G,F,R
DEL.	U. of Delaware	5	4	8	17	48	11	39	0.6				W/O		
D.C.	Catholic U. of Am.	10	2	4	16	70	53		0.7			2	W	2	
	Georgetown U.	1	6	4	11	32	17	24	0.9	2	W/O	3	W/O	2	G,R
FLA.	Florida State U.	10	6	12	28	107	56		0.4	1	W/O		W/O	2	G,F,R
	U. of Florida	15	3	13	31	100	41	55	0.6			2	W/O	2	G,F,R
	U. of Miami	6	2	5	13	32	New	23	0.4	1	W	2 & 3	W,W	2	G,F,R
GA.	Georgia Inst. of Tech.	13	5	4	22	42	27	75	0.9	0		3	W/O	1	G,F,R
	U. of Georgia	5	2	16	23	40	New	10 (3 yrs.)	0.2				W	1	
HAW.	U. of Hawaii	11	5	6	22	40							W/O	1	G,F,R
IDA.	U. of Idaho	4	1	4	9	19	2	12	0.3	1	W		W/O	2	G,F,R,I
ILL.	U. of Chicago	28	2	8	38	211	97	184	1.5	2			O	2	
	Illinois of Tech	3	9	7	19	44	24	31	0.6	1				2	G,F,R
	U. of Illinois	40	12	14	66	330	131	14	0.4	2	W/O		O	1 or 2	G,F,R
	Northwestern U.	15	9	8	32	60	32		0.2	2	W/O		O	1	G,F,R,I,C,J
IND.	Indiana U.	10	8	11	29	96	37	30	0.5	0 or 1		3		2	T
	Notre Dame U.	10	10	8	28	80	49		0.4			3		1	G,F,R
	Purdue U.	24	18	17	59	187	74	185	0.9	1	W	2 or 3	W/O	1	G,F,R
IOWA	Iowa State U.	18	9	11	38	150	86		0.5	2		3	W/O	*	
	U. of Iowa	5	7	8	20	75	34	65	1.0			3	W/O	2	G,F,R
KAN.	Kansas State U.	8	4	7	19	36	19	36	0.6	2			W/O	2	G,F,R
	U. of Kansas	11	3	5	19	84	24	58	0.9	2	W		O	2	T
KY.	U. of Kentucky	10	3	8	21	66	18	35	0.5			2 or 3	W/O	2	G,F,R
LA.	Louisiana State U.	7	7	12	26	79	34	25	0.5	1		2		2	G,F,R
	Tulane U.	2	5	3	10	27	12	47	1.0			3	W/O	2	G,F,R
ME.	U. of Maine	5	2	2	9	9	New	12	0.3				W/O	2	
	Johns Hopkins U.	8	5	4	17	93	71		0.8		W/O			2	G,F,R
MD.	U. of Maryland	23	17	34	74	315	100	83	0.5			3	W/O	1 or 2	G,F,R,T
MASS.	Boston College	2	5	5	12	19	5	18	0.4	2		4		2	G,R
	Boston U.	8	3	5	16	52	19	47	0.8	2	W	3	O	2	G,F,R
	Brandeis U.	6	4	10	20	67	37		0.4	2	W			2	G,R,T,F,I
	Clark U.	2	2	1	5	10	New	7 (4 yrs.)	0.4	0 or 1	W	3	W/O	1	G,R
	Harvard U.	15	2	6	23	158	101		0.9	2	O			1 or 2	R,G,F,I,J
	Harvard (Applied)	14	2	4	20	91						2	O	2	
	Lowell Inst. Tech.	12	2	4	18	15	New			1 or 2	W	3	W/O	2	G,F,R
	Mass. Inst. of Tech.	58	13	25	96	300	210	72	0.6	0	W	2 or 3	W/O	1 or 2	G,F,R
	Northeastern U.	9	10	10	29	63		119	0.8	1	W/O	3	W/O	2	G,F,R
	Tufts U.	5	3	8	16	42	13	16	0.4		W		O	2	G,F,R
	U. of Massachusetts	7	10	17	34	82	New	54	0.3	2	W	3	W/O	2	G,F,R,T
	Worcester Poly. Inst.	5	3	5	13	21	New			2	W	2	O	2	G,F,R
MICH.	Michigan State	20	6	10	36	127	62	131	1.1	0	W	2	W	2	
	U. of Michigan	25	13	15	53	170	97		0.4					1	
	Wayne State U.	4	11	10	25	69	23	45	0.5			2	W/O	2	G,F,R,T
MINN.	U. of Minnesota	20	17	11	48	150	43	91	0.6	1	W	3	O	2	G,F,R
MO.	St. Louis U.	5	5	5	15	40	17	48	0.9		W		O	2	G,F,R,T
	U. of Missouri	4	4	8	16	52	28	58	1.1	1	W			2	
	U. of Missouri (Rolla)	5	8	7	20	53	15 (4 yrs.)	56	0.7	1	W/O		W	1	G,F,R
	Washington U.	7	9	5	21	72	33	48	0.8	2	W			1	G,F,R
MONT.	Montana State U.	3	4	6	13	23	1	6	0.1	1 or 2				2	G,F,R,J,C
NEB.	U. of Nebraska	6	4	8	18	49	19	54	0.8	2			W	*	

G–German, F–French, R–Russian, I–Italian, S–Spanish, J–Japanese, C–Chinese, T–Tool of the trade (computer language, etc.), *–Required, ( )–Not an absolute requirement

TABLE 2. GRADUATE PROGRAMS IN PHYSICS AND ASTRONOMY (continued)

PHYSICS		Faculty				Graduate students	Degrees granted 1962-1967			Basic examination		Advanced examination		Foreign language examination	
		Prof.	Assoc.	Assist.	Total		PhD's	MS's	Ratio	Year	W/O	Year	W/O	Number	Choices
NEV.	U. of Nevada	7	6	3	16	36	5	29	0.4	1				2	G,F,R
N. H.	Dartmouth College	6	2	6	14	25	New					2		*	
	U. of New Hampshire	7	3	6	16	39	6	24	0.4			1 or 2		1	G,F,R
N. J.	Princeton U.	20	3	14	37	109	98		0.5	1		2	W/O	2	G,F,R
	Rutgers U.	15	10	9	34	104	40	85	0.7			2		1	
	Stevens Inst. Tech.	11	6	6	23	54	30	85	1.0	2	W/O			2	G,F,R
N. M.	New Mexico Inst. of M. & T.	5	6	2	13	25	New	13	0.2	1				1 or 2	G,F,R
	New Mexico State U.	9	6	5	20	70	31	41	0.7			2	W/O	2	G,F,R
	U. of New Mexico	7	5	6	18	34	21	60	0.9	1	W/O		W/O	1	
N. Y.	Adelphi U.	2	3	7	12	22	6	45	0.9			3	W/O	2	G,F,R
	City U. of New York	19	16	14	49		New			2					
	Clarkson College of Tech.	5	2	6	13	30	4	12	0.2	2			W/O	2	G,F,R
	Columbia U.	15	3	8	26	181	146	3	1.1	1				2	
	Cornell U.	32	15	4	51	215	103	48	0.6	1		3	W/O	0	
	Fordham U.	2	4	6	12	33	13		0.2	2				2	G,F,R
	New York U.	17	6	5	28	127	68	235	2.2				W/O	1	G,F,R
	Poly. Inst. of Brooklyn	7	10	10	27	45	14	52	0.5			2	W	1	G,R
	Rensselaer Poly. Inst.	9	7	7	23	93	54	44	0.9	1 or 2	W		O	1	G,F,R
	U. of Rochester	18	8	6	32	118	66	29	0.6			3		0	
	SUNY at Albany	12	1	7	20	30	New			1		2 or 3	W/O	1	G,F,R
	SUNY at Binghamton	4	1	4	9	13	New	4	0.09			2 or 3	W/O	2	G,F,R
	SUNY at Buffalo	11	9	10	30	79	23	26	0.3	0		3		1	
	SUNY at Stonybrook	18	14	12	44	110	New			1		3	W/O	1	G,F,R
	Syracuse U.	16	4	3	23	99	49	83	1.2	0		3	W/O	2	T
	Yeshiva U.	9	3	3	15	48	14 (4 yrs.)		0.2	2	W	3	W/O	2	G,F,R,I
N. C.	Duke U.	9	3	9	21	73	59		0.6	0		2 or 3	O	2	G,F,R
	North Carolina State U.	16	7	6	29	45	16	52	0.5	2			W/O	1 or 2	G,F,R
	U. of North Carolina	11	8	7	26	65	39	38	0.7	1	W		W/O	2	G,F,R
OHIO	Air Force Inst. of Tech.	2	4	8	14								W/O	*	
	Case Western Reserve U.	15	17	20	52	143	59	85	0.6	2	W/O			1	G,F,R
	U. of Cincinnati	10	7	3	20	29	20		0.2		W/O			1	
	Kent State U.	4	2	6	12	23	18	15	0.6	2	W/O			2	G,F,R
	Ohio State U.	23	15	10	48	239	99 (7 yrs.)	167	1.0				W/O		
	U. of Ohio	8	7	7	22	70	29	23	0.5				W/O	2	T
OKLA.	Oklahoma State U.	5	3	2	10	52	22	38	1.2	2			W/O	1 or 2	G,F,R
	U. of Oklahoma	6	6	4	16	65	18		0.2	2	W		W/O	1	
ORE.	Oregon State U.	4	8	5	17	55	14	21	0.4	2 or 3	W/O			1 or 2	
	U. of Oregon	12	4	6	22	97	17		0.2	2 or 3	W		O	2	G,F,R
PA.	Bryn Mawr	3	0	1	4	6	4	8	0.6	0	O	2 or 3	W/O	2	G,R,F,I,S
	Carnegie-Mellon U.	14	6	12	32	106	55		0.3	1 or 2	O	2 or 3	O	1 or 2	
	Drexel Inst. of Tech.	6	5	6	17	23					W		W/O	2	
	Lehigh U.	5	5	7	17	39	21	53	0.9			3	W/O	2	
	Pennsylvania State U.	16	11	10	37	137	78	84	0.9	1	W/O		W/O	2	G,F,R
	U. of Pennsylvania	19	8	20	47	134	72	12	0.4	2				1	G,F,R,I,S
	U. of Pittsburgh	20	8	5	33	117	37	30	0.4	1	W	2	W	1	G,F,R,C
	Temple U.	7	10	8	25	63	22	41	0.5	1	W/O	3	W/O	2	G,F,R
R. I.	Brown U.	20	8	17	45	124	59		0.3		W/O	2 or 3	W/O	1	
S. C.	Clemson	2	8	6	16	38	9	18	0.3			3	W	2	G,F
	U. of South Carolina	5	5	3	13	34	11 (3 yrs.)	18	0.6			1 or 2	W/O		
S. D.	South Dakota M & T	1	1	2	4	9	New	16	0.8				W/O	1 or 2	T
TENN.	U. of Tennessee	10	14	10	34	92	54	86	0.8			3		1	G,F,R
	Vanderbilt U.	8	4	4	16	76	42	4	0.6	0 or 1		2 or 3		2	G,F,R
TEX.	Baylor U.	3	2	4	9	16	New	22	0.5				W/O	2	G,F,R,T
	U. of Houston	7	8	3	18	38	5	16 (4 yrs.)	0.8	1			W/O	2	
	North Texas State U.	3	4	5	12	30	New	30	0.5			2		2	G,F,R
	Wm. Marsh Rice U.	9	3	3	15	55	49	60	1.5				O		
	Southern Methodist U.	3	1	4	8	4	New	18	0.5	2			O	2	
	Texas A. & M.	6	3	13	22	43	36	68	1.2				W/O	1 or 2	
	Texas Christian U.	6	4	1	11	25	9	4	0.2			2	W/O	2	G,F,R

TABLE 2. GRADUATE PROGRAMS IN PHYSICS AND ASTRONOMY (continued)

		Faculty				Graduate students	Degrees granted 1962-1967			Basic examination		Advanced examination		Foreign language examination	
PHYSICS		Prof.	Assoc.	Assist.	Total		PhD's	MS's	Ratio	Year	W/O	Year	W/O	Number	Choices
	Texas Tech. College	3	5	3	11	36	New			0				1	G,F,R
	U. of Texas	29	8	9	46	105	67	75	0.6				O	1	G,F,R
UTAH	Brigham Young U.	8	9	5	22	54	12	20	0.3	0	W	2 or 3	W/O		
	Utah State U.	1	4	4	9	15	4	10	0.3	1		2 or 3	W/O		
VT.	U. of Vermont	3	3	4	10	25	New	15	0.3	2		3		0	
VA.	Virginia Poly. Inst.	6	4	20	30	45	19	35	0.4	2	W	3	O	2	G,F,R
	U. of Virginia	8	8	9	25	88	52	8	0.5			2		2	
	William and Mary College	2	7	8	17	35	New	53	0.6	1		2		2	G,F,R
WASH.	Washington State U.	5	3	6	14	44	14	6	0.3			2 or 3		1	
	U. of Washington	19	7	6	32	168	55	120	1.1	0		2 3	W O	1	G,F,R
W. VA.	West Virginia U.	4	3	4	11	34	12	40	0.9	2				2	G,R
WIS.	U. of Wisconsin	27	11	9	47	237	120	224	1.5	1 or 2	W		W/O	1 or 2	
	U. of Wisconsin, Milwaukee	5	2	5	12	18	New	5 (4 yrs.)	0.1				W/O	2	
WYO.	U. of Wyoming	5	6	8	19	61	New	21	0.2				W/O	2	G,F,R,T
ASTRONOMY															
ARIZ.	U. of Arizona	5	4	5	14	30	7		0.1	1		3	W/O	2	G,F,R
CAL.	Cal Tech	7	3	0	10	30	13		0.3	0					
	UC Berkeley	6	1	4	11	44	27	23	0.9	2	W	3	O	2	G,F,R
	UCLA	4	0	4	8	27	7 (3 yrs.)		0.3			2		2	G,F,R
	UC Santa Cruz				10		New								
COL.	U. of Colorado									0	W	2	W/O	2	G,F,R
	U. of Colorado (Astrogeophysics)	9	1	4	14	54	22	10	0.5	1	W/O		W/O	2	G,F,R
FLA.	U. of Florida	5	0	5	10	16	7	13	0.4					1 or 2	G,F,R
ILL.	U. of Chicago	5	3	4	12	16	12		0.2	2					
	U. of Illinois	4	2	2	8	20	7	14	0.5				W/O	2	G,F,R
IND.	Indiana U.	2	1	4	7	29	8	30	1.1	1 or 2	W			2	G,F,R,T
MD.	U. of Maryland	5	3	3	11	36	5		0.09			3 or 4	W/O		
MASS.	Boston U.	1	1	1	3	8	New	8	0.3	2	W	3	O	2	
	Harvard U.				9	49	23		0.5	2	W/O		O	2	G,F,R
	U. of Massachusetts	3	3	4	10	82	New			2		3		1	G,F,R
MICH.	U. of Michigan	5	2	6	13	35	21	31	1.0	2	W			2	G,F,R
N. J.	Princeton U.	14	3	1	18	42	18		0.2	1		2	W/O	2	G,F,R
N. M.	U. of New Mexico						New			1	W/O		W/O	1	
N. Y.	Columbia U.	4	2	1	7	10	3	3	0.2	1		3			
	Cornell U.				17					2	W/O	3	O	1	G,F,R
	Rensselaer Poly. Inst.	1	1	2	4	11	3		0.2	1 or 2	W		O	1	G,F,R
	U. of Rochester	2	1	2	5	9	3		0.1						
	SUNY at Albany	3	4	1	8	2	New								
OHIO	Case Western Reserve U.	1	2	2	5	18	10		0.4		W/O	3	W	2	G,R
	Ohio State U.	6	3	3	12	24	3	13	0.3	0	W/O	3	W	2	G,R
PA.	U. of Pennsylvania	4	1	2	7	22	15	12	0.8						
TEX.	U. of Texas	4	3	3	10	35	4	2 (3 yrs.)	0.1	1 or 2	W	2 or 3	W/O	2	G,F,R,T
VA.	U. of Virginia	2	2	6	10	26		8	0.2	1 or 2				2	G,F,R,T
WASH.	U. of Washington	4	1	1	6	12				1		2		2	

G–German, F–French, R–Russian, I–Italian, S–Spanish, J–Japanese, C–Chinese, T–Tool of the trade (computer language, etc.), *–Required, ( )–Not an absolute requirement