

SURVEY OF GRADUATE STUDENTS IN PHYSICS

By Henry A. Barton, R. Bruce Lindsay, and Leonard O. Olsen

THE President of the United States referred in his press conference of January 15, 1962, to manpower studies published by the National Science Foundation, and stated: "This has been a matter of some concern to me for some time because one of the most critical problems facing this nation is the inadequacy of scientific and technical manpower to satisfy the expanding requirements of this country's research and development efforts in the near future."

The American Institute of Physics has for a number of years been engaged in the study of manpower in physics, and in the spring of 1960 it began to employ some of its own funds to study the training of physicists at the most critical level—namely, the period of graduate study. It was hoped to learn, for example, why the annual output of PhD's in physics was increasing so slowly even though graduate-student enrollments were up, and even though the opportunities for good employment had increased rapidly. After consultation with the staff of the Office of Scientific Personnel of the National Academy of Sciences—National Research Council (whose generous and continued cooperation is gratefully acknowledged), a questionnaire was designed to assess the factors, other than the time it takes to master the subject, which determine how many years after the baccalaureate the doctorate is attained. Knowledge was also sought about reasons for discontinuing graduate study prior to attainment of the doctorate. Finally, it was desired to gain a statistical picture of the flow of physicists in training as a function of their full-time or part-time status, degree sought, age, sex, nationality, marital status, employment, economic circumstances, undergraduate major, and other factors.

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Specifically the questions asked for the biographical facts and also for:

- Intended goal (PhD, MS, or just courses)
- Appointments held (teaching assistant, etc.)
- Whether full- or part-time student
- In the cases of those discontinuing graduate study—why?
- Specific delaying factors (finances, military service, others)

The first survey covered the academic year 1959-60. Because distribution of questionnaires occurred too late in the spring, only about half were returned and used for analysis. Even so, much interesting information was obtained. This has not been published although an outline of principal conclusions was mailed to graduate students along with questionnaires for the second year's survey, covering 1960-61. On the basis of the first year's experience, a more effective plan of distribution was adopted, yielding replies from over 84% of all graduate students, and certain changes were made in the questionnaire. The latter were designed to amplify and clarify some information, abandon unproductive inquiries, and to elicit additional responses concerning specialized interests, sources of scholarship and fellowship funds, foreign-language competence, etc.

Because of the much greater coverage of the survey of 1960-61 and the fact that the conclusions of the two years are generally not discrepant, the statistical part of this report is based upon this second year only, the few significant variances being indicated at appropriate places. In a concluding section about the interesting voluntary comments, both years are covered.

HIGHLIGHTS

Questionnaires were mailed in May 1961 to about 9400 graduate students whose names were kindly reported to the American Institute of Physics by the heads of physics departments of the 218 institutions offering graduate work in physics. Usable replies were received from 7907 (84.1%). An analysis has been made with the aid of punched cards, the principal conclusions of which may be summarized as follows:

Table 1. Graduate Physics Students by Full or Part-Time Status and Degree Sought as of June 1961

	<i>United States</i>				<i>Foreign</i>	<i>Total</i>	<i>Percent</i>
	<i>Full-Time Student</i>	<i>Part-Time Student</i>	<i>Full-Time Employed</i>	<i>Total US</i>			
Attaining PhD in 1961	359	119	92	570	86	656	8.3
Attaining master's degree in 1961, then discontinuing	48	40	27	115	28	143	1.8
Continuing to PhD	2362	1240	827	4429	681	5110	64.7
Continuing to master's degree but uncertain about PhD	380	380	715	1475	60	1535	19.4
Continuing only to master's degree	63	57	188	308	14	322	4.1
Just taking courses	—	—	—	138*	3	141	1.7
TOTAL	3212	1836	1849	7035	872	7907	100.0
PERCENT	40.6	23.2	23.4	89.0*	11.0	100.0	

* US, just taking courses: 1.6%.

Table 2. Analysis of US Graduate Students of Physics by Age Groups

<i>Age Group</i>	<i>Male</i>	<i>Female</i>	<i>Total</i>	<i>Percent</i>
Under 20	1	—	1	—
20-24	2165	72	2237	32.4
25-29	2909	48	2957	42.9
30-34	1088	17	1105	16.1
35 and over	569	27	596	8.6
No report of age	136	3	139	—
TOTAL	6868	167	7035	
TOTAL REPORTING AGE	6732	164	6896	100.0

Table 3. Analysis of US Graduate Physics Students by Marital Status, Goal of Study, and Sex

<i>Marital Status</i>	<i>Male</i>					<i>Female</i>				
	<i>Aiming at PhD</i>	<i>Uncertain Beyond MS</i>	<i>MS Only</i>	<i>Courses Only</i>	<i>Total</i>	<i>Aiming at PhD</i>	<i>Uncertain Beyond MS</i>	<i>MS Only</i>	<i>Courses Only</i>	<i>Total</i>
Single	2065	606	136	48	2855	54	34	18	5	111
Married—										
no dependents	480	99	41	7	627	31	7	9	1	48
1 dependent	410	98	18	10	536	3	3	—	—	6
2 dependents	772	198	58	14	1042	—	—	—	—	—
3 or more dependents	1162	423	139	52	1776	—	—	2	—	2
No report of marital status	22	7	2	1	32					
TOTAL	4911	1431	394	132	6868	88	44	29	6	167

- Almost 73% (5766) of the respondents indicated their intention of continuing graduate study to the doctorate degree. About 20% more (1535) were uncertain as to whether or not they would continue to the doctorate.
- About 11% of the respondents were foreign.
- Only 2.3% of the U.S. citizens in the survey were women. However, almost 6% of the foreign students were female.
- Over 75% of the respondents were between 20 and 30 years of age.
- 58% were married.
- Almost 44% of the married students reported three or more dependents.
- Almost one third reported scholarship or fellowship aid. Almost half of the full-time doctoral candidates were receiving this kind of assistance.
- Over 60% reported some income from campus employment (exclusive of fellowship or scholarship).
- Two thirds of the respondents were enrolled in the graduate schools of large institutions. (i.e., those awarding three or more PhD's annually.)
- More than half (55%) received the bachelor's degree from institutions offering graduate study to the doctoral level.
- Almost 19% had been awarded the baccalaureate degree in majors other than physics.
- Of the more than 80% who indicated that they were meeting language requirements, over 88% were offering German, almost 68% French, and almost 22% Russian.
- Of those completing or discontinuing graduate study, and who had made a job selection, about 24% were going into college teaching, another 38% were going to be employed by private industry, and about 17% were going into research activities either in nonprofit or academic institutions.
- Almost 27% reported inadequate finances as a retarding factor in their graduate work. About one third reported delays due to full-time employment. About 14% were delayed by military service. Better than 37% reported positively no delay in graduate study.

Table 4a. Time Spent by US Students of Physics in Graduate Study to the Doctorate

WITH FELLOWSHIP OR SCHOLARSHIP AID

No. of Years	Full-Time Students				Part-Time Students				Full-Time Employed				Total	Percent
	Degree Expected				Degree Expected				Degree Expected					
	1961	1962	Later	Total	1961	1962	Later	Total	1961	1962	Later	Total		
1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	2	2	—	4	—	—	—	—	—	—	—	—	4	0.2
3	10	29	45	84	—	2	6	8	—	—	2	2	94	5.5
4	43	94	268	405	3	20	42	65	—	3	3	6	476	27.6
5	70	116	250	436	6	20	86	112	1	2	7	10	558	32.3
6	44	92	58	194	5	16	26	47	1	4	18	23	264	15.3
7	15	35	18	68	12	9	7	28	2	7	16	25	121	7.0
8	12	15	11	38	6	3	12	21	1	3	5	9	68	4.0
9	1	11	8	20	2	4	2	8	—	1	10	11	39	2.3
10	2	7	3	12	2	1	1	4	—	—	8	8	24	1.4
over 10	4	16	16	36	2	6	7	15	1	3	22	26	77	4.4
No report	—	1	54	55	—	1	41	42	—	—	24	24	121	—
TOTAL	203	418	731	1352	38	82	230	350	6	23	115	144	1846	100.0

WITHOUT FELLOWSHIP OR SCHOLARSHIP AID

1	—	—	—	—	—	—	—	—	—	—	—	—	—	—
2	1	1	2	4	—	—	—	—	—	—	—	—	4	0.1
3	3	9	32	44	1	3	15	19	1	1	—	2	65	2.3
4	18	71	232	321	5	35	163	203	1	5	24	30	554	19.7
5	43	104	244	391	17	71	244	332	5	7	66	78	801	28.6
6	49	99	107	255	8	47	101	156	6	16	73	95	506	18.3
7	20	57	44	121	22	26	39	87	10	6	72	88	296	10.5
8	9	25	17	51	11	18	18	47	10	10	56	76	174	6.2
9	7	17	10	34	9	8	9	26	9	10	37	56	116	4.1
10	1	13	4	18	6	6	8	20	12	8	33	53	91	3.3
over 10	4	18	11	33	1	9	15	25	30	23	83	136	194	6.9
No report	—	1	95	96	1	—	93	94	3	—	159	162	352	—
TOTAL	155	415	798	1368	81	223	705	1009	87	86	603	776	3153	100.0

ANALYSIS OF RETURNS

The usable 7907 returns came from 7688 men and 219 (2.8%) women. Of this total, 6971 were US citizens, 58 had applied for citizenship, 6 reported they were stateless, and 872 were foreign nationals. For the analysis the first three groups, 7035 (89%) were lumped as "US students". The 872 (11%) foreign have only been analyzed in certain respects (Table 1 and a later section).

Table 1 analyzes all graduate students of physics in terms of their intended goal and their full- or part-time status, except that foreign students are lumped in the latter respect. The large number (1849; 26.2%) of US students who report they are full-time employed suggests that provisions for such students need careful attention. The arrangement of courses at convenient times and locations for these students should expedite the training of more good physicists.

It is notable that of 6897 continuing students enrolled for degrees, only 322 (4.7%) were definitely *not* intending to pursue their studies to the doctorate.

Tables 2 through 14 relate only to US graduate students of physics. Table 2 requires no comment. For Table 3, the first column includes both those who expected to attain the PhD in 1961 and those intending to continue on to the PhD. The third column likewise includes both those terminating with and those continuing on to the master's degree only. Quite a large number of graduate students had three or more dependents. They were asked to count these as on their income tax blanks. To see that finances must cause much delay or difficulty, one has only to look at the "total male" column of Table 3 expressed as percentages of all those reporting. Thus, 26.0% have three or more dependents, 15.2% have two, and 7.8% have one. Including 9.2% who claim no dependents, 58.2% of US male graduate students are married.

**Table 4b. Time Spent by US Students of Physics in Graduate Study to the Master's Degree
WITH FELLOWSHIP OR SCHOLARSHIP AID**

No. of Years	Full-Time Students				Part-Time Students				Full-Time Employed				Total	Percent
	Uncer- tain	MS Only	Com- plete	Total	Uncer- tain	MS Only	Com- plete	Total	Uncer- tain	MS Only	Com- plete	Total		
1	16	—	5	21	3	1	—	4	1	—	—	1	26	7.3
2	50	6	9	65	40	2	3	45	6	—	1	7	117	33.0
3	13	3	1	17	20	5	2	27	11	1	—	12	56	15.8
4	9	1	1	11	7	1	—	8	12	11	2	25	44	12.4
5	8	1	—	9	7	2	—	9	18	10	—	28	46	13.0
6	2	—	1	3	3	2	—	5	4	4	1	9	17	4.9
7	2	—	—	2	4	1	1	6	9	—	—	9	17	4.9
8	2	—	1	3	—	—	—	—	3	1	—	4	7	2.0
9	—	—	—	—	—	—	—	—	6	—	—	6	6	1.7
10	1	—	1	2	—	—	—	—	—	—	1	1	3	0.8
over 10	—	2	—	2	1	—	—	1	6	5	1	12	15	4.2
No report	35	5	1	41	20	—	1	21	34	8	—	42	104	—
TOTAL	138	18	20	176	105	14	7	126	110	40	6	156	458	100.0

WITHOUT FELLOWSHIP OR SCHOLARSHIP AID

1	21	—	5	26	14	2	2	18	2	—	—	2	46	4.2
2	97	16	13	126	99	15	13	127	31	5	2	38	291	26.9
3	41	6	2	49	51	8	8	67	71	9	4	84	200	18.5
4	8	2	2	12	20	5	3	28	78	35	4	117	157	14.5
5	11	4	—	15	11	2	3	16	76	24	3	103	134	12.4
6	6	1	2	9	5	2	1	8	35	12	3	50	67	6.2
7	2	2	—	4	3	1	1	5	24	12	1	37	46	4.2
8	—	2	1	3	2	—	—	2	17	8	—	25	30	2.8
9	2	3	1	6	1	—	—	1	15	4	1	20	27	2.5
10	—	2	—	2	—	—	—	—	15	8	2	25	27	2.5
over 10	2	1	2	5	—	2	1	3	35	14	1	50	58	5.3
No report	52	6	—	58	69	6	1	76	206	17	—	223	357	—
TOTAL	242	45	28	315	275	43	33	351	605	148	21	774	1440	100.0

Table 4 gets directly into the matter of how long it takes to obtain advanced degrees in physics. Respondents were asked when they started graduate study, when they anticipated receiving the degree of their intent, and how many years were lost from graduate study on account of military service, illness, etc. The anticipated number of years of actual study so calculated was punched on their card thus paving the way for the analyses of Table 4 (a and b). As an example of how this table may be used, it will be noted that among the 1352 full-time students whose income included scholarship or fellowship aid (Table 4a), 1297 reported the expected duration of their study for the doctorate. Of these, 929 required five years or less. In other words, 71.6% of the aided students reporting finished or expected to finish within five years. This

was true for only 59.7% of the students whose income did not include such aid.

From Table 4b, similarly, it may be found that among the full-time students, 63.7% of those receiving scholarship or fellowship aid completed or expected to complete study for their master's degrees in two years as contrasted with 59.1% of those not so aided.

Generally speaking, the duration of graduate study is not strikingly different between those aided and those not aided by scholarships or fellowships. Since the majority of the unaided group is composed of those who have stipends as teaching or research assistants, the efficacy of this method of financing graduate students is confirmed. Nevertheless, there is a difference between the two groups and it is in the expected direction.

Table 5 reports responses concerning sources of in-

Table 5. Derivation of Income of US Graduate Students of Physics¹

5a. ALL ENROLLED 1960-61										
Source of Income	To PhD	Per- cent	Uncer- tain	Per- cent	MS Only	Per- cent	Courses Only	Per- cent	Total	Percent
Fellowship or scholarship ²	1846	37.1	353	24.1	105	25.3	17	12.3	2321	33.2
Teaching assistantship	1309	26.3	349	23.9	52	12.5	15	10.8	1725	24.7
Research assistantship ³	1819	36.5	202	13.8	30	7.2	8	5.8	2059	29.4
Contract research ³										
Other academic	337	6.8	105	7.1	49	11.8	7	5.0	498	7.1
Off-campus employment	949	19.0	697	47.7	172	41.4	102	73.9	1920	27.5
Educational loans	90	1.9	23	1.6	5	1.2	1	0.7	119	1.7
Family	169	3.4	51	3.5	14	3.3	3	2.1	237	3.5
Other	251	5.0	102	7.0	47	11.3	8	5.8	408	5.8
No report—source of income	22	—	15	—	8	—	1	—	46	—
TOTAL REPORTING	4977		1460		415		138		6989	
5b. PHD COMPLETE 1961					5c. TERMINATING WITH MASTER'S DEGREE					
Source of Income	Number	Percent								
Fellowship or scholarship	247	43.3								
Teaching assistantship	68	11.9								
Research assistantship ³	291	51.0								
Contract research ³										
Other academic	55	9.6								
Off-campus employment	66	11.6								
Educational loans	11	1.9								
Family	9	1.6								
Other	17	3.0								
No report—source of income	—	—								
TOTAL REPORTING	570									
					5c. TERMINATING WITH MASTER'S DEGREE					
Source of Income	Number	Percent								
Fellowship or scholarship	33	29.4								
Teaching assistantship	27	24.1								
Research assistantship ³	23	20.5								
Contract research ³										
Other academic	9	8.0								
Off-campus employment	32	28.5								
Educational loans	2	1.8								
Family	2	1.8								
Other	15	13.4								
No report—source of income	3	—								
TOTAL REPORTING	112									

1. Respondents usually indicated more than one source of income.

2. Results of 1959-60 tabulation showed that 25.3% of the respondents were receiving fellowship or scholarship aid as against 33.2% for 1960-61.

3. Because so many respondents indicated difficulty in separating these two, we have combined them for computation.

Table 6. Reasons for Delay Reported by US Students Enrolled for Advanced Degrees in Physics¹

Reasons for Delay	With Scholarship or Fellowship					Without Scholarship or Fellowship						
	To PhD	Uncertain	MS Only	Total	Percent	To PhD	Uncertain	MS Only	Total	Percent	Total	Percent
Inadequate finances	379	90	24	493	22.6	870	344	72	1286	28.9	1779	26.9
Graduate study limited by full-time employment	178	95	29	302	13.8	673	446	129	1248	28.1	1550	23.4
Interruption of graduate study due to employment	90	52	16	158	7.2	330	168	54	552	12.4	710	10.7
Military service	200	68	16	284	13.0	453	181	35	669	15.0	953	14.4
Illness	38	8	1	47	2.1	67	33	9	109	2.4	156	2.3
Inadequate undergraduate preparation	169	63	11	243	11.1	358	181	47	586	13.2	829	12.5
Other reasons	81	13	4	98	4.5	176	59	16	251	5.6	349	5.3
Positive report of no delay	926	111	25	1062	48.7	1125	269	37	1431	32.2	2493	37.6
No report	123	1	2	126	—	144	7	—	151	—	277	—
Number reporting	1723	352	103	2178		3009	1115	318	4442		6620	
TOTAL ENROLLED	1846	353	105	2304		3153	1122	318	4593		6897	

1. Some students reported more than one reason for delay.

Table 7. US Graduate Students of Physics by Major Subject for Bachelor's Degree

	Total	Physics	Per- cent	Math.	Per- cent	Chem.	Per- cent	Engin.	Per- cent	Other and No Report	Per- cent
Cont. to PhD	4999	4211	84.2	203	4.1	85	1.7	381	7.6	119	2.4
Uncertain	1475	1138	77.2	47	3.2	38	2.6	176	11.9	76	5.1
MS only	423	290	68.6	18	4.2	4	0.9	74	17.5	37	8.8
Courses only	138	87	63.0	10	7.3	3	2.2	26	18.8	12	8.7
TOTAL	7035	5726	81.4	278	4.0	130	1.8	657	9.3	244	3.5

come first for all students enrolled in 1960-61 and then for those terminating graduate study with either the PhD or the master's degree.

Table 6 gives the number of students reporting certain causes of delay. It is notable that 953 (14.4%) students were delayed in obtaining their physics training by military service. This is a smaller percentage

than that reported in 1959-60 (22%), but 953 is not a small number. If it be true that scientific work contributes as much or more to the national security than does conventional military activity, this number represents a considerable waste that is still going on.

Tables 7 and 8 give information about the undergraduate preparation of graduate students of physics,

Table 8. Type of Institution in which US Graduate Students of Physics Received the Bachelor's Degree

<i>Type of Institution by Degrees Awarded</i>	<i>Total</i>	<i>Percent</i>	<i>To PhD</i>	<i>Percent</i>	<i>Uncer- tain</i>	<i>Percent</i>	<i>MS Only</i>	<i>Percent</i>	<i>Courses Only</i>	<i>Percent</i>
No graduate study	2165	30.9	1397	28.0	540	36.7	173	41.1	55	40.5
Master's degree only	969	13.8	599	12.0	285	19.4	70	16.6	15	11.0
0-2 doctorates annually	1169	16.7	832	16.7	245	16.7	68	16.1	24	17.6
3-9 doctorates annually	1244	17.7	944	19.0	221	15.0	61	14.5	18	13.3
10 or more doctorates annually	1400	20.0	1164	23.3	166	11.3	47	11.2	23	16.9
Foreign	67	0.9	51	1.0	13	0.9	2	0.5	1	0.7
No report of institution	21	—	12	—	5	—	2	—	2	—
TOTAL	7035		4999		1475		423		138	
TOTAL REPORTING	7014	100.0	4987	100.0	1470	100.0	421	100.0	136	100.0

Table 9. Type of Institutions in which US Students are Enrolled for Graduate Study in Physics

<i>No. of Inst.</i>	<i>Type of Inst. By Degrees Awarded</i>	<i>Total</i>	<i>Percent</i>	<i>To PhD</i>	<i>Percent</i>	<i>Uncer- tain</i>	<i>Percent</i>	<i>MS Only</i>	<i>Percent</i>	<i>Courses Only</i>	<i>Percent</i>
102	Master's only	833	11.9	250	5.1	409	27.8	141	33.3	33	23.9
62	0-2 PhDs annually	1513	21.5	1014	20.3	357	24.2	115	27.2	27	19.6
37	3-9 PhDs annually	2481	35.3	1866	37.3	455	30.8	116	27.4	44	31.9
17	10 or more PhDs	2202	31.3	1863	37.3	254	17.2	51	12.1	34	24.6
	No report of inst.	6	—	6	—						
218	TOTAL	7035	100.0	4999	100.0	1475	100.0	423	100.0	138	100.0

Table 10. Number of US Graduate Students of Physics Offering Certain Languages

<i>Languages Offered</i>	<i>To PhD</i>	<i>Uncertain</i>	<i>MS Only</i>	<i>Courses Only</i>	<i>Total No.</i>	<i>Percent of Those Reporting Languages</i>
French	3247	494	78	14	3833	67.9
German	3921	880	147	28	4976	88.2
Russian	962	230	29	9	1230	21.8
Others	33	15	6	1	55	0.9
No report of language	706	387	206	99	1398	—
TOTAL REPORTING ONE OR MORE LANGUAGES	4293	1088	217	39	5637	

18.6% of whom took their first degrees in other than physics-major curricula. Using the figures of Table 7, it may be shown that 73.5% of those graduate students of physics whose undergraduate major was also physics definitely intend to go on to the doctorate. This percentage is a little higher than for graduate students of physics whose undergraduate majors were in other subjects, viz.: 73.0% for mathematics, 65.3% for chemistry, and 57.9% for engineering.

Table 8 gives statistical information about the undergraduate origins of graduate students making use of the indicated arbitrary classification of institutions. Table 9, giving information about the distribution of graduate students among different types of institutions, provides a basis for observing future trends.

In response to the question: "If you have to meet

language requirements, which of the following do you intend to offer?", the tallies given in Table 10 were obtained. Since many offered more than one language, the columns do not add to the number reporting which is given in the last line. The 5637 reporting languages are 80.1% of the 7035 US respondents.

Because industry has recently emphasized its need for solid-state physicists, and because government agencies have stressed high-energy and space physics, it was decided to ask respondents to indicate whether they have specialized in some field by checking one of the specialties listed in Table 11. The table gives the numbers of students indicating each. One is tempted to compare columns to discern any trend in the popularity of fields but it is doubtful if anything is thus shown beyond a broader interest on the part of less advanced

Table 11. Number of US Graduate Students of Physics Interested in Certain Areas of Specialization

Continuing to PhD

<i>Specialty</i>	<i>1961</i>	<i>1962</i>	<i>Later</i>	<i>Sub-total</i>	<i>Uncertain</i>	<i>MS Only</i>	<i>Courses Only</i>	<i>Total</i>	<i>Percent</i>
Acoustics	8	14	34	56	22	5	2	85	1.7
Astrophysics & astronomy	21	15	53	89	21	4	1	115	2.2
Atomic & molecular physics	54	101	136	291	47	5	—	343	6.7
Biophysics	2	10	34	46	17	5	3	71	1.4
Chemical physics	1	4	19	24	10	5	1	40	0.8
Electromagnetic waves & electron physics	18	29	76	123	54	16	5	198	3.9
Electronics	1	7	45	53	99	51	15	218	4.3
Geophysics	1	9	13	23	10	2	—	35	0.7
High-energy particle physics	67	153	231	451	40	5	—	496	9.7
Mechanics	1	4	8	13	12	6	3	34	0.7
Other nuclear physics	105	207	317	629	103	36	6	774	15.2
Nuclear engineering	—	5	38	43	35	13	4	95	1.9
Optics	9	8	25	42	27	4	2	75	1.5
Physical meteorology	—	2	9	11	3	1	1	16	0.3
Physics of fluids	23	42	71	136	23	7	2	168	3.3
Solid state	138	315	621	1074	183	36	10	1303	25.7
Space physics	8	14	57	79	29	2	4	114	2.2
Theoretical physics	87	232	474	793	66	13	5	877	17.3
Thermal phenomena	1	8	13	22	2	—	—	24	0.5
No report of specialty	25	68	908	1001	672	207	74	1954	—
TOTAL	570	1247	3182	4999	1475	423	138	7035	
TOTAL REPORTING	545	1179	2274	3898	803	216	64	5081	100.0

students. They could hardly be expected to have sharpened their interests as much as finishing students.

ANALYSIS OF GRADUATE DROPOUTS

In a national situation demanding more physics-trained manpower than is available, it is of interest to determine, as well as the limitations of questioning permit, how many quit this training prior to the doctorate and why. Tables 12, 13, and 14 present the evidence collected. The factors of competence, ambition, and the like cannot be determined from the data at hand. Of the 304 who reported that they were stopping to improve their financial situation, a third still intend to attain the PhD. Fifty-nine were stopping to fulfill military obligations, nearly half of whom intend to go on. This total of 363 seemingly involuntary dropouts represents a loss that should be mostly avoidable. Some, of course, will drop out because they have found physics incompatible. This cannot be the case, however, for the fifteen who are going on to the PhD in physics, even though for the present they "will not be working in any scientific field". In fact, ten of these were entering military service and two were in religious orders.

Readers who compare the first two lines of Table 12 with the first two lines of Table 1 may be puzzled that 781 completed work for the doctorate but only 570 expected degrees in 1961, leaving 211 unaccounted for. The survey showed that 184 of these expected their PhD's to be awarded in 1962 and 27 hopefully later. Similarly, 314 completed work for the master's degree but only 115 expected to receive it in 1961. The rest either expected to receive the master's degree later or hoped to continue their graduate work to the doctorate later.

ANALYSIS OF FOREIGN STUDENTS

Data for foreign students are as follows:

Status of Graduate

<i>Study</i>	<i>Men</i>	<i>Women</i>	<i>Total</i>	<i>Percent</i>
Continuing to doctorate	724	43	767	88.0
Uncertain	51	9	60	6.9
MS only	42	—	42	4.8
Courses only	3	—	3	.3
Total	820	52	872	100.0

Institutions Where Enrolled for Graduate Study

<i>(Type of Institution by Degrees Awarded)</i>	<i>Number Enrolled</i>
Offering graduate study to the MS only	38
Awarding 0-2 doctorates annually	156
Awarding 3-9 doctorates annually	355
Awarding 10 or more doctorates annually	321
No report of institution of graduate study	2
Total	872

Native Country of Foreign Students

AFRICA

Northern (incl. Egypt)	7
Ghana	1
South Africa	3

ASIA

China & Formosa	131
Southeastern Asia	10
Indian subcontinent	195
Japan & Korea	139
Indonesian Islands	2
Hong Kong	6
Northern Asia	3
Arabian Peninsula	21
Levant, Iran, Iraq	30
Australia, New Zealand	6

EUROPE

British Isles	28
Benelux countries	13
Western Europe	42
Greece (incl. islands)	18
Eastern European countries	8
Scandinavian countries	11
Iberian Peninsula	2

NORTH AMERICA

Canada	76
Caribbean Islands	1
Central America (incl. Mexico)	12

SOUTH AMERICA

Colombia, Ecuador, Peru	4
Venezuela	2
Brazil	8
Argentina, Uruguay, Paraguay	5
Chile, Bolivia	4
Pacific Islands	1
No report of native country	83

Total 872

COMMENTS

Although factual statistics about the number, progress, work situations, finances, marital status, and factors delaying graduate students were the primary goal of these surveys, it was felt that unrestricted comments

Table 12. Reasons for Stopping (US Graduate Students of Physics)

	<i>To PhD</i>	<i>Uncertain</i>	<i>MS Only</i>	<i>Total</i>
Work completed for doctorate	776	5	—	781
Work completed for masters	26	171	117	314
Must fulfill military service obligation	26	29	4	59
Wish to improve financial situation	110	167	27	304
Prefer working to studying, at least for the present	28	117	46	191
Other	16	51	17	84
No report	—	—	7	7
TOTAL	982	540	218	1740

Table 13. Utilization of Training (US Graduate Students of Physics)

<i>Type of Employment</i>	<i>To PhD</i>	<i>Uncertain</i>	<i>MS Only</i>	<i>Total</i>	<i>Percent</i>
Will be working in physics	865	341	121	1327	76.3
Not in physics, but in related field	44	153	70	267	15.3
Will not be working in scientific field	15	18	10	43	2.5
No report	58	28	17	103	5.9
TOTAL	982	540	218	1740	100.0

Table 14. Type of Employer (US Graduate Students of Physics)

	<i>To PhD</i>	<i>Percent</i>	<i>Uncertain</i>	<i>Percent</i>	<i>MS Only</i>	<i>Percent</i>	<i>Total</i>	<i>Percent</i>
Industrial	233	28.1	250	51.7	92	49.2	575	38.3
Self-employed	1	0.1	6	1.2	2	1.0	9	0.6
Teaching, col. or univ.	281	33.9	55	11.3	23	12.3	359	23.9
Teaching, secondary sch.	10	1.2	36	7.4	19	10.2	65	4.3
Nonprofit research (incl. academic)	189	22.8	41	8.5	20	10.7	250	16.7
Military service	46	5.5	44	9.1	9	4.8	99	6.6
Government	70	8.4	52	10.8	22	11.8	144	9.6
Uncertain	82	—	38	—	16	—	136	—
No report	70	—	18	—	15	—	103	—
TOTAL STOPPING	982		540		218		1740	
TOTAL REPORTING T OF E	830	100.0	484	100.0	187	100.0	1501	100.0

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should also be solicited to detect circumstances not generally realized and to help discover what changes could usefully be made in subsequent questionnaires. Accordingly, the 1959-60 questionnaire included the request: "Please write on the reverse side of this sheet any comments you wish to make on your graduate training as a preparation for your career." In 1960-61, this was shortened to: "Please write in any suggestions you may have on graduate education in physics." The 460 usable comments included in the 4896 questionnaires returned in 1959-60 and the 1273 out of 7907 questionnaires returned in 1960-61 did indeed supply valuable information, which is reviewed below, and the comments of the first survey did lead to changes and additions in the second year's questionnaire.

It should be noted that the percentage of all respondents commenting is not large; roughly 8% in 1959-60 and 16% in 1960-61, the increase the second year being perhaps attributable to a new paragraph in the covering letter explaining more fully the aims of the survey. Some may say that not too much weight should be given to responses in this number and that perhaps the most remarkable thing about the comments was that there were comparatively few of them. The authors of this report who have analyzed the comments would agree that some are to be discounted in that they are contradictory, one with another, or they are minor gripes which the best of circumstances could not altogether eliminate.

On the other hand, some types of comment are sufficiently numerous, sincere, and well-expressed as to be impressive. They should be reported as being worthy of consideration. A method of categorizing these was worked out by one of us (L.O.O.) on the basis of the 1959-60 comments. This has now also been used for the more numerous comments of 1960-61. The following are the results numerically and as percentages of all comments.

1. Comments referring to inadequate undergraduate preparation:

These totaled 20 (4% of all comments) in 1959-60 and 158 (12%) in 1960-61. Of the latter, 53 mentioned inadequate preparation in mathematics, only 21 in physics, 2 in chemistry, and 2 in languages.

2. Critical comments about the graduate-level curriculum:

This type of comment was very frequent, totaling 99 (23% of all comments) in 1959-60 and 374 (29%) in 1960-61. In both years nearly half of these comments criticized the course offerings of their institutions in some way. Some thought courses were too specialized, others too theoretical. Some wanted more mathematics. At least one wanted all formal courses eliminated! Some wanted fewer courses and an early start in "research practice". Even more criticized examination and grading procedures or called for standardization of requirements for Master's and Doctor's degrees and freer transfer of credits between institutions. About a sixth

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of these comments bemoaned language requirements, supposing—probably erroneously—that translation journals will always be available.

3. Critical comments about graduate-level teaching and counseling:

The number of these comments is the most disturbing result of the analysis. There were 143 (31% of all comments) in 1959-60 and 270 (21%) in 1960-61. Admitting again that these are small numbers in terms of all questionnaires returned (2.9% and 3.5% respectively), it is worth repeating that the numbers are not negligible especially in the light of the reasonable and convincing nature of many of the comments. Few comments question the competence or ability of faculty members engaged in the instruction and supervision of graduate students, but most of the comments in this group cited defects of attitude or preoccupation with other activities such as research. Direct charges of lack of interest in the graduate students, perfunctory lectures, and inadequate thesis supervision are among these in considerable number. Many respondents regretted what they called inadequate counseling with regard to courses or thesis or even the whole process of graduate training. More and better counseling, they felt, would have saved time and avoided frustration.

Since one object of these surveys is to pinpoint and help to eliminate causes of delay and frustration in the training of physicists, these comments are reported and urged for consideration. It is always to be hoped that progress can be made toward the betterment of the graduate training process by overcoming such severe difficulties as overwork of senior faculty members, the pressures of contract research and restricted physics department budgets. In view of the undeniable prevalence of these handicaps, it is perhaps encouraging that there are no more complaints of this nature. Financial circumstances still cause graduate students more delay than shortcomings in faculty attention.

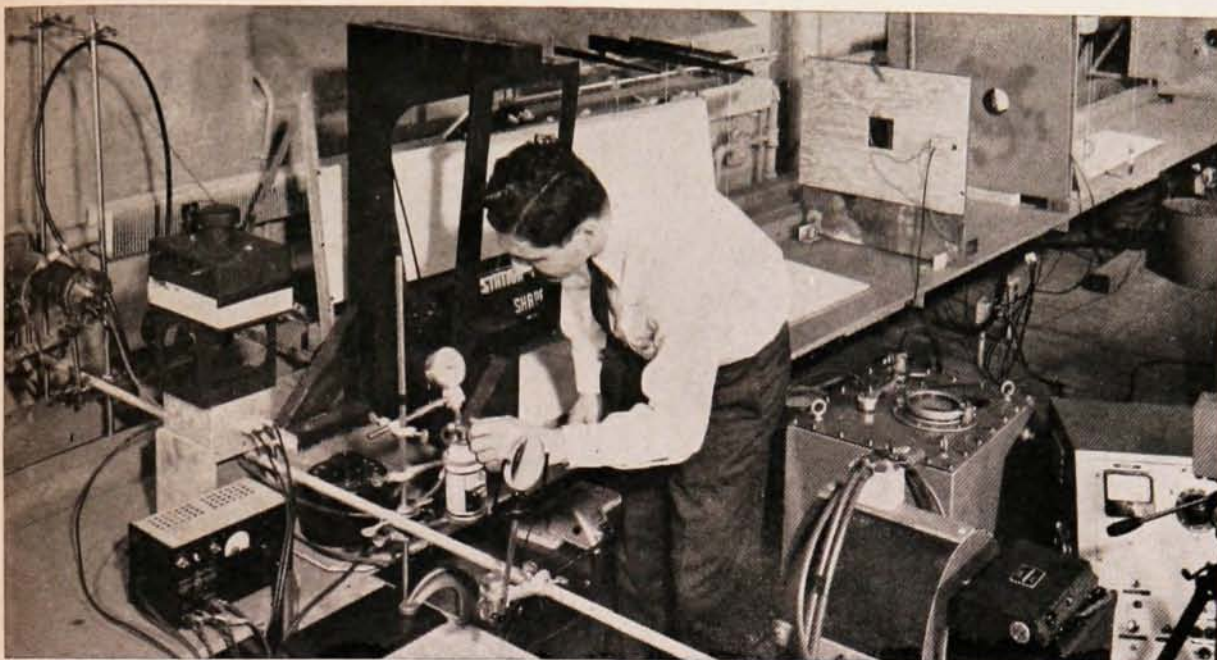
4. Critical comments about financial support:

In both years the face of the questionnaires asked for a check mark if delay was caused by inadequate finances. Thirty percent of all respondents in 1959-60 and 27% in 1960-61 so indicated. This subject was enlarged upon by volunteered comments to the number of 121 (26% of all comments) in 1959-60 and 264 (21%) in 1960-61. This is equivalent to 2.5% and 3.5% of all who returned questionnaires. It is to be noted that in this respect, and doubtless in others, many more graduate students reported that they experienced a difficulty than the number who went to the trouble of volunteering comments about it. In the matter of finances there were at least seven times as many.

A large number of these comments were general in nature and to the effect that the absolute level of support was inadequate to supply them (and their families) with a minimum standard of living. A few specifically urged reduction of the income tax bite either through changes in the tax regulations or in the book-

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keeping practices of their institutions. (For example, some institutions require payment of fees out of stipends, which are taxable, instead of remitting fees and providing a lower stipend.) About an equal number asked for more, and more adequate, loan programs. Very few decried their financial need to work as assistants in teaching or research. The delay so introduced in completion of graduate study averages no more than a year and this is partly offset by the value of added experience and training. Without the large support of graduate students by fellowships and contract research assistantships supported by funds from government agencies and other sources outside of the institutions, the financial circumstances of most graduate students would be dire.

5. Miscellaneous comments:

- a. In 1959-60 there were 40 comments, some bitter, about delays caused by military obligations. In 1960-61 the number was 63, a somewhat smaller percentage of all respondents. As indicated in Table 6, there were 953 reported delays for military service.
- b. Many respondents commented in various ways on the length of time required to attain the doctorate. The length of thesis work was most frequently decried, sometimes with a plea that it be started earlier in course. A growing number of graduate students, who are practically fully employed in industry and other research establishments, called for greater availability of graduate courses at convenient times and places—together with more free time made available by employers. Particularly in the second year of the survey a number urged the creation of a doctorate level degree for those who intend to teach and feel that the time devoted to specific research training might be reduced without detriment to their goal.
- c. Some comments called for cheaper books, perhaps paper backs.
- d. A number so few as to be negligible criticized the physical facilities available for graduate work.

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The authors wish to make it clear that in the detailed planning, mailing, recording and analysis operations of this survey, the major part of the work was done within the AIP Department of Education and Manpower by Mrs. Sylvia Barisch, Mrs. Margot Breslaw, and Miss Ruth Bryans. Without the experienced and efficient contribution of these members of the AIP staff this report would never have appeared. Dr. William C. Kelly's suggestions during its final preparation have been most helpful.

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