



chapter 2

Who Should Study Engineering?

WE HAVE said that engineering is a very broad field. Men and women of different interests and abilities will find satisfactory work in it. Moreover, an engineering education is good preparation for a career in areas where the basic operations may call for little or no technical "know-how." The reason for this is that the habits of orderly thinking and the ability to organize facts and information, which are hallmarks of the engineer, are also needed for success in other fields. One could present a strong argument for the value of an engineering education for general use. However, our discussion will be focused on its applications to the practice of engineering, with only incidental attention to its value as general education.

WOMEN IN ENGINEERING

Those who work in the various fields of engineering have been, largely, men. This is for the reason that men seem to be better adapted than are women to carry on the entire demands of most engineering fields. However, we find women doing every kind of job that men can do, in foreign countries and in this country. And many of the traditional notions that limited or restricted the activities of women in the professions are undergoing change.

Women with the proper aptitude, interest, and industry, master the work of an engineering curriculum as satisfactorily as men. Upon graduation they may take positions in many functional fields and branches of the profession, where they do make successful careers. Generally, women have not advanced into the areas of

construction and manufacturing where the management of machines, materials, and men is a requisite. The basic factor that has limited the employment of women in engineering is the reluctance of an employer to invest time and money in the training of an employee who, in all probability, will leave in a year or so to marry and make a home. This will always be true. And there will be exceptions. Any young woman who looks at engineering as a career should face this fact.

APTITUDES

As a rule, anyone who can complete the educational requirements for graduation from an engineering college can find a position in engineering which he can fill satisfactorily. For this reason we may estimate a man's probable success as an engineer in terms of his ability to graduate. That is to say, if he cannot do the engineering course work he cannot graduate and, therefore, cannot become an engineer. There are exceptions where men failed to complete their engineering courses satisfactorily yet were able to attain success in engineering work. In many such instances the college failure was caused by something other than lack of ability.

An engineer's work as well as his studies requires above-average ability to think clearly in quantitative terms. He must make precise measurements, set up formulas and solve mathematical problems, deal with statistics, plot graphs. He must know the properties and uses of materials as well as the basic scientific laws and principles upon which those properties and uses depend. He is expected to have sound financial judgment and a knowledge of the feasibility and practicability of all that he undertakes. He is often called upon to organize and direct the work of others.

We shall explore in more detail the aptitudes, interests, and personality that a successful student in engineering would have. Aptitudes for the following have been found to have some significance: (1) learning higher mathematics, (2) space visualization, (3) manual skill.

Mathematics. A man's aptitude for learning higher mathematics such as algebra, trigonometry, analytic geometry, calculus, and their applications is the most significant index of his ability to succeed in an engineering curriculum. The reason seems clear. Mathematics and its applications appear throughout the engineering curriculum. To be successful in higher mathematics one must have the ability to reason clearly, accurately, and logically. He should be orderly and systematic. These mean more than the arithmetical

skill of a bookkeeper or a clerk. The most essential element seems to lie in the type of reasoning. A mind that follows the mathematical way of reasoning will also master the engineering courses. No man need be in doubt on that point. If his grades in high school algebra have not been above average it is probable that he will have to work very hard to master college mathematics. Poor grades in mathematics and the fundamental science courses of the first two college years are apt to lead to discouragement which may start a train of events that ends in withdrawal from college. Anyone with a yearning for engineering who has doubts about his mathematical ability should take a mathematics aptitude test. This can be obtained and administered by his high school teachers.

Space Visualization, which is the ability to perceive the sizes, shapes, and relations of objects in space, and to think clearly about those relations, is an important asset to an engineer. However, men who have this trait weakly developed can master an engineering curriculum without serious difficulty. After graduation they may choose fields of work where the lack of that ability may not be a serious handicap. Men who choose the technical fields, such as design, development, research, and experiment, will find facility in visualization a significant factor in their success. It may be rated as one of the *plus* values—a man can get along without it, but he will be a stronger and better engineer with it.

✦ This ability to visualize appears in a variety of ways. Essentially, it means translating a two-dimensional sketch into a three-dimensional picture. Solid geometry in high school and descriptive geometry in college are courses that test one's ability to visualize. In the practical field, examples would include a person who is ingenious at finding what is wrong with a machine, or who is able to perceive the relationships between parts of a complicated mechanism, or one who is adept at cutting and fitting intricate shapes such as are handled by a sheet-metal worker. Clearly, this aptitude would be very significant in many trades. As pointed out before, an engineer can get along without it, but he who has it is apt to forge ahead of his otherwise equally endowed associates.

Anyone who is in doubt about his aptitude for dealing with spatial relationship may arrange to take one or more of the well-authenticated tests which have been developed for that purpose.

Manual Skill. Aptitude for acquiring manual skill—that is, the ability to perform operations with one's hands with considerable dexterity—is a very useful but scarcely essential trait for an engineer. During the engineering graduate's first year or two on the job, a better-than-average ability to do things with his hands may

help to bring him to the attention of his superiors, which may lead to earlier and better opportunities for advancement. Also, manual aptitude may be helpful in judging the performance of others. This aptitude, like space visualization, is a *plus* quality for an engineer. He can succeed very well without it; it cannot replace mental ability; yet the man who has it with the other essentials will be a better engineer than he who lacks this manual ability. There are tests which one may take to test his manual aptitude.

Engineering Drawing. Aptitude for engineering drawing and manual arts have some significance to the prospective engineer, but the ability must be evaluated carefully. In drawing, if the proficiency lies only in ability to make neat and accurate plans, side and end views of simple objects, the good drawing grades are not such important indicators of engineering aptitude as they would be if the student were able to make difficult sectional views or details of hidden and intricate portions. In other words, the first indicates manual dexterity and neatness, the second, some space visualization.

Similarly with shop work such as boys do in high school, manual skill and dexterity in sawing and fitting boards are not indicators of engineering aptitude. But the ability to visualize, plan, and make a piece of equipment, even though done with only fair workmanship, does indicate one of the *plus* engineering aptitudes — the ability to *see things before they are built*.

Many people mistakenly base estimates of a young man's probable success in an engineering college on his manual skill, his ability to make model airplanes, or his liking for machinery. It cannot be emphasized too strongly that these traits, though desirable and useful, must be accompanied by the aptitude to master an engineering curriculum. Furthermore, this interest in and liking for things mechanical is not an uncommon trait in boys. Therefore, parents should be cautious about giving too much weight to this when estimating their son's future in engineering.

Chemistry and Physics are important subjects in an engineering curriculum, and a young man's high school grades in these subjects are a useful measure of his probable success in the same subjects in college. Frequently, a student's high school work has not included chemistry and physics. In that event he would be wise to take both a chemistry and a physics aptitude test. They can be arranged by his high school teachers. These tests are designed to measure abilities that are presumed to be indicators of one's aptitude for learning the subject.

Neither chemistry nor physics is as significant an index of one's aptitude for engineering as is mathematics. Yet they call into use

and develop certain abilities that are used in subsequent engineering courses, such as the ability to organize related material; the ability to answer questions after reading pages of printed material; the ability to set up and solve problems when the essential data is given, frequently in an indirect form; the ability to make arithmetical and algebraic computations such as are common throughout the engineering curricula.

English. Aptitude for learning English should have some attention. Boys are traditionally *poor* in grammar. Yet engineers must write clear and logical reports and present good oral discussions. So a good vocabulary and a better-than-average high school grade in grammar are distinct assets to the prospective engineering student. This is not as essential to success in the engineering curriculum as is evidence of ability in mathematics. Yet the boy who has a small vocabulary and a poor command of grammar may not have the general mental alertness that is needed in an engineering curriculum, and he certainly will be handicapped in his reading assignments. However, the man who is very fluent in his use of English, and who writes readily and well, may become dissatisfied with the details and mental discipline of an engineering curriculum.

INTERESTS

Interest and aptitude are closely related. As in the case of the chicken and the egg, it is hard to say which is first. If we had a way to measure a man's desire, which is the manifestation of interest, we could predict his achievement. Interest means more than glamour or a popular fancy. It is a deep-seated urge. Oftentimes young men are intrigued by the popular appeal of an engineering achievement such as the airplane or radio. Sometimes the attraction goes further and we find them constructing model airplanes and homemade radio sets. A young man and his parents infer from this that he is *interested* in engineering. Perhaps he is, but he should undergo further testing.

Importance of Interest. There are several reasons why this matter of interest is so important. First, we like to do what interests us and we do not care to do what does not interest us; this is one reason why a prospective engineering student should know whether engineering will interest him. A second and very important reason is that everyone would like to be working with congenial people in suitable surroundings; again, the student should know whether his likes and dislikes are similar to those of engineers because some of those engineers will be his colleagues. Third, as mentioned above, a man can learn to do best those things which interest him most, and he is likely to develop an interest in doing

those things that he seems to do best. A fourth reason for inventorying one's interests is that the study and investigation may uncover and open up other fields that might have been overlooked.

Test for Interest. Ascertaining a person's interest for engineering is not easy. There will be a considerable amount of testing, but the results in the form of personal satisfaction will be worth the effort. One may do three things: (1) Take a test for vocational interest. (2) Review his like or dislike for certain courses in high school. (3) Get a job at work that engineers do.

The use of interest tests will help a person recognize his interests more logically and more quickly than he can without the tests. However, interests change rapidly during the formative years of youth and one should not make a final choice of his vocation on the basis of a test taken at age twelve, for example.

There are some widely known and frequently used tests on the market. One of these is the Strong Vocational Interest Blank for men and women. It does not measure specific interest. It compares a person's interest with the interests of more than forty groups of professional people, such as mathematician, banker, engineer, minister. Another test is the Kuder Preference Record which shows the tested person's interest in ten occupational groups—outdoor, mechanical, computational, scientific, persuasive, artistic, literary, musical, social service, and clerical. A third test is the Brainard Occupational Preference Inventory which shows one's interest rating in twenty-eight rather specific occupational groups. For other tests, see the Appendix.

Regarding high school courses, if a person enjoyed algebra, geometry, mechanical drawing, physics and chemistry, it is probable that he would like the corresponding courses of an engineering curriculum. There should be positive evidence that he *actually* liked those subjects. This liking would show in his spare-time activity. He would make more than the required number of drawings; he would try to make frequent use of algebra; he would try all sorts of experiments in chemistry and physics.

It should not be hard to find a job at work that engineers do. This would include office work at computing and drafting; field work on a survey party as rodman or chainman; assistant time-keeper on a building, bridge, pipeline, or other type of construction; factory work, such as materials clerk in a plant where machines are built; a few weeks in a vocational summer camp. The experiences will be brief, fragmentary, and oftentimes inconclusive. They will help any person who is giving serious attention to the choosing of his career.

Interpretation of Tests. The determination of the meaning of the foregoing tests and experiences calls for a great deal of experience and knowledge. In fact, the written interest tests must be taken under an experienced guidance counselor such as one would find in his local high school. However, if the tested person's score on the interest test was not positive for engineering or a related occupation, or his interest in the key high-school subjects only lukewarm, or his reactions to his experience with engineering work indifferent, he should count his *interest* in engineering as *not proved*, possibly *doubtful*. If he decided to study engineering in spite of his uncertain interest it would be very important that he have a proved aptitude for the significant high school subjects, or have a very strong determination and willingness to work at college subjects which, in the beginning at least, might prove uninteresting. This is very important because a large number of the failures in college may be traced to lack of interest strong enough to carry the student through the early disappointments and reverses that come at the beginning of his college work.

Personal Qualifications. Because engineers find work in so many fields there is no particular type of personality that is essential to success in engineering. There is a general notion that engineers are lone workers, inclined to be thoughtful, retiring, and somewhat individualistic, with a preference for work with machines, books, and symbols rather than with people. The facts are that large numbers of engineers in manufacturing, construction, selling, and other fields, are called upon to work with and supervise others, and the most successful engineers, as in other lines of work, are the men who, in addition to doing an excellent technical job, are also the leaders of men and the organizers and managers of enterprises.

There are certain traits that an engineer should have. He should have a liking for accuracy, for exactness, and for detailed and persistent study. Many of his problems are long and involved. He must have the patience and persistence to keep himself at those problems until they are solved. Nervous and erratic people, even though mentally keen, are apt to become impatient with such work. He must be honest in the sense that he can weigh all facts judiciously and arrive at a fair result. He should have a sound and healthy body. During his early assignments a young engineer will be called upon to do considerable manual work. Some of this will be out of doors in all kinds of weather; some will be in large factories or mills that are hot and dusty. Most of his later assignments may be in more pleasant surroundings. His advancement may depend upon

how creditably he does his first assignments, so it is important that he be able to endure some hardships and unpleasantness.

SUMMARY

The following outline gives the essential characteristics which should be possessed by a man who hopes to be successful with an engineering curriculum. When considering these points it is understood that a man must be able to earn a minimum passing grade in a given subject, regardless of the significance of that subject, if he expects to graduate.

Aptitudes

1. **Mathematics.** Ability to learn this subject as shown by a better-than-average high school record or equivalent test scores is essential.
2. **Chemistry and Physics.** Aptitude for these subjects is not as significant as is aptitude for mathematics, but a large number of scholastic failures in the engineering colleges include one or both of these subjects.
3. **Visualization.** This is an important but not an essential trait. The best engineers will possess it strongly. Those with the trait less strongly developed should choose jobs where that ability is not an important requisite. Some of their engineering courses may be harder to master because of weakness in this trait.
4. **Manual Skill.** This is a desirable but not essential trait. Those who possess it may use it to advantage. Those who lack it will not be affected adversely if they choose work where manual skill is not an important requisite for success.
5. **Mechanical Drawing.** If this indicates ability to visualize, it is an important but not an essential trait. It has greater significance as an interest factor.
6. **English.** This aptitude is very desirable but not essential. Too much proficiency in English may make one restive in a technical curriculum. Too little proficiency can make learning slow and difficult.

Interests May Be Tested By:

1. Vocational interest tests.
2. Like or dislike for mathematics, physics, chemistry, and mechanical drawing. This may be different from ability to master these courses, yet should be closely related to that.
3. Like or dislike for work that engineers do, based on actual experience at such work.

Personal Qualifications, Personality

1. Honesty and fairness in weighing facts.
2. Patience, persistence, and little tendency to be flighty.
3. A liking for accuracy and exactness.
4. A sound, healthy body.

Other Important Traits. In conclusion, it should be re-emphasized that we have been seeking to point out the traits which differentiate an engineer from a man in another field. We have purposely refrained from discussing a large number of traits that must be possessed by successful men in all walks of life. Failure to discuss such things as judgment, common sense, initiative, resourcefulness, efficiency, thoroughness, character, integrity, and many others, does not mean that they are not important. Those are traits that all successful men must have. In addition, the successful engineer should be strong in the traits that we have emphasized.