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THE  
**Ideal Course of Instruction for an  
Engineer.**

BY CHAS. P. ALLEN.

*(A Paper read before the Sydney University Engineering Society.)*

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# THE IDEAL COURSE OF INSTRUCTION FOR AN ENGINEER.

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To introduce this subject it is proposed to give some reasons why to become an engineer a candidate should be trained in a recognized academy of engineering.

The main advantage that might be pointed out is that of word of mouth teaching, as compared with the independent study of the text-books of the science. In the ancient history of the world those who wished to study philosophy travelled to Crotona to hear Pythagoras, or to Athens to become a disciple of Socrates. In our own time and in our own profession it is likewise a benefit to be trained under a man who has made himself prominent in the profession; to have the advantage of being intimately acquainted with his method, and the opinions formed by him on cases submitted for his advice.

There can be no doubt that a man may become not only an engineer but also a celebrated one with but few aids in the form of teaching and systematic technical education; witness the pioneers of engineering—James Watt, Stephenson, or Swedenborg, who learnt drafting with instruments constructed of wood and string. The study of the career of these and similar men reveals the secret of their prominence in their calling; and from such study we may evolve the principles which should underlie any scheme for making an engineer out of an ordinary individual.

The great requisites are firstly "Method," and secondly "Judgment," and the essential nature of at least the greater portion of every course in "Engineering" should be such as to compel the student to exercise these two qualities. In this way from the commencement to the close of the student's training he would be obliged to make himself familiar with problems, small as well as great, such as would be encountered in future practice.

A question I would here ask is, "Does the prevailing system of examination encourage the exercise of the judgment and the deliberate formation of a professional opinion?" This I think must be answered in the negative; on the contrary, it encourages slipshod work and an abnormal exercise of memory, while conducive to hurry in execution.

So much by way of introduction. I will now indicate first a general scheme for instruction in the ideal school; and, secondly, a detailed classification of subjects for the entrance and for the period of study, to extend over three years. The desideratum in the proposed Academy will be the "attending of classes" but not for the sole purpose of taking notes. All lectures will be printed and sold as text-books in lecture form, and each lecture read beforehand. The attendance at classes will be for the purpose of obtaining marks, in this wise:—For the sake of example

let us assume the lecture to be on Applied Mechanics. Then all the students, not exceeding twelve, will have blackboards, suitably arranged, and will work out, with the aid of the book, practical problems not given in the text-book, but written up before lecture time. As each student does the problem he will be marked according to the care and correctness of execution. No second problem should be attacked by any student unless the first is completed either by himself or with the lecturer's aid, for which help marks will be deducted. After ample time has been given for the first problem to be finished, the lecturer will mark according to what has been done and finish the problem on one board for the rest to copy, while those who have done the question without aid may attempt the next one in order. Any special variations of a principle might be lectured on separately, where notes may, as usual, be taken by a student to help him in his difficulty.

The particular advantage of this system is that the student has individually solved a practical example, either with or without aid; he has thus been compelled to exercise his judgment, an exertion which if continued throughout the course must tend to equip him as an engineer, thus affording great advantages over the present method of trusting to indiscriminate scoring in an examination. The ideal school will have its yearly and degree examinations, those on professional subjects in the third year being searching *viva voce* ones as well as written papers.

So much for the general scheme of procedure in the school and I now propose to indicate a syllabus of subjects for the entrance examination arranged with the view of giving everyone a chance.

The subjects which may be considered necessary for Entrance to an Engineering School are, I might suggest, Arithmetic, Algebra, Geometry, Trigonometry, Elementary Statics, and Dynamics. These in number make up six which equal those of the Senior Public Examination. The introduction of this last subject is of great importance, for in the first year in our course here, students find Engineering Construction particularly hard to grasp simply through the lack of knowledge of the Elementary portion of Statics and Dynamics, such *e.g.* as Components and Resultants, Moments, Couples and Moments of Inertia.

It may be noticed in the three modes of Entrance to our Engineering School, Latin is a *sine quâ non* as well as a Modern Language. I think that since they are irrelevant to the question of Engineering, even in the most general sense, and as most of us have had an enforced acquaintance with the languages at school, they should not be made compulsory, neither should those of us who have neglected those subjects for some time furbish them up, since they are of little use in an Engineering Course, however suitable from a general point of view. This question is one which was much debated concerning Public Schools such as Cheltenham and Marlborough which have their curricula divided into a

commercial and classical side; would it not be sufficient if the choice of subjects were limited by the examiners as regards number only without particularizing subjects.

The usual argument against the omission of Latin and languages is that it tends to divide a University into a number of merely professional schools. I do not think this would be the result, for no one can fail to acknowledge the importance of what concerns others as greatly as scientific subjects do us. By enforcing Latin, however, in our Entrance Examination time is unsuitably occupied. On the other hand those who have just left school will not find any difficulty in passing an examination in Latin, and for their sake Latin, or any other appropriate language as an optional subject, may be included, together with Elementary Surveying, Astronomy, Mechanics and Applied Mechanics.

So much for the Entrance *Examination*. And now I would like to refer to preliminary training. In Engineering magazines it was much debated *pro et con* whether a mechanical training was necessary for a 19th century engineer. For a course approaching the ideal one, such a training is surely necessary, if only from a general point of view apart from being the training of a mechanic. By such training one obtains a very fair acquaintance with material and with the use of all the machines in a workshop, particularly the modes of overhauling machinery and the economy of engine ramming. The best kind of workshop for this purpose is a general shop where contracts are tendered for, where it may be a harbour dredge at one time, a small bridge at another time, and a stationary engine at a third. Variety of work, and how work it done, is learned. Later on, when studying the theory of engineering in the form of Applied Mechanics, the Theory of the Steam Engine, and Machine Design, we evolve machines from mechanisms, the training referred to would assist one in determining a practicable machine from an unpracticable one, a workable design from an unworkable one, for undoubtedly the Essence of Engineering is THE PRACTICAL.

This period of practical training, should, I think, extend over three years if possible, to include (a) Pattern Making, (b) Moulding, (c) Fitting, and (d) Engine-running, as, for example, a large set of Marine Engines.

Although in an ideal course the question of expense should, perhaps, not be advanced, it may be mentioned that before entering a school the expense of such practical work would be a minimum, for one can go into a workshop for three years at the age of sixteen, without paying a premium such as would be demanded at a later age. Suppose, for the sake of illustration, we take a simple practical case in working amongst engines, viz., the practice of making a steam-tight joint. A youngster serving his time in a fairly equipped shop finds that there are substances

such as copper-wire, asbestos, red and white lead, and lead wire for that purpose, and accordingly uses a particular one for the joint in question. Now, later on, he finds that in better finished engines a steam-tight joint may be made without insertion of any kind. This, to him, is a departure from what he has previously learned and must necessarily be additional knowledge, unless he has read up or thought out the why and the wherefore of the rule of thumb practice, which is, "that a thoroughly steam-tight joint can be made by two perfectly plane faces or even annular rings bolted closely together to prevent the passage of steam between them," and as plane faces take time to produce with the scraper, machine cut faces are the usual practice, with the insertion of some suitable material to fill up the hollows, and which will be unattacked by steam—hence our red lead and copper, etc., or even brown paper. This is but typical of the manner in which a knowledge of the theory dissipates a number of apparent peculiarities in the *economy of practice*, and which remain difficulties until the theory is understood.

The necessity of economy of practice is why mechanical training in a workshop has advantages as compared with amateur work done in an academical laboratory, where a student may acquire the use of the file, of the hammer and chisel, and of machines. These are not the only requirements, for in detail work we have time and expense to contend with. An amateur may produce a perfectly finished model fit for an exhibition, but engineers as a body do not work solely for artistic effect.

The scheme—preliminary training and examination—is so far general; in extending it, a decision as to what branch the student shall give especial attention must now be predicated in order to proceed with its further consideration. By way of example, suppose Civil Engineering in particular be selected, for the reason, perhaps, that the Civil Engineer is the nearest to the ideal Engineer. From the nature of the works he has to construct the faculty of construction must be his strong point. For the first year the two subjects which seem to be of importance are Engineering Construction and Mathematics, both of which should be assiduously studied. The first should include extensive testing experiments with inspections of any construction works in the neighborhood, as water or sewerage works. Then should come Physics, with two terms of laboratory practice, on account of the great value of Electricity nowadays. Drawings should be worked at steadily during term time, quality being more desirable than quantity. One term of descriptive Geometry, one term of Inorganic Chemistry with analysis of only simple salts with a pass in Physical Geography and Geology should complete the course for the first year. Lectures in Machine design might be included for one term, so that drawings might be done from design at the second drawing of the year, the first drawing being done direct from a machine.

Continuing our scheme we may now develop the Second Year's Course for the ideal student. This is what the next year has in store for him. First and foremost we have Civil Engineering and Surveying, next in order of merit Applied Mechanics, Physics, and finally Mathematics. The Civil Engineering will comprise Hydraulic, Sanitary and Harbour Engineering with Railway Engineering in alternate years. Harbour Engineering would do well to include lectures on Naval Architecture in place of a science as Geology which in the second year might cease to be a compulsory subject for a Civil Engineer's Course.

The main portion of the Third Year is to be taken up by designing a structure as would be done in practice and carrying out the design on paper, attended with lectures on Materials and Structures, Civil Engineering, Surveying, Architecture, and experiments in cement testing, together with the absolutely necessary Mathematics to the professional degree of requirement. We have now passed our student through a course of all round Engineering up to the second year and made him carry out one line in particular in the third year, making all else subordinate to that idea. The results of examination in this last year should not carry so much weight as the value of the design carried out and the quality of the drawings. This should require the highest percentage to pass in and weigh most in his qualification for a degree. Materials and Structures, and Civil Engineering carrying a second grade possible percentage, Surveying a third grade, and only a pass being required in Mathematics.

The Student ought now to be able to make the most of any future experience, having been shown the theory of Engineering, and the results of previous works. He has actually designed one structure as if in practice. He is not in the most vague sense of the word an expert. A degree does not claim that, but he has been trained to learn and to shape his course in the execution of future work better we will hope than one of equal natural ability who has depended only on the time which he can obtain for study as an articulated pupil to an Engineer. It is not likely with him, any more than it is with a doctor or a lawyer, that he will have to do anything very difficult and special at first. In fact, he most probably will feel that the wide area covered in his first two years of study was so much perambulation in the field of knowledge, and that anybody with a Pocket Molesworth and some practice in drafting could fulfil the subordinate positions he has at first to occupy. I may add that if the local field is not large enough and that if he asks for more scope he must, as apprentices are advised, when finishing a term of indenture, travel and see the world. And, as all must start at the commencement, let that commencement be on as large works as circumstances allow, always keeping in mind that his wider knowledge will one day bring him wider possibilities.