付Ⅱ テクニシャン教育シラバス

1. 機械工学科シラバス

THE EAST AFRICAN EXAMINATIONS COUNCIL

REGULATIONS AND SYLLABUSES

1021

MECHANICAL ENGINEERING
TECHNICIANS CERTIFICATE.

THE EAST AFRICAN EXAMINATIONS COUNCIL

REGULATIONS AND SYLLABUSES.

1021

MECHANICAL ENGINEERING TECHNICIANS CERTIFICATE

ALL CORRESPONDENCE TO:

HEADQUARTERS
The Secretary
East African Examinations Council
P. O. Box 7066
Kampala
Uganda
Cables: EXAMCO' Kampala

REGIONAL OFFICE
The Deputy Secretary
East African Examinations Council
P. O. Box 73598
Nairobi
Cables: 'COXAM' Nairobi

Acknowledgements, for their assistance in producing these Regulations and Syllabuses, are made to the members of the International Advisory Committee for Mechanical Engineering.

THE EAST AFRICAN EXAMINATIONS COUNCIL

THE COUNCIL AND ITS CONSULTATIVE MACHINERY

1. The Council consists of a Chairman, who is the Vice-Chancellor of one of the Universities of East Africa (the Office is held in rotation for a period of three years), six members appointed by the Senates of the three Universities, three members appointed by each of the three Governments of East Africa, two Heads of Schools from each of the three countries of East Africa, two representatives of the East African Community, and one representative of the University of Cambridge Local Examinations Syndicate.

2. The Technical Examinations Committee:

The Technical Examinations Committee of the Council is responsible for the following:

entry regulations, regulations for award of certificates, forms of certificates awarded by the Council, approval of subjects to be examined, subject syllabuses prepared by International Advisory Committees, appointment of examiners and approval of Technical examination centres.

The Committee consists of a Chairman elected from the members. The Committee membership includes the following:

(a) Three representatives appointed by the three Government partner states.
(b) Three representatives from the Universities of East Africa.
(c) Three Principals or their representatives of the Technical Colleges in East Africa.
(d) Two representatives from the East African Community.
(e) One Director of Industrial Training Board of each Partner State.
(f) One representative of the Federation of Employers from each partner State.
(g) One representative from the East African Institute of Engineers.
(h) The Secretary to the Council.

3. International Advisory Committees:

The Council has International Advisory Committees to cover every subject or group of subjects examined. Each committee includes appropriate representatives from each country, examiners and professional men. The International Advisory Committees are responsible for drawing up and revising syllabuses and receiving criticisms and suggestions concerning existing syllabuses. They also work closely with the National Advisory Panels which are responsible for devising syllabuses suitable for their respective countries. The Secretary to the Council or his representative is an ex-officio member of each committee.

4. National Advisory Panels:

There are National Advisory Panels in each of the three countries whose function is to advise the Government on the examinations to be made available in the country and to make representations as appropriate to the Council in regard to the examinations and other matters with which the Council is concerned. Each country appoints members to its National Advisory Panels.

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;021 Mechanical Engineering Technician's Certificate

Introduction

This scheme for courses of part-time study and related examinations is intended to provide a broad technical education and examinations is intended to provide a broad technical education and an appropriate qualification for those employed in mechanical engineering who follow an apprenticeship, or other suitable form of training in industry, and whose objective will be a position of some responsibility which necessitates a basis of practical training. It is especially suited to the needs of those who aspire to supervisory duties, shop and process control, drawing office practice, plant maintenance and other forms of responsibility, based upon practical experience and detailed knowledge of machines and processes, combined with technical ability to allow the unaided solution of routine problems and difficulties. In addition to the technical subjects, General Studies are included in order to develop the students' ability to absorb, interpret and transmit information, whether in spoken or written form, and contribute to their general education and personal development. It is assumed that there will be close co-operation throughout between colleges and local industry, with particular reference to links with industrial practical training programmes.

Course of Study

2. The scheme has been devised on the assuption that normally students will attend a technical college on a part-time day or block release basis. It is in three parts.

(a) Part 1 (about 700 hours of technical studies) is appropriate to the needs of junior technicians who require a general understanding of the basis of their work. It is designed as the first part of an integrated and continuous scheme, and at least 25 per cent of the total course time should be devoted to the Scheme of Practice Work, parts A and B. In the science—section of the syllabus, approximately 50 per cent of the subject time should be spent on experimental and demonstration work.

(b) Part II (about 700 hours of technical studiese) makes provision for further study, some of which is of a general character, but it also includes optional specialised studies in certain important techniques. Attention is also drawn to the following:— in the subjects of Engineering Science and Workshop Technology, not less than one-third of the total time should be spent on laboratory/practical work.

(c) Part III (about 320 hours of technical studies, including 70 hours of Applied Technology) covers a number of different aspects of control and supervising duties and provides for the higher grade technician.

3. The subjects of the course are shown below.

Part I Workshop Processes and Practice
- Scheme of Practical Work, Parts A and B
- Engineering Drawing
- Engineering Materials
- Mathematics
- General Studies

Part II The following specialisms are available:
- Workshop Technology
- ✓or Plant Maintenance and Works Services
- or Mechanical Engineering Drawing
- ✓or Control Systems Technology.

For each specialism the course includes
- Appropriate Technology
- Laboratory/Practical Work
- Construction and Materials (if applicable)
- Engineering Science
- Mathematics
- Applied Technology (optional)
- General Studies

Part III The following specialisms are available:
- Product Design
- or Engineering Production
- or Plant Engineering
- or Control Engineering.

4. The E.A.E.C. will consider proposals for college-devised syllabuses and examinations for additional specialist technologies at Part II and Part III.

Draft syllabuses for college-devised schemes must be submitted to the E.A.E.C. not later than six months before the course is due to begin

4. Course work, consisting of class-work, laboratory and practical work, and general studies is regarded as an integral part of the course. With General Studies (see para I) the aim should be to allocate about 60 hours per Part, and up to 30 hours per part where local conditions make this possible. The E.A.E.C. will not examine in General Studies and colleges are free to devise their own syllabuses and approach to the subject. The E.A.E.C. has published a pamphlet in which an approach to General Studies is suggested.

Entry to the Courses

6. Students for the courses must satisfy one of the following conditions or have reached the appropriate standard bp an alternative route.

(a) Part I (i) East African Certificate of Education issued by the E.A.E.C. at Ordinary Level in English, Mathematics and one appropriate Science.

(ii) Part II Certificate with credit in Mechanical Engineering, Craft Practice—Course 155. [1002]

(iii) Appropriate academic ability in a mature student.

(b) Part II (i) A pass in the Part I Examination for Mechanical Technicians.

(ii) Completion of other suitable courses in engineering, e.g. [Ordinary Diploma] Part I with Workshop Technology as a subject.

(c) Part III (i) A pass in the E.A.E.C. Part II examination for Mechanical Engineering Technicians or the corresponding examination of another appropriate engineering technicians schemes.

(ii) Any appropriate Higher Diploma or Certificate.

Countries Outside East Africa

7. This scheme is available to countries outside E.A. at those colleges which have received the approval of the E.A.E.C. Applications for approval of a course should be made on the appropriate form prescribed by the E.A.E.C.

Examination Regulations

8. The E.A.E.C. will offer examinations at the end of Part I of the course. Approved colleges may hold their own examinations at this stage as indicated below:—

1021/01	Workshop Processes and Practice	3 hours
1021/02	Engineering Drawing	3 hours
1021/03	Engineering Materials	2 hours
1021/04	Engineering Science	2 hours
1021/05	Mathematics	2 hours
1021/06	General Studies	2 hours

E.A.E.C. Certificate will be issued at this stage. Students should not be permitted to proceed to Part II unless they have reached a satisfactory standard in the Part I examinations.

9. Part II Examinations will be offered by the E.A.E.C. in December of each pear, and will be conducted according to this regulations published by the E.A.E.C.

Each examination will consist of a common paper 1021/10 Engineering Science and Mathematics and the two papers of the option selected, and candidates will be required to take at one time, all the relevant papers.

In addition to paper 1002/20 written papers for the Part II examinations will be offered as follows:—

1021/11	Workshop Technology—General	3 hours
Optional 1021/12	Workshop Technology— Engineering Construction and Materials	3 hours
1021/13	Plant Maintenance and Works Services es Theory	3 hours
1021/14	Plant Maintenance and Works Services Pratice	3 hours
1021/15	Mechanical Engineering Drawing Paper I	3 hours
1021/16	Mechanical Engineering Drawing Paper II	3 hours
1021/17	Control Systems Technology— Paper I	3 hours
1021/18	Control Systems Technology Paper II	3 hours
1021/19	College Syllabus—Paper I	3 hours
1021/20	College Syllabus—Paper II	3 hours

A candidate who has already qualified for the award of a Paper II certificate is not required to repeat paper 1021/20 when attempting a further option, provided the E.A.E.C. is informed before the date of the examination.

10. Part III Examinations will be held in December of each year. Written examinations for Part III will be offered as follows:—

1021/21	Product Design (1)	3 hours
1021/22	Product Design (2)	3 hours
1021/23	Engineering Production (1)	3 hours
1021/24	Engineering Production (2)	3 hours
1021/25	Plant Engineering (1)	3 hours
1021/26	Plant Engineering (2)	3 hours
1021/27	Control Engineering (1)	3 hours
1021/28	Control Engineering (2)	3 hours
1021/29	College Syllabus (1)	3 hours
1021/30	College Syllabus (2)	3 hours

Each examination will consist of the two papers of the option selected.

Draft question papers for college syllabus examinations must be submitted to the E.A.E.C. six months in advance of the examination dates in accordance with the rules prescribed in the E.A.E.C. regulations.

NOTE: Examinations in Engineering Drawing will normally be based on the latest version of B.S. 308 Engineering Drawing Practice. A college wishing to adopt any other recognised and published standard must apply to the E.A.E.C. for prior approval. Should such approval be given appropriate alternative questions will be set if necessary.

Projects

11. In Part II where the necessary additional time is provided an optional subject of Applied Technology may be taken. The E.A.E.C. may examine or assess Applied Technology projects at Part II level.

In Part III at least 70 hours should be spent by each student on an individual or group project in Applied Technology. Each project should be reported briefly in writing by each student, in the group.

The subject may be examined by the E.A.E.C. but the college will be asked to report on all group and individual projects (including the college's assessment of the performance or contributing of each candidate), and they may also be asked to submit some, or all, of the candidates own reports for inspection by the E.A.E.C.

At the discretion of the college, a candidate may be required to undertake additional project work.

Entry for Examinations

The E.A.E.C. will not accept any entry form an individual applicant. Candidates must submit their entries through an examinations centre on the prescribed form which is obtainable from that centre.

Entries must reach the E.A.E.C. by 30th June for December Examinations

No candidate will be admitted to the examinations or be eligible for a certificate unless he has satisfactorily completed an approved course at a technical college or other institution for further education. Colleges should submit to the E.A.E.C. on the prescribed forms lists of the full names and college records of all students entered for each examination. External candidates (i.e. those who have not attended an approved course) cannot be admitted under any circumstances.

Late entries, subject to an additional fee may be accepted at the discretion of the E.A.E.C..

Records of Students' Work

13. Records of marks awarded for course work must be kept by colleges for submission to the E.A.E.C. on the appropriate form in respect of each candidate entered for examinations. Laboratory and Practical work note books must be kept and must be available for inspection by the E.A.E.C. or its examiners when called for.

Attendance and Course Work Requirements

14. Each candidate will be required to make at least 75% of the possible attendances in each subject, including General Studies. Each candidate will be required to complete the schedule of classwork, laboratory and practical work, as prescribed by the syllabus.

Colleges will be required to submit evidence of such marks awarded, after the examination has been taken. These marks will be assessed by the E.A.E.C. as Course Work. (see Para 13)

Results and Certificates

Full Technological Certificate

Candidates wishing to be awarded Full Technological Certificate, should write to E.A.E.C. for the appropriate form quoting course No. 1021 Mechanical Engineering Technicians.

16. Results in the examinations as a whole will be issued in four classes, and for the individual papers, including course work, in eight grades. The relationship between grades and classes is:

Pass with Distinction	Grades 1 and 2
Pass with Credit	Grades 3 and 4
Pass	Grades 4 and 6
Fail	Grades 7 and 8

Each candidate will receive a record of performance, giving his result in terms of class and grade.

Certificates are awarded to candidates who pass all parts of the examination in the same examination series, and satisf the course work requirements, and, in Part III, also meet the requirements for Project Work.

The certificates indicate the level of examination, i.e. Part II or Part III as appropriate, and the class of result, as well as the name of the subject or specialist technology passed.

17. If, during the currency of the scheme the E.A.E.C. deems it appropriate to modify the pattern of the examinations and awards, the necessary changes to the regulations will be notified to colleges in advance of their being applied.

Part I

SYLLABUSES

PART I

Workshop Processes—First Year

NOTE: In all cases the need for persistent attention to detailed requirements for safe working should be stressed and correct procedure demonstrated.

A brief reference to the origin and production of iron and steel; rolling and forging; production of black and bright stock, and their characteristics.

Introduction to heat treatment of steel; its external effect on plain carbon steels omitting considerations of microstructure, method of heat treatment of hand tools such as the chisel; elementary forging processes.

Metal joining by soldering and brazing; solders and spelter; purposes and use of fluxes; soldering and brazing procedures.

Measuring equipment; care and use of instruments such as the rule, calipers, scribers, square, dividers, straight edge and plane; the micrometer, vernier caliper, bevel gauge and protractor; use of marking-out equipment such as surface plate, angle plate, surface gauge and vee blocks.

The importance, and limitations, of hand processes for metal working; filing and scraping; uses and cutting characteristics of hand tools.
Machined articles considered as a basic combination of flat surfaces and circular forms; simple explanation of generating and forming.
The lathe: identification and function of main features and controls; drive, speed and feed change arrangements; simple explanation of features of design. Turning between centres; simple chuck work; facing and boring; use of compound slide rest; use of steadies. Cutting tools; the cuting action; standard shapes of single-point tools for mild steel and cast iron; cutting angles; introduction to cutting speeds; tool posts and holders; the setting of single-point tools.
The double-end (off hand) grinding machine: its uses and safe operation; mounting and changing its wheels.
The sensitive drilling machine its control and operation; the setting-up of work; uses of machine vice and other holding methods;, the twist drill and its characteristics; flat drills and their uses; drilling speeds; drilling procedures.
The shaping machine identification and function of main features and controls; explanation of quick-return motion and stroke setting, clapper box and tool; tools and machining methods for horizontal, vertical and inclined surfaces; feeds; methods of setting up work; safety precautions in the use of the machine.

Workshop process–Second Year

NOTE: In all cases the need for persistent attention to detailed requirements for safe working should be stressed and correct procedure demonstrated.
Heat treatment of plain carbon steels; hardening, tempering, normalizing and annealing;simple consideration of change points and internal structure; surface hardening by pack and salt-bath methods. Temperature measurement by thermometer and thermo-couple instruments. Construction and use of simple muffle and salt-bath furnaces; fuels and temperatures used. Hardness and impact tests.
An outline of foundry processes; the special characteristics of cast metals.
An outline of forging processes; the respective merits and uses of castings and forgings for components.
The use of flat surfaces and reference planes; use of the level, height gauge and depth gauge; the dial indicator, its accesories and uses; slip gauges; their use as reference blocks in the workshop.
Introduction to interchangeability and limit system; limits; clearance and interference; types of fit for plain work, with reference to current British Standards; simple plug, ring and gap gauges for plain work.
Introduction to the theory of cutting tools; forces acting at tool point; chip produced; effects of top rake and material cut; clearance angle; the standard straight-edged cutting tool. Heat produced by cutting; use of high-speed steel tools. Effect of cutting fluids; common types of fluid and their application.
Lathe work; more complex examples of chuck work; faceplate work; use of steadies; taper turning and boring; advantages and use of four-way tool post. Screw cutting; calculation of gear trains for metric pitches; cutting of single-start vee threads, with or without the chasing dial; use of single-point tools and chasers.
Use of drilling machine for spoot facing, counterboring and tapping; radial-arm and compound table drilling machines; further examples of setting up work anddrilling procedure. The milling machine: classification of types and uses; identification and function of main features and controls of horizontal and vertical-spindle machines; common cutters, their characteristics and mounting; face, slab and side-and-face milling; form and end milling and slotting; common methods of setting up work; simple indexing; use of rotary table; special safety precautions in use of machine.

Scheme of Practical Work, Parts A and B

NOTE: In all cases the need for persistent attention to the detailed requirements for safe working should be stressed and correct procedure demonstrated.
The 23 jobs outlined under Part A below, are intended to provide a course or laboratory work in Workshop Processes and should be regarded as Experiments rather than as Workshop 'Exercises' or Test Pieces, although some of them may be covered as part of an execise or project completed under Part B.
In the first year, each student should perform at least seven of the jobs 1 to 11, including at least one from each Section, and in the second year at least seven of the jobs 12 to 23, including at least one from each section. Additional jobs may also be provided by the teacher.
A record of each job performed, including an operation sheet where appropriate, should be kept by each student. Any job not performed by a student should be seen demonstrated.

PART A
SECTION I

1 Fitting, involving the use of normal marking-out equipment, a normal range of hand tools and measuring instruments.
2 Fitting, involving the scraping and bedding of mating surfaces.
SECTION II
3 Metal Joining. Soldering and brazing small assemblies in sheet or

other forms of supply, with inspection of joints produced.

4. Heat Treatment. Normalizing, hardening, tempering and testing of hand or other single-point tools made plain carbon steels.

SECTION III

5 Tool Grinding of single-point turning or shaping tools, with observation of resultant cutting action.

6 Tool Grinding of twist drills, with observation of resultant cutting action and the effect of any errors in grinding.

STCTION IV

7 Drilling clear and blind holes to mark-out positions and, for the latter, to prescribed depth from machine settings.

SECTION V

8 Turning of work requiring sliding, boring, facing and the use of steadies.

SECTION VI

9 Measurement, involving setting and testing with a dial indicator.

SECTION VII

10 Shaping of faces in right-angled relationship at one setting.

11 Shaping of angular faces and of slots.

SECTION VIII

12 Heat Treatment. Surface hardening of a component by pack or salt-bath method and testing resulting hardness.

13 Heat Treatment, involving furnace control by pyrometric means of hardening and tempering operations.

SECTION IX

14 Drilling, involving angular and co-ordinate settings, and operations such as spot facing and counterboring.

SECTION X

15 Turning, involving the production of accurate external and internal tapers.

16 Turning, involving the cutting of single-start threads.

17. Turning and boring, involving face-plate work.

SECTION XI

18 Measurement, Checking a suitable feature or component using slip gauges or other standards.

19 Measurement of angles or tapers on a suitable component.

20 Measurement. Use of limit gauges. Determination of hole centre distances.

SECTION XII

21 Milling of flat faces in correct angular and dimensional relationship using face or slab cutters. Use of feed-screw dials or indices to obtain optimum stock removal in roughing cuts and to control finishing cuts.

22 Milling, involving face, side-and-face, end form or other cutting to produce features toleranced in relation to each other.

23 Milling, involving simple indexing.

PART B

In the first year, students should complete an exercise or project in which as many as possible of jobs 1 to 11 are properly integrated and, in the second year, another exercise or project in which as many as possible of jobs 12 to 23 are properly integrated.

Students may work together on these exercises or projects provided the work enables each student of a group to gain equivalent experience of the processes involved.

Engineering Drawing and Materials—First Year

NOTE: The aim of the course should be to develop the ability of the student to interpret and construct workshop drawings, together with a facility in sketching and visualizing objects at various stages of manufacture.

All sketching, drawing and dimensioning should be in accordance with current British Standards.

DRAWING

First and third-angle projection in the production of working drawings. Simple sections, hidden details and auxiliary views.

Working drawing of component parts and simple assemblies.

Dimensioning: the importance of dimensioning from centre and reference lines, machined and datum faces, and of functional dimensioning; introduction to tolerancing.

Sketching of component parts and machine details in othographic projection and pictorial representation.

The fastening of machine parts: standard fastenings and their conventional representation. Plane geometry related to perpendicular, angles, chords tangents, arcs and inscribed and escribed figures; workshop applications such as profiles and templates.

The development of simple shapes in sheet metal, including the economical use of material.

MATERIALS

NOTE: The treatment of the subject of materials should give the student a general understanding of the main properties, uses advantages and limitations. The aim should be to show how and where the various materials can be effectively and economically used, and not to explore their metallurgical detail.

The general characteristics of mettallic and non-metallic materials used in engineering manufacture; simple consideration of physical properties such as ductility, malleability, hardness, toughness and resistance to impact in relation to uses and common manufacturing processes.

An outline of the properties, characteristics and common engineering uses of cast iron, wrought iron, mild steel, tin zinc copper, lead cadmium and alluminium; common forms of supply.

Engineering drawing and Material—Second Year

NOTE: All sketching, drawing and dimensioning should be in accordance with current British Standards.

with current British Standards.

DRAWING

Working drawings of machine parts, components and assemblies.

Dimensioning for manufacture, with reference to Clauses 1 to 17 and 21 of B.S.308; indication of machining marks. Tolerance with reference to B.S.4500A Selected ISO Fits—Hole Basis.

Use of balloon referencing (labelling), cross-reference and listing of component parts and materials.

Selection of scales; standard drawing sheets.

Conventional representation of screw fastenings, springs, and other simple common features.

Standard screw-thread profiles and proportions.

Drawing of gauges, small tools, clamping devices, and other accessories.

Introduction to the principles of jig and fixture design.

Lubricating and bearing arrangements for shafts and machine parts.

Practical application of development of surfaces and intersections of solids such as cylindrical and other prisms, where the axes intersect.

MATERIALS

NOTE: The treatment of the subject of materials should give the student a general understanding of the main properties, uses, advantages and limitation. The aim should be show how and where the various materials can be effectively and economically used, and not to explore their metallurgical detail.

An outline of the properties, characteristics and uses of plain carbon steels, brass, bronze, gunmetal anti-friction metals and light alloys.

A simple account of plastics materials in common use in engineering their comparisons with metals.

The use of current British Standards for materials and materials testing.

Engineering Science—First Year

Elements, compounds, mixtures, and alloys, the distinction between atoms and molecules and between physical and chemical changes.

The composition of air. Elementary treatment of oxidation, corrosion, and combustion related to workshop practice.

The effects of dust and moisture contents in air.

Effects of heat on solids, liquids, and gases; coefficient of linear expansion, with workshop applications such as errors in measurement and interference fits.

Charges of state; specific heat capacity and sensible heat; latent heats of melting and fusion and their workshop applications.

Heat produced by friction.

The effects of an electric current. The simple electrical circuit; conductors and insulators.

An introduction to voltage, current, resistance, and power.

The vector representation of forces. The triangle of forces, with workshop applications.

The principle of moments: its applications to simply-supported beams, cranked levers, centre of area and centre of mass.

Force, distance covered, time, speed, work, energy, and power in relation to workshop and other engineering applications. Efficiency as a ratio of output to input in work and power.

The relationship between mechanical, electrical, and heat energies, work, and power.

Engineering Science—Second Year

Quantity of heat; heat energy; simple examples of heat storage and transfer in workshop operations, with consideration of heat losses.

Simple magnetism: permanent magnets and electromagnets; magnetic fields: the magnetic effect of an electric current; magnetic devices in the workshop.

Resolution of forces into right-angled components. Application to toggles, wedges, slings and other workshop uses.

Direct stresses and strains; Hooke's law; elastic limit, proof stress and plastic deformation; working stresses and safety factors, with their appropriate values for workshop applications; tensile and compressive tests.

Friction: simple treatment of the differences in friction between dry and lubricated surfaces.

Coefficient of friction; workship examples of useful and wasteful friction, e.g., clamping devices, drives, machine slides, and bearings.

Work done by a constant force; work done by a variable force, treated graphically. Couples and torque: work done by a constant torque; frictional torque. Power consumption in machine tool operations; frictional and other losses.

Velocity ratio, mechanical advantage and efficiency of machine transmissions and workshop lifting devices, Pulley and gear-wheel ratios: belt speeds; simple and compound gear trains of workshop application.

Mathematics—First Year

NOTE: Topics need not necessarily be treated in the order given but it is important for them to be correlated as much as possible. The approach should be practical and illustrated throughout by engineering and workshop applications.

The setting out of calculations; the extraction and cancellation of common factors.

Significant figures; degrees of accuracy; rough checks.

Workshop applications of averages, percentages, ratios, and proportion.

Use of tables of squares, square roots, and reciprocals.

Units of length, area volume, mass,and force commonly used in engineering manufacture; common applications. Use of logarithms for multiplication, division, and positive integral powers and roots.

Elementary use of the slide rule.

Use of symbolic notation to produce simple equations and formulae.

Solution of simple equations by algebraic and graphical methods.
Use of brackets and factors; simplication of fractions.
Manipulation of formulae, including transposition; evaluation of formulae in practical problems, including the use of logarithms:
Geometrical properties of the circles, including chords and tangents.
Trigonometric ratios for acute angles, with special reference to angles of 0%, 30%; 45%, 60, and 90; use offour-figure trigonometric tables; use of four-figure trigonometric tables: use of radian.
Solution of workshop problems on the right-angled triangle by algebraic and trigonomatrical methods.
Extension of graphical work to algebraic equations, trigonometric functions, and practical problems.
Areas and perimeters of common plane figures; surface areas, volumes, and masses of common regular solids of prismoidal and cylindrical shapes; use of tables of area, volumes, and masses of simple standard shapes and sections.
Workshop problems in setting out, marking out, measurement, speeds, feeds, etc., based on the above.

Mathematics—Second Year

NOTE: Topics need not necessarily be treated in the order given but it is important for them to be correlated as much as possible. The approach should be practical and illustrated throughout by engineering and workshop applications.
Setting out of calculations.
The extension of the use of logarithms to positive and negative vulgaf fractional indices; applications in the evaluation of formulae.
Quadratic equations: solution by factors, by formulae (without proof) and by graphs.
Formation of equations and formulae for problems, and their solution.
Further work on graphs, particularly of workshop applications. Interpretation of plotted information including the determination of the equation to a straight line.

Trigonometric ratios of angles from 0° to 180°. Use of the sine and and cosine rules with practical applications. Area of a triangle. Elementry trigonometrical identities based on Phythagoras theorem and the ratios of sides. Radian measure.
Extension of work on surface areas, volumes, and masses of common solids of pyramidical, conical, and spherical shapes; solids of revolution (without proof of formulae). Workshop applications.
Workshop problems in setting out, machining and measurement based on the above and including elementary problems involving the use of precision measuring equipment.

General Studies

See para 5 of the regulations.

PART I—SUPPLEMENTARY SUBJECTS

1 Non-Metallic Materials

A review of the properties and engineering uses of glass, ceramics, asbestos and its derivatives, wood and wood laminates, natural rubber and ebonite. Methods of forming and machining. Plastics materials: general classification of thermo-plastic and thermo-setting types. The properties and uses of the more common materials in each group. The limitations of plastics materials and their advantages relative to metals: machineability; factors such as toxicity and behaviour above room temperature.
An outline of moulding and forming processes; machines and equipment used: elements of mould and die design: injection and transfer moulding. Product design for plastics application. The influence of the moulding process and properties peculiar to plastics.
Brief account of synthetic rubbers: properties of interest to engineers, e.g., oil resistance.
Glass fibre plastics as constructional material.
Epoxy resins for flooring, resistant surfaces and adhesives.

2 Electrical Theory and Practice

NOTE The following syllabus should not be treated at an advanced level. It is intended primarily for the mechanical technician who is a user of electrical equipment; it should therefore be taught from the angle of the user, not the designer.
The simple electric circuit; the simple effects of an electric current: conductors and insolators. Electromotive force, current and resistance: volts, amperes and ohms and their measurement by voltmeter and ammeter. Ohm's Law. Resistors in series and in parallel. Dependence of resistance upon dimensions, material and temperature of conductor; resistivity. Current density. Measurement of resistance: use of Wheatstone bridge.
Electrical power and energy. Electric, mechanical and heat units, and their conversion. Permanent magnetic fields and poles: attraction and repulsion. Magnetic field round a current-carrying conductor, a coil and a solenoid. Electro-magnetic induction. Force on a current-carrying conductor in a magnetic field; principle of motor and generator. The moving-coil and moving-iron voltmeter and ammeter: use of shunts and multipliers. Introduction to alternating currents and wave-forms: maximum, mean and r.m.s. values. Frequency, amplitude, single and three-phase supply line and phase voltage and current. A simple approach to inductance and capacitance; the henry; phase relationships; expression by vectors; capacitance.
The principle of the transformer.
A brief review of rotating electrical machines in common use, e.g. the series and shunt-would motors, the induction motor, the synchronous motor and alternator; their important external characteristics and uses.

The need for starter gear and protective devices. Electric wiring requirements: types and construction of common types of conductor: properties of the various forms of sheathing. Typical wiring systems, e.g. screwed conduit, mineral-insulated, etc. Earth continuity and testing.

Typical lighting circuits, switching, fuses, fuse sizes and ratings. Socket outlets and plugs: maximum loading of socket outlet circuits.

Installation of motors and generators, foundations and mounting, regulations for fixing and earthing, provision of starter and protective gear, fault testing.

3 Primary Processes A—RAW MATERIALS

elementary approach to the extraction of a metal from its ore; oxide and sulphide ores, with particular reference to the purity of the parent metal and the impurities which remain.

The purpose of alloying.

Initial processes. The production of ingots for subsequent processing, ingot defects. The production of steel by the converter, open-hearth, and electric furnace methods, Blister copper and its purification. Distillation of zinc. Aluminium production by the electric furnace.

Review of testing procedures. Physical properties and their determination, such as ultimate strength, hardness, elongation. Elementary descriptive treatment of non-destructive testing A review of heat-treatment as specifically applied to primary processes. Hardening, normalizing, anealing stress relieving. Mass effect. Ageing, natural and artificial. manipulative processes. Ingot breakdown; rolling, extrusion, the production of bar, sheet, forgings, rolled section, strip, pipe and wire. Methods in common use for various materials. Defects due to impurities such as inclusion and segregation.

3 Primary Processes B—MELTING AND CASTING

Iron and steel. Methods of melting for foundry work. The cupola, its construction and management, the nature of the charge. A short account of the converter, open-heart and electric-arc furnaces.

Moulding sand, its main properties and behaviour in contact with molten metal. Difference in sand requirements for iron and steel and other metals. A simple account of sand testing. Mould construction. The pattern and its use in moulding boxes and on the floor. Green and dry sand moulds Loam moulding. Cores and their manufacture. The CO_2 and shell moulding processes.

Plate moulding and moulding machines. Lay-out and operation of the mechanized foundy.

Centrifugal casting and its uses.

Diecasting. Advantages and limitations of metal moulds. Materials used in the mould.

Metals suitable for die-casting.

Gravity die-casting and its applications.

Pressure die-casting: hot and cold chamber machines and their uses; examples of dies and their products.

Furnaces for melting and holding metal for die-casting purposes.

The investment and lost wax processes and their uses for casting in difficult materials and shapes.

An elementary accounts of the behaviour of metal during solidification: characteristic structures and properties of cast metals. Shrinkage its effects; porosity and cavitation.

Ageing of castings.

A simple account of methods of testing cast articles, hardness and impact tests use of cast-on test pieces. Non-destructive testing including crack-detection and raiography. Use of isotopes.

5 Primary Processes C—FORMING AND JOINING

A brief account of the production of steel and aluminium from the ore and the manufacture of ingots. Defects in ingots and their consequences. Forging, the effect of forging on the structure and properties of metal, especially on the structure left by solidification. The importance of grain flow.

Drop-forging. The drop stamp. Simple examples of drop forged parts and the dies used.

Hot forming by rolling. Forming by bending, pressing, and spinning.

Extrusion. A review of hot extrusion processes and products produced.

Examples of continuously extruded sections especially in light metals; saving of machining and extensive range of shapes so obtained.

Impact extrusion, limitations, typical uses.

A simple account of powder metallurgy, range and limitations of the process; metals used: properties of compacted and finished parts, impregnation.

Examples of typical powder metal parts and their methods of production.

Welding: oxy-acetylene and metal-arc fusion welding; details of the equipment used: method of making a simple weld in each case. An outline of the range of each process and their comparative values.

Difficulties encountered in welding metals other than mild steel. Submerged and shielded arc welding.

Bronze welding and brazing and their applications.

Hard surfacing and its uses.

Frame-cutting equipment and its uses.

A brief account of resistance welding.

The use and merits of welding for basic fabrication as an alternative to processes such as casting.

Methods of testing: use of macro-section and sulphur printing on hot-worked section; test pieces and their choice in relation to grain flow.

Methods of testing of welds: bend and fracture tests; macro-etching.

Methods of non-destructive testing including crack detection; radiography: use of isotopes.

6 Power Production

NOTE: The following syllabus should not be treated at an advanced level. It is intended primarily for the mechanical technician who is a user of a variety of power plants; it should therefore be taught from the angle of the user, not the designer.

Work, energy and power. Forms of energy, e.g. heat, mechanical and electrical and their units.

Conversion of energy; relationship between units; simple calculations.

A general descriptive account and elementary theory of:

(a) The internal-combustion engine cycles of operation; two-stroke, four-stroke, spark-ignition and compression-ignition, common types of engines. Typical efficiencies, fuels used and their calorific values.

(b) General lay-out and operation of steam plant. Common types of engines and turbines. General properties and behaviour of steam, pressures and temperatures used in typical applications. Typical efficiencies, fuels used and their calorific values.

(c) D.C. and a.c. motors, their leading characteristics and their uses. The alternator; the use of single-and three-phase supplies; the principle of the transformer.

Examples of the use of the above plant for power producing or converting units, including direct drives.

Elementary account of the use of nuclear energy for power production. Control of power; use of throttles and governors; direct control of electrical machines, simple account of switch gear and protective devices, storage batteries, stand-by and emergency arrangements.

Installation of power plant, arrangements for handling, foundations; elimination of vibration; methods of mounting and aligning.

Maintenance and servicing of power plant; typical inspection requirements and maintenance schedules; examples of common failures and overhaul requirements.

7 Basic Physics

Heat. Temperature scales and heat units. Calorimetry. Linear expansion. Superficial and volumetric expansions. The expansion of gases at constant temperature and constant pressure, Boyle's Law, Charles's Law and their applications. Latent heat. Conduction of heat.

Light. Rectilinear propagation, shadows, pinhole camera. Reflection at plane surfaces; applications to instruments such as rotating plane mirrors, parallel plane mirrors and mirrors right angles. Reflection at concave and convex spherical surfaces; principal focus; focal length; images; magnification.

Refraction, refractive index and its simple determination. Critical angle, refraction through a prism; lenses; focal length; images and magnification; application to instruments. Formulae relating to object and images with spherical mirrors and thin lenses (convention optional). Introduction to spherical aberration and colour. Elementary approach to wavetheory, frequency of coloured light.

Illumination, the candela, lux and lumen. Inverse square and cosine laws. Simple description of photo-electric meter.

Sound. Wave motion of sound; velocity; frequency; wavelength. Transverse and longitudinal vibrations. Loudness; pitch; quality. Resonance and beats.

Part II — Engineering Science and Mathematics

PART II — AND MATHEMATICS

The following Syllabuses in Engineering Science and in Mathematics are

ENGINEERING SCIENCE—First Year

common to all courses leading to the Part II examination and must be taken by all students.

Engeering Science — First Year

Direct stresses and strains, modulus of elasticity, temperature stresses.

Statics; resolution of forces into mutually perpendicular components, e.g. forces at a tool point. Polygon of forces, practical examples.

Motion; displacement and velocity; linear velocity and acceleration; angular velocity and acceleration; workshop examples and applications. Work done and power developed by a torque.

Simple properties of fluids; density and specific gravity; Archimedes' principle.

Elementary consideration of the structure of metals; crystals; grains and grain boundaries. General behaviour of metals during solidification, hot-working, and cold-working; effect of these on structure and properties. Examination of structure, preparation of specimens for micro- and macro-examination; use of the metallurgical microscope; identification of simple structures including grain flow and other evidences of working.

A simple approach to the metallurgical basis of heat treatment operations applied to plain carbon steels. Hardening, tempering, normalizing and annealing; relationship between structure and machineability. The influence of carbon content and mass effect on hardenability; the Jominy test.

ENGINEERING SCIENCE—Second Year

Further work stresses such as stresses in simple compound bars. Standard tests for materials in tension, compresion, torsion, and shear.

Extension of polygon of forces to the forces in simple frameworks; simple ment of shear force and bending moment on simply supported

treatment of shear force and bending moment on simply supported beams and cantilevers; applications in machine tools and workshop assemblies. Friction on an inclined plane with applications such as screw threads (square thread only); transmission of power transmitted with flat and vee belts; belt tensions and power transmitted (without rigorous proof of formulae); calculation or driving efficiency.

Potential and kinetic energy; conservation of energy; the purpose of a flywheel; calculation of the energy stored in a simple flywheel (mass concentrated at the rim); impact of a falling weight and other workshop applications.

Hydraulics, the hydraulic press total energy of a fluid, practical applications.

Elementary consideration of alloying of metals: purposes and effects: solid solution, precipitation.

basis of heat treatment operations commonly carried out on:

(a) low-alloy steels with reference to temper brittleness:

(b) high-speed steels;

(c) aluminium alloys.

Impact and hardness tests and their value.

Mathematics — First Year

NOTE: topics need not necessarily be treated in the order given, but it is important for them to be correlated and linked with the other subjects of the course as much as possible. The approach should be practical and illustrated throughout by engineering and workshop applications.

Further practical examples involving the solution of quadratic equations. Equations readily reducible to quadratics (e.g., by substitution).

A simple approach to the metallurgical basis of heat treatment operations commonly carried out on:

machine drives. Logarithms; limitations of four-figure tables; use of seven figure tables; examples in applications such as fine measurement.

Introduction to continued fractions and their use in problems such as gear trains.

Graphs; determination of laws reducible to linear form (excluding logarithmic transformations). Graphical treatment of 'slope of a line' with its meaning, such as velocity on a distance-time graph.

Trigonometry; application to the measurement of large bores, large radii, and taper features.

Mensuration; use of the Mid-ordinate Rule for irregular areas; use of the planimeter.

MATHEMATICS—FIRST YEAR

NOTE: topics need not necessarily be treated in the order given, but it is important for them to be correlated and linked with the other subjects of the course as much as possible. The approach should be practical and illustrated throughout by engineering and workshop applications.

Further practice in the solution of quadratic equations: problems leading to quadratic equations, workshop and other practical applications.

Introduction to binomial expansions with simple engineering applications such as approximations. Elementary approach to statistical probability: arithmetical mean and standard deviation: Binomial, Poisson, and normal distributions (without rigorous proof of formulae). Practical examples, e.g., sampling.

Further work on continued fractions including intermediary value; applications such as hobbing.

Extension of graphical work to the use of logarithmic rulings: determination of laws, use of logarithms to produce straight-line graphs.

Slope of a line; graphical treatment of simple cases of maxima and minima related to manufacturing problems.

Tangent to a curve, meaning of a differential coefficient. Differentiation $y=ax$ without proof of formula, differentiation of simple expressions such as $y=x^2-3x+3$.

Guildinus' theorem applied to the surface area and volume of simple solids of revolution.

Trigonometry; extension to 'solid' angles, e.g., cutting tool points, tool angles and forms, and the compound sine table. Calculations relating to typical setting-up, machining, and inspection problems.

Consuration; further practical probles involving sectors and segment of the circle.

SPECIAL TECHNOLOGIES:
WORKSHOP TECHNOLOGY

Curriculum: Workshop Technology
Engineering Construction and Materials
Engineering Science
Mathematics

Syllabuses as for all subjects.
General Studies (see para 5 of the Regulations)
Applied Technology (optional)*

WORKSHOP TECHNOLOGY — FIRST

NOTE: Safety and safe practices should form an integral part of all instruction, especially that relating to machinery in motion and to electrical supplies. Matters relating to safety may be expected to enter into examination questions.

An outline of the principal types of welding processes to show their possibilities, limitations, and place in manufacture: oxy-acetylene welding and cutting; metal-arc welding including submerged and shileded arc; flash, butt, and resistance welding. Weld testing.

Measurement; slip gauges, length bars, and other working standards, care and use.

Direct use of slip gauges for measurement and inspection. Simple Simple methods of checking slip gauges.

of slip gauges for measurement and inspection. Simple methods of checking slip gauges.

The principle of the comparator; typical mechanical, electrical, optical and pneumatic instruments and their uses.

The optical projector and its use for examining profiles.

The structure and application of the standard limit system, B.S. 4500 simply explained. The use and accuracy of limit gauges (with reference to B.S. 969).

Testing of simple gauges including adjustable gap gauges.

Cutting tools; forces acting at the point of a single-point tool and their relation to the machining process; tool face friction and chip flow, effect on tool life and efficiency; basic points of design for efficient cutting; comprison of positive and negative rake cutting.

Capstan and turret lathe work; principal features of construction and operation for simple bar and chuck work, Standard tool holders, die heads and collapsible taps, thread chasing, simple tool layouts, collet and chuck; use of soft jaws; cutting of special threads, effect on tool shape and setting.

Special considerations in the turning of large work; differences in machine construction and operation.

A review of the various types of drilling machine and their range of uses. The horizontal boring machine and its uses. A brief account of the use of these machines for production purposes and for large work.

Milling; a review of the scope of the process and the types of machine used; conditions for optimum tool life and stock removal; up-cut and down-cut milling; negative rake milling. Typical production operations with a standard range of cutters; use of the dividing head for indexing; the rotary table.

* This is practical subject to supplement the theoretical syllabuses. It may be covered as an optional part of the course. The Institute will not examine or assess Applied Technology projects at Part II level.

WORSHOP TECHNOLOGY — SECOND YEAR

Diecasting; gravity and pressure methods and machines simply explained; accuracy of castings; typical diecast products considered in relation to machining and other forms of manufacture. An outline of the process of investment moulding with common applications.

Heat-treatment furnace operation and control; types of furnace and their heating arrangements;simple methods of furnace control for consistent quality; use of protective atmospheres.

Nitriding.

Sintered products; a brief account of the production and range of application of powdered metal parts.

Non-destructive testing; crack detection, radiography and other common methods.

Measurement of external and internal screw threads of vee form.

Surface fininish; its importance and assessment; the centre-line average value; measurement by stylus methods.

The auto-collimator and 'angle dekkor' and their uses for alignment testing, circular division testing, and the measurement of angle in conjunction with angular slip gauges. The principles of alignment testing of machine tools.

Grinding machines; standard types and their uses. The abrasive wheel; simple consideration of cutting action; influence of wheel structure and material; effect of cutting speed, coolants and other variables upon performance; choice of wheel; wheel dressing and balancing.

Simple surface, cylindrical, and taper grinding operations.

Production of fine surfaces by cutting tool and abrasive methods.

Correction of errors by the geometry of the honing and lapping process.

Co-ordinate machining; the principle of the jig-boring machine; accuracy obtainable; use of this and similar machines for production work.

LABORATORY WORK

It is intended that the instruction in Workshop Technology should be covered by a carefully planned combination of classroom work and practical work. Demonstration may be included but the work should, if possible, be performed by the students, either singly or in groups. Some topics might be covered by practical work (this applies particularly to much of the work on measurement) and it is considered wasteful to duplicate such instruction in the classroom.

The arrangement of this work, and its exact form, are matters for the teacher, but it is expected that the work in each year of the course will include not less than eight of the topics given below, to which others may be added by the teacher.

FIRST YEAR

1 Fusion welding.
2 Resistance welding
3 Weld testing.
4 Measurement: direct use of slip gauges.
5 Measurement use of comparators.
6 Measurement: optical projection.
7 Measurement: testing of gauges.
8 Cutting tools: use of tool force dynamometer.
9 Drilling or boring including drill performance.
10 Lathe work.
11 Non-destructive testing.
12 Capstan lathe tool setting.
13 Milling: tool performance.
14 Milling:set-ups for various operations including indexing.

SECOND YEAR

1 Furnace operation and pyrometric control.
2 Non-destructive testing.
3 Measurement: screw threads.
4 Measurement:surface finish.
5 Measurement: auto-collimator.
6 Measurement: alignment testing.
7 Honing or lapping.
8 Co-ordinate setting and/or machining.
9 Milling: cutter grinding.
10 Grinding: wheel balancing and fitting.
11 Grinding: machine operation.
12 Diecasting.
13 Precision casting.

ENGINEER CONSTRUCTION AND MATERIALS

The work in this subject should include the completion of design details and the creation of simple designs by the student from original ideas, and should avoid mere copying. In dealing with the drawing of components and assemblies, emphasis should be placed on the correct use of materials, methods of construction, sound principles of design, machining or other processes involved, suitability of limits and tolerances; correct use of workshop instructions to ensure satisfactory manufacture and performance.

Frequent use of sketching should continue.

The treatment of the subject of materials should give the student a general understanding of their main properties, uses, advantages and limitations. The aim should be to show how and where the various materials can be effectively and economically use, and not to explore their metallurgical detail.

CONSTRUCTION — FIRST YEAR

Loci; simple linkages as applied to machine tool transmission, measuring devices, and other practical purposes.

Design of simple edge cams (restricted to centre-line followers)

Standard proportions for involute gears.

Construction of accurate outlines, e.g., for use when projecting for manufacturing and inspection purposes, including tolerance boundaries.

Further drawing practice to extend knowledge and appreciation of the constructional and operational features of machinery and equipment in items such as machine tool spindle, drives, slides and their adjustments, power transmision, mechanisms controlling precise movements, measuring devices, inspection equipment, test equipment, and typical industrial assemblies.

MATERIALS — FIRST YEAR

An outline of the general composition, physical properties, torms ot supply, suitability for manufacuring processes and specific appiications of the following:

(a) Nickel and nickel-chrome steels.
(b) Manages steels.
(c) Corrosion and heat-resisting steels.
(d) Malleable, high-duty, and spheroidal graphite cast irons.
(e) Sintered metals.

CONSTRUCTION — SECOND YEAR

Sketching or drawing to show the shape and important cutting angles of single-point tools, clamped tools and bits, inserted teeth, and simple form tools.

Further drawing practice involving constructional and operational features of machinery and equipment. More difficult assemblies including the use of conventional representation, e.g., for gearing to simplify assembly drawing.

Design of simple blanking and bending tools.

Limits and Its with reference to B.S. 4500 and Data Fits 4500A Selected ISO Fits-Hole Basis.

Design, current of gauges with reference to curent British Standards. Simple position and receiver gauges.

Elementary consideration of geometrical and positional tolerancing with reference to B.S. 308, clauses 19 to 22.

Jigs and fixtures, main principles of design such as accurate location, simplicity, ease of operation with economy of movement, rigidity, durability, and swarf disposal. Selection of locating points, locating pins, sliding, first vees, ettc. Clamping devices of various types for fist and subsecuent operations. Drill bushes and common standard details Application to simple jigs and fixtures (by sketching or drawing).

MATERIALS — SECOND YEAR

An outline of the general composition, physical properties, forms of supply, suitability for manufacturing process, and specific purposes of the following:

(a) Common aluminium and magnesium base alloys.
(b) Zinc base and other diecasting alloys.
(c) Nickel base alloys, e.g., monel and high-temperature alloys.
(d) High-tensile brasses and bronzes.
(e) Common bearing metals.

Applied Workshop Technology

Where the necessary additional time is available the option subject of examine or assess this subject. For this subject, it is recommended that, examine or assess this subject, Paragraph ror this subject, it is recommended that, for much of the time, students should work in small groups on joint projects, Examples of such projects are: the manu-jig or position gauge; a complex capstan set-up; the erection of a facture of a small jig or position gauge: a complex capstan set-up; the erection of a test rig; the inspection of a group of related gauges; the reconditioning of a small machine; a working or experimental model, or some similar task.

The group should plan the work to be done and produce a scheme for its completion in the time available. They should prepare necessary sketches and subdivide the work amoungst themselves in accordance with their scheme, their individual experience abilities, Para the object should be to develop the ability to work together in a group, to execute forward planning of a project and to carry the project through to completion by proper use of time and facilities and the abilities available within the group. It is not essential to provide each student with the same experience, but to ensure his contribution to the task. A project might require from afew weeks to some months, and could well involve preparatory drawing and design.

Press Tool Technology

Curriculum: Press Tool Technology
Press Tool Construction and Materials
Engineering Science
Mathematics

Syllabuses for all subjects.
General Studies (see para 5 of the Regulations)
Applied Technology (optional).*

Press Tool Technology

NOTE: Safety and safe practices should form an integral part of all instruction, especially that relating to machinery in motion and to electrical supplies. Matters relating to safety may be expected to enter into examination questions.

FIRST YEAR

PRESSES

Fundamentals of press construction: rigidity, power, accuracy of alignment. Types of press; the single-acting press, geared and ungeared, 'C' type and straight sided. Hand feeding and roll feeding, scrap cutting. Press capacity; power required for cutting operations, with associated calculations. Press guarding. Alignment tests.

PRESSWORKING OPERATIONS

Cutting operations in presswork; effect of die clearance, effect of shear, effect of differing material thickness. Bending operations in presswork; effect of bend radii, effect of grain direction, effect of temper, 'spring-back' and its correction. Preparation of operation sheets for simple components.

TOOLMAKING

The use of the centre lathe for form turning and the accurate positioning and boring of die holes using toolmaker's buttons. The use of the following machine tools with their standard accessories in the manufacture of press tool details: the universal milliig machine: the universal grinding machine; the shaping machine and the slotting machine.

MATERIALS FOR PRESSWORKING OPERATIONS

Properties of sheet metal used in presswork, limited to mild steel, deep drawing steel, cartridge brasses and light alloys. Defects in presed articles due to faults in materials. Season cracking. Interstage annealing. Age hardening. Roller levelling and skin passing.

SECOND YEAR

PRESSES

Brief reveiw of previous work on press construction and its extension to the double-action press and the press brake. More complex feeding devices such as gripper, slide, hopper, and magazine feeds. Ejecting devices; top knockouts, including of presses, air ejection, more complex press guards, guards for more than one operator; sequentially operated press guards; built-in guards on press tools.

* This is a practical subject to supplement the theoritical syllabuses. It may be covered as an optional part to the course. The Institute will not examine or assess Applied Technology projects as Part II level.

PRESSWORKING OPERATIONS

Drawing: flow of material, formation of wrinkles. The theory of the blankholder; effect of different pressures; use of draw rings and draw beads. Use of die cushions. Division of a deep draw into a number of stages; methods of deep drawing; variation of wall thickness. Defects particular to deep drawing. Drawing speeds, drawing lubricants, power required for drawing operations, with associated calculations. Preparation of operation sheets for more difficult components.

TOOLMAKING

The use and operation of the jig-borer and jig-grinder and the surface grinder including attachments for form grinding. The forming and dressing of grinding wheels. Special purpose machine tools commonly used in the tool-rom; the punch shaper, the universal filling and sawing machine, the 'toolmakers miller'

MATERIALS FOR PRESSWORKING OPERATIONS

Review of previous work on materials and its extension to properties of stainless steel and copper. Properties of non-metallic materials such as fibre board, impregnated papers and fabrics and plastic laminates.

Laboratory Work

It is intended that the instruction in Press Tool Technology should be covered by a carefully planned combination of classroom work and practical work. Demonstrations in the workshop and/or laboratory should, if possible, be performed by the students, either singly or in groups. Some topics may be dealt with wholly through practical work (this applies particularly to defects which arise in pressworking) and it is considered wasteful to duplicate such instruction in the classroom. The arrangement of this work, and its exact form, are matters for the teacher, but it is expected that the work in each year of the course will include not less than eight (first year) and six (second year) of the topics given below, to which others may be added by the teacher.

FIRST YEAR

1 Simple alignment test on a press (fly or power).
2 Distortion of a press under load (with and without tie bars).
3 Effect of shear on cutting pressure.
4 Effect of shear on flear on flatness of finished work.
5 Effect of varying die clearance with constant material thickness.
6 Effect of constant die clearance with varying material thickness.
7 Variation of springback due to different materials.
8 Effect of grain direction on springback.
9 Boring of a simple follow-on die using toolmakers' buttons.
10 Cupping tests on raw materials.
11 Effect of annealing.
12 Age hardening of a light alloy.
13 Maching a punch of complex form.
14 Grinding a matching punch and die to produce a given die clearance.
15 Determination of neutral axis in a simple bending operation.

SECOND YEAR

1 Timing diagrams for slides of a double-action press.
2 Effect of varying pressure on a blank holder.
3 Effect of varying pressure on a die cushion.
4 Jig boring.
5 Jig grinding of holes on co-ordinate centres.
6 Surface form grinding.
7 Forming of a grinding wheel.
8 Demonstration of the deeper draw obtainable with the 'inside-out' redraw.
9 Effect of speed of drawing.
10 Effect of drawing lubricants.
11 Effect of air trapping.

Press Tool Construction and Materials

The work in this subject should include the completion of constructional details and assemblies and the creation of simple desgns from original ideas, and should avoid mere copying. Emphasis should be placed on the correct use of materials, methods of construction, sound principles of design, machinery or other processes involved, and workshop instructions to ensure satisfactory manufacture and performance. Frequent use of sketching should continue.

The treatment of the subject of materials should give the student a general understanding of the main properties, uses, advantages and limitation. The aim should be to show how and where the various materials can be effectively and economically used, and not to explore their metallurgical detail.

CONSTRUCTION — FIRST YEAR

Development of blank sizes for the length of bent strips (including allowance for thinning at bends), for drawn shells and for rectangular boxes, including associated calculations. Blank layout in relation to economy of material.

Factors governing the basic design of press tools; design for safe operation: effect on design of the quantity, quality and dimensional limits of the finished product; easy replacement of wearing parts and tool maintenance.

Design of press tools such as blanking, single-run blank and pierce follow-on, piercing, vee-bending and forming tools. Tool design to accommodate difficulties in heat treatment such as split die construction and the positioning of dowel and screw holes.

Press tool details, fixed stops, pilots, self-centering devices; side cutters, finger stops, pressure pads and ejectors.

MATERIALS — FIRST YEAR

Plain cast steels, silver steel, alloy steels, such as non-shrinking steel.

CONSTRUCTION — SECOND YEAR

The construction of pres mechanisms such as non-repeating cluthes, roll feeds and scrap cutters. Arrangements for adjusting for wear on presses in bearings and slides. Lubrication of working parts on presses, gravity ndand pressure types. Extension of press tool design to double-run blank and pierce, simple drawing, redrawing, reverse drawing, and compound tools of the blank-and-pierce and blank-and-draw types. The construction of cushion devices, air and hydraulic. Use of standardized press tool details such as die sets and trigger stops.

MATERIALS — SECOND YEAR

Review of press tool materials and an extension to the use of non-metalic materials such as impregnated woods, epoxy resins and cemented carbides. Special purpose metallic materials, such as 'kirksite and 'cerromatrix'.

Applied Press Tool Technology

Where, the necessary additional time is provided the optional supplementary subject of Applied Press Tool Technology may be taken. The Institute will not examine or assess this subject.

For this subject it is recommended that, for much of the time, students should work in groups on joint projects, an example being the manufacture of a series of press tools for the production of a sheet metal component. The group should plan the work to be done and produce a scheme for its completion in the time available. They should prepare necessary sketches and subdivide the work amongst themselves in accordance with their scheme, their individual experience and abilities. The object should be to develop the ability to work together in a group, to execute forward planning of a project and to carry the project through to completion by proper use of time and facilities and the abilities available within the group. It is not essential to provide each student with the same experience, but to ensure his contribution to the task. A project might require from a few weeks to some months, and could well involve preparatory drawing and design.

PLASTICS MOULD MAKING TECHNOLOGY

Curriculum: Plastic Mould making Tecchnology.
Plastics Mould making Construction and Materials.
Engineering Science
Mathematics
General Studies (see paga 5 of the Regulations).
Applied Technology (optional)*.

Plastics Mould Making Technology — First Year

NOTE: (i) Attention is drawn to supplementary syllabuses offered at the Part I grade. It is considered that students could with advantage complete the supplementary course entitled Non-metallic materials' before proceeding to the Part II course in Plastics Mould making Technology.

(ii) Safety and safe practices should form an integral part of all instruction, especially that relating machinery in motion and to electrical supplies. Matters relating to safety may be expected to enter into examination questions.

A review of the principal types of press and moulding machine used in plastics manufacture.

Relationship between product type and size and the capacity of machines used. Arrangements for attaching, handling and operating dies.

More difficult operations on the lathe including the use of faceplate, collet, and chuck, use of soft jaws; cutting of special threads, effect on tool on tool shape and setting.

Application of lathework to operations connected with the production Measurement; slip gauges, length bars, and other working standards, in machine construction and operation.

Measurement; slip gauges, length bars, and otser working standards, standards, their care and use.

Direct use of slip gauges for measurement and inspection.

The principle of the comparator; typical mechanical, electrical, optical and pneumatic instruments and their uses.

The optical projector and its use for examining profiles.

The structure and application of the standard limit system (B.S.4500) simply explained. The use and accuracy of limit gauges (with reference to current British Standards.) Testing of simple gauges including adjustable gap gauges.

Cutting tools; forces acting at the point of a single-point tool and their relation to the machining process; tool face friction and chip flow; effect on too life and efficiency; basic points of design for efficient cutting; comparison of positive and negative rake cutting.

A review of the various types of drilling machine used in mould manufacture. The horizontal boring machine and its uses. A brief account of the use of these machines for the production of mould cavities, including large work. The use of boring tools and boring heads for preparatory work and finish in mould cavities; special drilling techniques, e.g., deep hole drilling for vents.

Milling A review of the scope of the process and the types of machine used including those designed, or with attachments, for die-sinking; conditions for optimum tool life and stock removal; up-cut and down-cut milling; negative rake milling. Typical operations with a standard range of cutters; use of the dividing head for indexing; the rotary table. The use of

slotting and other attachments to extend the use of the standard machir to the production of mould cavities.

Grinding machines; standard types and their uses. The abrasive wheel: simple consideration of cutting action; influence of wheel structure and material; effect of cutting speed and other variables upon performance; choice of wheel; wheel dressing and balancing. Simple surface, cylindrical, and taper grinding operations. The use of formed wheels. Methods of forming including wheel crushing.

Plastics Mould Making Technology—Second Year

An outline of the process of investment moulding. Its application to mould and die construction.

An outline of the principal types of welding processes to show their possibilities, limitations and place in manufacture; oxy-acetylene welding and cutting; metal-arc welding including submerged and shielded arc; weld testing.

Heat treatment furnace operation and control; types of furnace and their heating arrangements; control of temperature; use of protective atmospheres. Nitriding. Precautions in quenching and other special considerations in the treatment of moulds.

Non-destructive testing: crack detection, radiography and other common methods.

Measurement of external and internal screw threads of vee form.

Surface finish; its importance and assessment; the centre line average value; measurement by stylus methods.

The auto-collimator and 'angle dekkor' and their uses for circular division testing and the measurement of angles in conjunction with angular slip gauges.

Production of line surfaces by cutting tool and abrassive methods. Correction of errors by the geometry of the honing and lapping process. Surface finish requirements for plastic moulding and their relationship to finishing processes. The effect of surface finish on product quality and mould life.

Co-ordinate machining: the principle of the jig boring machine, accuracy obtainable; use of this and similar machines for production work, e.g., for accurate repetition without use of jigs.

A review of the principal copying and diesinking operations applied to mould and die manufacture.

A review of special processes of importance in mould manufacture, e.g. hobbing, spark erosion and other electro-forming methods. The use of non-metallic and non-ferrous materials for moulds or patterns. Special grinding processes, the use of mounted and shaped wheels, alrasive discs, polishing media, liquid honing and rotary files.

Equipment and methods for the direct heating of moulds.

Use of full-size and scale models, e.g., for die-sinker copying a review of model-making techniques. Suitability of various materials for models for copying purposes; surface hardness and other properties required. Principles of construction of models, e.g., minimum radii, working to scale, accuracy required; application of standard mechining processes to model-making.

Laboratory Work

It is intended that the instruction in Plastics Mould Making Technology should be covered by a carefully planned combination of classroom work and practical work. Demonstration may be included, but the work should, if possible be performed by the students, either singly or in groups.

Some topics might be covered entirely by practical work (this applies particularly to much of the work on measurement) and it is considered wasteful to duplicate such instruction in the classroom.

The arrangement of this work, and its exact form, are matters for the teacher, but it isexpected that the work in each year the course will include not less than eight of the topics given below, to which others may be added by the teacher. The work done should be related as far as possible to plastics mould making examples and processes.

FIRST YEAR

1 Operation of injection and/or transfer moulding or compression processes.
2 Measurement: direct use of slip gauges.
3 Measurement: use of comparators.
4 Measurement: screw threads.
5 Measurement: testing of gauges.
6 Cutting tools: use of tool force dynamometer.
7 Drilling or boring including drill performance.
8 Lathe work (standard operations).
9 Lathe work (application to mould making).
10 Milling: tool performance.
11 Milling: set-ups for various operations including indexing, profiling and cavity milling.
12 Grinding: wheel balancing and fitting.
13 Grinding: machine operation.

SECOND YEAR

1 Welding process and the testing of welds.
2 Furnace operation and pyrometric control.
3 Non-destructive testing.
4. Measurement: srew threads.
5 Measurement: surface finish.
6 Measurement:auto-collimator.
7 Honing or lapping.
8 Co-ordinate setting and/or machining.
9 Milling: cutter grinding.
10 Grinding: use of formed and mounted wheels.
11 Moulding finishing processes.
12 Diesinking.
13 Copying.

Plastics Mould Making Construction and Materials

The purpose of the subject is to deal with the constructional features of plastics moulds and their ancillaries, with moulding equipment and with appropriate machine tools, to give the student an appreciation of the reasons for distinctive features of design in relation to mould making and the successful operation of equipment.

Emphasis should be placed on the correct use of materials, methods of construction, sound principles of design, machining or other processes involved, the use of limits and tolerances and of workshop instructions to secure satisfactory manufacture and performance.

Work might well include the design of simple moulds from product details, provided undue time is not spent on this topic.

Frequent use of sketching should continue.

The treatment of the subject of materials should give the student a general understanding of their main properties, uses advantages and limitations. The aim should be to show how and where the various materials can be effectively economically used, rather than to explore their metallurgical detail.

CONSTRUCTION—FIRST YEAR

Loci; simple linkages as applied to pantograph and copying devices, measuring instruments, machine tools, and other practical purposes.

The construction of accurate outlines as required for templates and master forms, working to scale; effect of follower on master form. Master forms for projection purposes, use of tolerance boundaries, reverse profiles, e.g., for hidden forms.

Proportions of screw threads modified for or peculiar to plastics products. Proportions of typical mettalic inserts for plastics products. Dimensioning, application of tolerances, use of co-ordinate dimensions and other methods of specifying forms and curves.

Practice in the use of 'scrap' views to show details of mould parts, including features of importance in the finishing of mouldings. Part section and progressive sections to show the development of mould form.

Sketching and drawing of simple assemblies, features of machines, machine tool adjustments, details of measuring and inspection equipment, cutting and forming tools.

MATERIALS—FIRST YEAR

A brief review of plastics materials considered as main groups; their general properties, behaviour during moulding, possible effects upon mould materials, special considerations such as taxicity, abrasive characteristics and the use of solvents.

An outline of the general composition, physical properties, forms of supply, suitability for manufacturing processes and specific applications of the following:

(a) Nickel-chrome, and similar low-alloy steels including those suitable for carburizing and nitriding.
(b) Typical corrosion and heat resisting steels.
(c) Malleable, high duty, and spheroidal graphite cast irons.
(d) High speed steel.
(e) Sintered metals.

CONSTRUCTION—SECOND YEAR

Sketching or drawing to show the shape and important cutting angles of single-point tools, clamped tools and bits, drills and simple cutters. Elementary consideration of geometrical and positional tolerancing with reference to B.S.308, clauses 18 to 21.

Drawing simple gauges with reference to current British Standards.

Practice in drawing examples or part details of typical plastic moulds including cross-sections of the mould assembly.

Moulds: typical compression and injection moulds; features such as a layout of multiple impressions, sprues, gates and runners, ejectors, position of insert, strippers, heating and cooling arrangements.

Use of wood and other materials in dies or moulds for sheet forming.

Examples of press details including guards. Injection machine details such as mould closing mechanisms.

An introduction to the design of simple jigs, fixtures, and holding-devices for non-repetitive or small-quantity work related to the plastics industry.

MATERIALS—SECOND YEAR

(a) Special alloy steels used in mould and die construction, e.g. low shrinkage steels.
(b) Metal surface treatments for moulds, e.g., chromium plating, and their properties.
(c) Non-ferrous alloys used for plastic moulds, e.g., common aluminium and magnesium base alloys.
(d) Common non-metallic materials used for moulds, e.g., wood and laminates for pressure forming.

Applied Plastics Mould Making Technology

Where the necessary additional time is provided the optional supplementary subject of Applied Plastics Mould Making Technology may be taken. The Institute will not examine or assess this subject.

For this subject it is recommended that, for much of the time, students should work in groups on joint projects. Examples of such projects are the manufacture of a small jig, a mould or position gauge; the erection of a test rig; the inspection of a group of related gauges; the reconditioning of a small machine; a working, experimental, or mould-making model, or some similar task.

The group should plan the work to be done and produce a scheme for its completion in the time available. They should prepare necessary sketches and subdivide the work amongst themselves in accordance with their scheme, their individual experience and abilities. The object should be to develop the ability to work together n a group, to execute forward planning of a project and to carry it through to completion by proper use of time and facilities and abilities available within the group. It is not essential to provide each student with the same experience, but to ensure his contribution to the task. A project might require from a few weeks to some months, and could well involve preparatory drawing and design.

Part II— Plant Maintenance and Works Services Technology

PLANT MAINTENANCE AND WORKS SERVICES TECHNOLOGY

Curriculum: Plant Maintenance and Works Services — Theory
Plant Maintenance and Works Services — Practice
Engineering Science
Mathematics

Syllabuses for all subjects
General Studies (see para 5 of the Regulations)
Applied Technology (optional).*

Plant Maintenance and Works Services—Theory

This subject should be taught from the point of view of the technician concerned with the installation and operation of equipment rather than with design and manufacture. The instruction should be carried out by a carefully planned combination of classroom work and practical work in the workshop and laboratory. Practical work should, as far as possible, be performed by the students themselves.

Some topics might be covered entirely by practical work and at least one-third of the time allotted to the subject should be spent in the laboratory or workshop.

FIRST YEAR

(A) WORKS SERVICES

STEAM

Formation of steam; relationship between pressure and temperature of formation; saturated steam, dryness fraction of wet steam; superheated steam.

Sensible heat, latent heat, superheat and total heat; use of steam tables with calculations related to the total heat and specific volume of steam.

Combustion of solid, liquid and gaseous fuels; the combustion process; quantity of air required for combustion; the products of combustion.

Calorific values of fuels in common use: calculations related to air supply and calorific value. Thermal conductors and insulators; simple problems on heat transfer and heat loss using standard formulae.

AIR

Properties of air in relation to its compression and expansion, density, humidity and temperature.

Boyle's Law and Charles's Law; calculations of volumes, pressures and temperatures during compression and expansion.

WATER

Water supply and treatment. Measurement of water flow by notches, orifices and venturi meters; calculations based on standard formulae.

Calculations of pressures in pumps, pipes and operating cylinders of hydraulic pressure machines.

* This is a practical subject to supplement the theoretical sylabuses. It may be covered as an optional part of the course. The Institute will not examine or assess Applied Technology projects at Part II level.

ELECTRICITY

Review of the simple electric circuit; effects of an electric current: conductors and insulators; electromotive force, current and resistance; volts, amperes and ohms and their measurement by voltmeter and ammeter.

Applications of Ohm's Law to resistors in series and in parallel.

Dependence of resistance upon dimensions, material and temperature of conductor; resistivity. Calculations on the d.c. current-carrying capacity of cables.

Measurement of resistance by simple laboratory experiments and by common workshop methods and instruments.

Electrical power and energy.

Permanent magnets; magnetic fields and poles. The magnetic field round a current-carrying conductor, a coil and a solenoid.

Electro-magnetic induction; force on a current-carrying conductor in a magnetic field: principle of the motor and the generator and the generation of a.c. and d.c. current. The moving-coil and moving-iron voltmeter and ammeter; use of shunts and resistances.

(B) PLANT INSTALLATION AND MAINTENANCE

Basic principles of power transmission by belts, chains, spur, bevel helical and worm gearing; transmission calculations based on standard form ulae.

Cranes and fixed lifting tackle; general principles of construction and use; calculations on mechanical efficiency; principles and practice relating to lifting and slinging.

(C) SKETCHING AND DRAWING

Drawing practice to extend knowledge and appreciation of the constructional and operational features of machinery and equipment in items such as machine tool drives, slides and their adjustments, power transmissions, material handling equipment, machine and engine mountings.

Geometrical construction of standard involute gear tooth profiles and of structural steel sections.

Sketching of items of plant equipment with indication of the properties influencing selection of materials used.

SECOND YEAR

(A) WORKS SERVICES

STEAM

The ideal steam engine cycle; variations from the ideal cycle in reciprocating steam engines and in steam turbines.

Cadculations on steam generation and thermal efficiency in boilers and on steam consumption and thermal efficiency in reciprocating engines and steam turbines.

Calculations on steam generation and thermal efficiency in boilers and on steam consumption and thermal efficiency in reciprocating engines and steam turbines.

Calculations on the heat content and thermal efficiency of steam used for process work and space heating.

INTERNAL COMBUSTION ENGINES

Cycles of operation for two-stroke and four-stroke engines based on compression-ignition, spark-ignition or hot-bulb ignition: calculations of power output and of mechanical and thermal efficiencies.

Compositions of typical hydrocarbon fuels; calculations of calorific values, air supply and exhaust gas analysis to show the effect of excess and insufficient air.

AIR

Adiabatic and isothermal changes in relation to compression, distribution and utilization of compressed air. Treatment of air during compression to avoid pollution, overheating and excessive water content.

Compressed air distribution; measurement of air flow; pressure losses due to friction, obstructions and leakage. Calculations of airflow based on standard formulae.

WATER

Calculations of head and pressure. Losses of pressure due to friction, change of section, bends and valves, using standard formulae. Applications to pipe-lines, branches and distribution systems. Use of graphs and charts for pipe flow problems.

Calculations of power outputs and efficiencies of pumps and pressure-operated machines. Introduction to the principles of operation of centrifugal pumps and water turbines.

ELECTRICITY

Introduction to alternating currents and wave forms: maximum, mean and root-mean-square values: frequency, amplitude, single-and three-phase supply; line and phase voltage and current.

A simple approach to inductance; the henry, phase relationships; expression by vectors; capacitance.

The principle of the transformer.

A brief review of rotating electrical machines in common use; series and shunt-wound d.c. motors; the induction motor; the synchronous motor; the alternator; their important external characteristics; the need for starter gear and protective devices.

(B) PLANT INSTALLATION AND MAINTENANCE

The characteristics of machine tools and similar equipment (including power presses) in relation to mass, size, stability, rigidity, running speed and loading under conditions of use. The effect of these characteristics on the type of foundation and installation use.

Shock-absorbing materials and devices: holding-down bolts.

Properties of concrete, brick and timber in relation to plant installation.

Alignment of machine-tool beds and machine drives: principles of construction and operation of mechanical and optical instruments in common use for alignment setting and testing. Elementary consideration of transmission details and couplings designed to accommodate errors in alignment.

Calculations of power transmitted by shafts couplings friction clutches based on the use of standard formulae.

Principles of lubrication of shaft bearing, slides and plungers; common lubricants.

(C) SKETCHING AND DRAWING

Drawings and line diagrams of typical piping installations and layouts for plant services. Use of standard symbols and colour coding to indicate functions and materials.

Drawings and sketches of typical plant equipment details and assemblies to show materials used and principles of construction and operation.

Plant Maintenance and Works Services—Practice

Safety and safe practices should form an integral part of all instruction. Matters relating to safety may be expected to enter into examination questions.

Emphasis should be given to the importance of regular inspection and servicing and to the keeping of adequate records.

At least one-third of the time allotted to the subject should be spend in the workshop or on visits to typical plants and plant maintenance departments together with the writing of reports on matters observed.

FIRST YEAR

(A) PLANT SERVICES

Types of steam boiler used for generating low-pressure steam for heating and process work, and for high-pressure steam for power generation in reciprocating engines and steam turbines. Description of construction and/use of boiler mountings; steam boiler accessories, feed pumps, feed-water heaters, economizers and superheaters.

Boilerhouse practice: water supply and treatment; methods of stoking and burning solid, liquid and gaseous fuels.

Use and maintenance of boilerhouse instruments such as pyrometers, CO_2 recorders, draught gauges, steam and water meters.

General layout and operation of steam power plants; common types of steam reciprocating engines and steam turbines; typical efficiencies, fuels used; steam and fuel consumptions. Internal combustion engines for main power production or 'stand-by' provision. Types of compression-ignition, spark-ignition and hot-bulb ignition engines in general use.

Use of air for power supply with particular reference to portable tools.

Types of compressor in general use; factors affecting the choice of compressor — single- or multi-stage, reciprocating, rotary or axial flow; lubrication and servicing of compressors. Air storage; types of receiver; volume in relation to compressor output; common types of safety valves and control valves.

Water pipe-lines and distribution systems; valves, control gear and flow-meters; joints and jointing materials for hydraulic pipe-lines.

Types of a.c. and d.c. electricity supply available and their relationship to circuits used for supply and distribution; ring mains; metering and recording instruments for power and lighting purposes.

Electrical wiring requirements; common types of conductor; properties of various forms of sheathing. I.E.E. regulations.

Typical wiring systems including screwed conduit, clamped conduit, lead-covered cable and mineral-insulated cable. Earth continuity and testing.

Types of lamps; their characteristics and maintenance; typical lighting circuits, switches, uses, fuses sizes and ratings. Socket outlet and plugs.

(B) PLANT INSTALLATION AND MAINTENANCE

Types of buildings in which plant is installed and the effects on installation and maintenance practice.
Materials handling equipment: the use and maintenance of cranes and hoists in common use, including derrick and gantry cranes. The construction, use and maintenance of conveyors including roller, belt, chain and overhead conveyors.
Types or trucks and pallets used in handling raw materials, part-finished and finished products; their construction, use and maintenance.
Installation, servicing and maintenance of all the equipment included in Section (A) Plant Services.

SECOND YEAR

(A) PLANT SERVICES

Steam as a carrier of heat and the steam circuit including condensate return. Pipe layouts and sizes; use steam, separators and of control and reducing valves; provision for drainage, de-aeration, expansion and anchorage for main and branch supply lines; pipe joints and pipe covering. Selection of materials for all these details.
Use of steam for power generation and process work; factors governing the choice of installation under varying proportions of power and process load on the steam supply. Examples of the use of process steam e.g., laundries and paper-making.
Methods of dealing with peak loads and of steam storage; use and distribution of steam and/or hot water for space heating systems.
Factory heating; hot water and steam heating; calorifiers. Conditioning air and ventilation; use of low pressure air for ventilation; size and positioning of ducts. Temperature and humidity control. Dust extraction.
Types of internal combustion engines for power supply and driving auxiliary equipment including the use of the gas turbine as a power unit.
Compressed air distribution; pipe sizes and materials; provision for inspection and drainage. Air supply to portable tools, types of air hose and connections. Causes and prevention of icing in air-operated power tools. Main classification of pneumatic tools in comon use, i.e., percusson, rotary and reciprocating; air consumption.
Types of hydraulic pumps and machines in common use; hydraulic presses, lifts and cranes; provision of hydraulic accumulators and control gear.
Water suply and other arrangements for fire services.
Description of transformers, alternators, motors, converters and rectifiers in common use, with special reference to methods of installation and starting, load behaviour and methods of control, including Ward-Leonard control.
Power supply circuts; switchgear, fuses and protective gear.
I.E.E. regulations for fixing and earthing of power circuts and machines.
Fault testing. Electricity supply with particular reference to machine shops, portable tools. 'stand-by' and peak-load conditions.

(B) PLANT INSTALLATION AND MAINTENANCE

Methods of mounting and aligning machines on beds.
The special problems of machine tools, pumps and process machines using isolated electric motor drive, in relation to alignment, positioning and mounting of control panels, isolating and safety switches. Electrical connections to machines permitting flexibility of arrangement. Installation of steam and internal combustion engines; foundations; arrangements for lifting and handling. The special problems of high-speed engine installations in relation to engine vibration, fuel and cooling water supply and exhaust gas dispersal.
Maintenance and servicing of power plants; typical inspection requirements and maintenance schedules; examples of common failures and overhaul requirements.
Instalation testing and maintenance of hydraulic machines and equipment.
Overhaul of piston seals and packing glands.

MAINTENANCE ORGANIZATION

Parts supply and replacement store and stock control for consumable and non-consumable stores; facilities for repairs, routine inspection and overhaul. Records and planned schedules of maintenance programmes.
Typical maintenance shops for a range of industries such as steel works, chemical plant, general engineering shop, large scale production factory, small works for products such as textiles or light electrical components.
Special problems of maintenance in factories engaged in double-shift working or on continuous process.

Applied Plant Maintenance and Works Services Technology

Where the necessary additional time is provided the optional supplementary subject of Applied Plant Maintenace and Works Services Technology may be taken. The Institute will not examine or assess this subject.
For this subject, it is recommended that, for much of the time, students should work in groups on joint projects. Examples of such projects are:
the preparation of a detailed scheme of preventive plant maintenance for a typical instalation, e.g., a manufacturing unit based on fabrication by casting or welding, machining and assembly processes, or
a small chemical manufacturing plant or section of a larger plant involving processes and material handling equipment.
The selection of an example could arise from a particular works visit or be based on a specification prepared independently.
The preparation of a detailed scheme of conversion, e.g.:
a power supply installation from steam generation to internal combustion

engines including plant removal, alteration to buildings and supplies installation and testing of new equipment and resultant internal distribution of services: or

conversion of a general engineering shop from belt-driven machines to a system involving unit drive machines and extensive materials handling equipment to assembly points.

TESTING AND EVELOPMENT TECHNOLOGY

Curriculum: Testing and Development Technology
Engineering Construction and Materials
Engineering Science
Mathematics
General Studies (see para 5 of the Regulations)
Applied Technology (optional).

Syllabuses as for all subjects

NOTE: Safety and safe practices should form an integral part of all instruction, particularly that relating to machinery in motion and to electrical supplies and equipment. Matters relating to safety may be expected to enter into examination questions.

Testing and Development Technology—First Year

NOTE: (i) It is intended that the instruction in Testing and Development Technology should be covered by a carefully planned combination of classroom work practical work and demonstration.

(ii) The object should be to give the students an understanding of the manufacture and use of equipment and prototypes for testing, investigation and development rather than the commercial manufacture of products.

(iii) Some topics might be covered entirely by practical work and at least one-third of the time allotted to the subject should be spent in the laboratory or workshop.

An outline of the principal types of welding processes to show their possibilities, limitations and place in the manufacture of experimental and test equipment; oxy-acetylene welding and cutting; metal-arc welding including submerged and shielded arc; flash, butt and resistance welding. Common methods of weld testing.

Measurement. Slip gauges, length bars and other working standards, care and use. Direct use of slip gauges for measurement and inspection. The principle of the comparator; typical mechanical, electrical, optical and pneumatic instruments and their uses.

The optical projector and its use for examining profiles.

The structure and application of the standard limit system B.S.4500 simply explained. The use and accuracy of limit gauges (with reference to the current British Standard).

Cutting tools. Forces acting at the point of a single-point tool and their relation to the machining process; tool face friction and chip flow, effect on tool life and efficiency; basic points of design for efficient cutting: comparison of positive and negative rake cutting. Lathe work: differences in machine construction and operation for large work; special considerations in the turning of large work.

Drilling and boring: a review of the various types of drilling machine and their range of use. The horizontal boring machine and its uses for *the construction of test equipment and prototyres.*

Milling: a review of the scope of the process and the types of machine used; conditions for optimum tool life and stock removal; up-cut and down-cut milling; negative rake milling. *Typical operations with a* standard range of cutters; use of dividing head for indexing; the rotary table.

Testing *of machine tools: the auto-collimator and 'angle dekkor'* and their uses for alignment testing, circular division testing and the measurement of angle in conjunction with angular slip gauges.

The principles of alignment testing of machine tools.

Surface finish: its importance and assessment: the centre-line average value; measurement by stylus methods.

Production of the fine *surfaces by cutting tool and abrasive methods.*

Correction of errors by the geometry of the honing and lapping process.

Grinding machines; standard types and their uses. The abrasive wheel; simple consideration of cutting action: influence of wheel structure and material; effect of cutting speed, coolants and other variables upon perforance and surface finish; choice of wheel; wheel dressing and balancing.

Co-ordinate machining, the principle of jig-boring machines; accuracy obtainable; use of this and similar machines for manufacture of experimental equipment and prototypes.

LABORATORY WORK

The following are suggested as suitable examples for laboratory work, to which others may be added by the teacher.

1 Fusion welding.
2 Resistance welding.
3 Weld testing.
4 Measurement: direct use of slip gauges.
5 Measument: use of comparators.
5 Measurement: auto-collimator with reference to alignment tests.
7 Cutting tools; use of tool Torce dynamometer.
8 Tool performance tests in drilling and milling operations.
9 Machining: lathe, boring machine and milling machines operations.
10 Use of indexing equipment.
11 Co-ordinate setting.
12 Grinding; wheel balancing and fitting.
13 Grinding; machine operation.
14 Tool and cutter grinding.
15 Honing and lapping.

16 Comparison of surface finish produced by various operations.

Engineering Construction and Materials

The work in this subect should include the completion of constructional details and assemblies and the creation of simple design from original ideas, and should avoid mere copying. Emphasis should be placed on the correct use of materials, methods of construction, sound principles of design, machinery or other processes, involved, workshop instructions to ensure satisfactory manufacture and performance. Frequent use of sketching should continue.

The treatment of the subject of materials should give the student a general understanding of the main properties, uses advantages and limitatons. The aim should be to show how and where the various materials can be effectively and economically used, rather than to explore their metalurgical detail.

It is suggested that the syllabus should be completed in the first year of the course.

CONSTRUCTION

Loci: simple linkages as applied to machine-tool and engine mechanisms, measuring devices and cam-operated mechanisms.

Design if simple edge cams (restricted to centre-line followers).

Standard proportion for involute gears.

Drawing practice to extend knowledge and appreciation of the constructional and operational features of machinery equipment in items such as spindles and bearings, slides and their adjustments, drivers and power transmisions, mechanisms controlling precise movements, measuring devices, inspection equipment, test equipment and rig assemblies.

Use of conventional representations to simplify assembly drawing, e.g., gearing, screw threads. Design of simple fixtures for holding test specimens and gauges.

MATERIALS

An outlines of the general composition, physical properties, forms of supply and specific applications of the following:

Nickel and nickel-chrome steels.

Manganese steels.

Corrosion- and heat-resisting steels.

Malleable, high-duty and spheroidal graphite cast irons.

sintered metals.

Common aluminium and magnesium base alloys.

Zinc base and other diecasting alloys.

Nickel base alloys, e.g., monel and high-temperature alloys.

High-tensile brasses and bronzes.

Common bearing metals.

Plastics materials; general classification, properties, uses and limitations.

Testing and Development Technology—Second Year

(Two examination papers will be set on this syllabus, which should receive a proportionate amount of teaching time.)

NOTE: About half the time of the course should be spent on actual tests of materials, components and complete units with the interpretation of results.

Basic requirements of testing: measurement of dimensions, mass, temperature, work and power, structural properties.

Importance of regular and orderly recording of observation as a basis for calculations leading to reliable quantitative conclusions and useful qualitative deductions. Methods of recording observations and interpreting them in tabular, graphical and chart form. The contribution of these records as a source of information on which future design or modification can be based.

Measurement of dimensions. Application of workshop instruments to the measurement of changes in dimension and to alignment tests of machine tools and structure; introduction to the use of mechanical strain gauges; measurement of deflection of springs and simple structures under load.

Measurement of temperature. Various types of thermometer and pyrometer; indicating and measuring instruments for furnace and engine temperatures.

Heat-treatment furnace operation and control. Types of furnace and their heating arrangements; simple methods of furnace control for consistent quality; use of protective atmospheres. Measurement of temperatures during heat-treatment and other furnace operations and in routine testing of simple power plants.

Heat and temperature; physical effects of heat on various engineering materials, e.g., in relation to expansion and contraction, strength and stiffness, with particular reference to prototype construction and testing.

Measurement of work and power. Dynamometers; principles of mechanical, hydraulic and electrical types; methods of use and precautions contributing to safe and accurate working. Calculations on work, energy and power.

Elementary dynamics related to inertia loading, centrifugal force and an introduction to simple harmonic motion.

Measurement of structural properties. Use of British Standard as guide to testing methods. Routine testing of terrous and non-forces metals and of non-metallic mateials. Tabulation of results and comparion with specification requirements.

Behaviour of materials in bending twisting and combined bending and twisting. Testing of components as mean of development of uniform performance in assemblies. Testing of lifting equipment, e.g., slings, chains.

Testing of complete units to well-defined specifications planned to stress particular features of design, construction and use.

LABORATORY WORK

The following are suggested as suitable examples of laboratory work, to which others may be added by the teachr, including the extension of laboratory work of the first year.

1 Measuring instruments and equipment: calibration of various types.
2 Machine tools: alignment tests, including effects of temporature.
3 Machine tools: accuracy of finished work under different conditions of speed, feed and depth of cut.
4 Machine tools: effects of coolants on accuracy and surface finish.
5 Measurement of power absorbed under different conditions using various types of mechanical, hydraulic and electrical dynamometers.
6 Transmissions: measurement of power transmitted by gearing, belt drives, friction clutches and gear drives.
7 Power plants: routine performance tests of comon power plants, including engines of road vehicles to determine brake power, mechanical and thermal efficiency, temperature changes and general behaviour under varying conditions of speed and load.
8 Power plants: determination of indicated power and thermal efficiency of low-speed engines.
9 Materials: routine tests on material specimens to British Standards, including a range of carbon steel, cast iron, non-ferrous metals and non-metallic substances.
10 Materials: routine tests to determine proof stress, ultimate, tesile strength and hardness number of steel and aluminium alloy specimens.
11 Lifting equipment: routine tests of slings, chains, etc.

Applied Testing and Development Technology

Where the additional time is provided, the optional supplementary subject of Applied Testing and Development Technology may be taken. The Institute will not examine or assess this subject.

For this subject it is recommended that, for much of the time, students should work in groups on joint projects.

Examples of such projects are:

A complete acceptance test on a modern machine tool including alignment tests; performance tests including maintenance of accuracy and surface finish to cover a range of specified operations.

A complete test on a light steel frame or fabrication structure to investigate deflections at various points in the structure under different conditions of simple and combined loads. The test should include the design or specification of methods of fixing the base of the structure, methods of applying loads and couples as specified and the design and fabrication of equipment for carrying dial gauges of other forms of strain gauge.

A complete test on a power plant (steam or internal combustion) including fuel tests, performance tests under specified conditions, exhaust gas analysis, temperatures and heat flow characteristics at critical points and conditions of operation.

The group should plan the work to be done and produce a scheme for its completion in the time available. They should prepare necessary sketches and subdivide the work amongst themselves in accordance with their scheme, their individual experience and abilities. The object should be to develop the ability to work together in a group, to execute forward planning of a project and to carry it through to completion by proper use of time and facilities and abilities available within the group. It is not essential to provide each student with the same experience, but to ensure his contribution to the task. A project might require from a few weeks to months, and could well involve preparatory drawing and design.

Part II — Mechanical Engineering Drawing

MECHANICAL ENGINEERING DRAWING TECHNOLOGY

Curriculum: Engineering Drawing
Materials and Processes
Engineering Science
Mathematics

Syllabuses as for subjects
General Studies (see para 5 of the Regulations)
Applied Technology (optional).

Engineering Drawing

NOTE: The work in this subject should include the completion of detailed drawing based on simple designs prepared by the student from original ideas, and should avoid mere copying. In dealing with the drawing of components and assemblies, emphasis should be place on the correct use of materials, methods of construction, sound principles of design, machining or other processes involved, suitability of limits and tolerances and the correct use of workshop instructions to ensure satisfactory manufacture and performance.

Special attention shuold be paid to the promotion of safety in the design of drawing details. All sketching, drawing and dimensioning should be in accordance with current British Standards. Frequent use of sketching should continue.

FIRST YEAR

Drawing Office Practice: standard sizes of sheet layout of drawings including title blocks, materials and/or parts lists, and system of zoning, indication of modifications. Types of drawing 'paper' in common use; preparation of drawing for sulsequent reproduction. Preparation of working drawing of machine parts, components and assemblies. Use of standardized details. Conventional representation of common features given in clause 9 of B.S. 308 for threads, gears, helical springs.

Practical applications of intersection of solids, including true shape of section, limited to solids with centre lines intersecting at right angles, together with appropriate development of surface.

Loci: linkages, helices and involutes; their applications in engineering practice, cams as loci. Pictorial representations, oblique and isometric views, approximate ellipse and isometric circles constructed with compasses.

Dimensional systems, dimensioning for functon: choice of datums. An introduction to positional tolerances, general and specific. Use of B.S. 4500 data sheets.

SECOND YEAR

Drawing office practice: types of drawing, sizes, border requirements, cheking, modifications and salvage, procedure, numbering systems, issue procedure, storage, reproduction, standard parts and preferred sizes. Interaction between drawing office and other departments.

Further work on interpenetration of solids, including intersections with offset centre lines and at angles other than right angles, with appropriate development of surface. Practical applications including approximate development of surfaces.

Velocity diagrams for simple mechanisms; instantaneus centres.

Geometric tolerances to current B.S. 308, their usefulness by comparison with other methods of tolerancing.

Surface finish requirements in accordance with curent B.S. 308.

Illustrated discussions including the following topics: fasteners; locking and locating devices; spigots; keys; keyways, splines; mating faces; gaskets, parting arrangements; bearings, plain. ball, parallel and taper roller, selection and fitting, abutments and adjustment; gears, pain, spur and bevel, skew and worm and typical applications; seals; oils and greases; methods of lubrication, machine environment, protection in conditions of water, grit, etc.; welding; exploded views. The appropriate B.S. conventions should be used.

Materials and Processes

The treatment of materials should give the student a general understanding of their main properties, uses, advantages and limitations. The aim should be toshow how and where the various materials can be effectively and economically used, and not to explore their metallurgical detail.

The treatment of processes should give the student an understanding of the type of process, its general uses and limitations, an dits effect on the choice and design of product, from the point of view of the Drawing Office rather than the Production Shop.

FIRST YEAR

Brief review of Part I work on the properties, characteristics and uses of cast iron, plain carbon steels, brass, bronze, gunmetal, antifriction and light alloys.

Malleable cast irons, whiteheart and blackheart. High duty cast irons. Review of heat treatment of plain carbon steels; hardening, annealing, normalizing, tempering; case hardening; carburizing, refining and hardening. Nitriding. Simple consideration of heat treatment of light alloys such as aluminium and magnesium-base alloys.

Market forms of supply with reference to castings, forgings, plates, sheet, rod and wires. Paragraph Choice of production methods based on function and quantities required.

Relative costs in relation to forms of supply and quantities fo production. Brief treatment of break-even charts.

Outline of primary forming processes; sand casting, forging, drop forging, pressing, extrusion, rolling and wire drawing; their effects on physical properties; a consideration of the accuracies associated with these processes.

Joining of metals; use of rivets, bolts, screws, circlips and locking devices; soldering and brazing. Application of gas and arc welding and flame-cutting.

Basic forms of work that can be produced on general-purpose machine tools.

Infuence of production processes on product design, including modifications to facilitate manufacture.

The use of standard proprietary parts such as journal and trust bearings; plain, ball and roller types. Arrangements for lubrication of working surfaces; grease and oil seals.

SECOND YEAR

Alloy steels; effects of elements such as chromium, nickel, tungsten, molybdenum. Free-cutting steels. Inoculated and spheriodal graphitic cast irons. Nickel-base alloys; phosphor, manganese and beryllium bronzes; zinc, aluminium and magnesium-base alloys. Brief reference to the newer metals coming into engineering use.

Common non-metallic materials. A review of the properties and enginering uses of the following: thermoplastics and thermosetting plastics; plastico laminates, wood, wood laminates, asbestos and its derivatives.

Metal forming techniques. An outline of the following: investment castings and shell moulding techniques; powder metallurgy, impregnated bearings; gravity and pressure discasting press work, spinning and stretch forming; impact extrusion.

Metal cutting. Review of common machining methods and their uses for turning and boring, milling, shaping, grinding, broaching and gear-cutting. Their influence on product design. Standards of surface finish obtainable by various machine processes.

Metal joining techniques and their applications. An outline of special welding techniques by argon-, shielded- and submerged-arc. Resistance welding: but, spot, seam and projection. The use of glues and adhesives.

Metal finishing. Elementary treatment of corrosion and protective treatment. Surface treatment by electrodeposition, anodizing and metal spraying.

Laboratory Work

It is intended that the instruction in Materials and Processes should be covered by a carefully planned combination of classroom work and practical work. Demonstration may be included but work should, if possible, be performed by the students, either singly or in groups.

In certain cases demonstrations could be arranged at industrial undertakings, but visits should be for the purpose of viewing a particular technique, not for a review of the activity of the entire plant. It is recommended that wherever possible the studets should participate in the actual process being considered.

Some topics might be covered entirely by practical work (this applies particularly to much of the work on heat-treatment) and it is considered wasteful to duplicate such instruction in the classroom.

The arrangement of this work, and its exact form, are matters for the teacher, but it is expected that the work in each year of the course will include not less than eight of the topics given below, to which others may be added by the teacher.

FIRST YEAR

1 Tensile test on a plain carbon steel.
2 Tensile test on an untreated and heat-treated light alloy.
3 Simple bend test on cold-drawn and hot-rolled steel.
4 Fracture of grey and malleable cast irons.
5 Casehardening by cyanide and pack methods.
6 Hardness obtained by cooling brine, water and oil.
7 Casting, including use of cores, in a split-mould using cast-iron, aluminium alloys, or a substitute such as type-metal or wax.
8 Simple drawing of a circular shell on a handpress.
9 Springback of a bend in presswork, with effect of bend radius.
10 Simple extrusion of lead in a handpress.
11 Macro-examination of a forging.
12 Strength of soldered joint with and without flux.
13 Comparative strength of riveted and brazed joints.
14 Welding by gas torch and electric arc.
15 Flame cuting.

SECOND YEAR

1 Tensile test on an alloy steel.
2 Tensile test on high-duty cast iron.
3 Chip obtained and rapidity of metal removal with a free-cutting steel.
4 Erichsen or simulated Erichsen ductility test.
5 Strength-weight ratio of a magnesium alloy.
6 Simple plastic moulding using standard workshop equipment.
7 Spinning on a lathe.
8 Finish obtained in turning, milling and grinding (comparison with standards).
9 Broaching (hand press if broaching machine not available).
10 Strength of a spotweld.
11 Arc welding of aluminium.
12 Strength of a joint made with an impact adhesive.
13 Corrosion, effect of moisture and dry air on steel turnings.
14 Long term corrosion test on painted and electrodeposited surfaces.
15 Flame cutting.

Applied Technology

Where the necessary additional time is provided the optional supplementary subject of Project Planing and Drawing may be taken.

For this subject it is recommended that, for much of the time, students should work in groups on joint projects. Examples of such projects are the completion of a set of designs for laboratory equipment or other assembly or the general arrangement and detail drawings of a special purpose machine, and a project may well include testing to assist the selection of suitable materials. The group should plan the work to be done and produce a scheme for its completion in the time available, and should subdivide the work amongst themselves in accordance with their scheme, their individual experience and abilities.

The object should be to develop the ability to work together in group, to execute forward planning of a project and to carry it through tocompletion by proper use of time and facilities available within the group. It is not essential to provide each student with the same experience, but to ensure his contribution to the task. A project should involve some estimating and process planning.

MECHANICAL ENGINEERING DRAWING—PAPER II

1 Introduction

This course is intended to offer advanced instruction in Engineering Drawing and Drawing Office Practice. It will be taken as an optional subject at Part Two level.

2. Aims of the Course

(a) To develop skill in producing working/detail drawings related to current industrial practices, and as an adjunct to the compulsary drawing subjects in the above courses.
(b) To liase with and visit local industries and drawing offices so that their practices, techniques and requirements can be assimilated.
(c) To instill the principles of elementary design.
(d) To promote the use of current drawing office standards, manufactures catalogues, codes of safety and standard parts.
(e) To enable the student to select and make correct use of the basic engineering materials.
(f) To develop an ability to plan operations and process sequences and to produce the associated planning drawings.
(g) To relate the use of limits and tolerances to both function and manufacturing processes.
(h) To produce from guided original ideas appropriate drawings leading to the actual manufacture of a component or small assembly.
(i) To be trained in the skills and use of modern drawing office equipment, both for drawing and the reproduction of drawings.

3 Length of Course

The course will comprise of two complete, full-time terms each of 52 hours duration; giving a total of 104 hours instruction over two Polytechnic terms on a sandwich basis.

4. Organisation

Students must work under drawing office conditions and to this end will be provided with an industrial drafting unit, facilities for filing and storing of drawings, access to and the use of reproductive equipment and the use of a small workshop for the three dimensional solution of problems.

SYLLABUS

FIRST TERM

Drawing Office Practice:

Revisision of standard sizes of sheet layout of drawing including title blocks, materials and/or parts lists and system of zoning, indications of modifications, and subsequent actions to be taken. Use of standard practices and specification sheets in drawing offices, and importance of drawing filing and location. Types of drawing 'paper' in common use and preparation of drawings for subsequent reproduction.

Familiarisation with BS, ISO and other current standards, manufacturers catalogues, codes of safety etc. for use as reference sources throughout the course.

Further work on the preparation of working drawings of machine parts, components and assemblies, including scale drawings. Use of standardized details and conventional representations to BS 308 Part I (1972) for threads gears, helical springs etc. Blending curves for drawing outlines, templates and profiles. Drawing accessories for standard forms such as ellipses, radii, hexagon nuts etc.

Additional practial applications of intersection of solids including offset axes, true shape of section, and appropriate surface developments.

Loci: Further work on linkages, helices and involutes; their application in engineering practice, cams as loci.

Pictorial representation, oblique and isometric views, approximate ellipse and isometric circles constructed with compasses.

Visits to machine shop and/or plant installation for "on-site" sketching of details with dimensions and subsequent production of working drawings.

Dimensional Systems. Dimensioning for function and the choice of datums. The relationship between datum choice, manufacturing process and operation planning. The need for realistic tolerances for both function and manufacture. An introduction to positional tolerances, general and specific. Use of BS 4500 A and B. Practical examination of, and exercises based on, production components, machine parts etc. should be carried out by the student.

SECOND TERM

Further drawing office practice:

Numbering system checking of drawings before issue, procedure and interaction between drawing office and other departments, e.g. design, manufacturing, purchasing, market research and sales, research and development. Proprietary systems for drawing alterations.

Design of, and velocity diagrams for, simple mechanisms.

Production planning drawings including progressive diagrams and sequence of operations. A brief treatment of operation planning and the selection of manufacturing processes related to particular components. The use of assembly sequence and sub-assembly drawings for the erection of large structures and complicated assemblies.

Gecmetric tolerances to current BS 308 Part III.

Surface finish requirements in accordance with current BS 308.

Welding symbols in accordance with current BS 308

Practical investigations into their applications and sketching of the following features, prior to the production of working drawing for some of them:—

Fasteners, Locking and Locating devices, spigots; keys; keyways; splines; gaskets, bearings including selection and fitting; gears spur

and bevel, skew and worm and applications; seals, oils and greases and lubrication methods; other transmission systems pulleys, belts, chains and couplings and clutches.
Schematic diagrams and simple exercises in the scale layout of plant and equipment.
Electrical circuit diagram and electrical components.
Jigs and Fixtures: Extension of the compulsory course work to include designs of jigs and fixtures for operations on components previously encountered during this course a brief review of the tool-room and methods of jig and fixture manufacture, including the selection of materials.

Part II — Control Systems Technology

CONTROL SYSTEMS TECHNOLOGY

Curriculum: Control Systems Technology
Electrical Theory and Practice
Engineering Science
Mathematics

Syllabuses as for all subjects
General Studies (see para 5 of the Regulations)
Applied Technology (optional).*

GENERAL INTRODUCTION

1 The importance of safety measures should form an integral part of all instruction. Matters relating to safety may be expected to enter into examination questions.

2 In the technology and science sections of the sylabuses at least one-half of the total teaching time should be spent on practical work in the laboratory or workshop and in demonstrations. Suggested laboratory work is given at the end of the syllabuses.

3 The subjects should be taught from the point of view of the technician who is concerned primarily with the installation and maintenance of control systems; principles of design are relevant only in so far as they assist in the understanding of the operation of systems.

4 Much of the work will be best taught in the laboratory where applications of theory can be seen at once. Graphical methods of presentation are strongly recommended and the ability to recognize and interpret response curves and characteristics should be cultivated.

5 Terminology and definitions used for control systems (see B.S. 1523) should be dealt with as they arise.

6 The syllabus for Electrical Theory and Practice is the same as that for the supplementary subject at the Part I stage. Students who have already covered this as a supplementary subject must pay special attention to the requirements of laboratory work quoted in para 2 above. It is sugested that this subject should only be included in the first year o fthis Part II course.

Control Systems Technology—First Year

RELEVANT MATHEMATICS

Manipulation and transposition of formulae; indices: evaluation of $e \pm xt$, square roots of numbers less than unity, evaluation of $\cos (2t + \phi$ and $\sin (xt + \phi)$ including angles greater than 2Π.
Rates of change of graphs to include distance, velocity and acceleration.
Examples of thermionic valve parameters.
Graphis of the form Graphs of the form
Graphs of the form
Simple harmonic motion. Sinusoidal wave forms. Graphical addition of waveforms. Introduction to computation o fsteady-state amplitude ratio and phase-lag for harmonic excitation of linear systems and components.

INSTRUMENTATION

Fundamentals of instrumentation:
(a) Signal detection, manipulation and display;
(b) manual, self and power operations;

* This is a practical subject to supplement the theoretical syłbauses. It may be covered as an optional part of the course. The Institute will not examine or asses Applied Technology projects at Part II level.

(c) calibration;
(d) coulomb and viscous frication, sensiticity, speed of response, lag and damping; damping ratio, bandwidth, maximum percentage overshoot, peak amplitude ratio, setting time;
(e) accuracy, reproducibility, compensation for error. Measuring instruments.

The treatment should include the principles of operation, sources of eror and failure, prevention of common faults and calibration.
Principles of operation of instruments for the measurement of:
(a) length: principles of comparative measurements;
(b) volume and mass: displacement and balance methods;
(c) presure; manometers, diaphragm, bellows and bourdon-tube gauges;
(d) temperature: bi-metallic thermometers expansion thermometers; resistance thermometers, thermocouples and radiation pyrometers;
(e) level: gauge glass; float type; diaphragm box; bubbler tube; mercury manometers and nucleonic types.

CONTROL SYSTEMS

Concept of open and closed-loop control systems and feed-back.
Basic elements of control sytems; elements for signal generation, amplification and actuation; processes, operations and control equipment considered as elements of a typical closed-loop system; use of block diagrams; relationship between input and output.

Consideration and graphical representation of behaviour of typical complete systems with different forms of input, e.g., step, velocity and sinusoidal inputs.

Control Systems Technology—Second Year

RELEVANT MATHEMATICS

Further work on graphs of the form y and y cos

Further work on computation of steady-state amplitude ratio and phase-lag for harmonic excitation of linear systems and components. Graphic addition of vectors to determine overal harmonic response of linear components in series, including incorporation of experimental results. Graphical addition of vectors to determine system responsose from component responses.

Block diagram manipulation. Derivation of system-transfer-function coefficients from component coefficients. Computation of standard quantities required for use of data sheets. Binary Codes. Modification to Binary Codes necessary for machine-tool control. Co-ordinate geometry including intersection points between circles and straight lines. Tangency.

Graphical interpolation.

INSTRUMENTATION

The treatment should include the principle of operation, sources of of error and failure, prevention of common faults, calibration and the importance of correct zero setting.

(a) Pressure difference devices; pitot tubes, orifice plates: concentric, eccentric, segmental, quadrant and conical entrance types: nozzles; venturi tubes: long and short patterns and the Dall tube. Bernoull's theorem of fluid flow, without mathematical proof. Flow through orifice plates, nozzles and venturi tubes; calculations based on standard formulae. Revision of differential pressure measuring instruments for use with the above devices; installation; square root extraction.

(b) Variable area meters; electro-magnetic and electronic turbine flow meters.

(c) Mass flow measurement meters.

Measurement of Kinetic Quantities.

Measurement of linear and angular motion:

(a) dislacement: potentiometers and encoders, variable reluctance devices, defraction gratings;

(b) velocity: techometers, tachometers, stroboscopes;

(c) acceleration: accelerometers including force balance and spring deflection types.

FLUID SYSTEMS COMPONENTS

Pneumatic and hydraulic components, such as pumps, control valves rams and cylinders, motors and relays and other combination into operating circuits and servo mechanisms.

ELECTRICAL AND ELECTRONIC COMPONENTS

The principles of operation, characteristics and application of the folowing:

(a) servo systems, error detection using a.c. and d.c. potentiometers, synchros and differential transformers; a.c. and d.c. amplifiers, drift; a.c. and d.c. servomotors;

(b) metal rectifiers;

(c) the diode;

(d) the triode;

(e) the semi-conductor devices;

(f) photo cell.

CONTROL SYSTEMS

Basic types of automatic control, two step (on-off), proportional, integral and derivative type. Building up a pneumatic three-term controller. Use of standard Nyquist diagrams for open-loop testing of simple feed-back control systems.

Investigation of control systems behaviour, factors affecting stability; graphical presentation of behaviour in response to step, velocity and sinusoidal inputs. Simple performance calculations based on the use of standard data sheets.

APPLICATIONS

Throughout the course, in the lecture room and in the laboratory, examples should be chosen to ensure a wide coverage of the fields of servo systems and process control. Considerable emphasis should be placed on the correct choice of testing and display equipment associated with specific experiments and demonstrations.

MAINTENANCE

Principles of routine inspection, testing, maintenance and overhaul of control equipment and instrumentation. The installation of common types of control equipment and instrumentation.

Laboratory Work

It is intended that instruction on Control Systems Technology should be covered in both years by a carefully planned combination of classroom and practical/laboratory work. Demonstration may be included but the work should, if possible, be performed by the students, either singly, or in groups.

Some topics might be covered entirely by practical work and duplication of such instruction in the classroom is unnecessary.

The arrangement and form of the work are matters for colleges to decide but not less than eight of each of the two sets of experiments given below should be included. Others may be added if time permits.

INSTRUMENTATION EXPERIMENTS

1 Calibration of pressure gauge.
2 Measurement of level, using purge system.
3 Calibration of orifice plate meter.
4 Calibration of venturi meter.
5 Calibration of rotameter using water.
6 Measurement of temperature, using:
  (a) expansion thermometers,
  (b) resistance thermometers,
  (c) thermocouples,
  (d) radiation pyrometers.
7 Investigation of the relationship between flapper position and pressure output on a flapper-nozzle system.
8 Investigation of the relationship between flapper position and rate of flow in a aflappernozzle system, using a variable area meter.
9 The determination of the characteristic curves for diodes, triodes, and semi-conductors.
10 The determination of characteristic curves of metal rectifiers.
11 Speed-torque characteristics for a.c. and d.c. motors used in control sytems.

AUTOMATIC CONTROL EXPERIMENTS

1 Investigation of the time delays in simple first order systems:
  (a) temperature-time curve;
  (b) charge and discharge of bellows through a capillary;
  (c) charge and discharge of a capacitor through a resistor.
2 Second-order time delays:
  (a) temperature-time curve;
  (b) pressure-time curve for pneumatic equipment;
  (c) voltage-time curve for electrical equipment;
3 Investigation of the behaviour of an 'on/off' control system, e.g., furnace or level control.
4 Investigation of the behaviour of a proportional control system.
5 Investigation of the behaviour of a proportional controller.
6 Investigation of the behaviour of a proportional plus integral controller.
7 Investigation of the behaviour of aproportional plus derivative controller.
8 Investigation of the limitations of a cam-controlled machine.
9 Programming and setting-up for co-ordinate positioning systems.
10 Fault finding and testing of equipment, including some performance testing and recording.

Electrical Theory and Practice—First Year

The simple electric circuit, the simple effects of an electric current; conductors and insulators. Electromotive force, current and resistance; volts, amperes and ohms and their measurement by voltmeter and ammeter. Ohm's Law. Resistors in series and in parallel. Dependance of resistance upon dimensions, material and temperature of conductor; resistivity. Current density. Measurement of resistance; use of Wheatsone bridge. Electrical power and energy.

Permanent magnets; magnetic fields and poles; attraction and repulsion. Magnetic field round a current-carrying conductor, a coil and a solenoid. Electro-magnetic induction. Force on a current-carrying conductor in a magnetic field; principle of motor and generator. The moving-coil and moving-iron voltmeter and ammeter; use of shunts and multipliers. Introduction to alternating currents and wave-forms; maximum, mean and r.m.s. values. Frequency, amplitude, single- and three-phase supply: line and phase voltage and current. A simple approach to inductance and capacitance; phase relationships; expression by vectors; capacitance.

The principle of the transformer.

A brief review of rotating electrical machines in common use, e.g., the series- and shuntwound motors, the induction motor, the synchronous motor and alternator; their important external characteristics and uses. The need for starter gear and protective devices.

Electric wiring requirements; types and construction of common types of conductor; properties of the various forms of sheathing. Typical wiring systems, e.g., screwed conduit, mineral-insulated, etc. Earth continuity and testing.

Typical lighting circuits, switching, fuses, fuse sizes and ratings. Socket outlets and plugs; maximum loading of socket outlet circuits.

Instalation of motors and generators, foundations and mounting, regulations for fixing and earthing, provision of starter and protective gear, fault testing.

Applied Control Systems Technology

Where the necesary additional time is provided, the optional supplementary subject of Applied Control Systems Technology may be taken. The Institute will not examine or assess this subject.

For this subject it is recommended that, for much of the time, students should work in groups on joint projects example of such projects are:—

1 The erection and testing of a simple control system.
2 The setting-up and commissioning of a simple closed-loop control system.
3 The setting-up and operation of a cam-controlled machine (excluding cam design).
4 The erection and calibration of a multi-point gauging system for a given component.

Each of the above should involve some performance testing and recording. The group should plan the work and produce a scheme for its completion in the time available, and should sub-divide the work amongst themselves in acordance with their scheme, their individual experience and abilities.

The object should be to develop the ability to work together in a group, to execute forward planning of a project and to carry it through to completion. It is not esential to provide each student with the same experience, but to ensure his contribution to the task.

PART III

JIG AND TOOL DESIGN

Jig and Tool Design Technology

In all cases the need for continuous attention to detailed requirements for safe working should be stressed.

ECONOMICS OF TOOL DESIGN

In Importance of the relation of tooling costs to the quantity and rate of production. Consideration of 'break-even' point, graphical representation. Alternative schemes of tooling with respect to batch size, total quantity rate of production, frequency of setting and quality of product.

PRINCIPLES OF TOOL DESIGN

Simplicity, ease and safety of operation, motion study applied to tool design. Rigidity, durability, replacement of wearing parts, swarf disposal. Six-point principle of location; redundant constraints, kinematic design; foolproofing.

Methods of construction; comparison of cast, fabricated and welded constructions. Reference to the use of special materials such as low temperature melting-point alloys, impregnated woods and plastic laminates.

TOOL DETAILS

Locations, jacks supporting pin. Drill bushes; plain, headed, slip, liner and clamping types. Clamping; special considerations to avoid distortion of work when clamping and while cutting; multiple and compensating clamps; rapid-action clamps such as the link-toggle, eccentric, cam and interrupted thread types. Use of pneumatic and hydraulic cylinders, magnetic positioners. Use of standard parts such as cast and machined section, fixture bases, jig feet, clamping discs, cee-washers, swing latches and jacks.

DESIGN APPLICATIONS

Common drilling jigs such as the table, channel, latch and box types. More elaborate jigs including the use of slip bushes and indexing devices; use of angle plates for inclined holes. Milling fixtures; setting blocks and tenons, multi-station and indexing fixtures; use of special vice jaws.

Consideration of special requirements for fixtures used on broaching machines, boring machines and grinding machines (cylindrical and surface types).

Turning fixtures; consideration of use of soft jaws and the need for pilot bushes and balancing; expanding and contracting registers and mandrels. Assembly and welding fixtures; special requirements to minimize distortion. Inspection fixtures.

CUTTINGS TOOLS

Cutting tool materials; selection for particular purposes, use of high-carbon and high-speed steels, stellite, cemented carbides and ceramics; economic usage, use of buttwelded and throwaway tips, inserted tooth cutters. Boring bars; counter-boring countersinking, chamfering and recessing tools. Special types of milling cutters such as the interlocking and form-relieved types. Circular and tangential form tools and holders; re-sharpening and re-setting; associated calculations limited to tools with zero cutting rake. Broach design and broach pullers.

PRESS TOOLS

Elementary approach to press tool design limited to the simple blank, follow-on blank and pierce, vee-bending, channel-bending and single-draw tools.

MANAGEMENT AND ORGANIZATION

The function of a tool drawing office in an enterprise and its relationship to other departments. Organization of a tool drawing office; personnel, records copying, issue of drawing, modifications. The function of the constract tool drawing office.

Applied Technology (Jig and Tool Design)

For this subject it is recommended that, for much of the time, students should work in groups on joint projects. An example of such a project is the design, manufacture and use of a complete set of tooling for a component, which may include the preparation of estimates of costs production times and the purchase of standard items. It is expected that, as part of the Applied Technology, each student will complete at least one example of jig and tool design.

The group should plan that work to be done and produce a scheme for its completion in the time available. They should prepare the necessary drawings and subdivide the manufacture among themselves in accordance with their scheme, their individual experience and abilities.

The object should be to develop the ability to work together in a group, to execute forward planning of a project and to carry it through to completion by proper use of time and facilities available within the group. It is not essential to provide each student with the same experience, but to ensure his controbution to the task. A project might require from a few weeks to some months, and could well involve preparatory drawing and design. Each project should be reported briefly in writing by each student in the group. The subject will not be examined by the Institute, but the colleges will be asked to report on all group and individual projects (including the colleges' assessment of the performance or contribution of each candidate) and they may also be asked to submit some, or all, of the candidates' reports for inspection by the Institute. At the discretion of the college, a candidate may be required to undertake additional project work.

PRODUCT DESIGN

1 The syllabuses are planned on the assuption that the student is a responsible senior technician engaged on the design of either (a) mechanical engineering products, or (b) products produced in quantity using methods and processes associated with mechanical engineering.

2 The design technician will normally be working under the guidance and general direction of a technologist but his responsibilities may include all or some of the following:

(a) Preparation of component and sub-assembly designs by extraction from general arrangement drawings or sketch designs and involving liaison with testing and development and/or production departments.

(b) Analysis of an existing design and its performance as a basis for the development of a modified or improved design.

(c) As a section-leader or senior design draughtsman responsible for the guidance of a team of junior and detail draughtsmen and the co-ordination of their individual contributions.

Product Design Technology

NOTE: The following syllabus should be treated as an extension of that of SPECIAL TECHNOLOGY—PART II (MECHANICAL ENGINEERING DRAWING) with some repetition and study in greater depth of items included in the subject syllabus for Materials and Processes and the syllabus for Engineering Drawing.

At all stages references should be made to the appropriate British Standards.

Extensive use of graphical methods of analysis should be made together with frequent use of sketching and some exercises in the pictorial representation of a finished design in black and white and in colour, to analyse the appearance characteristic of the design.

GENERAL DESIGN CONSIDERATIONS

The consideration of a design as comprising three principal and inter-related elements, viz.:

(a) Function, e.g., kinematic, structural and allied factors.

(b) Construction, e.g., materials, manufacture and assembly.

(c) Appearance, e.g., material, form and finish.

Elementary treatment of the principles of dimentional analysis with particular reference to the use of models in design procedure and in the development of prototypes for quantity production.

Consideration of forms, shapes and colours in relation to appearance and to the efficient use or structural properties of materials.

The limitations in shape, proportion and precision imposed by various manufacturing processes.

Use of 'mock-ups' and models for the study of methods of assembly, use and maintenance.

Introduction to the idea of cost analysis and estimates at the design stage.

Influence ofdesign on capital cost in relation to purpose and life, on maintenance and on safety of operation.

The function of the design department in an enterprise and its relationship to other departments. Organization of a design department, personnel, records, copying, issue of drawings, modifications.

MECHANICS OF MACHINES

Graphical treatment only of the following: velocity and acceleration diagrams for mechanisms based on the four bar chain and the slider-crank chain. Cams: displacement, velocity and acceleration of followers for tangent-flank and circular-arc profiles.

Turning moment diagrams; cyclical fluctuation of speed.

Flywheel design.

Balancing of rotating masses in parallel planes. Primary balancing of reciprocating masses.

Toothed gearing: a review of previous syllabus items on spur, helical, and worm gears.

(Part II—Special Technology—Mechanical Engineering Drawing.)

Simple and compound epicyclic gear trains. Advantages and applications of spiral gears, spiral bevel gears, and hypoid gears.

Fundamentals of dry, boundary and fluid frictions; introduction to the theory of lubrication, in journal and thrust bearings.

Ball and roller bearings; impregnated and 'oil-less' bearings, gas and hydrodynamic bearings, their applications and installation.

Applications of friction drives and clutches.

Simple harmonic motion; periodic time, frequency and amplitude.

Simple cases of longitudinal, transverse and torsional vibrations; whirling of shafts.

Introduction, without mathematical treatment, to damped and forced vibrations.

STRENGTH AND STRUCTURAL PROPERTIES OF MATERIAL

Relationship between the elastic constants; compound stresses and strains.

Stresses in simply supported beams, and torsion of solid and hollow circular shaft (without rigorous proof of formulae).

Shearing force, bending moment, curvature, slop and deflection relationships for simply supported, cantilever, built-in and propped beams using standard formulae and graphical integration methods.

Strength and deflection of close-coiled helical spring under axial loads and couples. Columns and struts; Euler, Rankine, and other empirical formulae in common use. Consideration of the behaviour of non-standard sections such as sheet metal pressings, castings in ferrous and non-ferrous metals and moulded plastic forms under load, based mainly on experimental testing with measurement of deflections and the use of surface strain gauges and brittle coatings.

Consideration of strength, structural, and other design problems created by built-in electrical equipment, including selection of conducting and insulating materials; strains and stresses arising from the heating and magnetic effects of electric circuits; vibration, noise, and dynamic loading arising from electric motors.

Vibration damping by the use of absorbent materials and special mountings.

MANUFACTURING METHOD

Selection and arrangement of materials in designs, based on a review of the previous syllabus items (in Part II Technology—Mechanical Engineering Drawing) on metal forming, cutting, and joining techniques, together with the special problems of pressings in relation to spring, back, folding, puckering, and edge finishing.

Methods of jointing dissimilar materials, e.g., sheet metal to non-ferrous casting; plastic materials to metallic castings, pressings, and machined stock.

Consideration of materials in relation to the stability to the component under service conditions.

FINISHING PROCESSES

Consideration of the standards and types of finish associated with the manufacturing methods referred to above.

Preparation of materials and surfaces for finishing processes:-cleaning, phosphating, and chromate priming. Types of paint used in finishing processes such as cellulose, lacquers, synthetic resins, thixotropic paints, polychromatic finish. Methods of application.

Electrolytic cleaning, electro-plating and anodic treatment.

Laboratory and Practical Work

The laboratory work should be closely connected with lecture and classroom work and should generally be of a qualitative rather than a quantitative nature.

The work of this section should include a selection of items from the syllabuses for Materials and Processes—Laboratory Work (Special Technology—Mechanical Engineering Drawing) not previously covered, together with some from the following list and others added by the

1 Determination of Young's modulus, modulus of rigidity and Poisson's ratio for mild steel.

2 Measurement of deflections of beams of various section and under various systems of loading. Effect of end loading.

3 Loading tests on brackets made of cast iron, diecasting alloy, sheet metal pressings and moulded plastics, with measurement of deflections and observation of structural and material failure.

4 Use of surface strain gauges and brittle coatings investigating stresses in sheet metal components.

5 Plotting of displacement diagrams for a cam-operated follower from experimental measurements, with the derivation of velocity and and acceleration diagrams.

6 Use and/or demonstration of a dynamic balancing machine.

7 Vibration experiments on beams and shafts.

8 Vibration experiments with the application of viscous damping to demonstrate the effect of frequency and amplitude.

9 Tests on jointing of dissimilar materials.

10 Experiments to investigate the appearance, thickness and adhesion of paint films (under vibration conditions) with various types of surface finish and treatment.

Applied Technology (Product Design)

(a) For this subject it is recommended that for about two-thirds of the time students should work in groups on joint projects.

Examples of such projects are:

(i) The completion of the design of a major component or sub-assembly, starting with the extraction of information from a specification and/or general arrangement drawing. The completion should include details of calculations (or graphical methods) relating to stresses and strains arising from static and dynamic loading and the kinematic analysis of any mechanisms involved. Itshould lead to the preparation of finished drawings, material specifications and parts lists together with outlines of a manufacturing programme and a cost analysis.

(ii) The analysis and/or testing design and product as a basis for the complete design of a similar product to satisfy modified conditions or specification. Each group should plan and sub-divide the work between its members to make full use of individual experience and abilities and to ensure regular checking at the various stages of design.

(b) In addition each student should complete at least one individual example of Product Design during the remaining 40 per cent of the time allotted for Applied Technology. Each project should be reported briefly in writing by each student in the group. The subject will not be examined by the Institute, but the colleges, will be asked to report on all group and individual projects (including the colleges' assessment of the performance or contribution of each candidate) and they may also be asked to submit some, or all, of the candidates' reports for inspection by the Institute. At the discretion of the college, a candidate may be required to undertake additional project work.

Part III Engineering Production

ENGINEERING PRODUCTION

Engineering Production Technology

In all cases the need for persistent attention to the detailed requirements for safe working should be stressed and correct procedure demonstrated.

MATHEMATICS

Extension of previous work on calculus to the determination of maxima and minima; practical applications such as the determination of an optimum batch size, optimum dimensions, and minimum usage of materials. Simple approach to partial differention; the total differential and its application to errors. Further applications of geometry and trigonometry such as the determination of gear tooth profiles, screw thread profiles and co-ordinate dimensions (cartesian and polar). The application of geometric progresion to schemes of preferred numbers, simplification and standardization to eliminate non-standard numbers.

METROLOGY

NOTE: It is expected that much of the work in this section will be covered by practical work in the laboratory. See laboratory work syllabus.

A review of basic considerations of measurement; the wave length of light as a standard of length; slip gauges for length and for angle; reference, inspection and workshop grades. The kinematics of instrument design; degrees of freedom, constraints, the principle of three rotations and three translations. Applications to measuring instruments such as the floating carriage micrometer and the pitch-measuring machine. Sources of error; temperature variation, parallax, cumulative errors, elastic deformation and the human element. The calibration, reliability and maintenance of measuring instruments.

Magnification systems; mechanical, electrical, optical and pneumatic as aplied to measuring instruments.

The principles of pneumatic gauging. Use of pneumatic gauging for comparative measurement. The nature and assessment of surface texture, reference to B.S. 1134 and B.S. 2634.

Comparative assesment with the use of standards and the use of a stylus.

INSPECTION AND GAUGING

Comparative measurement and limit gauging. The practical application of Taylor's principle to limit gauging. Gaugemaking tolerances and wear allowance, reference to BS. 969.

The design of gauges for checking profiles. Caliper type external screw gauges and gauges for internal screw threads. The inspection of gears; use of rollers and of gear testing machines. Acceptance tests for standard machine tools; equipment to be used and method of use.

Use of acceptance test charts and tables.

STATISTICAL CONTROL OF QUALITY

Review of previous work on statistical methods on mean and standard deviation; Binomial. Poisson and Gaussian distributions; sampling schemes. Extension to the construction of quality control charts for dimensions and for attributes. Descriptive treatment of single sampling, double sampling and sequential sampling techniques.

The aplication of 'Chi-square' and 'Student's' tests of significance, without deduction of formulae, but including use of charts.

PROCESSES AND MACHINE TOOLS

Control systems: descriptive (non-mathematical) treatment of the principle of automatic control; application of open-loop andclosed-loop systems, limited to control of spindle speed and positioning of tables. Descriptive treatment of numerical control; use of interference fringes, diffraction gratings and other counting devices; effect on the system of dimentioning of drawings. Use of gauging systems as controllers during machining operations. Simple hydraulic systems for control of machine tools, as operation of broaching machines and the movement of grinding machine tables.

Automatic lathes: review of previous work on capstan and turret lathes. Extension to the construction, capabilities and limitations of single-spindle automatic lathes of the 'rotating turret' and 'moving headstock' types. Determination of cycle times and construction construction of cam layouts for simple components.

Gear-cutting machines: construction, capabilities and limitations of gear-cutting machines of the hobbing, shaping and planing types. The machining of other standard profiles on gear cutting machines. Gear-finishing machines: shaving, grinding and burnishing.

Broaching machines; comparison of the 'pull-through' and 'surface broaching' techniques. Design of simple broaches and pullers circular holes, splined holes and keyways.

Grinding machines, a review of the grinding process and of wheel selection. Wheel balancing. Comparison of wheel dressing by crushing and by cutting. Review of plain cylindrical, universal and surface grinding machines. The centreless grinding machine; progressive rounding and lobing, through-feed, plunge-cut, and plunge-and-run techniques, controlled cycles. Machines for the grinding of forms; thread grinding machines of the single-rib and multi-rib wheel types, profile grinding machines. Honing, laping and superfininshing machines. Jigs and fixtures: brief review of previous work, extension to the use of jigs and fixtures on machines listed above such as broaching fixtures, grinding mandrels, and gear-blank mounting arbors.

Descriptive treatment only of material removal by spark-erosion, electrolytic grinding and ultrasonic means.

Metal forming processes: the plastic deformation process of bending, roliing, stretching, forging and extrusion. Economic comparisons with metal cutting processes.

Brief review of plastic moulding techniques for thermoplastics and thermosetting compounds. Injection moulding, use of metal inserts. Machines for cutting non-metallic materials; fundamental differences from metal working machines such as spindle speed, scrap removal and guarding.

MANAGEMENT AND ORGANIZATION

The function of the manufacturing and allied departments and their relationship to other departments. Progressing and scheduling, including a brief reference to the Grantt chart. The internal management of the production departments, the function of the foreman; the use of collective bargaining and the function of trade unions.

LABORATORY WORK

It is intended that the instruction in Engineering Production should be covered by a carefully planned combination of classroom work and practical work.
Demonstration may be included but the work should, if possible, be performed by the students, either single or in groups.
Some topics might be covered entirely by practical work (this applies particularly to much of the work on Metrology) and it is considered wasteful to duplicate such instruction in the classroom.
The arangement of this work, and its exact form, are matters for the teacher, but it is expected that the work will include not less than ten of the topics given below, to which others may be added by the teacher:

1 The complete measument of an external or an internal screw thread.
2 The measurement of a profile gauge.
3 Checking an inclined face using angle slip gauges.
4 Alignment of a large assembly fixture using an alignment telescope.
5 Checking of a long leadscrew.
6 Full aceptance test of a machines tool.
7 The production of a cam drawing for an automatic lathe.
8 The setting of an automatic lathe, cam and tooling provided.
9 The effect of different grinding wheel characteristics on surface finish.
10 The dressing of a grinding wheel and the subsequent grinding and inspection of a profile.
11 The setting and machining of a spur gear and its subsequent inspection.
12 Demonstrotion of spark-erosion or ultra-sonic machining.
13 Establishment of 'fraction defective' by sampling.
14 The compilation of a quality control chart for attributes.
15 The compilation of a quality control chart for measured dimensions.

Applied Technology (Engineering Production)

For this subject it is recommended that, for much of the time, the students should work in groups on joint projects. An example of such a project would be to take an assembly drawing and the associated detail drawings to produce planning sheets for the manufacture of individual details, to prepare operation drawing and to compile lists of special and standard tooling. The work may include the preparation of estimates of costs and of production times, and of a delivery schedule. The details could well be produced by different methods to obtain comparative costs, etc., and it is expected that at some time each student should undertake practical machining and/or inspection work. The work should be sub-divides among the group according to their individual experience and abilities.
The object should be to develop the ability to work together in a group to execute forward planning of a project, and to carry it through to completion by proper use of time and facilities available within the group. It is not essential to provide each student with the same experience, but to ensure his contribution to the task. A project might require from a few weeks to some months.
Each project should be reported brifly in writing by each student in the group. The subject will not be examined by the Institute, but the colleges wil be asked to report on all group and individual projects (including the colleges' assessement of the performance or cotribution of each candidate) and they may also be asked to submit some, or all, of the candidates' reports for inspection by Institute. At the discretion of the college, a condidate may be required to undertake additional project work.

MECHANICAL ENGINEERING INSPECTION

Inspection Technology

NOTE: The aim of this subject is to study the technical basis of inspection methods and equipment rather than customary practice. Teachers are advised to make extensive use of demonstrations and visual aids.

MACHINING PROCESSES (IN RELATION TO INSPECTION)

Throughout the teaching of this section attention should be paid to the assessment of probable accuracy.
A short review of the basic processes of drilling, boring, turning, shaping and planing, milling and grinding in relation to the work forms normally produced and their relative accuracies of size and geometry.
An outline of the fine surface production by processes such as scraping, lapping honing, superfinishing, burnishing, and ultra-fine (e.g., diamond) turning and borine: relative accuracies and costs of work.
A brief review of quantity production methods such as diecasting, hot and cold machine forging, presswork, thread rolling and milling,

broaching, automatic and copy turning, and centreless grinding with reference to typical work forms, accuracy and maintenance of accuracy.

PRINCIPLES OF MEASUREMENT

Control of measurement by standards; variables in measuring equipment, e.g., secular change, reversible change, wear, deformation and surface decay. International, English, and metric length standards, international standard conversion factor. A review of the intercomparison of end standards. Secondary standards for use in industry. Standard measuring temperature. An outline of the production and generation of slip gauges and end bars from a secondary standard. Grading of slip gauges; accuracy; maintenance of accuracy, use as industrial standards. The use of calibrated rollers and balls.

Generation of a plane surface. Comparison of characteristics of machine, scraped, and lapped surfaces. Outline of interference and contact methods of flatness measurement, including elementary treatment of interference fringes.

Elements of kinematic design; flatness, straightness, squareness, geometric slides, minimum constraint, elimination of friction, e.g., by strip hinge and rolling contact. The Abbe principle of alignment. Typical examples in standard instruments.

Principles of comparison; influence of errors in the standard and in the comparator. Basic mechanical, electrical, and pneumatic methods of magnification and examples of their use in typical length comparators. Relation between magnification and accuracy of determination; need for calibration; principle of repetitive readings.

Optics; principles of reflection from plane surface and concave mirror, refraction, path of light through prisms and lenses. Principle of optical lever; typical uses in measuring instruments. Magnification by projection, collimated light, effect of light source, simple optical system for profile and scale projection. Sources of error in optical systems. The autocollimator.

Standards of squareness and angle; the square tester; outline of method of use of angle guages, circular scales, and precision polygon. Principle of the spirit level, clinometer, dividing head and sine bar.

Importance of minimising deflection in measuring equipment; support of straight edges, scales and end bar. Control measuring pressure, the fiducial principle, contact compression and deflection.

Surface texture; importance of surface texture on the attainment and retention of accuracy and its effects on stressed components. Principle of stylus method of measurement, centre-line average method of assessment, value of a recorded trace.

Surfaces typical of common maching methods, B.S. surface index numbers.

Principle of hardness testing; the ball and diamond pyramid tests.

LIMIT SYSTEMS AND GAUGING

Elements of systems of limits and fits; tolerance, limits, hole and shaft basis, disposition of tolerances. Accumulation of tolerance, probability of extremes of tolerance and practical consequences.

Outline of the structure of B.S. 4500 system of limits and fits, primary and secondary selection of fits, examples of selection of special fits, e.g., conversion from hole to shaft basis and fits to existing components. Tolerances obtainable with various machining operations.

Principles of positional and geometrical tolerancing with reference to B.S.308 and typical applications. Methods of dimensioning to avoid ambiguity and to aid production. The concept of virtual size.

Fixed size and adjustable plain limit gauges, elements of good design, application of Taylor's principle; reference to B.S.1044. Outline of methods and materials used in gauge manufacture, including stabilization. Wear and its effects, recovery of worn gauges. Gauge tolerances B.S.969.

Examples of gauges for hole centres, depth, concentricity, and other simple geometrical features. Simple position gauges.

Principles of gauging screw threads of vee form, full form and effective diameter gauges. Comparison of types of caliper gauges and use of setting plugs. An outline of the requirements of B.S. limit systems for screw threads.

ORGANIZATION OF INSPECTION

The position of an inspection department within the works organization, its functions, responsiblities, and relationship with other departments, executives and external authorities. The concept of quality assurance as a management function involving the inspection department.

General structure of inspection departments, effect of size of firm and type of product. Standards; the standards room, its authority and responsibility in relation to control of all measuring equipment. Basic equipment, location layout and personnel required. The certification of standards equipment, liason with N.P.L. and other bodies. Testing and approval of machine tools and reference equipment.

Tool and gauge inspection, relation to toolroom, sub-contract suppliers, and production shops. Review of types of work undertaken. Control of use, replacement, and rectification of gauging equipment.

Inspection of work in production; methods applied to pre-maching, first-off, in progress (floor) inspection, pre-assembly, subassembly, and final inspection. Scrap prevention and reclamation. Control of machine setting, selective assembly and graded output.

Final testing, running, life and acceptance tests.

Inspection unit for incoming materials, relationship to purchasing and sub-contract departments; outline of materials, supplies, and components within scope of this unit.

Use of specifications and contract agreements for raw, semi-finished, and finished products.

Arrangements for special tests for chemical and metallurgical properties.

Use of stamps, seals and identification marks; bonding and quarantine of stock; requirements of Government and other official inspectorates. Essential contacts with planning, production progress, drawing and design, and development departments to eliminate faulty processes and production.

The inspector as an individual: qualities, experience and training appropriate to various kinds of work, authority and attitudes in relation to other personnel. The ethical requirements of inspection work.

Inspection Processes

NOTE: Throughout each of the following courses constant referen should be made to the need for special care, maintenance, correct to storage and control of all inspection equipment.

Particular attention should also be paid to the role of measuri. processes in achieving effective product and process control.

A—PRECISION ENGINEERING

Use of slip gauges, length bars, and their accessories; rollers balls and precision straightedges for precision marking, setting out, and the inspection of gauges and forms.

Gauge measuring interferometers; use for the determination of parallelism, flatness and absolute length. The optical-flat and its uses. Precision steel flats and surface plates. Precision comparators such as Eden-Rolt, Brookes, and electrical types, their use for calibration and intercomparison of slip and gauges. Horizontal comparators for measurement of work such as length bars; importance of positions of support; Airy points.

An outline of the various uses of comparators and measuring machines.

Methods of measuring angles and tapers, using sine bars, angle gauges, polygons, circular scales, and their associated equipment. Taper-measuring machines.

Methods of measuring and testing the elements of external and internal screw gauges.

Interdependence of errors; actual and virtual effective diameter.

Checking of profiles using the profile projector and the toolmakers's microscope. Profile tracers.

Master gear hobs and gear-cutters; measurement of gear tooth sizes and profile errors using involute tester, rolling tester, tooth calipers and roller methods.

Roundness testing; equipment and methods used for roundness testing of cylinders and spheres. Interpretation of results.

Surface texture; use of electrical stylus type instruments to obtain average meter and recorded trace readings. Interpretation of results.

Alignment testing; instruments and methods used for inspection of machine tools and large structures. Standard alignment test charts for machine tools.

Examples of inspection techniques for composite, position, and receiver gauges.

B—PRODUCTION AND GENERAL ENGINEERING

A review of common micrometer, dial gauge, and other hand instruments for size control at the machine or for inspection use; value relative to limit gauging; susceptibility to wear and damage.

Typical comparators for machine shop use and their applications.

Methods of storage, maintenance, issue, and control of gauges for the production shop.

Examples of a typical range of gauges for standards machining processes.

Inspection procedure with standard equipment, for machined casting and similar components which may incorporate bored holes, coaxial and otherwise, with related plan machine faces, and angular relationship.

Use of the optical projector and inspection enlarger for product control and inspection for assembly and adjustment. Master forms and tolerance diagrams. Examples of direct projection during machining. Methods for the projection of re-entrant or hidden forms.

Examples of receiver and position gauges; typical applications including work such as the gauging of thin shells and geometrical features.

Control of surface texture in production, B.S. index numbers, comparison specimens and methods; workshop tests, trace analysis.

Operation and setting-up of typical multi-gauging, through-gauging, auto-section, and auto-sizing equipment.

An outline of measuring, sizing, and auto-control requirements for transfer line and similar continuous-machining processes.

Procedure for first-off inspection, inter-operational inspection, partial, selective and full inspection.

Statistical control, frequency distributions, typical shapes, average values, measures of variability. Estimating the characteristics of frequency distributions from random samples. Quality control charts for (a) attributes and (b) measured dimensions. Single-and multi-stage sampling schemes; concept of the operating characteristic curve. Inspection schemes measured dimension. NOTE: The mathematics of a particular type of sampling and lot size are not required.

C—MATERIALS AND TESTING

General details and test procedure for physical properties of materials, e.g., tensile, impact torsion, bending, ductility, and hardness testing. Requirements of the relevant British Standards.

Procedure for simple metallurgical tests such as sulphur prints, macro-etching, and spot tests for composition factor (identification). Other identification tests such as magnetic and wheel-spark tests.

Typical test requirements for finish and coating by paints, plantings and chemical treatments.

Instruments of the assessment of film thickness and porosity.

Examination of welds; macro-etching; B.S. tests.

Common faults in casting and forgings; methods of testing; use of cast-on and simulated test pieces; directional properties, selection and cutting of test pieces. Flaw detection by magnetic, flourescent, dye penetrant, acid, and chalk methods. Detection of internal flaws by ultrasonic testing.

An outline of the equipment and methods used in the industrial radiography of casting and welds; advantages and limitations (including cost). Radiation risk and control.

A review of the normal forms of supply of standard engineering materials and 'bought-out' raw or semi-finished parts. Characteristic faults, liability to damage, reliability of contract or specification. Importance of B.S.I. and other official recommendations or requirements.

Suppliers' liability for faulty workmaship or materials.

An outline of the normal equipment, location, layout and organization of a 'goods-inwards' inspection department.

Laboratory Work in Inspection Processes

It is intended that the instruction in Inspection Processes should be covered by a carefully planned combination of classroom work and practical work. Demonstration may be included but the work should, if possible, be performed by the students, either singly or in small groups.

Some topics might be covered entirely by practical work (this applies particularly to the methods of operation of equipment) and it is considered wasteful to duplicate such instruction in the classroom.

The arrangement of this work, and its exact form, are matters for the teacher, but it is expected that the work in each year of the course will include an experiment or investigation in not less than six of the types of work given below. The work is divided into three groups and at least one should be selected from each of the three.

GROUP I. MEASUREMENT

1 Gauge measurement by means of slip gauges, rollers, balls, etc.
2 Slip gauge measurement or calibration by precision comparator or interference methods.
3 Measurement of angle, taper, or circular division.
4 Precision measurement of a screw thread.
5 Precision measurement of form and size of gear teeth.
6 Measurement and assessment of surface texture, and its characteristics in relation to various machining processes.
7 Measurement of work by optical projection.
8 Alignment testing of machine tools or other equipment.
9 Examination for wear and damage, and calibration of hand measuring instruments or comparators.
10 The use of standard measuring instruments for inspection of standard machine castings or similar components with bored holes and angular faces.
11 Detection of errors in and use of a receiver gauge, multi-gauging device, auto-sizing device, or continuous machining control process.

GROUP II. STATISTICAL CONTROL

12 Statistical control exercise on attributes.
13 Statistical control exercises on measured dimensions.

GROUP III. TESTING

14 Standard commercial test for physical properties.
15 Metallurgical test on a material or component.
16 Test for the quality and adhesion of a surface film, plating, or other finish.
17 Standard test for welds.
18 Tests or sectioning to reveal faults in cast or forged parts.
19 Crack detection or ultra-sonic testing.

Applied Technology (Inspection)

The work of this part of the course should be divided into two parts as follows:

(a) For this subject it is recommended that for about two-thirds of the time students should work in small groups on joint projects. Examples of such projects are the complete alignment test of a machine tool, statistical control of the output from a machine, a set of related physical tests, or some similar tests.

The group should investigate and obtain all necessary information on operation of the test, and the verification or calibration of the test operation of the teset, and the verification or calibration of the test equipment. They should share the sections of the work, or alternatively seek results by separate methods so as to obtain effective cross-checking of their procedure. The object should be develop the ability to work together in a group, to plan and carry the project through to completion by proper use of time and facilities, and to ensure each student's contribution to the task.

Each project should be reported briefly in writing by each student in the group.

(b) Each student must perform, unaided, at least one inspection project on any appropriate topic selected from the appropriate syllabus in Inspection Processes A, B, or C, during the remaining one-third of the time allotted for Applied Technology.

The project should be equivalent to the task performed by a responsible inspector in industry. The student must write a report on the project specifying the errors discovered and committing himself to a decision as to whether the article inspected is satisfactory or not. Projects should, as far as possible, be examined relative to conditions specified by B.S. specification or other standard requirement, or by fixed sized and limits as on a working drawing.

Each project should be reported briefly in writing by each student in the group. The subject will not be examined by the Institute, but the colleges will be asked to report on all group and individual projects (including the colleges' assessment of the performance or contribution of each candidate) and they may also be asked to submit some, or all, of the candidates' reports for inspection by the Institute. At the discretion of the college, a candidate may be required to undertake additional project work.

Part III — Plant Engineering

PLANT ENGINEERING

The syllabuses are planned for those responsible for the selection, installation and maintenace of plant equipment in a factory or department, or for one or more of these functions in a large manufacturing or process plant under the direction of a qualified engineer.

All subjects should be taught from the point of view of those concerned with specification, supply, installation and operation of equipment rather than the specialized design and manufacture of major units.

The instruction should follow a carefully planned programme of classroom work, practical and investigation work to be carried out in the college and by visits to typical plants and plant maintenance departments.

Safety and safe practices must form an integral part of all instruction. Matters relating to safety may be expected to enter into examination quetions.

At all stages reference should be made to appropriate British Standards for items of plant equipment and to statutory safety regulations.

Plant Services

Extension of the Part II work on the supply, distribution and utilization of steam, fuel, air, gas, water, and electricity for power and processes, with reference to economical use.

Fire protection and fire-fighting equipment.

STEAM

Reducing heat demand. Basis of efficiency of heat usage, kg of steam per kg of moisture evaporated or kg of steam per kg of product. Mechanical extraction of moisture, for example by centrifuges, suction, pressure. Reducing air quantities, re-circulation. Working at lowest possible temperatures, thermostatic control. Reducing standing losses, process loading and speeds.

Thermal insulation of buildings; heat loss calculations; effect of insulation; the cost of insulation; alternative methods of insulation.

The use of low grade heat. Maximum boiler feed temperature, maximum heat yield from economiser, hence economiser inlet temperature and condensate return temperature. Condensate return systems; condensate as boiler feed or process hot water. Flash steam recovery; calculation of flash stam quantities; plant to utilise flash steam. Recovery of heat from simple engine exhaust, feed pumps, steam hammers, etc. Recovery of process vapours, economies possible and difficulties to be recognized. Heat recovery from process hot liquors. Process preheating. Unorthodox use of economisers.

INTERNAL COMBUSTION ENGINES

Selection, installation, operation and maintenance of compression ignition engines for stand-by plant and mobile equipment.

GASES

The characteristics of town gas and producer gas. Their control and distribution.

LUBRICATION

Properties and selection of lubricants.

The application of refrigeration to manufacturing and process work. Refrigerants and their thermal and physical properties.

Refrigeration cycles in general use. The compression-expansion cycle; effect of choice of refrigerant on pressure and temperature ranges; cooling systems. The absorption cycle and its applications.

Comparison of the two cycles in relation to typical plant requirements.

MATERIALS HANDLING

Properties of materials which influence the selection of particular types of conveyor and other equipment for movement, storage and bulk measurement.

The special characteristics of various forms of solid fuels which determine the methods of handling fuel and ash.

ELECTRICAL DISTRIBUTION

Review of systems of distribution for manufacturing and process plants; voltage regulating devices and equipment for power-factor improvement. Tariffs. Simple measurement of maximum demand kWh and kVAh and meaning of load and diversity factors.

Units and standard of illumination; use of light meters; comparison of filament and discharge types of lamp in relation to intensity of illumination, utilization, running costs, installation costs and associated problems. General principles of illumination systems.

Plant Installation and Maintenace

Factory legislation in so far as it concerns the plant engineer; statutory requirements. Fire Protection and fire-fighting equipment.

PLANT INSTALLATION

Preparation of typical layout drawings line diagrams and sketches of plant installations including power supplies, ancillary services, processing operations and materials handling equipment; use of standard symbols. Preparation of equipment schedules and planning schemes for the installation of equipment in a new or converted building.

MAINTENANCE ORGANIZATION

Determination of permissible intervals between regular inspections and overhauls of various types of plant, including the application of simple statistical methods and with reference to statutory or other requirements.
Organization of supply and storage of spare units, components and materials to facilitate maintenance and reduce lost operating time.
Selection, training and organization of personnel required by the maintenance department. Planning of load charts and work cards.
Internal standing orders and procedures to deal with sudden breakdowns and emergencies.

Laboratory and Project Work

It is intended that the instruction in Plant Engineering should be covered by a carefully planned combination of classroom work and practical work. Demonstration may be included, but the work should, if possible, be performed by the students, either singly or in groups.
Some topics might be covered entirely by practical work and it is considered wasteful to duplicate such instruction in the classroom.
The arrangement of this work, and its exact form, are matters for the teacher, but it is expected that the work in the course will include not less than EIGHT of the topics given below, of which at least THREE should be selected from those marked*, and to which others may be added by the teacher.
Many of the experiments can be carried out in the Mechanics and Heat Engines Laboratories of the college but others should be performed on instaled items of equipment using commercial procedures and instruments and therefore may be regarded as group projects.

1 Measurement of steam quality using separator, throttling calorimeter, gauges, and thermometers.
2 Measurement of calorific values of solid, liquid, and gaseous fuels.
3 Experiments to compare the insulating and heat resisting properties of various forms of thermal insulation.
*4 Efficiency and performance test on a steam boiler.
*5 Efficiency and performance test on a simple reciprocating steam engine or turbine.
*6 Efficiency and performance test on a reciprocating internal combustion engine.
7 Exhaust gas analysis using commercial equipment.
*8 Routine test on an air compressor (reciprocating or rotary) to measure power supplied; temperature changes throughout the cycle, pressure, temperature, and volume of the air output.
9 Measurement of air or gas flow in pipes including the effect of bends and obstructions.
10 Measurement of water flow using a venturimeter and some types of commercial instruments.
*11 Routine test on a hydraulic pump (reciprocating or rotary) measuring power supplied, output volume pressure and velocity of liquid.
12 Testing typical plant electrical circuits for continuity and resistance to earth using commercial equipment.
13 Commercial tests to B.S. specifications of materials in common use in plant construction such as concrete, brickwork, timber, structural steel, cast iron.
14 Tests on various proprietary types of holding-down bolts and fixing devices.
15 Installation alignment tests for plant such as machine tools, main and counter shaft drivers, coupled motors and generators.

* These tests should include starting-up and shutting-down procedures where appropriate.

Applied Technology (Plant Engineering)

This subject is additional to the practical and investigation work of the main course and should take the form of a planned scheme of project work.
It will entail students working together in groups, using information arising from a Works visit (or a series of Works visits) or extracted from specifications prepared independently. At least ONE project should be concerned with Plant Maintenance (see 1 below) and at least ONE with Plant Installation or Conversion (see 2 below). The project can be based on a local requirement.

1 PLANT MAINTENANCE

The preparation of a detailed scheme of preventive plant maintenance, including routine tests of materials and equipment (including materials handling equipment) and the provision of stand-by and emergency equipment, e.g.,
(a) a manufacturing unit based on fabrication by casting or welding, followed by machining and assembly processes,
or
(b) a small chemical manufacturing plant or section of a larger plant involving special processes and handling equipment for a range of materials,
or
(c) a works power station using solid or liquid fuel, distributing power and process steam over a range of shops and warehouses.

2 PLANT INSTALLATION AND CONVERSION

The preparation of a scheme of plant conversion or installation including the preparation of detailed instructions, layout drawings and time schedules or charts to cover plant removal, alterations to buildings and supply points, installation and testing of old and new equipment and internal distribution of supplies, materials and products, e.g.,

(a) a works power supply installation from steam generation to internal combustion engines, or
(b) a manufacturing shop from belt-driven machines to a system involving unit-drive machines and extensive materials handling equipment to assembly points,
or
(c) the installation of equipment in a large warehouse to meet the requirements of a 'distribution-to-retailer' service of a wide range of refrigerated products and packaged goods,
or
(d) the layout of a boiler plant for process steam and system for space heating in a small factory.

Each project should be reported briefly in writing by each student in the group. The subject will not be examined by the Institute, but the colleges will be asked to report on all group and individual projects (including the colleges' assessment of the performance or contribution of each candidate) and they may also be asked to submit some, or all, of the candidates' reports for inspection by the Institute. At the discretion of the college, a candidate may be required to undertake additional work.

Part III — Press Tool Design and Utilization

PRESS TOOL DESIGN AND UTILIZATION

Safety and safe practices should form an integral part of all instruction, especially that relating to machinery in motion and to electrical supplies. Matters relating to safety may be expected to enter into examination questions.

PRESS TOOL DESIGN AND UTILIZATION

MATHEMATICS

Extension of previous work on calculus to the determination of maxima and minima; practical applications such as the determination of an optimum batch size, optimum dimensions, and minimum usage of materials.
Extension of Part II work on the Poisson and Binomial Distribution to inspection by sampling and the formation of a quality control chart for attributes.
Further work on Guldinus' theorem such as the determination of blank sizes for thin and thick circular shells. Simple calculations on load and deflection of close coiled helical springs used in preswork (without rigorous proof of formulae).

PRESSES

Brief review of the Part II on mechanical presses namely the geared and ungeared C-type and straight-sided presses, the double-action press and the press brake. Theuse of a double description of the construction and the press brake. (The use of a double description of the construction presses, and the multi-slide forming machine.)
C-type and straight-sided presses, the double-action press and the press brake. The use of a double-action press used as a triple-action press with the aid of a die-cushion.
Brief description of the construction and use of the coining, toggle, friction screw, high speed 'pull-down' presses, and of the multi-slide forming machine.
The hydraulic press; construction and use, comparison with the mechanical presss, typical hydraulic circuits. Associated calculations, e.. load on ram, speed of ram, and rise of temperature of the working fluid flowing through a pressure-reducing valve.
Simple velocity diagrams to obtain speed of drawing at particular points in the stroke and the motion of ancillary equipment such as feeding mechanisms. Consideration of fly-wheel size and speed in relation to energy absorbed in press-working operations.
Feeding mechanisms review of methods previously covered in the Part II syllabus; the 'mechanical hand' and the bow feed'. Linking of tools in a single press and the use of slider feed mechanisms. Linking of presses by conveyors hoppers and chutes.
The guarding of presses, mechanically operated guards; interlocking guards; sequentially operated guard with pneumatic control.
Method of ejection, e.g., knockouts, springs, die-cushions, inclining of presses; disposal of scrap, scrap cutters.

PRESS TOOL DESIGN

Capacity diagrams for presses, determination of closed tool height and maximum working area. The use of standardised pillar die sets.
Selection of materials used for press tools, including high-grade cast irons, low-melting point alloys and non-metallic materials. Methods of heat treatment and special precautions to avoid distortion.
Design of press tools for the following (including special consideration of the economic use of product material):
(a) cutting operations of the follow-on, compound and combination types;
(b) forming operations including follow-on and compound tools of the the pierce, form, and crop types;
(c) combination blank and draw tools, re-drawing tools, including consideration of blank holders, die faces and draw beads;
(d) tools to expanding, contracting, curling, wiring assembly;
(e) tools for trimming, broaching and shaving, including the use of the lathe in trimming.
Consideration of design requirements for work of very large size as forming tools for body panel on automobiles.

PRESSWORKING TECHNOLOGY

Press capacity, variation with stroke position. Further calculations on pressure required for cutting operations and for drawing of circular shells.

A simple approach to the metallurgy of deep-drawing; grain size, normalizing, annealing, age hardening and refrigeration, work hardening; use of roller levelling. Defects in the raw material; non-metallic inclusions, laminations, sub-surface discontinuities.

Defects due to the pressworking operation; puckers and wrinkles, tearing, age hardening, season cracking, stretcher-strain markings, orange-peel' effect.

Brief review of forming operations allied to presswork such as impact extrusion, explosive forming, stretch forming and hydroforming.

The use of rubber for cutting and forming operations.

Lubrication; drawing lubricants, methods of application to materials. Phosphating. Particular requirements for extreme pressure operations such as impact extrusion. Review of the assembly technique associated with pressworked components; spot, seam, stitch and projection welding, riveted joints with sold and 'pop' rivets. Mechanical joints formed by presswork. Adhesives.

MATERIALS FOR PRESSWORKING OPERATIONS

Materials used for production of components by pressworking; forms of supply and condition. Tolerance on metal thickness and its effect on finished components and pressworking operations.

Testing procedures on sheet metal; tensile, bend, and hardness tests, Olsen and Erichsen drawing tests, and their liminations.

Laboratory Work in Press Tool Design and Utilization

It is intended that the intruction in this subject should be covered by a carefully planned combination of classroom work and practical work. Some topics may be dealt with wholly through through practical work (this applies particularly to defects which arise because pressworking) and t s consdered wasteful to duplcate such instructions in the classroom.

The arrangement of this work, and its exact form, are matters for the teacher, but it is expected that the work will include not less than eight of the topics given below, to which others may ge added by the teacher.

1 Determination of stresses in a press frame under static load by the use of strain gauges.
2 Determination of velocity of a ram through experimental recording and numerical analysis of its position in the stroke with respect to amount of crankshaft rotation.
3 The construction of a timing diagram of a double-action press, from measurements taken experimentally on the press.
4 The determination of a blank size for a drawn shell and its subsequent proving by dummy tools.
5 A complete test on sheet material, to include tensile, bend, hardness and cupping tests.
6 The formation by simulation experiments of a quality control chart for attributes.
7 Micro-examination of a deep drawing material before and after a severe drawing operation.
8 The effect of the speed of drawing on the maximum depth of a simple drawn cup.
9 The construction of a complete capacity chart for either a single-action or a double-action press.
10 The effects of different lubricants in a drawing operation.
11 The effects of variations in metal thickness in a drawing operation.
12 Load/compression tests on springs to show general effect of number of coils, outside diameter and wire diameter.
13 'Swift' cupping test for limiting blank diameter.
14 The effects of punch radius, profile of die, and provision of dr beads in a drawing operation.

Applied Technology (Press Tools)

For this subject it is recommended that, for much of the time, the students should work in groups on joint projects. An example of such a project would be to take an assembly drawing incorporating several sheet metal components, as could occur in a portion of an aircraft, to prepare operation sheets for manufacture and assembly and to design the necessary tooling. The work may include the preparation of different designs for the same operation to obtain comparion of tool costs. Some of the tools might be made by other classes in the college but each student in this course should undertake some practical work in addition to actual design or calculations, such as testing of the raw material, tool setting, tool proving and dimension checks on finished components.

The object should be to develop the ability to work together in a group to execute forward planning of a project, and to carry it through to completion by proper use of time and facilities available within the group. It is not essential to provide each student with the same experience, but to ensure his contribution to the task. A project might require from a few weeks to some months.

Each project should be reported briefly in writing by each student in the group. The subject will not be examined by the Institute, but the college will be asked to report on all group and individual projects (including the colleges' assessment of the performance or contribution of each candidate) and they may also be asked to submit some, or all, of the candidates' reports for inspection by the Institute. At the discretion of the college, a candidate may be required to undertake additional project work.

RESEARCH AND DEVELOPMENT

NOTE: The following syllabus should be treated as an extension to that of Special Technology Part II (Testing and Development) with some repetitions and study in greater depth of items included in the syllabus.

The instruction should follow a carelly integrated programme of (a) classroom work;

(b) practical work to be carried out in the college; (c) investigation and project work which may be carried out in the college laboratory or, where practicable, in conjunction with an industrial concern.

At all stages reference should be made to the appropriate British Standards and/or accepted Codes of Testing Practice.

Safety and safe practices should form an integral part of all instruction. Matters relating to safety may be expected to enter into the examination questions.

Mathematics and Science are examined as separate subjects, but work beyond that of the Part II syllabuses should be included when appropriate to the technology content of particular sections.

Research and Development Technology—Theory

BASIC MEASUREMENTS AND INSTRUMENTATION

Types of transducers; mechanical, electrical, eletronic, pneumatic. Circuits employed to enable transducers to provide the type of display required, (a) indicators, (b) recorders.

Basic design features and ideal requirements of mechancal mechansms used in instrumentation:

(a) low friction, high stiffness;
(b) rotation about a fixed axis;
(c) motion along straight lines.

Illustrations to be taken from mechanisms forming the basis of such instruments as recorders, indicators, counters, meters for liquids and gases.

Performance and criteria of suitability, (a) high degree of repeatability, (b) accuracy of calibration.

Engineering and dimensional metrology.

Establishment of basic size; direct measuring instruments; comparator systems of measureemnt.

Applications to: measurement of regular geometric shape; measurement of surface texture; measurent of angle; measurement of profiles including cams, gears, aerofoil sections, screw thread forms, sections of solids of revolution. Dynamic characteristics of mechanisms.

Newton's laws of motion.

The basic theory of simple harmonic motion and vibration of spring-mass or equivalent combinations.

Considerations of the effects of damping and periodic loading. A rigid mathematical treatment is not expected, but sufficient demonstration and laboratory experiment should be included to give a general picture of forced vibrations over a range of frequencies, the conception of critical frequency, resonance and dynamic magnification, together with methods of damping and the effects of viscous friction upon the frequency, phase and magnitude of forced vibrations.

Principles of automatic control applied to: open and closed loop systoms, proportional, differential and integral control systems.

TESTING OF MATERIALS AND STRUCTURES

Impact testing of metallic and non-metallic materials; standard tests and and interpretation of results.

The behaviour of materials under repetitional loading; fatigue testing by laboratory and commercial methods and equipment, effects of surface texture on fatigue properties. Special tests devised for materials in relation to their use and methods of manufacture with particular reference to:

(a) press-work,
(b) machineability,
(c) weldability,
(d) high temperature application,
(e) shock loading.

Methods of investigating the strength and rigidity of structures incorporating welded, riveted and adhesive joints.

Use of scale models in investigating the strength and rigidity of structures with an introduction to dimensional analysis and scale-effect.

Environmental testing.

POWER SUPPLY

The three-phase alternating current supply as available from the national grid. Local h.t. transformers for large users. Tariffs for industrial users maximum demand and off-peak rates. Power factor correction.

Control gear for three-phase electrical equipment. Types and characteristics of three-phase motors.

Single-phase electrical supplies. Types and charateristics of single-phase motors and control equipment.

Types and applications of electrical dynamometers.

Safety precautions and regulations.

Hydraulic pumps and motors. Efficiency characteristics of constant and variable displacement equipment. Hydraulic cylinders and piston arrangements. Methods of control for common applications. Advantages of hydraulic power supplies.

Provision of compressed air as a common supply service.

Types and characteristics of compressors. Cooling, filtering and drying arrangements. Layout of supply network. Efficiency of pneumatic units. Range of control equipment available.

Advantages of air as a source of power for air motors and cylinders and piston arrangements.

MACHINING PERFORMANCE

The performance and reliability of the general elements of a machine tool. Exploration of the problems concerned, including transmissions, bearing slides and the maintenance of accuracy.
The basic principles of copying and generation.
Inspection and measurement (including geometrical accuracy) of work produced by different machining methods.
Investigation of the effects of different machining processes on the physical properties of the component material. Economics of different machining methods. Technical and economic exploration of tool wear, tool life and power consumed under various conditions. Coolants and cutting fluids. Examination of their properties and their influence on machining and cutting-tool characteristics.
The cold forming of metals on presses and other machine tools. Examination of the factors concerned with successful operation and further development of such processes.
The manufacture of parts in thermo-plastics and thermo-setting materials. The machining of plastics. Investigation of the physical and and economic factors involved.
Vibration and shock loading of machines and cutting-tools (including grinding). Investigation of this occurrence including the effects on machining finish.

Practical Work

Extension of the laboratory work of the Part II syllabus to cover investigation in greater detail and to include:

1 Calibration of instruments used for assessment and measurement of size, geometric form and surface texture of components.
2 Use of models to investigate the motion of a spring-controlled mass in forced and damped vibrations.
3 Investigation of the characteristics of simple dynamic instruments incorporating varying degrees of damping.
4 Calibration of tool dynamometer.
5 Measurement of the deflection characteristics of a built up structure incorporating welded and/or riveteed and adhesive joints under different conditions of support and loading.
6 Suitability of various power supplies.
7 Investigation into movement-ratio, force (or torque) ratio, power transmitted and efficiency of transmissions incorporating machanical, electrical, hydraulic and pneumatic systems.
8 Investigation of the movement ratio and force (or torque) ratio of a cam-operated mechanism.
9 Comparison of physical properties of (a) high-strength materials (b) allied iron in relation to standard tests.
10 Tests for materials under repetitional loading with interpretation of results.

Crack detection of metallic materials.

Organization and Administration

The need for testing and development and the part it plays in relation to research (including market and cost research), design and production.
A detailed examination of the essential stages in development of a product, assessment of technical possibilities; progressive appraisal of design alternatives, testing a each stage of development up to final approval for quantity (as distinct from prototype) production. The construction of a time schedule for a research and development programme with consideration of the need for reassessment in the light of actual progress at various stages. Possibilities of reducing the time schedule by the use of rigs and simulators; improved instrumentation; planned use of available manufacturing and testing facilities; incorporation of standard components in testing and development of equipment.
Sources of information available to testing and development personnel; research associations; national and industrial laboratories and their publications.
Need for close contacts with design, planning and production departments to ensure rapid and precise interpretation of the findings of research and development.

Applied Technology (Research and Development)

For this subject it is recommended that for much of the time students should work in group projects of not less than four per group.
The object should be to develop the ability to work together as a group, to execute forward planning of a project and to carry it through to completion by proper use of facilities and of the abilities within the group.
The group should plan the work to be done and produce a scheme and time schedule for its completion.
It is not essential to provide each student with the same experience, but rather to ensure his contribution to the work of the project.
It is expected that any project will be related to the complete investigation of the performance and characteristics of an existing product and prototype and the work should include:
(a) The specification of the product and the proposed method of mounting or instalation for test;
(b) the selection and calibration of any instrument to be used;

(c) the design and manufacture of any rigs, fixtures or brackets required;
(d) a detailed statement of the observations to be made with reasons for their selection;
(e) analysis of calculations involved and of the method of presentation of results by tables, charts or graphs;
(f) a summary of the conclusions arrived at from the test;
(g) recommendations for further development tests, specifying the range of variables affected, with a view to improvement overall or in one or more important details.

The selection of the project subject may well be decided by the local conditions at the college or in industries with which the students are associated; typical examples could be:

(a) A test on a machine tool including alignment and performance tests; recording of tool loads; analysis of geometrical and dimensional accuracy and of surface textures. All these associated with the effects of changes in speed, feed, depth of cut, tool material and tool angles.
(b) A complete test on a light steel frame or fabricated structure incorporating welded and/or riveted joints to investigate the deflection at various points in the structure under different loading conditions.
The final recommendations could include suggestions for modifying the structure to control or limit particular deflections.
(c) A test on an internal combustion engine, to include investigation of fuel characteristics, air and fuel supply, engine performance, heat-flow characteristics and a complete energy balance sheet under varying conditions of speed and output with a view to recommending an optional condition in relation to one variable.
(d) The design, manufacture and test of a model or rig to simulate a large-scale assembly of materials handling or conveyor or conveyor equipment to investigate the possible defects and performance and to include some consideration of scale-effect.

The project should be reported by each member of the group in writing. Colleges will be asked to report on all group and individual projects, including the college assessment of the performance and contributions of each candidates.

Colleges may be asked to submit some, or all, of the candidates' reports for inspection by the Institute.

At the discretion of the college, a candidate may be required to undertake additional project work.

CONTROL ENGINEERING

Control Systems Technology

MATHEMATICS

Further work on harmonic response plotting. Graphs involving logarithmic scales. Application to logarithmic form of steady state harmonic response.

Dynamic analogues. Determination of analogue quantities by comparison of coefficients of similar equations. Scaling. Simulation of simple transfer functions using d c. amplifiers and r.c. networks. Flow diagrams applicable to simple simulators.

Furtherwork on binary codes, and co-ordinate geometry associated with numerical control.

CONTROL SYSTEMS

Detailed study of servomechanisms, including:

(a) hydraulic servomechanisms,
(b) pneumatic servomechanisms,
(c) electro servomechanisms.

Discussion of the influence of noise on control-system performance and instrument measurements.

Further work on types of controller and methods used to generate the required control actions: pneumatic, hydraulic electric and electronic. Programmes control, ratio control, cascade control and feed-forward control, feedback compensation. Use of output derivatives to achieve desired performance of kinetic control systems.

Investigation of control-system behaviour in response to various standard inputs; improving transient and frequency response; methods of reducing and eliminating steady-state error in servo-systems, simple calculations based on the foregoing. Further performance calculations based on the use of standard data sheets. Determination of absolute stability and limiting time constant using Routh Hurwitz. Graphical methods of stability investigation. Nyquist, inverse Nyquist and Bode diagrams. Nichols charts. Fault finding using transient and frequency response techniques. Fault finding in typical simple systems.

Control Systems Applications

The examination paper will be set such that the candidate must answer questions based on Part A but will be given suitable options between Parts B and C.

PART A

More advanced work on pneumatic and hydraulic components and their combination into operating circuits. Introduction to electric, hydraulic and pneumatic logic circuits. Diagnosis of faults in simple logic circuits.

The principle of operation; use and limitations of the following:

(a) a.c. to d.c. conversion and stabilized power supplies,
(b) pentode valves and amplifiers,
(c) a.c. and d.c. amplifiers, drift; further work,
(d) semi-conductors amplifiers: comparision with valve-amplifiers,
(e) power amplifiers,
(f) use of cathode ray oscilloscope, in fault finding and testing,
(g) electronic voltmeter,
(h) rotary amplifiers,
(i) instrument servomechanisms,

(j) commercial dynamic test equipment currently available.

DATA PROCESSING

Analoque and digital methods. Methods and systems used for programming computation and recording; use of punched cards and punched and magnetic tape. Interpolation in machine-tool control systems.

CONTROL SYSTEMS COMPONENTS

Description of principles of operation and performance limitations of the following:
Transducers: electro-pneumatic; electro-mechanical; electro-hydraulic.
Transmitters: electrical and pneumatic.
Valve positioners: electrical and pneumatic

PART B

Description of non-linear phenomena, common non-linearities. Machine control, derivation of sequence charts for point-to-point machining operations from numerical information contained in punched cards or punched/magnetic tape form, such continuous contouring machines. Analogue simulation of simple dynamic systems. Incorporation of simulators for complete systems testing.
Discussion of problems met in the control of large inertia loads through flexible drives.
Discussion of problems met in hydraulic servomechanisms due to oil compressibility.

PART C

Revision and further applications of the systems studied in the second year of Part II.
Multiloop control systems. Estimation of simple load characteristics using harmonic response techniques.
Detached application of process control, including computer control to complex industrial manufacturing processes, e.g.:
(a) production of paper,
(b) steel industry,
(c) petroleum industry,
(d) gas reforming.
Matching a three-term controller to a process. The start-up problem of a batch process.
Forces acting on a valve stem, hysteresis. Use of valve positioner.

Some Possible Projects

(a) Setting up of an investigation of mixing or blending processes, paying special attention to varying environmental changes.
(b) Building a physical model of a two-stand rolling mill using plasticine or a similar material as the working substance.
(c) Building a control system to position an airfoil in a duct with variable air flow.
(d) Building a water-level control rig with facilities for demonstrating the effect of changes of supply, load and process characteristics.
(e) Other appropriate proposals which are related to local industry.

PLASTIC MOULDS DESIGN AND UTILIZATION

NOTE: It is recommended that this course should comprise at least 400 hours of study, including 100 hours of Applied Technology.

MATHEMATICS

Calculations of volumes of mouldings; more difficult examples of surfaces and volumes of revolution using the theorems of Pappus and/or Guldinus (candidates are not expected to remember positions of centroids of centroids of figures such as sectors and segments. Tabulated values for reference should be used and will be provided, if necessary, in examination questions). Review of the simple differentiation in the Part II course; extension to repeated differentiation and to maxima and minima; practical problems such as size of cylinder for minimum surface area and the determination of an optimum batch size based upon setting cost, and manufacturing cost, storage cost and financial charges. A review of Binomial (or Bernoulli), Poisson and Normal (or Gaussian) distributions. Extension to the construction of quality control charts for attributes and for variables. Descriptive (non-mathematical) treatment of single, double, and sequential inspection sampling.

SCIENCE

Review of stress, strain and the moduli of elasticity and rigidity. Volumetric stress (pressure), volumetric strain and bulk modulus. A simple approach to the theory and application of strain gauges. The deflection of flat and circular plates; calculations using standard formulae excluding proofs. (Candidates are not expected to remember formulae; if needed in examinations they will be given.)
Link mechanisms; the instantaneous centre, veocity diagrams (but NOT acceleration diagrams).
A review of previous work on hydraulics; typical hydraulic circuits on

plastics moulds presses; simple applications of the Bernoulli theorem; hydraulic intensifiers.

Compressible fluids; Boyle's, Charles', and the combined gas laws; simple calculations on flow of compressed air (using standard formulae which will be given if required in examinations and excluding development and proofs).

PLASTIC MATERIALS

(The nomenclaure of B.S: 3502 should be used, avoiding trade names or involved chemical teminology, e.g., PMM and not perspex or polymethylmethacrylate.)

NOTE: It is expected that teachers will refer to new plastics as they appear, e.g. PTCFE and ABS, but examination questions will be restricted to those quoted.

Initial separation into thermosetting plastics and thermoplastics. Additives to the basic plastics material, including fillers, dyes, lubricants and accelerators. Market forms of supply including powders, sheet, tube, rod.

A simple approach to the properties, applications and manufacture of thermosetting plastics including PF, UF and MF types.

A simple approach to the properties applications and manufacture of thermoplastics including PS, PE, PVC, PMM and Nylon types. Polyesters and Epoxy resins.

PLASTICS PROCESSES AND PLANT

Moulding presses; vertical up-stroke and down-stroke presses; general construction; provision of heat and associated simple calculations; machine specifications, maximum daylight and pressure; pressure on platens relating to materials and moulding size.

Simple circuit diagrams of electrical, pneumatic, hydraulic and combination circuits, using BS symbols and nomenclature.

Injection machines; capacities and dimensions, closing devices heat supply.

Further consideration of the compression and transfer moulding processes with reference to factors influencing output and efficiency.

Calendering, extrusion, vacuum and blow moulding processes, with brief description of the machines. The manufacture of plastics laminates. Pelleting, preforming, preheating and material reclamation. Double ejection devices for positive ejection to conveyors.

PLASTICS MOULD DRAWING AND DESIGN

The influence of themoulding process on design. Design features to be recommended or avoided in the design of the products. Consideration of manufacture of mould, e.g., availability of hobbing and/or diesinking and jigboring.

The systematic approach to mould design by the use of a design study, simple approach (graphical) to the break-even point and cost of tooling. Effect of component design on detail features of the mould; cavity size, area, depth, bulk factor; inserts, angled pins, split dies; multi-cavity dies; runner design, localized heating. Special considerations for injection moulding; ejection devices; special requirements with more complex forms, e.g. undercuts, re-entrant forms, geared systems for threads and bench rigs for pin extraction. Machine selection, shot capacity, clamping force, injection pressure, plasticizing rate; type of feed. Design of chamber and feeding devices to ensure efficient cleansing out of plastic material. Overheating of mould as limitation to production rate, temperature control including refrigeration.

Considering of mounting moulds in presses; closed height, tie bar and frame distances, clamping, maximum and minimum ejection, heating arrangements.

General arrangement and detail drawings of:

Compression moulds, two-plate and three-plate.

Transfer moulds.

Injection moulds.

MANAGEMENT AND ORGANIZATION

The function of the manufacturing and allied departments and their relationship to other departments. The particular function of the tool drawing office Progressing and scheduling, both of components and tools. Tool storage and tool maintenance.

LABORATORY WORK IN PLASTICS MOULDS DESIGN AND UTILIZATION

It is intended that the instruction in this subject should be covered by a carefuly planned combination of classroom work and practical work. Some topics may be dealt with wholly through practical work (this applies to such topics as the behaviour of plastic material during moulding, flow properties, shringage) and it is considered wasteful to duplicate such instruction in the classroom.

The arrangement of this work and its exact form, are matters for the teacher, but it is expected that the work will include not less than six of the topics below, to which others may be added.

1 The use of strain guages to determine stresses in the hydraulic press with particular reference to the deflection of the platen.
2 Testing plast[illegible] materials for mechanical properties, i.e. tensile strength, elongation at breaking modulus, shear strength, impact strength.
3 Testing plastic materials for flow propertiese. The effect of heat and pressure on the flow of both thermosetting and thermopla[illegible] materials.
4 Testing plastic materials for thermal properties, heat resistance and decomposition.

5 Testing plastic materials for chemical and/or electrical resistance.
6 Thermosetting Plastics.
The effect on component quality of:
(a) Insufficient material in mould.
(b) Variations in curing time.
(c) Variations in mould temperature.
7 Thermoplastic.
The effect on component quality of:
(a) Variations in freezing time.
(b) Variations in temperature.
(c) Variations in platen and injection pressure.
8 The determination of optimum cycle time for a given component.

APPLIED TECHNOLOGY (PLASTICS MOULDS)

For this subject it is recommended that, for much of the time the students should work in groups on joint projects. An example of such a project would be to take a typical plastics component presenting a number of production/design problems, and to prepare assembly drawings of the moulds, together with the necessary operational planning data.
The work may include the preparation of different types of moulds and/or materials to compare tooling costs and material costs involved in the use of different materials. Some of the tools may be made by other classes in the college, but each student in this course should undertake some practical work in addition to actual design or calculations, which should include operations as:
(a) Workshop exercises involving specialized techniques such as cavity milling use of rotary table for circular tangential forms, extended pitch screw threads.
(b) Modification of existing moulds to improve production methods, e.g., conversion to automatic moulding.
(c) Making necessary fitments for fixing moulds, ejector details, plates, pins of various types.

(d) Manufacture of extension dies to produce specific and the possible subsequent modification to ensure meeting specification.
The students may be presented with a problem which will involve the design or redesign of a mould to produce either a new or redesigned component and enable a more efficient method of production to be employed. A tangible and practical problem should be posed and the students be allowed to solve it with the minimum of guidance.
The object should be to develop the ability to work together in a group to execute forward planning of a project and to carry it through to completion by proper use of time and facilities available within the group. It is not essential to provide each student with the same experience, but to ensure his contribution to the task. A project may require from a few weeks to some months.
Each project should be reported briefly in writing by each student in the group.

The subject will not be examined by the Institute, but the college will be asked to report on all group and individual projects (including the college's assessment of the performance or contribution of each candidate), and they may be asked to submit some, or all, of the candidates' reports for inspection by the Instiute.
At the discretion of the college, a candidate may be required to undertake additional project work.