Elements of Engineering Design A-Level at Manshead School

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Elements of Engineering Design is a Cambridge Board A-level course devised to involve sixth form pupils in the creative and constructive disciplines of the design engineer. As an examination syllabus it offers a balance between theoretical aspects of the technology of materials and processes; mechanics, designed practical project work. The importance of a candidate's ability in the solution of design problems from defining a brief through analysis, synthesis, realization and evaluation is indicated by a coursework mark of 40%.

A pilot scheme for A-level Elements of Engineering Design was conducted in a number of schools and it was approved by the Schools Council for national use in the examinations of June 1974. Although the syllabus has an obvious appeal to the sixth former intending to study engineering in one of its many branches at University or Polytechnic, it is not narrowly vocational and could be usefully studied by any sixth form student of mechanical and creative aptitude. Unlike J.M.B. Engineering Science it is not intended as an alternative to A-level Physics, but rather a complementary subject.

At Manshead School Elements of Engineering Design was introduced in September 1972 when the syllabus was first open to all schools. Manshead School is a 13-18 year comprehensive Upper School which developed from Dunstable Grammar School and moved into purpose built premises in September 1971. There had for many years been a high proportion of students leaving the sixth form to study engineering, technology or applied science at university or polytechnic. With the excellent technical workshops that the school now possessed it seemed appropriate to offer students aiming for such studies a course which not only gives the opportunity for the acquisition of technical skills and knowledge, but also the embodiment of the creative and disciplined design experience so vital to the successful future professional engineer. However, although the potential merit of the inclusion of Elements of Engineering Design in the sixth form was obvious, there would be little point in adopting a course if the A-level qualification was unrecognized for entry to Higher Education. The Cambridge Examination Syndicate was unable to offer us details of the acceptability of the syllabus so it was decided to conduct our own survey from Manshead. A copy of the course syllabus was sent to the Head of Engineering Faculty of all Universities and Polytechnics offering appropriate courses and an accompanying letter invited a reply to the following questions:

i) Where you require 2 A-levels for entry to degree courses in engineering would Elements of Engineering Design be an acceptable subject?

ii) Where you require 3 A-levels for entry to degree courses in engineering would Elements of Engineering Design be an acceptable subject?

iii) Is Elements of Engineering Design unacceptable for entry to degree courses in engineering?

The letter also invited comments on the syllabus and its suitability for potential students in Higher Education.

Out of seventy-four universities and polytechnics contacted, replies were received from fifty-eight (71%). A summary of replies has been tabulated.

About half of the replies included comments about the approach and content of the syllabus and these made absorbing reading. In most instances the remarks were those of individuals and did not necessarily convey the official policy of a particular university or polytechnic. A considerable lack of concencus of opinion as to the role of design, engineering and technology in the school sixth form was forcibly illustrated.

Certain replies felt that the syllabus was too broad whilst others thought that it was too narrow.

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A–LEVEL
ACCEPTABILITY OF ELEMENTS OF ENGINEERING DESIGN (CAMBRIDGE BOARD) FOR ENTRANCE TO ENGINEERING DEGREE COURSES

1) Will accept EED as 3rd Subject when approved subjects are Maths and Physics.

Bristol Uv
Cambridge Uv
Hull Uv
Kent Uv
Lancaster Uv
Leicester Uv
Liverpool Uv
Imperial (London) Uv
Kings (London) Uv
Queen Mary (London) Uv
Uv. College (London) Uv
Nottingham Uv
Salford Uv
Sheffield Uv
Southampton Uv
Surrey Uv
Warwick Uv
N. Wales Uv C
Cardiff Uv C
Uwist (Cardiff)
Swansea Uv
Aberdeen Uv
Dundee Uv
Edinburgh Uv
Glasgow Uv
Herriott Watt Uv
Strathclyde Uv
Queens Belfast Uv
Brighton Poly
Bristol Poly
Hatfield Poly
Leicester Poly
Oxford Poly
Plymouth Poly
Sheffield Poly
NE Poly
Kingston Poly

N.B. Several universities stated that they would accept lower grades in Maths and Physics if EED was the third subject offered.

2) Will accept EED as one of 2 subjects when only 2 subjects required (Approved subject is Maths).

Brunel Uv
Exeter Uv
Leeds Uv
Lanchester Poly
Leeds Poly
Liverpool Poly
Newcastle Poly
Portsmouth Poly
N. Staffs Poly
Wolverhampton Poly
City of London Poly
Oxford Poly (Indust. Engineering CNAA only)
S. Bank Poly
Sunderland Poly

3) Will not accept EED as either approved or general requirements.

Durham Uv
Essex Uv
Newcastle Uv

"The syllabus is wide ranging and anticipates a good deal of material we aim to cover in the first year at University."
University of Wales Institute of Science and Technology

"The syllabus is narrow in that it is restricted to solid mechanics and materials."
University of Durham

There was a dichotomy of opinion as to whether a sixth form course should include engineering and technology project work to stimulate creative thought or whether the time is better used by the acquisition of pure scientific and mathematical knowledge.

> "It would be quite a good thing for potential students of engineering to have the kind of introduction proposed in the A-level paper so that they have a better idea of what a University engineering course is all about".
>
> University of Cambridge

> "Since a University course requires a very thorough grounding in pure science, we prefer the engineering orientation left until students are with us."
>
> Queen Mary College,
> University of London

We were heartened by a number of replies which welcomed the introduction of design into sixth form studies and the acknowledgement of its function in the development of enquiring and creative minds.

> "It [EED] has the immense advantage of a substantial design content, and if this is well done should be very useful indeed in indicating potential talent."
>
> University of Lancaster

> "We are particularly keen to encourage design abilities in [6th form] students".
>
> Brunel University

> ". . . [EED] might also be useful in developing a design mentality at an early age."
>
> Imperial College,
> University of London

On balance it was felt that the favourable reactions on the content and approach of the syllabus gave the justification for embarking on a full A-level course in Elements of Engineering Design. Whilst few Universities or Polytechnics would accept the qualifications as one of two entry subjects (Mathematics and Physics or JMB Engineering Science being normally required), only three would not accept the qualification as one of three A-levels. Several faculties indicated a willingness to accept lower grades in Maths and Physics if Elements of Engineering Design was the third subject offered.

An attraction of the course for many students is the allocation of 40% total marks for coursework. This is divided into two sections:

1) Minor Project.

   A small investigation chosen from three topics set by the Examining Board.

2) Major Project

   A constructional design project selected by the candidate. The nature of the project is submitted to the Board for their approval before it is undertaken. A complete record of the development of the project must be presented and should include: the statement and definition of the design brief, results of preliminary investigations, calculations, initial sketches, development drawings, mock-ups, simulations and all correspondence.

Both projects are marked by a visiting examiner who also interviews the candidates. Assessment considers the candidates ability to appraise a problem and an understanding of the principles involved in its solution, skill in design, ingenuity of construction, practical ability and sensitivity of evaluation.

The variety and complexity of the major projects provides a real challenge to both student and teacher. Listed below are those selected by a group of students at Manshead School for the examination in June 1974.

Plastics injection moulding machine.
Record deck with electronic speed control and amplifiers.
A teaching-machine.
Small wood-turning lathe for the home workshop.
Heated hydraulic press for sand casting.
Model aircraft engine investigation.
Plastics compression moulding machine.
Universal testing machine for metal specimens.

A comprehensive list of projects is available on request from University of Cambridge Local Examinations Syndicate.

From a list of titles it is difficult to assess the design content and student involvement in the project work and three case studies have been detailed.

Case Study 1. Plastics Injection Moulding Machine

This project involved the candidate in the following steps:

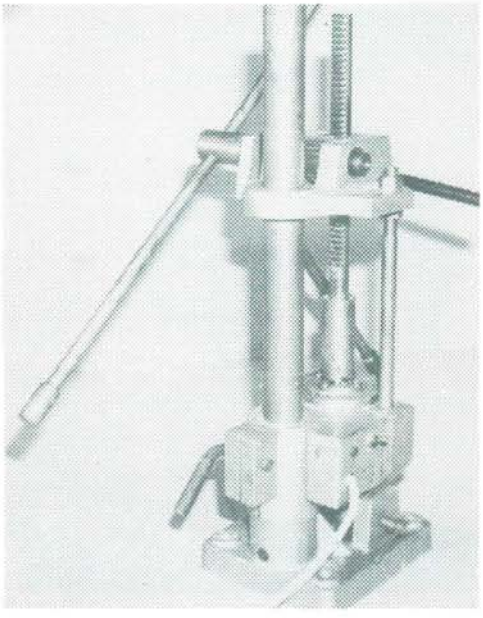
a) Pre-Design. A preliminary study of the background of injection-moulding helped by various text-books and objective literature from I.C.I.

b) Specification. Arriving at a sensible capacity.

c) Investigations. The design of a barrel torpedo and nozzle. Various methods of applying pressure. Methods of holding moulds. Suitability of materials for support casings.

d) Initial Designs. From a number of ideas a possible solution was selected.

e) Calculations. For this possible solution a period of time was spent in detail calculation for the pressure of the ram; the heat required, and the coil to produce the heat. This led to considerations of the insulation of the main torpedo from its support The time from identification of the topic to the arrival of a final design in the form of working drawings was six months. As the thought processes had been carried out methodically the construction of the project was made to the specified size without a single deviation from the working drawings.

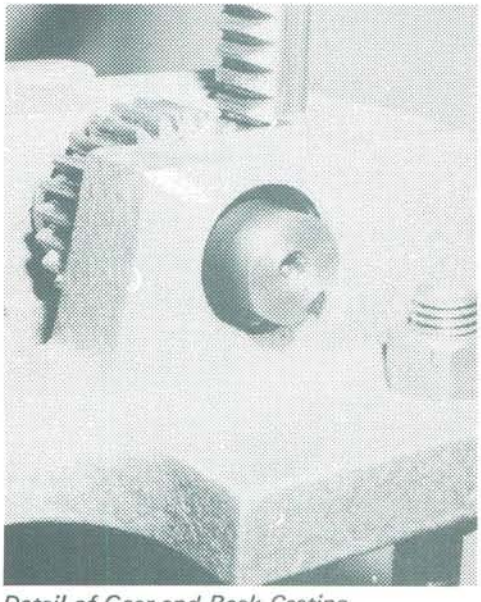


Plastics Injection Moulding Machine.

Outline of constructional processes:

1. Patterns and Core Boxes.
2. Production of castins.
3. Manufacture of special tools for turning the main torpedo and nozzle to a 5^{o} interior angle of 2 mm diameter.
4. Production of main barrel and torpedo achieving a high degree of tolerance and a high finish.
5. Machining of rack.
6. Insulation and winding of coil.
7. Final assembly and fitting.

A mould was then made and the machine tested. A written evaluation was undertaken and the project made ready for assessment.



Detail of Gear and Rack Casting.

Case Study 2. Record Deck with Electronic Speed Control and Amplifiers.

This project was sparked by the fanatical interest of the candidate in Disco and Hi-Fi equipment. The end product was a professional quality piece of work ranking with highly expensive commercial products both in appearance and performance. A major aspect of this project was a file which contained exhaustive notes on every aspect of the study; aesthetic appearance and consumer appeal, methods of tracking; speed control mechanisms, frequency response of amplifiers; wow, flutter and rumble elimination. Also included were sequence of operation diagrams for each item including suggestions for adaptation for mass production. Again a written appraisal of the project was an integral feature.

View of Record Deck.

Detail of Arm.

Case Study 3. Teaching Machine.

It took this candidate twice as long in design at the drawing board as in construction of the project. It caused many hours of concern as pages of malfunctioning circuits mounted without a sign of a breakthrough.

The device was designed to be plugged into a carousel slide projector, a programme of multiple choice questions being represented on a set of slides. The pressing of numbered buttons on the consul advanced the machine to one of three positions where either an answer or additional information was then displayed on the screen. The circuitry was based on relays and the sequence of correct answer positions could be altered by plugging different edge connectors into the circuit. Many modifications had to be made to make the circuit tamperproof. All the work on the project was also documented and the candidate wrote his own programme for the machine. The examiner was able to work through this programme to test the various features.

The three projects described above give an idea of the range of practical engineering design that may be attempted for coursework. It is impossible for any one teacher to answer all the problems likely to be encountered and the role of the teacher is to direct students to sources of reference; books, individuals, firms, etc. In many instances the teacher becomes a co-learner with the student.

A problem posed for the teacher is to strike a balance between time required for project work and the large theory and mechanics content of the syllabus. It has been found that two hours per week on project work is barely sufficient and a candidate may expect to spend many hours after school if an ambitious project is to be undertaken.

Having outlined the course, if one is to sum up its merit in a few lines it could be said that it provides a valuable opportunity for potential future engineers to gain ex-

perience in a variety of traditional and modern materials. Students will also develop an understanding of the integration of mathematical, scientific and technological knowledge that is inherent in creative engineering design and a realization that knowledge is more than a mere expression of facts or lifeless figures.

TEACHING MACHINE (Used in conjunction with Carousel Projector).