

IVQs in Engineering (2565)

**Level 5 IVQ Advanced Technician Diploma
in Engineering**

**– Mechanical Engineering – Manufacturing
– Mechanical Engineering – Plant Technology
(2565-03) (500/5794/7)**

Qualification handbook for centres



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Important notice

Following the accreditation of the Technician IVQs in Engineering (2565) on the National Qualifications Framework of England, Wales and Northern Ireland (NQF), some changes have been made to the qualification, at the request of the Office of the Qualifications and Examinations Regulator (Ofqual), the qualifications regulator in England.

These changes took effect on 1 June 2009 and are outlined on pages 5–6.

Note: the content of the qualifications has not changed following accreditation.

Changes to the qualification titles

The qualification titles have changed as follows:

Advanced Technician Diploma in Engineering – Applied Mechanical Engineering (Manufacturing) (2565-03)
changed to

Level 5 IVQ Advanced Technician Diploma in Engineering (Mechanical Engineering – Manufacturing) (2565-03)

Accreditation number: 500/5794/7

Advanced Technician Diploma in Engineering – Applied Mechanical Engineering (Plant Technology) (2565-03)
changed to

Level 5 IVQ Advanced Technician Diploma in Engineering (Mechanical Engineering – Plant Technology) (2565-03)

Accreditation number: 500/5794/7

Changes to the unit titles

Following the accreditation of the Technician IVQs in Engineering, each unit has been given an accreditation reference number which will appear on the Certificate of Unit Credit.

The content of the units is unchanged.

Level 5 IVQ Advanced Technician Diploma in Engineering (Mechanical Engineering – Manufacturing) (2565-03)

Accreditation number: 500/5794/7

F/502/2583 – Computer Aided Draughting 2 Practical Assignments

J/502/2584 – Engineering Project

L/502/2585 – Mechanical Principles

R/502/2586 – Engineering Materials and Processes

Y/502/2587 – Advanced Manufacturing and Management

D/502/2588 – Advanced Manufacturing Engineering Practical Assignments

Level 5 IVQ Advanced Technician Diploma in Engineering (Mechanical Engineering – Plant Technology) (2565-03)

Accreditation number: 500/5794/7

F/502/2583 – Computer Aided Draughting 2 Practical Assignments

J/502/2584 – Engineering Project

L/502/2585 – Mechanical Principles

H/502/2589 – Plant Technology and Maintenance Procedures

Y/502/2590 – Advanced Plant Practical Assignments

D/502/2591 – Plant Hydraulics and Pneumatics

H/502/2592 – Plant Hydraulics and Pneumatics Practical Assignments

Registration for theory examination

Registration process for the theory examination has not changed.

Result submission for practical assessment

Result submission process for the practical assessments has not changed.

Change to the grading

The grade 'Credit' has been changed to 'Merit'. All other grades are unchanged. The content of the units concerned is also unchanged.

Notification of Candidate Results (NCR) and Certificate of Unit Credit (CUC)

Notification of Candidate Results (NCR) and Certificate of Unit Credit (CUCs) continue to be available on completion of each assessment (theory or practical).

Final certificate will be issued on successful completion of all the required assessments.

'Theory only' routes

The 'Theory only' routes continue to be available as unaccredited qualifications.

Changes to the certificate layout

Certificates issued on completion of an accredited IVQ show the accredited title and the accreditation number for the qualification. The level in the accredited title refers to the NQF level the qualification is accredited at.

The certificate also lists all the units achieved, including the grade and the unit accreditation number.

The certificate carries the logos of the regulatory authorities in England, Wales and Northern Ireland indicating that the NQF accreditation only applies to these countries.

Levels of City & Guilds qualifications

All City & Guilds qualifications are part of an integrated progressive structure of awards arranged over eight levels, allowing people to progress from foundation to the highest level of professional competence. Senior awards, at levels 4 to 7, recognise outstanding achievement in industry, commerce and the public services. They offer a progressive vocational, rather than academic, route to professional qualifications. An indication of the different levels and their significance is given below.

NQF level#	City & Guilds qualifications/programmes	Other qualifications*
8	Fellowship (FCGI)	Doctorate
7	Membership (MCGI) Master Professional Diploma Level 5 vocational awards NVQ/SVQ Level 5	Master's Degree Postgraduate Diploma Postgraduate Certificate
6	Graduateship (GCGI) Associateship (ACGI)**	Bachelor's Degree Graduate Certificate and Diploma
5	Level 5 IVQ Advanced Technician Diploma Full Technological Diploma	Higher National Diplomas Foundation Degree Diplomas of Higher and Further Education
4	Licentiate'ship (LCGI) Higher Professional Diploma Level 4 vocational awards NVQ/SVQ Level 4	Certificate of Higher Education
3	Level 3 IVQ Advanced Diploma Level 3 IVQ Specialist Advanced Diploma*** Level 3 IVQ Technician Diploma Level 3 vocational awards NVQ/SVQ Level 3	A Level Scottish Higher Advanced National Certificate in Education BTEC National Certificate/Diploma
2	Level 2 IVQ Diploma Level 2 IVQ Specialist Diploma*** Level 2 IVQ Technician Certificate Level 2 vocational awards NVQ/SVQ Level 2	GCSE grades A*-C Scottish Intermediate 2/Credit 5 Grade BTEC First Certificate
1	Level 1 IVQ Certificate Level 1 vocational awards NVQ/SVQ Level 1	GCSE grades D-G Scottish Intermediate 1/General 5 Grade Scottish Access 1 and 2
#	National Qualifications Framework of England, Wales and Northern Ireland (NQF)	
*	Broad comparability in level	
**	Only graduates of the City & Guilds College, Imperial College of Science, Technology and Medicine, are awarded the Associateship (ACGI)	
***	Part of a new qualification structure which is being introduced across the IVQ provision	
IVQ	International Vocational Qualifications	
NVQ	National Vocational Qualifications	

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About City & Guilds

We provide assessment and certification services for schools and colleges, business and industry, trade associations and government agencies in more than 100 countries. We have over 120 years of experience in identifying training needs, developing assessment materials, carrying out assessments and training assessment staff. We award certificates to people who have shown they have mastered skills that are based on world-class standards set by industry. City & Guilds International provides a particular service to customers around the world who need high-quality assessments and certification.

Introduction to this programme

We have designed the Advanced Technician Diplomas in Mechanical Engineering programme for those undergoing training or employed in this area of work. The programme aims to reflect the international nature of the knowledge and skills and activities needed for different countries or cultures.

We provide certificates for all work-related areas at seven levels within our structure of awards shown in Appendix B. This programme covers level 4. The standards and assessments for the Certificate (level 2) and the Diploma (level 3) are published separately.

Certificate

The certificate (about 300-450 guided learning hours) provides a broad introduction to the theory and practical sides of engineering for a front line worker or a person beginning an academic training programme.

Diploma

The diploma (about 600 guided learning hours) provides more practice involving a broader range of skills appropriate to a person who may also supervise, or who is going on into higher education.

Advanced Diploma

The advanced diploma (about 600 guided learning hours) takes these skills to the level appropriate for a person preparing for or working in first-level management. It is also appropriate for someone who wants to receive specialised training at a high level.

We stress that these figures are only a guideline and that we award certificates and diplomas for gaining and showing skills by whatever mode of study, and not for periods of time spent in study.

Full Technological Diploma

We will award the Full Technological Diploma (FTD) in Engineering to someone who is at least 21, who has had at least two years relevant industrial experience, and who has successfully finished the assessments for the diploma and advanced diploma levels of this award. If candidates enter for this diploma, they must also send us a portfolio of evidence to support their application.

Making entries for assessments

Candidates can only be entered for the assessments in this subject if the approved examination centres agree. Candidates must enter through an examination centre we have approved to carry out the assessments for 2565 Technician Awards in Engineering.

There are two ways of entering candidates for assessments.

Internal candidates

Candidates can enter for examinations if they are taking or have already finished a course at a school, college or similar training institution that has directed their preparation whether by going to a training centre, working with another institution, or by open learning methods.

External candidates

These are candidates who have not finished a programme as described above. The examination centres must receive their application for entry well before the date of the examination concerned. This allows them to act on any advice you give about assessment arrangements or any further preparation needed. External candidates carrying out practical assignments and projects will need extra time and guidance to make sure that they meet all the requirements for this part of the assessment.

In this publication we use the term 'centre' to mean a school, college, place of work or other institution.

Resources

If you want to use this programme as the basis for a course, you must read this booklet and make sure that you have the staff and equipment to carry out all parts of the programme. If there are no facilities for realistic practical work, we strongly recommend that you develop links with local industry to provide opportunities for hands-on experience.

Assessments

Summary

There is one level of this award.

Advanced diplomas

We use a numbering system to allow entries to be made for our awards. The numbers used for this programme are as follows.

We use award numbers to describe the subject and level of the award.

Award number

2565-03 Advanced Technician Diploma in Applied Mechanical Engineering – Manufacturing

Advanced Technician Diploma in Mechanical Engineering Theory – Manufacturing

Advanced Technician Diploma in Applied Mechanical Engineering – Plant Technology

Advanced Technician Diploma in Mechanical Engineering Theory – Plant Technology

We use component numbers to show units for which we may award a certificate of unit credit.

Component numbers

026	Mechanical Principles
030	Engineering Project
033	Materials and Processes
034	Advanced Manufacturing and Management
035	Advanced Manufacturing Engineering Practical Assignments
038	Plant Technology and Maintenance Procedures
039	Advanced Plant Practical Assignments
040	Plant Hydraulics and Pneumatics
041	Plant Hydraulics and Pneumatics Practical Assignments
047	Advanced Mathematics
	This unit is an option recommended for candidates entering Higher Education
048	Computer Aided Draughting 2

We use these numbers throughout this booklet. You must use these numbers correctly if you send forms to us.

Assessments required for specific awards

Advanced Technician Diploma in Applied Mechanical Engineering – Manufacturing

To carry out what is needed for the Advanced Technician Diploma in Applied Mechanical Engineering – Manufacturing, candidates must be successful in all of the following assessments.

2565-03-026	Mechanical Principles (written paper which lasts one and a half hours)
[2565-03-030]	Engineering Project Practical Assignment
2565-03-033	Materials and Processes (written paper which lasts two hours)
2565-03-034	Advanced Manufacturing and Management (written paper which lasts three hours)
[2565-03-035]	Advanced Manufacturing Engineering Practical Assignments
[2565-03-048]	Computer Aided Draughting 2 Practical Assignments
(Total three written papers)	

The practical assignments are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us. (See appendix A).

To receive this award candidates must complete the following practical assignments.
030/1, 035/1, 035/2, 048/1, 048/2, 048/3 and 048/4.

(Total seven practical assignments)

Advanced Technician Diploma in Mechanical Engineering Theory – Manufacturing

To carry out what is needed for the Advanced Technician Diploma in Mechanical Engineering Theory – Manufacturing, candidates must be successful in all of the following assessments.

2565-03-026	Mechanical Principles (written paper which lasts one and a half hours)
2565-03-033	Materials and Processes (written paper which lasts two hours)
2565-03-034	Advanced Manufacturing and Management (written paper which lasts three hours)
(Total three written papers)	

There are no practical assignments for this award.

Advanced Technician Diploma in Applied Mechanical Engineering – Plant Technology

To carry out what is needed for the Advanced Technician Diploma in Applied Mechanical Engineering – Plant Technology, candidates must be successful in all of the following assessments.

2565-03-026	Mechanical Principles (written paper which lasts one and a half hours)
[2565-03-030]	Engineering Project Practical Assignment
2565-03-038	Plant Technology and Maintenance Procedures (written paper which lasts three hours)
[2565-03-039]	Advanced Plant Practical Assignments
2565-03-040	Plant Hydraulics and Pneumatics (written paper which lasts three hours)
[2565-03-041]	Plant Hydraulics and Pneumatics Practical Assignments
[2565-03-048]	Computer Aided Draughting 2 Practical Assignments
(Total three written papers)	

The practical assignments are carried out during the learning programme and should be finished by the date of the written examination so you can send all the results to us. (See appendix A).

To receive this award candidates must complete the following practical assignments.
030/1, 039/1, 039/2, 041/1, 041/2, 048/1, 048/2, 048/3 and 048/4.
(Total nine practical assignments)

Advanced Technician Diploma in Mechanical Engineering Theory – Plant Technology

To carry out what is needed for the Advanced Technician Diploma in Mechanical Engineering Theory – Plant Technology, candidates must be successful in all of the following assessments.

2565-03-026	Mechanical Principles (written paper which lasts one and a half hours)
2565-03-038	Plant Technology and Maintenance Procedures (written paper which lasts three hours)
2565-03-040	Plant Hydraulics and Pneumatics (written paper which lasts three hours)
(Total three written papers)	

There are no practical assignments for this award.

Fixed and free date assessments

We provide assessments in two ways:

a Fixed date

These are assessments which are carried out on dates and times we set. These assessments have no brackets around their numbers.

b Free date

These are assessments which are carried out at a college or other training establishment on a date or over a period which the college chooses. These assessments have brackets around their numbers.

In this programme the written assessments are fixed date. The practical assignments are free date.

You must carry out assessments according to our International Directory of Examinations and Assessments. If there are any differences between information in this publication and the current directory, the Directory has the most up-to-date information.

Results and certification

Everyone who enters for our certificates, diplomas and advanced diplomas receives a 'Notification of Candidate Results' giving details of how they performed.

If candidates successfully finish any assessment within this programme (for example, any one of the examination papers) they will receive a certificate of unit credit towards the certificate or diploma for which they are aiming. We grade coursework assessments (practical assignments) as pass or fail. We grade written assessments on the basis of fail, pass, credit or distinction. The certificate of unit credit will not mention assessments which they do not enter, which they failed or from which they were absent.

Each certificate or diploma clearly states what candidates need for full certification at the relevant level, allowing schools, colleges and employers to see whether they have met the full requirements.

If candidates successfully finish all the requirements for a full certificate or a diploma, they will automatically receive the appropriate certificate.

We will send the 'Notification of Candidate Results', certificates of unit credit, certificates, diplomas and advanced diplomas to the examination centre to be awarded to successful candidates. It is your responsibility to give the candidates the certificates. If candidates have a question about the results and certificates, they must contact you. You may then contact us if necessary.

We will also send you a results list showing how all candidates performed.

How to offer this programme

To offer this programme you must get approval from us. There are two categories of approval.

Subject approval

We give approval to offer a teaching course based on this syllabus.

Examination centre approval

We give approval to enter candidates for examinations.

To be approved by us to offer a teaching course you must send us the application form.

To enter candidates for examinations you must be approved by us as an examination centre. For this programme it is possible to act as a registered examination centre only, and accept external candidates. Approved examination centres must provide suitable facilities for taking examinations, secure places to keep the examination papers and materials, and may have an appointed visiting verifier to review practical work.

After we have received and accepted an application, we will send an approval letter confirming this. You can then send entries in at any time using the International Directory of Examinations and Assessments for guidance.

Please note that in this section we have provided an overview of centre approval procedures. Please refer to the current issue of 'Delivering International Qualifications – Centre Guide' for full details of each aspect of these procedures.

Other information

Designing courses of study

Candidates for the various awards in engineering will have come from different backgrounds and will have different employment and training experiences. We recommend the following:

- carry out an assessment of the candidates' achievements so you can see what learning they already have and decide the level of entry they will need; and
- consider what learning methods and places will best suit them.

When you assess a candidate's needs, you should design teaching programmes that consider:

- what, if any, previous education qualifications or training the candidate has, especially in the various general vocational education certificates we provide; and
- what, if any, previous practical experience the candidate has which is relevant to the aims of the programme and from which they may have learned the relevant skills and knowledge.

When you choose learning methods and places, you should consider the results of your assessments and whether the following are available.

- Open or distance learning material.
- Workplace learning that can be carried out on site or between you and a local workplace. This will allow the candidates access to specialised equipment and work experience.
- Working with other registered centres to share facilities.
- Opportunities for co-operative learning between candidates for different certificates who need to gain similar skills.

As long as the candidates meet the aims of this learning programme the structures of courses of study are up to you. So, it is possible to include extra topics that meet local needs.

You should avoid teaching theory alone. As far as possible the practical work should be closely related to work in the classroom so that candidates use their theory in a realistic work environment. You can use formal lectures in the classroom with appropriate exercises and demonstrations. Candidates should keep records of the practical work they do so they can refer to it at a later date.

We assume that you will include core skills, such as numeracy, communication, working with people, and organisation and planning throughout a teaching programme.

Presentation format of the programme

Competence statements

Each unit consists of a number of competence statements which are generally followed by a range statement.

For example:

'26.9 Solve problems involving the stresses in thin-walled cylindrical and spherical pressure vessels, taking into consideration joint efficiency and factor of safety. Stresses: hoop, axial, tangential'

In the above statement there is a list or range of 'stresses' which the candidate should be familiar with. Candidates should cover the complete range. When a range starts with the abbreviation 'eg' the candidates only need to cover some of the ranged areas or can use suitable alternatives.

Competence statements cover practical skills and knowledge. The knowledge needed is closely linked to the practical competences, so it is best to teach the two together so that the candidate appreciates the topic more.

Practical assignments

You should make sure all practical assignments are supervised, and instructors must make sure that the results reflect the candidates' own work. You must hold all the documents and associated materials in a file (portfolio) for each candidate for eight weeks after the application for a certificate. You must also keep separate records of the dates of all attempts by each candidate.

Entry levels

We consider the following programmes to be relevant preparation for this programme.

Technician Diplomas in Engineering (2565)

Mechanical Engineering Technicians Part 2 (2550)

We also consider the following Pitman Qualifications award as relevant alongside this programme.

English for Speakers of Other Languages – higher intermediate level

Progression routes and recognition

A number of UK universities and other higher-education institutions will accept success at diploma or advanced diploma level of this programme for direct entry onto higher-level programmes. The decision to accept a candidate on to a degree programme, and the level of entry, is up to the institution. We provide details of organisations recognising achievement in this programme.

Useful publications

We can provide a list of suggested text books covering specific areas of this programme. We may also have knowledge about other support materials. You should make sure that you have the latest information. We will automatically send updated lists to centres we have approved to offer this programme.



Plain English Campaign's Crystal Mark only covers the Technician Awards in Engineering regulations.

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Syllabus

IVQ in Engineering 2565

Component numbers and titles

026 Mechanical Principles
030 Engineering Project Practical Assignment
033 Materials and Processes
034 Advanced Manufacturing and Management
035 Advanced Manufacturing Engineering Practical Assignments
038 Plant Technology and Maintenance Procedures
039 Advanced Plant Practical Assignments
040 Plant Hydraulics and Pneumatics
041 Plant Hydraulics and Pneumatics Practical Assignments
047 Advanced Mathematics (option unit recommended for candidates entering Higher Education)
048 Computer Aided Draughting 2 Practical Assignments

Introduction

The emphasis of the teaching should be on the understanding of mechanical principles and relationships through associated laboratory work, and on their use as a tool to solve engineering problems.

Knowledge requirements

Instructors must ensure that candidates are able to:

Statics

- 26.1 Explain the 'polygon of forces' and use it to solve problems.
- 26.2 Explain the general conditions of equilibrium and state the equilibrium equations.
Equations: $\Sigma F_H = 0$
 $\Sigma F_V = 0$
 $\Sigma M = 0$
- 26.3 Construct free body diagrams of components in equilibrium and use the equilibrium equations to solve problems.
- 26.4 Explain the term 'simple framework' and identify statically determinate and statically indeterminate frameworks.
- 26.5 Determine the force in each member of a loaded framework using the graphical method, and calculate the load in selected members using the method of sections.
Loading: vertical, horizontal, inclined
Frameworks: simple supported, hinged and simply supported, cantilever
- 26.6 Define shearing force and bending moment and establish an appropriate sign convention.
- 26.7 Calculate the support reactions for loaded simply supported and cantilever beams, construct shearing force and bending moment diagrams and identify key features.
Loading: point, uniformly distributed, combined
Key features: position of zero shear force, position and values of maximum shear force and bending moment, points of contraflexure

Stress and strain

- 26.8 Explain the relationship, strain energy = $\frac{1}{2} Fx$ and use it to solve problems involving the stress produced in a bar by impact or a suddenly applied load.
- 26.9 Solve problems involving the stresses in thin-walled cylindrical and spherical pressure vessels, taking into consideration joint efficiency and factor of safety.
Stresses: hoop, axial, tangential
- 26.10 Calculate for compound bars, stress and change in length produced by direct loading and temperature change.

- 26.11 Explain the simple bending relationship, $\frac{T}{J} = \frac{\sigma}{y} = \frac{E}{R}$ and the assumptions on which it is based.

- 26.12 Use the simple bending relationship to solve problems involving loaded simply supported and cantilever beams having a symmetrical cross-section.
Loading: point, uniformly distributed, combined

- 26.13 Define modulus of rigidity.

- 26.14 Explain the simple torsion relationship, $\frac{T}{J} = \frac{\tau}{r} = \frac{G\theta}{L}$ and the assumptions on which it is based.

- 26.15 Use the simple torsion relationship to solve problems involving shafts and the transmission of power.
Shafts: solid, hollow, composite

Kinematics

- 26.16 Explain the term 'relative velocity'.
- 26.17 Construct and use velocity diagrams to solve problems that involve the relative velocity of two unconnected bodies.

Dynamics

- 26.18 State the relationships, momentum = mv and impulse = change of momentum.
- 26.19 Explain the principle of conservation of momentum and its application to inelastic collisions.
- 26.20 Use impulse and momentum to solve problems involving linear systems.
Systems: vehicles, materials handling transporters, pile drivers
- 26.21 Explain the relationship for moment of inertia, $I = mk^2$.
- 26.22 Obtain relationships for angular motion by analogy with those for linear motion, and use them in conjunction with the principles of conservation of energy and momentum to solve problems involving rotating systems.
Relationships: $T = I\alpha$, $KE = \frac{1}{2} I\omega^2$, momentum = $I\omega$
Systems: flywheels, clutches, hoists
- 26.23 Solve problems involving kinetic energy of a body having both translation and rotational motion.
- 26.24 Explain the term 'centripetal acceleration' and the distinction between centripetal and centrifugal force.
- 26.25 Explain the relationships, $\alpha_c = \omega^2 r$ and $F_c = m\omega^2 r$ and use them to solve problems involving motion in a curved path.
Problems: co-planer balancing of machinery, skidding and stability of vehicles on horizontal and banked tracks

Friction

- 26.26 Define the angle of friction (Φ), state the relationship $\mu = \tan\Phi$ and explain its significance in the design of chutes and hoppers.
- 26.27 Apply the angle of friction to motion on an inclined plane, and use the principles involved to solve problems involving screw jacks and similar devices operated by a square thread.

Incompressible fluids

- 26.28 Identify water and oil as incompressible fluids.
- 26.29 Describe the features of fluid pressure, explain its transmission and solve problems on the operation of hydraulic machines.
Machines: jack, accumulator, intensifier
- 26.30 Explain the relationship, $p = \rho gh$, and use it to solve problems involving manometers and the thrust on submerged vertical and horizontal surfaces.
Manometers: piezometer tube, U – tube (simple, inclined, inverted and differential)
- 26.31 Explain the relationship, total head $h + \frac{v^2}{2g} + \frac{p}{\rho g}$
- 26.32 Explain Bernoulli's equation and the effect of losses due to turbulence or friction.
- 26.33 Explain the continuity equation $Q = A_1 V_1 = A_2 V_2$
- 26.34 Use Bernoulli's equation and the continuity equation to solve problems involving fluid dynamic systems.
Systems: reservoir and pipeline, Venturi meter, discharge through a small orifice

Test specification for written paper Mechanical Principles (2565-03-026)

This is a written examination paper lasting one and a half hours with five questions. Candidates must answer **all** 5 questions.

The examination paper will cover the knowledge specifications:

Topic	Approximate % examination weighting
Statics	20
Stress and strain	20
Kinematics, dynamics and friction	40
Incompressible fluids	20

030 Engineering Project Practical Assignment

Introduction

The intention of this unit is to provide an opportunity for candidates to solve a realistic engineering problem which requires the application and integration of other modules within the Advanced Diploma programme of study.

The aim of the unit is for candidates to acquire:

- planning, organisation and communication skills
- experience in methods and techniques for product and process improvement
- and to develop personal qualities such as creative ability, imagination, initiative and maturity.

Practical competences

The candidate must be able to do the following:

Specification and analysis

- 30.1 Select the problem to be solved.
- 30.2 Identify the main elements of the problem.
- 30.3 Define the objectives of the problem.
- 30.4 Prepare a specification of the problem to be solved.
- 30.5 Determine the tasks to be performed to enable the attainment of the objectives to be achieved.
- 30.6 Organise the tasks chronologically.

Scheduling and planning

- 30.7 Plan the initial programme for solving the problem.
- 30.8 Determine the resource requirements for each of the tasks.
- 30.9 Estimate the time needed to complete each task.
- 30.10 Prepare a schedule of work.

Execution and performance

- 30.11 Obtain the information necessary to solve the problem.
- 30.12 Select equipment or methods of operation to carry out each task.
- 30.13 Perform experimental/investigatory work necessary for the execution of the tasks.

Evaluation and communication

- 30.14 Evaluate the validity of the results.
- 30.15 Assess the success of the work undertaken.
- 30.16 Make recommendations for further work.
- 30.17 Prepare a project report to specified layout.
Layout: eg title page, summary, contents page, list of figures, tables, symbols as required, introduction, work carried out, evaluation of the results, conclusions as related to the aims of the project, practical recommendations, references, appendices.
- 30.18 Ensure that the body of the report includes the following work.
Work: eg relevant background information, clear and precise documentation of the aims of the project, relevant theory, previous work undertaken by other people within the area of activity, the actual work undertaken.
- 30.19 Prepare material for an oral presentation.
Materials: eg slides/transparencies, flip charts, audio or video tapes, supporting notes

030 Engineering Project Practical Assignment

Practical assignment 030/1: Solve an Engineering Problem

1 Competence references

30.1-30.19

2 Preparation

2.1 Location of test

The training centre or other venue where supervision and appropriate working conditions will be provided.

2.2 Requirements

Paper, pens, pencils and ruler **or** a computer system running appropriate software (eg word processing, computer aided draughting software) and a printer connected to the system, with paper loaded and set up ready to print.

Manuals for software.

Copy of section 3 and section 6.

2.3 Instructor notes

Candidates are required to select and solve individually an engineering problem which can realistically be achieved (see section 6 for suitable suggestions) within 60 hours. The project must be agreed between candidate and instructor and must take into account the amount and level of work required and the resources available. The nature of the work must demonstrate the candidate's ability at advanced diploma level.

The project is generally considered to be a student centred activity. The instructor's main responsibility is to create an effective learning environment. In particular the instructor should check the project objectives, monitor the candidate's progress, advise on project progression, exercise leadership if needed, assist in development of the candidate's skills and knowledge and counsel as appropriate.

Candidates may carry out research and produce materials during the allocated time but the report must be produced at the centre under supervision.

It is recommended that candidates should be allowed adequate time to produce the final report. Candidates may use word processors to produce their report provided they have sufficient word processing skills to do so efficiently.

On completion of the report, candidates are required to carry out an oral presentation of their work to the instructor and peer group. It is envisaged that such a presentation will take between 15-30 minutes.

3 Candidates' instructions

- 3.1 You are requested to select and solve a realistic engineering problem. At each stage of this project you must refer to your instructor for continuous guidance and direction. You must keep a log book summarising the work undertaken each week. This log book will be useful in producing the final report. You have 60 hours to complete this assignment.
- 3.2 Select an appropriate project and agree it with your instructor.
- 3.3 Maintain on a regular basis a log book or diary detailing work undertaken.
- 3.4 Identify the main elements of the problem to define the objectives of the project.
- 3.5 Prepare a detailed specification of the problem and organise the tasks to be undertaken chronologically (network diagram or similar).
- 3.6 Plan the initial programme for solving the problem and determine the resource requirements in terms of time, equipment and materials.
- 3.7 Prepare a schedule of the work to be carried out (Gantt chart or similar).
- 3.8 Undertake research in order to obtain the information necessary to solve the problem.
- 3.9 Select equipment or methods of operation to progress the project.
- 3.10 Carry out the work necessary for the completion of the project.
- 3.11 Evaluate the success of the work undertaken and make recommendations for further work.
- 3.12 Prepare a project report using an appropriate format and layout (see section 6.2), which should contain all the work produced in 3.2-3.11 above.
- 3.13 Prepare an oral presentation and present it to your instructor/colleagues.
Oral presentation: eg notes, overhead transparencies
- 3.14 Ensure your name is on the report and hand it in to your instructor.

4 Marking

- | | | |
|------|---|-----|
| 4.1 | Project completed in approximately 60 hours. | () |
| 4.2 | Realistic engineering project selected and agreed with instructor. | [] |
| 4.3 | Log book or diary maintained throughout the project. | [] |
| 4.4 | The main elements of the problem identified and the objectives defined. | [] |
| 4.5 | | |
| | 4.5.1 Detailed specification prepared. | [] |
| | 4.5.2 Tasks to be undertaken organised chronologically. | [] |
| | 4.5.3 Network diagram or similar produced. | [] |
| 4.6 | | |
| | 4.6.1 Initial programme planned. | [] |
| | 4.6.2 Resource requirements determined in terms of time, equipment and materials. | [] |
| 4.7 | Schedule of work prepared (Gantt chart or similar). | [] |
| 4.8 | Appropriate research undertaken and relevant information obtained | [] |
| 4.9 | Appropriate equipment and methods to progress the work selected | [] |
| 4.10 | Necessary work carried out to complete project. | [] |
| 4.11 | | |
| | 4.11.1 Success of the project evaluated and work assessed. | [] |
| | 4.11.2 Recommendations for further work made. | () |
| 4.12 | Project report completed. | [] |
| 4.13 | Oral presentation prepared and presented. | [] |
| 4.14 | Report handed in. | [] |

5 Assignment completion

- The candidate will have satisfactorily completed this assignment if successful in all items marked with a [].
- Candidates who fail to achieve the requisite number of outcomes should be encouraged to carry out further work in order to complete the assignment satisfactorily.

6 Assignment documentation

6.1 Choosing a project

The theme of the project is to investigate a particular section of a company and to improve the section in terms of costs or procedures (manufacturing, maintenance, marketing, management). Possible areas for project work are listed below:

- improvement of the efficiency or effectiveness of an existing process
- introduction and commissioning of new plant
- modification of existing equipment to perform new or additional operations
- improvement of maintenance procedures on selected plant or equipment
- introduction of new procedures for measuring, testing and calibrating products or equipment
- standardisation of component parts for product assembly.

6.2 Project report writing

The general layout of the project report should be as follows:

title page
summary
contents page
list of figures, list of tables, list of symbols, as required
introduction
work carried out
evaluation of the results
conclusions as related to the aims of the project
practical recommendations
references and appendices.

The work carried out should include:

relevant background information
clear and precise documentation of the aims of the project
relevant theory
previous work undertaken by other people within the area of activity
the actual work undertaken

Introduction

The technician engineer needs to possess an in-depth understanding of the behaviour, performance and processing of traditional and modern engineering materials.

Knowledge requirements

Instructors must ensure that candidates are able to:

Steels and heat treatment of steels

- 33.1 Examine the iron-carbon equilibrium diagram and using the inverse lever rule calculate the ratios of different structures produced during various cooling cycles with different carbon content.
Structures: pearlite, martensite, austenite, ferrite, cementite
- 33.2 Explain the difference and identify the importance of the relationship between processing, properties, structures and their uses.
- 33.3 Explain the effects of adding alloying elements to steels.
Effects: increase in strength, increase in hardness, changes in other mechanical/physical properties
Elements: silicon, manganese, nickel, copper, cobalt, chromium, tungsten, molybdenum, vanadium, aluminium
- 33.4 Interpret time-temperature transformation diagrams and continuous cooling transformation diagrams to look at grain structure effects/formation induced by different cooling rates.
- 33.5 Describe the effects of quenching steels in terms of grain structure formation.
- 33.6 Define hardenability.
- 33.7 Describe the procedures for carrying out a Jominy test and interpreting the results.
- 33.8 Explain the heat treatment effects of a range of processes.
Processes: tempering, annealing, martempering, austempering, surface hardening

Metals and alloys for casting

- 33.9 Describe the different alloys used for casting.
Alloys: aluminium-silicon, magnesium, copper-tin, zinc die casting, cast iron
- 33.10 State the factors to be considered when choosing an alloy for casting.
Factors: melting point, heat treatment effects, applications, weldability, machinability, fluidity

- 33.11 Examine the equilibrium diagram for aluminium-silicon alloy and use the inverse lever rule to calculate the various structures during cooling and identify the mechanical properties achieved.
Properties: tensile strength, ductility, hardness
- 33.12 Explain the factors which influence failure of metals.
Factors: creep, fatigue

Polymers

- 33.13 Identify the structure of a polymer as a combination of many small molecules to form large molecules resulting in a network chain.
Structure: linear, branched, cross-linked chains, linear amorphous, folded linear, polymer chains
- 33.14 Explain how crystallinity occurs in polymers.
- 33.15 Explain melting temperature with respect to polymeric materials.
- 33.16 Explain the significance of glass transition temperature and state typical values for a range of polymers.
Polymers: polyethylene, polystyrene, polyvinyl chloride, polypropylene
- 33.17 Describe the features of a tensile test on a polymeric material.
Features: non-linear stress/strain relationship, commencement of necking, cold drawn state
- 33.18 Describe internal and external plasticisation and list the change in properties with plasticisers.
Properties: tensile strength, ductility
- 33.19 Compare the mechanical properties of commonly used polymers and explain the effects of temperature.
Properties: tensile strength, ductility
- 33.20 State basic methods of shaping polymers and typical applications.
Methods: moulding, extrusion, vacuum forming, machining
- 33.21 State benefits of manufacturing products and components using polymeric materials and typical applications.
Benefits: range of shapes, final shape, finish achieved, low temperature process
- 33.22 Describe the extrusion process.
- 33.23 Describe the moulding processes.
Processes: injection, compression, transfer
- 33.24 Describe the processes used for the production of film, sheet and hollow objects.
Processes: slit-die extrusion, blow-film, blow moulding, rotational moulding

33.25 Describe thermoforming processes and state typical applications.

Processes: vacuum, pressure, mechanical

33.26 Describe the hand lay-up process using glass reinforced plastic (GRP) and state typical applications.

33.27 Describe the process of producing component parts using carbon fibre.

Finishing processes

33.28 Sketch the structure of a grinding wheel and list types of abrasive/grain size and bond.

Abrasive: aluminium oxide, silicon carbide, cubic boron, diamond

Bond: vitrified, silicate, rubber, resinoid, shellac, metallic

33.29 Describe a typical abrasive wheel specification, eg A54 M5V, and describe each part.

33.30 Describe the cutting action of an abrasive wheel.

33.31 Explain the terms 'wheel structure' and 'wheel grade'.

33.32 Explain the principle of operation of a range of finishing processes.

Processes: grinding, honing, lapping, super-finishing, polishing, buffing

Powder metallurgy

33.33 Describe the process stages of powder metallurgy.

Stages: blending/mixing of the powder, compacting, sintering, sizing, impregnation (for porous materials), heat treatment

33.34 State the design advantages of powder metallurgy.

Advantages: large quantities, controlled porosity, wide range of metals and alloys

Sheet metal processes

33.35 Describe the deep drawing process and state common defects and typical applications, eg cans and sinks.

33.36 Describe types of presses.

Types: gap frame, press brake, side frame

33.37 Describe various tube bending methods.

Methods: stretch, draw, compression

33.38 Describe the process of spinning and state applications eg components, cooking utensils.

Alternative machining processes

33.39 Describe the electrochemical machining (ECM) process, state typical ECM applications their advantages and disadvantages.

Advantages: use on very hard materials, no component burrs, low tool wear, no distortion, complex geometrical shapes

Disadvantages: high consumption of electricity, cost, workpiece must be an electrical conductor

33.40 Describe the electric discharge machining (EDM) process, state typical applications their advantages and disadvantages.

Advantages: removal of metal from delicate parts, hole drilling at acute angles, machining of hard metals, no distortion, complex geometrical shapes

Disadvantages: tool wear could be a problem due to heat generation, work piece must be an electrical conductor

33.41 Describe the electric discharge wire cutting (EDWC) process and state typical applications.

Surface texture

33.42 State that surface texture is a geometrical property and explain associated terms.

Terms: lay, roughness, waviness

33.43 Calculate the surface roughness value given a simple sinusoidal shaped trace.

Values: arithmetic mean value (Ra), root mean square (Rq)

33.44 State typical roughness values for standard machining processes.

Processes: rough turning, finish turning, milling, drilling, grinding, honing

Test specification for written paper Materials and Processes (2565-03-033)

This is a written examination paper lasting two hours with six questions. Candidates must answer **all** questions.

The examination will cover the knowledge specifications:

Topic	Approximate % examination weighting
Steels and heat treatment of steels } Metals and alloys for casting }	34
Polymers	34
Finishing processes } Powder metallurgy } Surface texture }	16
Sheet metal processes } Alternative machining processes }	16

Introduction

This unit is divided into two parts. The first part is Advanced Manufacturing Systems. The second part is Management of the Manufacturing Process.

Advanced Manufacturing Systems

This section of the unit focuses on the application of computers in engineering with a particular emphasis on manufacturing.

Practical competences

The candidate must be able to do the following:

Computer numerical control (CNC)

- 34.1 Specify operation sequence using operation sheets.
- 34.2 Produce and check a part-program manually.
- 34.3 Produce and check a computer aided part-program.
- 34.4 Prepare, verify, correct errors as necessary, a part-program to produce particular features on a component using a CNC machine (milling machine or lathe).
Features: (milling) internal and external, profiles, straight, angular, circular interpolation, slots, pockets; (lathe) external profiles, multi-diameters, chamfers, radii, undercuts, parting off, internal profiles, drilling, reaming, threaded holes

Knowledge requirements

Instructors must ensure that candidates are able to:

Computers in engineering

- 34.5 Identify engineering applications that affect the choice of computer systems.
Applications: design, draughting, financial control, inspection, manufacture, projects, process/stock control, testing, quality control
- 34.6 State the benefits and limitations of using a computer aided design system to create design drawings and product models.
Benefits: repeatability, speed, simple editing, reduced storage space, modifications
Limitations: cost of training and equipment
- 34.7 Describe a range of computer terms.
Terms: central processing unit, hardware, software, random access memory (RAM), read only memory (ROM), files, program, network

- 34.8 Describe the main advantages and limitations of a computer system.

Advantages: cycle/feed times, reduced production costs, accuracy, best use of resources, information, productivity, quality

Limitations: high training and equipment costs

- 34.9 Describe the steps to develop and implement a computer system.

Steps: commissioning, investment, forecasting, staffing, leasing, planning, training

CNC systems

- 34.10 Describe the needs and use of guards and interlocking devices on CNC machines.
- 34.11 State the hazards associated with manual and automatic work and tool changing.
- 34.12 State the problems associated with the removal of waste (swarf) from the working zone.
- 34.13 State procedures for the restarting of CNC machines after emergency shutdown.
- 34.14 Explain the advantages and limitations of CNC machine tools over conventional tools.
Advantages: high repeatability/accuracy, complex shapes
Limitations: high equipment costs, specialist training
- 34.15 Identify the three basic axes of CNC machines.
Axes: x, y, z
- 34.16 Explain the different coordinate systems of CNC machines.
Co-ordinates: absolute, incremental, polar
- 34.17 Describe different types of datum used.
Datum: shift on zero, fixed zero, floating zero
- 34.18 Describe the principle of open loop and closed loop positioning systems used on CNC machines.
- 34.19 Explain the CNC programming terms.
Terms: subroutines, macros
- 34.20 Explain the difference between manual part-programming and computer part-programming techniques.
- 34.21 Compare features of a high level programming language with equivalent machine code instructions.
Features: ease of programming, speed and execution, storage and memory, cost

Flexible manufacturing systems

- 34.22 Describe typical manufacturing systems.
Systems: jobbing shop, production workshop, stand-alone CNC machine tool, flexible manufacturing cell (FMC), flexible manufacturing systems (FMS), flowline and transfer line

- 34.23 Explain how FMS compares with conventional manufacturing systems.
- 34.24 Describe the basic components of FMS and their integration in the data processing system.
- 34.25 Explain the integration of computer design with manufacturing systems.
- 34.26 Compare the concept of flexible manufacturing cells (FMC) with flexible manufacturing systems (FMS).
- 34.27 List the advantages and limitations of FMC and FMS.
Advantages: high machine tool utilisation, reduced lead times, reduced labour, reduced inventory, reduced work in progress (WIP), parts produced randomly in various batch sizes
Limitations: high cost of system, specialist training
- 34.28 Explain how robots are used within the FMS system.

Computer aided manufacture (CAM)

- 34.29 State that computer-integrated manufacture (CIM) is the computerised integration of all aspects of design, planning, manufacturing, distribution and management.
- 34.30 Describe the benefits of CIM.
Benefits: lower product cost, shorter product life cycle, rapid response to market demand, quality, improved use of materials and machinery, reduced work-in-progress (WIP), improved employee utilisation
- 34.31 Identify the major stages involved in the use of computers to assist in all aspects of the manufacture of a product.
Stages: design, draughting, processing, ordering, manufacturing, assembly, inspection, testing, storage, transport
- 34.32 Identify the elements of a CAM system.
Elements: machine tools, material handling, tool handling, production control and inspection

Management of the Manufacturing Process

This section of the unit focuses on planning, quality control, process management and people management.

Planning and control

- 34.33 Explain the terms 'production planning' and 'production control' and diagrammatically show the link between them.
- 34.34 Describe the functions of a typical production planning and control system.
Functions: master production schedule (MPS), bill of material (BOM), material requirement planning (MRP), capacity planning (CP), inventory records (IR), purchasing and manufacture

- 34.35 Describe a master production schedule.
- 34.36 Describe the function of a process planning sheet (route card) and identify the information on it.
Information: part number, part name, contract number, material, planning engineer, date, a brief description of the operation performed, equipment, tooling, times
- 34.37 Identify factors related to the economics of component manufacture as opposed to purchasing from other sources (sub-contracted).
Factors: eg reduced costs, loss of control
- 34.38 Explain the goals of 'just in time' (JIT) production.
Goals: eliminate waste (materials, money, lead times, effort), receive supplies just in time to be used to produce parts, produce sub-assemblies just in time to be made into finished products, produce and deliver finished products just in time to be sold
- 34.39 Describe the manufacturing requirements which are essential to achieving the aims of JIT and state the advantages.
Requirements: product design for ease of manufacture, improved production control, multi-skilled workforce, flexible manufacturing, emphasis on quality
Advantages: low inventory, easily corrected faults, lower product cost

Quality control

- 34.40 Explain quality in terms of conformance to requirements and fitness for use.
- 34.41 Examine several products and components and analyse the two quality requirements in terms of product feature and freedom from defects.
Feature: design configuration, ease of use, aesthetic appeal, function and performance, reliability, durability, serviceability
Defects: conformance to specification, components within tolerance, no missing parts, no early failures

- 34.42 Explain the term 'process capability.'

- 34.43 Use statistical process control techniques to analyse process variations.

Process management

- 34.44 State methods of process management.
Methods: critical path analysis (CPA), linear programming
- 34.45 Describe the technique of critical path analysis.
- 34.46 Solve simple problems using critical path techniques.
- 34.47 Describe the technique of linear programming and areas where it is used, eg production schedule.
- 34.48 Explain why it is necessary to forecast product sales.

- 34.49 Describe methods of forecasting.
Methods: moving averages, weighted moving averages, exponential smoothing, exponential smoothing with trend adjustment

People management

- 34.50 Explain the meaning of 'human resource management'.
- 34.51 Describe the personnel functions within a manufacturing company.
Functions: job design, recruitment and selection, performance management, job evaluation and design of pay structures
- 34.52 Describe the benefits of manpower planning.
Benefits: to review the present levels of manning, to recruit personnel in good time, training programmes can be prepared in advance, the implications of change can be assessed, redundancies can be anticipated or even avoided by redeployment
- 34.53 State various theories of motivation.
Theories: extrinsic, intrinsic, significance of needs/wants, influence of goals, importance of expectations, self efficacy, behavioural theory, social learning theory, attribution theory, role modelling
- 34.54 Describe various leadership styles and give examples of each.
Styles: exploitive authoritative, benevolent authoritative, consultative and participative group management
- 34.55 Explain the need for flexibility in the workplace.
Need: to be competitive, to be adaptive, impact of new technology, new organisation structure
- 34.56 Explain why training is important within any organisation.
- 34.57 Describe methods of training, both on-the-job and off-the-job.
Methods: demonstrations, skill practice, simulation, lectures and talks, discussions, tutorials, audio-visual aids, case studies, role-play exercises, business games, projects
- 34.58 State the health and safety aspects of employment.
Aspects: safety of employees and public is of paramount importance, safety takes place over expediency, every effort made to involve all employees in development and implementation of health and safety procedures, health and safety legislation complied with 'in spirit' as well as according to the letter of the law

Test specification for written paper Advanced Manufacturing and Management (2565-03-034)

This is a written examination paper lasting three hours with ten questions. Candidates must answer **all** questions.

Topic	Approximate % examination weighting
Computers in engineering	10
CNC systems	20
Flexible manufacturing systems	10
Computer aided manufacture (CAM)	10
Planning and control	10
Quality control	10
Process management	10
People management	20

035 Advanced Manufacturing Engineering Practical Assignments

Practical assignment 035/1: Operate a CAM System

1 Competence references

34.1, 34.3, 34.4

2 Preparation

2.1 Location of test

The training centre or other venue where supervision and appropriate working conditions will be provided.

2.2 Requirements

A computer aided draughting system with a mouse and a laser printer.

Computer Aided Manufacture software.

Computer Numerical Control Milling machine.

Materials as specified in drawing AMEE3A (see section 6).

Copy of section 3 and section 6.

2.3 Instructor notes

Instructors may produce the profile using CAD and save it on disks for candidates to use, or may require candidates to produce their own profiles.

The aim of this assignment is to produce/use a profile of drawing AMEE3A, transfer it to a CAM package, produce a CNC program, transfer it to a milling machine and machine the profile.

Candidates are allowed 12 hours to complete this assignment and may work alone or in small groups.

Instructors must monitor candidates' work throughout the assignment.

3 Candidates' instructions

3.1 You are required to produce/use a profile of drawing AMEE3A, transfer it a CAM package, produce a CNC program transfer it to a milling machine and machine the profile. You are allowed 12 hours to complete this assignment and may work alone or in small groups. Read the instructions carefully and if you do not understand anything then ask your instructor.

Check with your instructor before commencing whether you are required to produce a profile of drawing AMEE3A or use a profile which your instructor has produced and saved on disk.

3.2 Produce/use a profile of drawing AMEE3A.

3.3 Complete the Operation Sheet (see section 6) to include:

3.3.1 machine sequence

3.3.2 tools required

3.3.3 work holding and/or fixtures

3.3.4 calculations including speeds and feeds.

3.4 Tabulate co-ordinates:

3.4.1 draw up a list of co-ordinates using sheet A (see section 6)

3.4.2 show all calculations on sheet B (see section 6).

3.5

3.5.1 Transfer profile of drawing AMEE3A to CAM package.

3.5.2 Produce a draft CNC program and store on disk.

3.6 Plot the programmed tool path.

3.7 Edit the program and produce a listing.

3.8 Transfer the program to a milling machine, set tool offsets and machine the profile.

3.9 Calculate the time to produce component and compare the calculated time with the actual machining time.

3.10 Put your name on your work and hand it in to the instructor.

4 Marking

- 4.1 Assignment completed within 12 hours. ()
- 4.2 A profile produced/used of drawing AMEE3A using CAD. []
- 4.3 An Operation Sheet produced to include:
 - 4.3.1 machine sequence []
 - 4.3.2 tools required []
 - 4.3.3 work holding and fixtures []
 - 4.3.4 calculations including speeds and feeds. []
- 4.4 Co-ordinates tabulated:
 - 4.4.1 a list of co-ordinates drawn up using sheet A (section 6) []
 - 4.4.2 all calculations shown on sheet B (section 6). []
- 4.5
 - 4.5.1 Profile transferred to CAM package. []
 - 4.5.2 A draft CNC program produced and stored on disk. []
- 4.6 The programmed tool path plotted. []
- 4.7 The program edited and a listing produced. []
- 4.8 The program transferred to a milling machine, tool offsets set and the profile machined. []
- 4.9 The time to produce component calculated and the calculated time compared with the actual machining time. ()
- 4.10 Work handed in to the instructor. []

5 Assignment completion

- The candidate will have satisfactorily completed this assignment if successful in all the items marked with [].
- A period of several days must elapse before an unsuccessful candidate may retake this assignment.

6 Assignment documentation

6.1 Machining sequence for flange – Operation Sheet

SEQUENCE NO	OPERATION	TOOLS & FIXTURE

Sketches of work holding and fixtures

FIRST SETUP	SECOND SETUP

6 Assignment documentation

6.2 Sheet A – tabulated co-ordinate list

Tabulate the absolute X-Y co-ordinates of points ('B' to 'Y') with respect to the X-Y zero point at 'A'.

Position	X Co-ordinate	Y Co-ordinate
A	0.00	0.00
B		
C		
D		
E		
F		
G		
H		
I		
J		
K		
L		
M		
N		
O		
P		
Q		
R		
S		
T		
U		
V		
W		
X		
Y		
Z		

6 Assignment documentation

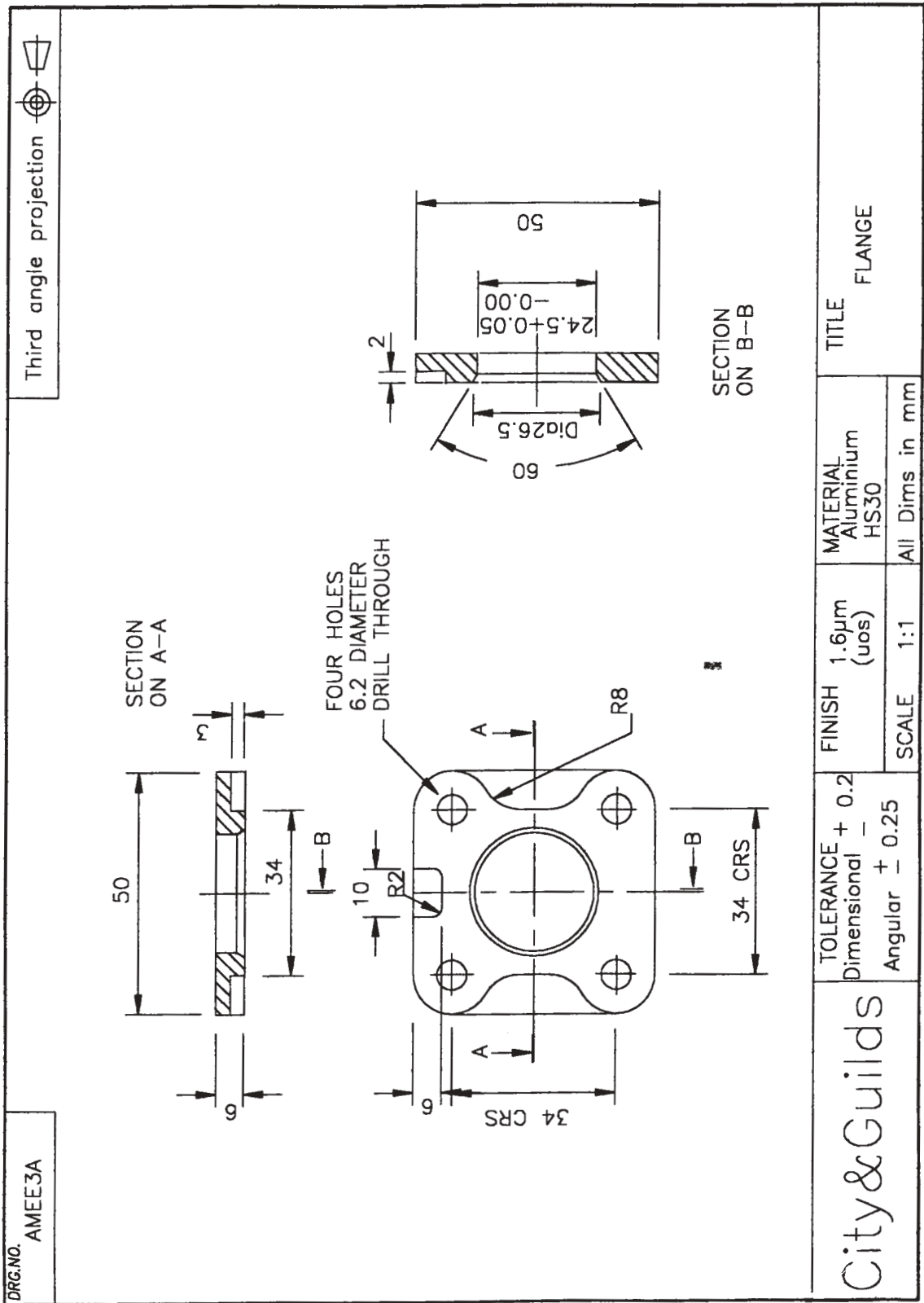
6.3 Sheet B – show speeds and feeds calculations here.

For high speed tooling and the material as aluminium take 'S' to be 40 m/min and the feed per tooth to be 0.05 mm.

Operation	Tool No	DIA	'S' m/min	RPM	Feed/min

6 Assignment documentation

6.4 Drawing AMEE3A



035 Advanced Manufacturing Engineering Practical Assignments

Practical assignment 035/2: Write a Programme Manually to Produce a Spindle

1 Competence reference

34.1, 34.2, 34.4

2 Preparation

2.1 Location of test

The training centre or other venue where supervision and appropriate working conditions will be provided.

2.2 Requirements

Computer Numerical Control Milling machine.

Materials as specified in drawing AMEE3B (see section 6).

Copy of section 3 and section 6.

2.3 Instructor notes

The aim of this assignment is to write a CNC programme to produce a spindle (see drawing AMEE3B – section 6) and machine the profile.

Candidates are allowed 8 hours to complete this assignment and may work alone or in small groups.

Instructors must monitor candidates' work throughout the assignment.

3 Candidates' instructions

3.1 You are required to write a CNC programme manually to produce a spindle (see drawing AMEE3B – section 6) and machine the profile.

You are allowed 8 hours to complete this assignment and may work alone or in small groups. Study drawing AMEE3B.

3.2 Produce an Operation Sheet (see section 6) to include:

3.2.1 machine sequence

3.2.2 tools required

3.2.3 work holding and fixtures

3.2.4 calculations including speeds and feeds.

3.3 Tabulate co-ordinates:

3.3.1 draw up a list of co-ordinates using sheet A (see section 6)

3.3.2 show all calculations on sheet B (see section 6).

3.4 Write a programme to produce the spindle.

3.5 Manually input the programme and edit it.

3.6 Set tool offsets.

3.7 Set the lathe into machine mode and complete a dry run using single step mode.

3.8 Set machine to autocycle mode and machine 'first off' in wax, polystyrene, or any other suitable material.

3.9 Machine actual component.

3.10 Put your name on your work and hand it in to the instructor.

4 Marking

- | | | |
|-------|---|-------|
| 4.1 | Assignment completed in 8 hours. | () |
| 4.2 | An Operation Sheet produced to include: | |
| 4.2.1 | machine sequence | [] |
| 4.2.2 | tools required | [] |
| 4.2.3 | work holding and fixtures | [] |
| 4.2.4 | calculations including speeds and feeds. | [] |
| 4.3 | Co-ordinates tabulated: | |
| 4.3.1 | a list of co-ordinates drawn up using sheet A | [] |
| 4.3.2 | all calculations shown on sheet B. | [] |
| 4.4 | A programme written to produce the spindle. | [] |
| 4.5 | The programme manually input into the machine and edited. | [] |
| 4.6 | Tool offsets set. | [] |
| 4.7 | The lathe set into machine mode and a dry run completed using single step mode. | [] |
| 4.8 | Machine set to autocycle mode and 'first off' machined in wax, polystyrene, or other suitable material. | [] |
| 4.9 | Actual component machined. | [] |
| 4.10 | Work handed in to the instructor. | [] |

5 Assignment completion

The candidate will have satisfactorily completed this assignment if successful in all the items marked with [].

A period of several days must elapse before an unsuccessful candidate may retake this assignment.

6 Assignment documentation

6.1 Machining sequence for a spindle – Operation sheet

SEQUENCE NO	OPERATION	TOOLS & FIXTURE

FIRST SETUP	SECOND SETUP

6 Assignment documentation

6.2 Sheet A – tabulated co-ordinate list

Tabulate the absolute X-Y co-ordinates of points ('B' to 'Y') with respect to the X-Y zero point at 'A'.

Position	X Co-ordinate	Y Co-ordinate
A	0.00	0.00
B		
C		
D		
E		
F		
G		
H		
I		
J		
K		
L		
M		
N		
O		
P		
Q		
R		
S		
T		
U		
V		
W		
X		
Y		
Z		

6 Assignment documentation

6.3 Sheet B – show speeds and feeds calculations here.

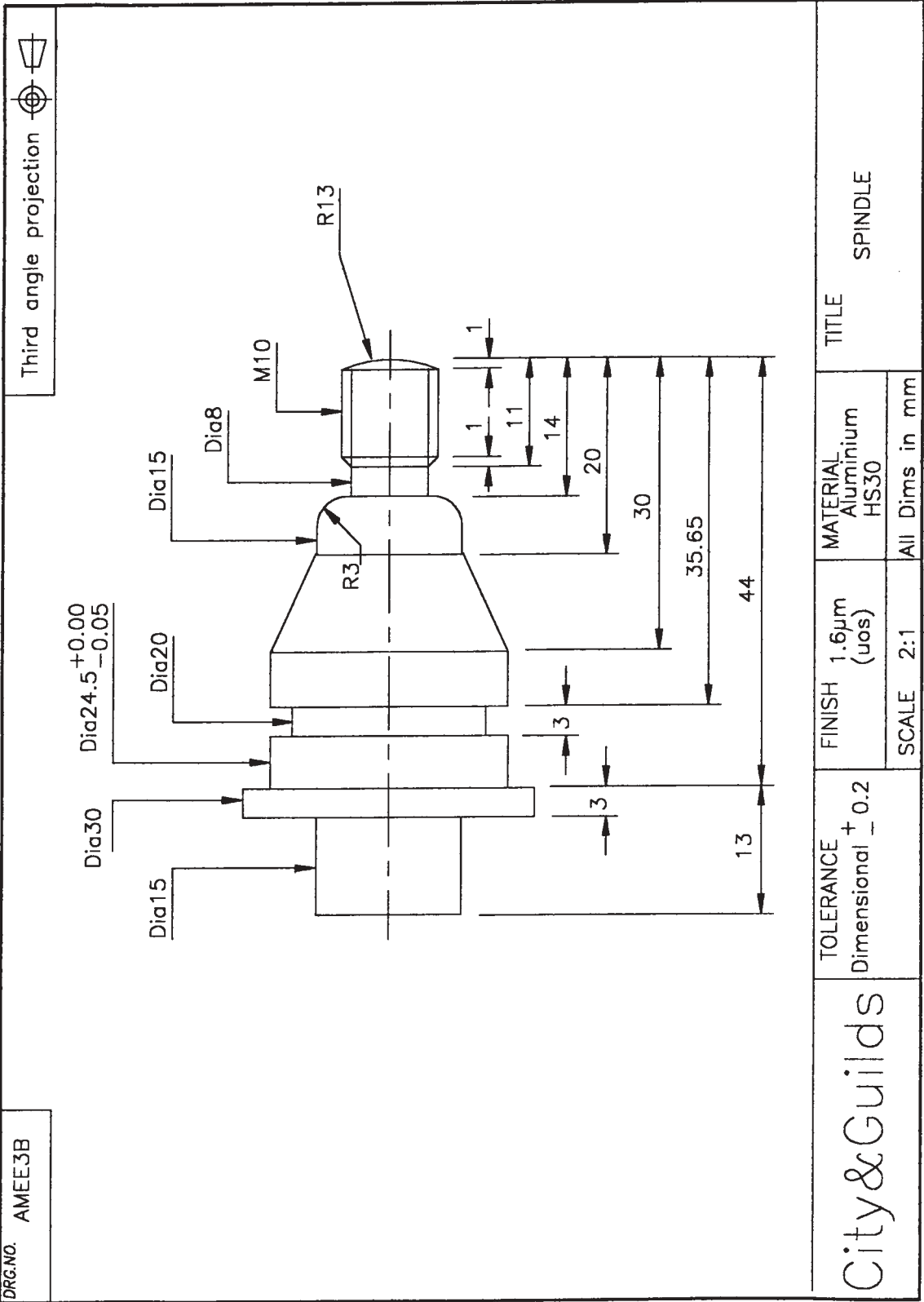
For high speed tooling and the material as aluminium take 'S' to be 40 m/min and the feed per tooth to be 0.05 mm.

Sketches of work holding and fixtures

Operation	Tool No	DIA	'S' m/min	RPM	Feed/min

6 Assignment documentation

6.4 Drawing AMEE3B



City&Guilds

TOLERANCE
Dimensional ± 0.2

FINISH
1.6µm (u005C)

MATERIAL
Aluminium
HS30

TITLE
SPINDLE

038 Plant Technology and Maintenance Procedures

Introduction

This unit is divided into two parts. The first part is Advanced Plant Technology and the second part is Plant Maintenance Procedures.

Advanced Plant Technology

This section of the unit is designed to give candidates a knowledge of the construction and operation of plant, the related theoretical principles and performance calculation procedures. Health and safety procedures must be emphasised throughout this unit.

Practical competences

Candidates must be able to do the following:

- 38.1 Draw line diagrams of a given steam generation and power plant.
- 38.2 Identify the components and state their function and principles of operation.
- 38.3 Draw line diagrams to show the layout of a given refrigerated building and the details of vapour compression refrigeration units.
- 38.4 Calculate co-efficient performances, refrigeration effecting and refrigerating load for a vapour compression refrigerator.

Knowledge requirements

Instructors must ensure that candidates are able to:

Combustion

- 38.5 Calculate the percentage analysis by mass of 'wet' and 'dry' products of the complete combustion of solid and liquid fuels where excess air is supplied.
- 38.6 Explain why it is usual to quote only the 'dry' products.
- 38.7 Calculate the percentage analysis by volume of 'wet' and 'dry' products of a gaseous fuel where excess air is supplied.
- 38.8 Define higher and lower calorific value.
- 38.9 Calculate the higher calorific value of a fuel given the calorific value of the constituent parts.
- 38.10 Define the properties of a liquid fuel.
Properties: flash point, ignition temperature, octane and cetane number

Refrigeration

- 38.11 State the main elements of a vapour compression refrigerator and explain with the aid of a block diagram its operation.
Elements: compressor, condenser, throttle valve, evaporator
- 38.12 Sketch the cycle of operation of a vapour compression refrigerator on a pressure/enthalpy diagram and describe the stages.
Stages: compression, condensation, expansion, evaporation
- 38.13 Explain that an isentropic process is a constant temperature entropy process.
- 38.14 State that for ideal conditions the compression of the refrigerant in a vapour compression refrigerator is isentropic.
- 38.15 Solve problems to find the temperature of the refrigerant after isentropic compression.
- 38.16 Define a range of refrigeration terms.
Terms: co-efficient of performance (COP), refrigerating effect, refrigerating load (tonnes of refrigerant)
- 38.17 Explain the effect on refrigeration of undercooling after condensation and superheating after compression.
- 38.18 Solve problems on a range of terms using tables of thermodynamic and transport properties of fluids (eg. Mayhew and Rogers).
Terms: co-efficient of performance (COP), refrigerating effect, refrigerating load
- 38.19 State the main elements of a vapour absorption refrigerator and explain with the aid of a block diagram its operation.
Elements: pump, heater element, throttle valve, evaporator
- 38.20 State the properties of commonly used refrigerants giving their advantages and disadvantages.
Refrigerants: ammonia, refrigerant 409 A (409 A replaces Freon 12 and has similar characteristics)
- 38.21 Describe the methods of leak detection for refrigerants.
Refrigerants: ammonia, refrigerant 409 A
- 38.22 Explain what is meant by the terms 'direct' and 'indirect' refrigeration.
- 38.23 Explain how a control system operates in a refrigerator.

38.24 Demonstrate a knowledge of safe procedure and working practices in a refrigeration plant.

Safe procedures: gas masks, check for leaks, permit to work, pressure vessels, non-spark tools

Working procedures: purifying system, correct labelling of refrigerants, disposal of refrigerants, refrigerant recharging

Thermal insulations of buildings and furnaces

38.25 Explain the need for the insulation of buildings and furnaces.

38.26 Describe methods of insulating buildings, furnaces and cold rooms.

Methods: cladding, fire bricks, refractory rendering, cork panelling

38.27 Explain the meaning of the term 'heat transfer coefficient' (U value) and recognise that all materials have specific values.

38.28 Evaluate the overall U value for a composite wall given the individual values of each layer.

38.29 Calculate total heat transfer from the buildings, furnaces and cold rooms given all relevant information.

Information: dimensions, materials, U values, surface temperatures

38.30 Solve problems in cost saving after insulation has been carried out.

Steam generation

38.31 Derive an expression for the equivalent evaporation of a steam generating plant 'from and at 100°C' and state that generators are rated as actual evaporation and equivalent evaporation.

38.32 Solve problems involving steam generation, plant efficiency, equivalent evaporation and the amount of heat transferred in the economiser, evaporator, superheater.

38.33 Draw up an energy balance on a percentage basis for a steam generating plant, consisting of an economiser, evaporator and super heater.

38.34 Explain where energy losses occur in the plant and how these losses can be minimised.

Losses: flue gases, radiation, incomplete combustion, air ingress

38.35 State the factors affecting the thermal efficiency of steam generation.

Factors: air ingress, poor firing equipment, fouling of heat transfer surfaces, excess air

38.36 State reasons for controlling the upper and lower limits of feedwater temperature flowing through an economiser.

38.37 Calculate outlet temperatures of feedwater from economisers given inlet temperatures and flue gas conditions.

38.38 Explain briefly external methods of water treatment.

Methods: sedimentation, filtration, precipitation softening, ion exchange system

Steam power plant

38.39 Explain the difference between steam for process and steam for power.

38.40 Explain the use of back pressure, pass out and condensing turbines for supplying both power and process steam.

38.41 Explain the use of a reducing valve and de-superheater to by-pass a turbine when a required steam demand has to be met for process work.

38.42 Explain the reasons why the largest heat loss occurs in the condenser.

38.43 Carry out calculations to show that the largest heat loss occurs in the condenser.

38.44 Explain how a vacuum is produced and maintained in a condenser.

38.45 Explain the need for cleaning condenser tubes on a regular basis.

38.46 State the effects of cooling water leakage into the condensate.

38.47 Solve problems involving rate of flow of cooling water in a condenser given steam conditions and flow rates.

38.48 Explain why throttling is a wasteful process and the turbine can be used to reduce steam pressure for process work.

38.49 Explain why most heat exchangers are contra-flow.

38.50 Explain why a low exhaust pressure is important if a turbine is to develop maximum power.

Steam utilisation

38.51 Explain what is meant by the term 'flash steam' and state that flash steam may be generated from high pressure and high temperature condensate.

38.52 Calculate the quantity of 'flash steam' produced from given values.

Values: pressures, temperatures, and flow rates

38.53 Describe the construction of a typical 'flash steam' vessel.

38.54 Describe the application of thermostatic control to items in common use.

Items: heating calorifiers, constant temperature heaters

- 38.55 Describe the harmful effect of air in a steam plant and explain how air enters the system and how it can be removed.

Prime movers

- 38.56 State the various types of prime movers.
Types: electric motor, CI and SI engines, steam, gas turbines
- 38.57 State the factors that should be considered when selecting a prime mover.
Factors: cost, power requirement, availability, energy source, mass, efficiency, maintenance requirement, environment
- 38.58 Describe the need for various services to prime movers.
- 38.59 Select a prime mover for a given purpose and justify the choices made.
- 38.60 Explain that some prime movers are more suitable for stand-by emergency equipment.

SI and CI engines

- 38.61 Explain engine performance criteria.
Criteria: indicated and brake power, mechanical efficiency, thermal efficiency, specific fuel consumption
- 38.62 Solve problems involving engine performance criteria
- 38.63 Draw up a heat balance on a percentage basis from given test data.
- 38.64 Draw a graph of brake power against mechanical efficiency, thermal efficiency and specific fuel consumption to show the characteristics of both types of engines under full-load conditions and compare the results.

Gas turbines

- 38.65 Explain the advantages limitations and applications of an open circuit gas turbine plant.
Advantages: high power outputs, utilisation of hot exhaust gases, fast start-up time to fuel load
Limitations: low thermal efficiency, automatic devices required because of high temperatures and speed
Applications: aircraft engines, stand-by plant, marine propulsion
- 38.66 Explain the difference between an open circuit and closed circuit system and give advantages of the closed system.
- 38.67 Explain with the aid of a p/v diagram the cycle of operation for a gas turbine.

Steam turbine

- 38.68 Explain the basic principle of operation of steam turbines.
- 38.69 State that turbines are classified as 'impulse' and 'reaction' and explain their differences.

- 38.70 Explain why it is essential to use superheated steam for turbine operations.

- 38.71 Describe pressure and velocity compounding.

- 38.72 Describe the advantages, limitations and applications of steam turbines.
Advantages: low pressure steam can be used, high power for comparatively small units, flow process
Limitations: low thermal efficiency compared with CI engines
Applications: generation of electrical power

- 38.73 Solve simple problems in determining power output thermal efficiencies.

Electric motors

- 38.74 Explain the basic principles of operation of electric motors.
- 38.75 Explain the advantages, limitations and applications of electric motors.
Electric motors: dc motors (shunt and series), ac motors (induction and synchronous)
- 38.76 Explain why the overall efficiency of a motor from generation to output is about 30 percent.
- 38.77 Solve problems for power outputs in single and three phase induction motors given voltage, current and power factor.
- 38.78 Solve problems involving power factor correction when using capacitors or synchronous motors.

Illumination

- 38.79 Explain a range of illumination terms and units used in lighting design.
Terms: luminous flux, luminous intensity, illuminance, luminance, luminosity, glare, efficacy, reflectance, colour rendering
Units: lumen, candela, lux
- 38.80 Demonstrate a knowledge of the use of an illuminance meter and a luminance meter.
- 38.81 Describe, with the aid of diagrams, the main constructional features of a range of lamps.
Lamps: filament, fluorescent, sodium
- 38.82 Compare a range of lamps in the following terms.
Terms: efficacy, rated life, colour rendering, main applications, cost
- 38.83 Explain how stroboscopic and flicker effects from discharge lamps may be reduced.
- 38.84 Select from standard codes suitable illuminance levels for particular plant situations.

38.85 Define the terms 'utilisation factor' (UF) and 'maintenance factor' (MF)

38.86 Explain the 'lumen' method of design and calculate the number of lamps required for a particular situation.

Plant Maintenance Procedures

This section focuses on health and safety codes of practice, maintenance systems, maintenance control and fault diagnosis. Reference should be made to BS 3811:1984 'Maintenance Management Terms in Terotechnology' and BS 4778:1991 'Quality Vocabulary' or the corresponding International Standards.

Knowledge requirements

Instructors must ensure that candidates are able to:

Health and safety

38.87 Explain the classification of fires and for each class state the type of extinguisher that should be used.

Classes: A, B, C, D

38.88 Describe permit-to-work procedures.

Procedures: situations, types, documentation, monitoring

38.89 Explain the main requirements of statutory codes of safety.

Codes: guarding of machinery, use of abrasive wheels, chemical hazards

Maintenance systems

38.90 Explain the aims of maintenance management and the objectives of a maintenance organisation.

38.91 Describe maintenance systems and draw a 'family tree' to show how they are grouped.

Systems: planned, unplanned, preventive, scheduled, condition-based, corrective (including emergency)

38.92 Make comparisons between planned and unplanned maintenance.

Comparisons: materials, lost production, labour

38.93 Describe the resources required to operate a preventive maintenance programme effectively.

Resources: suitable workshop and equipment, tools, test equipment, spares, materials, trained personnel, reference data

38.94 Describe the steps to be taken before preventive maintenance is commenced, and the procedures that should be implemented on completion.

38.95 Describe the activities that are included in a scheduled maintenance programme.

Activities: cleaning, lubrication, replenishment, adjustment, testing, inspection, reconditioning, replacement of 'lifted' components, inclusion of modifications

38.96 Write typical maintenance schedules for items of plant.

Items: prime mover, compressor, machine tool

38.97 Explain the purpose of condition monitoring and describe typical methods used.

Methods: recording, (temperature, vibration, noise), spectrographic oil analysis, particle retrieval, relative displacement measurement)

38.98 Explain the purpose of corrective maintenance and distinguish between the terms used.

Terms: symptoms, fault description, diagnosis of the cause

Maintenance control

38.99 Describe the application of a computerised system for maintenance data processing.

Application: tasks undertaken, organisational arrangements, effects on other sections of the factory, cost effectiveness

38.100 Explain the concept and importance of reliability and the consequences of unreliability in both hardware and software systems.

38.101 Explain reliability characteristics and the concept of failure classification.

Characteristics: reliability, mean life, failure rate, mean time to failure (MTTF), mean time between failures (MTBF)

38.102 Solve problems relating to characteristics in 38.101.

38.103 Distinguish between the terms 'fault' and 'failure'.

38.104 Draw and interpret typical failure-time 'bathtub' curves.

38.105 Explain the concept of availability and maintainability.

38.106 Describe the effect of obtaining improved reliability and maintainability.

Fault diagnosis

- 38.107 Explain the basic principles of determining the prime cause of a fault.
Principles: knowledge and understanding, experience and expertise, step-by-step strategy
- 38.108 Describe the stages of logical fault finding and rectification.
Stages: collection and collation of defect data, plant information and resources, analysis of evidence, use of fault location techniques, diagnosis and classification of cause, rectification of fault (repair or replace), functional checks
- 38.109 Describe defect recording procedures.
Procedures: completion of standardised report, recommendations, distribution to appropriate departments

Test specification for written paper Plant Technology and Maintenance Procedures (2565-03-038)

This is a written examination paper lasting three hours with ten questions. Candidates must answer **all** questions.

The examination will cover the knowledge specifications.

Topic	Approximate % examination weighting
Combustion	5
Refrigeration	15
Thermal insulation	5
Steam generation Steam power plant Steam utilisation	20
Prime movers SI and CI engines Gas turbines Steam turbines Electric motors	20
Illumination	5
Health and safety Maintenance systems Maintenance control	20
Fault diagnosis	10

039 Advanced Plant Practical Assignments

Practical assignment 039/1: Steam Generation and Power Plant

1 Competence reference

38.1, 38.2

2 Preparation

2.1 Location of test

The training centre or other venue where supervision and appropriate working conditions will be provided.

2.2 Requirements

Writing materials, drawing board and Tee square or draughting machine or a computer system running appropriate software (eg word processing, computer aided draughting software) and a printer connected to the system, with paper loaded and set up ready to print.

Manuals for software.

Copy of section 3 and section 6.

2.3 Instructor notes

In this assignment candidates are required to write a report on a steam generation and power plant (see section 6).

Candidates should be encouraged to use the computer facilities to complete this assignment. The time allocated is 6 hours.

3 Candidates' instructions

3.1 The time allowed for this assignment is 6 hours. The assignment is based on steam generation and power plant. The details are shown in section 6.

You are advised to read all the instructions before commencing work. If you do not understand all the instructions then please ask the instructor.

3.2 Draw a line diagram of the plant showing steam, condensate pipelines and traps. Include in the line diagram all necessary fittings and equipment for the safe and efficient running of the plant.

3.3 On the line diagram, show how the high pressure steam could be utilised to heat up the chemicals when the turbine is shut down for maintenance.

3.4 Explain using the diagram how the chemical in heat exchanger B could be kept at a constant temperature during transit.

3.5 Name the type of steam trap which should be used to accommodate the heavy condensate load produced in heat exchangers C and D.

3.6 Describe a method of lifting the condensate efficiently to the storage tank.

3.7 Produce a brief report and include the line diagram and the information produced in 3.3-3.6.

3.8 Ensure that your name is on the report and hand it in to the instructor.

4 Marking

- | | | |
|-----|---|-----|
| 4.1 | Assignment completed in 6 hours. | () |
| 4.2 | A line diagram of the plant produced showing steam, condensate pipelines, traps and all necessary fittings and equipment for the safe and efficient running of the plant. | [] |
| 4.3 | Utilisation of the high pressure steam to heat up the chemicals when the turbine is shut down for maintenance shown on the line diagram. | [] |
| 4.4 | How the chemical in heat exchanger B could be kept at a constant temperature during transit explained. | [] |
| 4.5 | The type of steam trap which should be used to accommodate the heavy condensate load produced in heat exchangers C and D named. | [] |
| 4.6 | Efficient lifting of this condensate described. | [] |
| 4.7 | Report including diagram and information relating to 4.3-4.6 produced. | [] |
| 4.8 | Report handed in to the instructor. | [] |

5 Assignment completion

The candidate will have satisfactorily completed this assignment if successful in all items marked with a [].

Candidates who fail to achieve the requisite number of outcomes should repeat the assignment using an alternative set of data.

6 Assignment documentation

Steam produced by two in-line boilers is used for electrical power production and process heating. The boilers supply steam at 25 bar and 350°C to a back pressure turbine which exhausts steam at 9 bar with a dryness fraction of 0.95. This exhaust steam is transported through a pipeline 150m long to heat up various chemicals passing through four separate heat exchangers A, B, C and D.

From heat exchanger A, the condensate produced is discharged into a flash steam vessel which is at 3 bar. The flash steam is then used for space heating in another part of the plant. The condensate from the flash vessel is discharged together with the condensate from the other heat exchangers into a storage tank 2m above the exchanges where it is indirectly cooled. It is then returned to the power plant as boiler feedwater.

A chemical with a low specific heat capacity has to be pumped from heat exchanger B a distance of 100m and has to be kept at a constant temperature whilst being moved. The masses of the chemicals passing through the heat exchangers C and D can vary immensely over any 24 hour period, producing a heavy condensate load at times.

039 Advanced Plant Practical Assignments

Practical assignment 039/2: Calculate heat transference and refrigeration requirements to keep a building at a constant temperature

1 Competence reference

38.3, 38.4

2 Preparation

2.1 Location of test

The training centre or other venue where supervision and appropriate working conditions will be provided.

2.2 Requirements

Writing materials, drawing board and Tee square **or** draughting machine **or** a computer system running appropriate software (eg word processing, computer aided draughting software) and a printer connected to the system, loaded and ready to print.

Tables of thermodynamic and transport properties of fluids.

Copy of section 3 and section 6.

Formulae sheet showing details of formulae and relationships.

2.3 Instructor notes

In this assignment candidates are required to draw and label a refrigerated warehouse (see section 6) and calculate the energy transfer, the capacity of the refrigeration unit and its co-efficient of performance.

Instructors must provide candidates with details of formulae and relationships required (Formulae sheet). Instructors must also check candidates' calculations at each stage.

Candidates should be encouraged to use the computer facilities to complete this assignment. The time allocated for this assignment is 9 hours.

3 Candidates' instructions

3.1 The time allowed for this assignment is 9 hours. You are required to produce a report on a refrigerated warehouse, see details in section 6. You may use a word processor and computer aided draughting software to carry out the assignment. Make sure you have a copy of the Formulae sheet and that you check your calculations with your instructor at each stage.

You are advised to read all the instructions before commencing work. If you do not understand all the instructions then please ask the instructor.

3.2 Draw a labelled line diagram showing the layout of the warehouse and refrigeration unit within its building. The diagram should show the evaporator, condenser, throttler, compressor and how the brine is pumped around the warehouse using a manifold system to give a uniform distribution.

3.3 Calculate using the relevant equations (see Formulae sheet) and the given data:

3.3.1 the energy transferred per minute through the fabric of the warehouse

3.3.2 the minimum capacity required of the refrigeration unit in tonnes of refrigeration.

3.3.3 the co-efficient of performance (COP) of the refrigerator.

3.4 Produce a brief report on the refrigerated warehouse and include the line diagram with details of calculations performed and final results obtained.

3.5 Hand in the report to the instructor.

4 Marking

- 4.1 Assignment completed in 9 hours. ()
- 4.2 A line diagram showing all the necessary features of the building and correctly labelled evaporator, condenser, throttler and compressor. The diagram must show how the brine is chilled and the brine is pumped around the warehouse using a manifold system to give a uniform distribution. []
- 4.3 The following calculations carried out:

4.3.1 The energy transferred per minute through the fabric of the warehouse correctly calculated. []

4.3.2 The minimum capacity required for the refrigeration unit in tonnes of refrigeration. []

4.3.3 The co-efficient of performance (COP) correctly calculated. []
- 4.4 Report produced which includes line diagrams with details of calculations performed and final results obtained. []
- 4.5 Work handed in to the instructor. []

5 Assignment completion

The candidate will have satisfactorily completed this assignment if successful in all items marked with a [].

Candidates who fail to achieve the requisite number of outcomes should repeat the assignment using an alternative set of data.

6 Assignment documentation

A refrigerated warehouse has internal dimensions of width 12m, length 50m and height of 5m to the eaves. The centre ridge of the roof runs the full length of the building and the roof has a pitch of 30°. The warehouse is to be kept at 2°C by an indirect refrigeration system using brine to circulate around pipe fixed to the walls. The refrigeration unit is to be installed in a building adjacent to it and the primary refrigerant used is ammonia.

There are two air changes per hour, due to produce being transported in and out of the warehouse, and the outside air temperature is on average 15°C. (Underfloor temperature to be taken as the same as outside).

Necessary data.

Heat transfer coefficients	W/m ² K
Insulated walls and ceiling	0.06
Concrete floor	0.4
Doors to be considered as walls	
Density of air	1.2 kg/m ³
Specific heat capacity of air	1.01 kJ/kg K
1 tonne of refrigeration	233 kJ/min
Pressure range of refrigerant	1.447 bar to 5.346 bar
Temperature after isentropic compression	56°C
Refrigerant undercooled	4°C
Refrigerant leaves evaporator dry saturated	
Efficiency of brine chiller	90%

Introduction

This unit is divided into two parts Plant Hydraulics and Plant Pneumatics.

It is recommended that the teaching of hydraulic and pneumatic components and circuits should be delivered by practical work using hydraulic and pneumatic rigs. Candidates should prepare basic circuits to discuss and demonstrate the characteristics of hydraulic/pneumatic components and their interconnection.

Plant Hydraulics

This section of the unit covers hydraulic theory and hydraulic components and circuits.

Practical competences

Candidates must be able to do the following:

- 40.1 Select an appropriate industrial hydraulic system and identify its function.
- 40.2 Identify hydraulic system components using standard terminology.
- 40.3 Prepare circuit diagrams using manual or computer aided draughting system.
- 40.4 Explain the operation of the hydraulic circuits and the major components.
Components: pumps, actuators, directional control valves, flow control valves, pressure control valves
- 40.5 Use appropriate formulae and nomograms to obtain circuit parameters.
Parameters: working pressure, maximum load capacity of actuators, actuator speed, flow rates, pipe size

Knowledge requirements

Instructors must ensure that candidates are able to:

Hydraulic theory

- 40.6 Identify symbols recommended by CETOP (BS or ISO) for circuit diagrams.
- 40.7 Explain and use the formulae and nomograms to determine circuit parameters.
Parameters: working pressure, maximum load capacity of actuators, actuator speed, flow rates, pipe size

Hydraulic components and circuits

- 40.8 Draw a circuit diagram to show the layout of a basic hydraulic circuit and explain the function of each element.
Element: reservoir, pump, relief valve, control valves, actuator
- 40.9 Describe the construction and operation of commonly used pumps in a circuit and compare their performance characteristics.
Pumps: vane and piston (including variable types), gear
- 40.10 Describe the construction and operation of actuators.
Actuators: linear, rotary, semi-rotary
- 40.11 Identify the various types of seals used in hydraulic systems and explain the reasons for the choice of materials.
- 40.12 State and compare the characteristics of hydraulic motors.
Characteristics: torque, power, speed
- 40.13 Describe the construction of a reservoir and explain the purpose of each fitting.
Fitting: oil level indicator, breather, filling-cap, drain plug, baffle plate
- 40.14 Describe the construction, operation and application of accumulators.
Accumulators: deadweight, spring loaded, gas charged
- 40.15 State the properties of a typical hydraulic fluid.
Properties: viscosity, lubricity, toxicity
- 40.16 Describe the merits and limitations of a range of hydraulic fluids.
Hydraulic fluids: mineral oil, emulsions, water, glycol mix, synthetics
- 40.17 Explain the necessity of filtration in hydraulic systems and the methods of rating filters (b values).
- 40.18 Describe the types of filters used and state their location within a system.
Types: surface, depth
- 40.19 Describe fluid conductors and associated joints and fittings.
Fluid conductors: pipe, tube, flexible hose
- 40.20 Describe the construction, operation and application of directional control valves.
Valves: poppet, spool
Application (centre types): closed, open, floating, tandem, regenerative
- 40.21 Describe methods of valve actuation.
Methods: manual, mechanical, electrical, pneumatic, electro-hydraulic

- 40.22 Explain the construction, operation and application of pressure control valves.
Valves: relief, reducing, unloading, sequence, counter balance
- 40.23 Describe the construction, operating and application of flow control valves.
Flow control valves: non-compensated, pressure compensated
Flow control (methods): meter-in, meter-out, bleed-off
- 40.24 Describe the construction, operation and application of check valves and pilot operated check valves.
- 40.25 Design circuits based on standard components to meet given control requirements eg lifting equipment and machine tools, simple process plant control.

Plant Pneumatics

This section of the unit covers compressed air theory and pneumatic components and circuits.

Practical competences

Candidates must be able to do the following:

- 40.26 Prepare circuit diagrams using manual or computer aided draughting systems.
- 40.27 Identify pneumatic system components using standard terminology.
- 40.28 Select an appropriate pneumatic system and identify its function.
- 40.29 Explain the operation of the pneumatic circuits and the major components.
Components: compressors, actuators, directional control valves, flow control valves, pressure control valves
- 40.30 Use appropriate formulae and nomograms to obtain circuits parameters.
Parameters: working pressure, maximum load capacity of actuators, actuator speed, flow rates, pipe size

Knowledge requirements

Instructors must ensure that candidates are able to:

Compressed air theory

- 40.31 Explain and use the formulae and nomograms to determine circuit parameters.
Parameters: working pressure, maximum load capacity of actuators, actuator speed, flow rates, pipe size

Pneumatic components and circuits

- 40.32 Identify symbols recommended by CETOP (BS or ISO) for circuit diagrams.
- 40.33 Draw a circuit diagram to show the layout of a basic pneumatic circuit and explain the function of the elements.
Elements: compressor, receiver, control valves, relief valves and actuator
- 40.34 Describe conductors and associated joints and fittings
Conductors: pipes, tubes, flexible hose
- 40.35 Describe the construction and operation of air service units.
- 40.36 Describe the construction and operation of actuators.
Actuators: linear, rotary, semi-rotary
- 40.37 Describe seals used in pneumatic components eg 'O' rings.
- 40.38 Explain the construction and operation of valves.
Valves: poppet, plate slide, spool, flow control, quick exhaust, timer (delay)
- 40.39 Describe the air flow through typical directional control valves.
Types: 3/2, 4/2, 5/2, and 5/3, non-return and shuttle (OR), two pressure (AND)
- 40.40 Describe methods of valve actuation.
Methods: manual, mechanical, electrical, pneumatic, electro-pneumatic
- 40.41 Describe the construction and operation of pneumatic proximity-sensing devices.
Sensing devices: air barrier, reflex, back pressure and pneumatic proximity switch
- 40.42 Describe the construction and operation of a range of pneumatic components.
Components: pressure amplifier, vacuum suction nozzle and a pneumatic-electrical converter
- 40.43 Describe methods of eliminating maintained (trapped) signals should they occur.
Methods: one way trips, reservoir and orifice, impulse generator
- 40.44 Use circuit diagrams to describe the functions required for simple sequential control of cylinders.
Functions: control from more than one point (AND, OR), indirect control, automatic return and cycling, speed control, pressure dependant return, time dependant return/auto-cycling and a combination of AND, OR, time, speed and safety control

- 40.45 Use circuit diagrams to describe the control of up to four cylinders, making use of letters, signs and travel-step diagrams to identify cylinders and movements.
- 40.46 Use circuit diagrams and explain the principle of cascade for two group type and three or more group systems.
- 40.47 Describe and compare the application of pneumatic cascade sequencing with program logic control (PLC) systems.
- 40.48 Design circuits based on standard components to meet given control requirements eg lifting equipment, machine tools, simple process plant control.

Test specification for written paper
Plant Hydraulics and Pneumatics
(2565-03-040)

This is a written examination lasting three hours with ten questions. Candidates must answer **all** questions.

The examination will cover the knowledge specifications:

Topic		Approximate % examination weighting
Hydraulic theory	}	50
Hydraulic components and circuits		
Compressed air theory	}	50
Pneumatic components and circuits		

041 Plant Hydraulics and Pneumatics Practical Assignments

Practical assignment 041/1: Investigating an Hydraulic System

1 Competence reference

40.1 - 40.5

2 Preparation

2.1 Location of test

The training centre or other venue where supervision and appropriate working conditions will be provided.

2.2 Requirements

Writing materials, drawing board and Tee square or draughting machine or a computer system running appropriate software (eg word processing, computer aided draughting software) and a printer connected to the system, with paper loaded and set up ready to print.

Manuals for software.

Formulae sheet, nomograms, table of appropriate symbols related to the course and a copy of section 3.

2.3 Instructor notes

In this assignment candidates are required to investigate a real-life industrial hydraulic system and produce a report on it. Candidates must select and agree an appropriate system with their instructor and must be given the opportunity to inspect the system and obtain relevant information.

It is recommended that instructors visit an appropriate location with candidates and advise on selection of an hydraulic system. Instructors must provide candidates with formulae sheets/nomograms and table of symbols.

It is recommended that candidates use computer systems to produce the report for this assignment. The time allowed for this assignment is 15 hours.

3 Candidates' instructions

3.1 The time allowed for this assignment is 15 hours. You are required to produce a report on an industrial hydraulic system. You must select and agree a system with the instructor and visit the industrial site to obtain the relevant information.

You are advised to read all the instructions before commencing work. If you do not understand all the instructions then please ask the instructor.

3.2 Visit an industrial location and select an hydraulic system, and agree it with the instructor.

3.3 Collect relevant information on chosen hydraulic system.

3.4 State the function of the system.

3.5 Prepare circuit diagrams and identify all components using standard terminology and symbols.

3.6 Explain the circuit operation in detail.

3.7 Explain the operation and describe the construction of all the major components:

3.7.1 pumps

3.7.2 actuators

3.7.3 directional control valves

3.7.4 flow control valves

3.7.5 pressure control valves.

3.8 Use formulae/nomograms to obtain:

3.8.1 working pressure

3.8.2 maximum load capacity of actuators

3.8.3 actuator speed

3.8.4 flow rates

3.8.5 pipe size.

3.9 Produce a report on computer, or manually, to include the above information.

3.10 Ensure your name is on all your work and hand it in to the instructor.

4 Marking

- | | | |
|-------|---|-------|
| 4.1 | Assignment completed in 15 hours. | () |
| 4.2 | An hydraulic system selected and agreed with the instructor. | [] |
| 4.3 | Relevant information on hydraulic system collected. | [] |
| 4.4 | The function of the system stated. | [] |
| 4.5 | Circuit diagrams prepared and all components identified using standard terminology. | [] |
| 4.6 | The circuit operation explained in detail. | [] |
| 4.7 | The operation explained and the construction of all the major components and symbols described: | |
| 4.7.1 | pumps | [] |
| 4.7.2 | actuators | [] |
| 4.7.3 | directional control valves | [] |
| 4.7.4 | flow control valves | [] |
| 4.7.5 | pressure control valves. | [] |
| 4.8 | Parameters correctly obtained: | |
| 4.8.1 | working pressure | [] |
| 4.8.2 | maximum load capacity of actuators | [] |
| 4.8.3 | actuator speed | [] |
| 4.8.4 | flow rates | [] |
| 4.8.5 | pipe size. | [] |
| 4.9 | Report completed. | [] |
| 4.10 | Work handed in to the instructor. | [] |

5 Assignment completion

The candidate will have satisfactorily completed this assignment if successful in all items marked with a [].

Candidates who fail to achieve the requisite number of outcomes should be encouraged to carry out further research in order to complete the assignment satisfactorily.

041 Plant Hydraulics and Pneumatics Practical Assignments

Practical assignment 041/2: Investigating a Pneumatic System

1 Competence reference

40.26 – 40.30

2 Preparation

2.1 Location of test

The training centre or other venue where supervision and appropriate working conditions will be provided.

2.2 Requirements

Writing materials, drawing board and Tee square or draughting machine or a computer system running appropriate software (eg word processing, computer aided draughting software) and a printer connected to the system, with paper loaded and set up ready to print.

Manuals for software.

Formulae sheet, nomograms, table of appropriate symbols related to the course and a copy of section 3.

2.3 Instructor notes

In this assignment candidates are required to investigate a pneumatic system and produce a report on it. Candidates must select and agree an appropriate system with their instructor and must be given the opportunity to inspect the system and obtain relevant information.

It is recommended that instructors visit an appropriate location with candidates and advise on selection of a pneumatic system. Instructors must provide candidates with formulae sheets/nomograms and table of symbols. The time allowed for this assignment is 15 hours.

It is recommended that candidates use computer systems to produce the report for this assignment.

3 Candidates' instructions

3.1 The time allowed for this assignment is 15 hours. You are required to investigate and produce a report on a pneumatic system. You must select and agree a system with your instructor and obtain relevant information about the system.

You are advised to read all the instructions before commencing work. If you do not understand all the instructions then please ask the instructor.

3.2 Select a pneumatic system and agree the system with the instructor.

3.3 Collect relevant information on the chosen system.

3.4 State the function of the system.

3.5 Prepare circuit diagrams and identify all components using standard terminology and symbols.

3.6 Explain the circuit operation in detail.

3.7 Explain the operation and describe the construction of all the major components:

3.7.1 pumps

3.7.2 actuators

3.7.3 directional control valves

3.7.4 flow control valves

3.7.5 pressure control valves.

3.8 Use formulae sheets/nomograms to obtain:

3.8.1 working pressure

3.8.2 maximum load capacity of actuators

3.8.3 actuator speed

3.8.4 flow rates

3.8.5 pipe size.

3.9 Produce a report to include the above information (either manually or using a computer).

3.10 Ensure your name is on all your work and hand it in to the instructor.

4 Marking

- | | | |
|-------|---|-------|
| 4.1 | Assignment completed in 15 hours. | () |
| 4.2 | A pneumatic system selected and agreed with the instructor. | [] |
| 4.3 | Relevant information collected. | [] |
| 4.4 | The function of the system stated. | [] |
| 4.5 | Circuit diagrams prepared and all components identified using standard terminology. | [] |
| 4.6 | The circuit operation explained in detail. | [] |
| 4.7 | The operation explained and the construction of all the major components and symbols described: | |
| 4.7.1 | pumps | [] |
| 4.7.2 | actuators | [] |
| 4.7.3 | directional control valves | [] |
| 4.7.4 | flow control valves | [] |
| 4.7.5 | pressure control valves. | [] |
| 4.8 | Parameters correctly obtained: | |
| 4.8.1 | working pressure | [] |
| 4.8.2 | maximum load capacity of actuators | [] |
| 4.8.3 | actuator speed | [] |
| 4.8.4 | flow rates | [] |
| 4.8.5 | pipe size. | [] |
| 4.9 | Report produced. | [] |
| 4.10 | Work handed in to the instructor. | [] |

5 Assignment completion

The candidate will have satisfactorily completed this assignment if successful in all items marked with a [].

Candidates who fail to achieve the requisite number of outcomes should be encouraged to carry out further research in order to complete the assignment satisfactorily.

Introduction

Much of the study of the technical units at the diploma and advanced diploma levels has integrated the mathematical content in with the applied technology. This unit, at the higher diploma level, provides additional mathematics to both advance and broaden a candidate's understanding of mathematics to supplement other studies at this level and to also provide a sound foundation for further study. Where possible, it is expected that worked examples will be selected to represent relevant engineering problems.

Knowledge requirements

Instructors must ensure that candidates are able to:

Trigonometry

- 47.1 Prove simple trigonometrical identities involving $\sin A$, $\cos A$, $\tan A$, $\operatorname{cosec} A$, $\sec A$ and $\cot A$.
- 47.2 Use trigonometrical identities to assist in the solution of simple trigonometrical equations.
- 47.3 Manipulate and use the compound angle formulae expansions of $\sin(A+B)$, $\cos(A+B)$, $\tan(A+B)$ in the solution of trigonometric problems.
- 47.4 Manipulate and use the double angle formulae expansions of $\sin 2A$, $\cos 2A$ and $\tan 2A$ in the solution of trigonometric problems.
- 47.5 Manipulate and use the half angle formulae expansions of $\sin A$, $\cos A$ and $\tan A$, including those using the substitution $t = \tan \frac{A}{2}$ in the solution of trigonometric problems.
- 47.6 Transform expressions of the form $a \sin \theta \pm b \cos \theta$ to the form $r \sin(\theta + \alpha)$ and use this to solve problems.

Geometry

- 47.7 Create a diagram from given data to a suitable scale.
- 47.8 Estimate the area under curves between given limits by using the mid-ordinate, trapezoidal and Simpson rules.
- 47.9 State Pappus' theorems.
- 47.10 Use Pappus' theorems to calculate volumes and surface areas of curved shapes.

Algebra

- 47.11 Sketch graphs of the type $y = ae^{bx}$ and $a(1 - e^{bx})$ for given values of a and b

- 47.12 Determine exponential / logarithmic laws by plotting graphs on log-log or log-linear graph paper for functions such as $y = ax^n$, $y = ae^{bx}$

- 47.13 Determine the partial fractions for expression in which the denominator contains linear factors, repeated linear factors or quadratic factors ie functions of the following types

$$\frac{f(x)}{(x-a)(x-b)}, \quad \frac{f(x)}{(x-a)^3}, \quad \frac{f(x)}{ax^2+bx+c}$$

Complex Numbers

- 47.14 Define a complex quantity as a number which has real and imaginary parts.
- 47.15 Use the definition $j = \sqrt{-1}$ to identify the imaginary parts of a complex number.
- 47.16 Describe vectors and phasors as complex quantities.
- 47.17 Represent complex quantities on an Argand diagram using cartesian ($a \pm jb$) and polar ($r \angle \theta$) forms.
- 47.18 Identify $\pm j$ and $\pm \sqrt{j}$ as instructions to rotate phasors through angles of $\pm 90^\circ$ and $\pm 45^\circ$ respectively.
- 47.19 Convert complex quantities from cartesian form to polar form and vice versa.
- 47.20 Perform scalar multiplication and division on complex numbers in cartesian form.
- 47.21 Define and use the conjugate of a complex number.
- 47.22 Calculate the sums and differences of complex quantities.
- 47.23 Calculate the products and quotients of complex quantities.
- 47.24 Solve quadratic equations which produce complex roots.

Matrices and determinants

- 47.25 Calculate the sum and differences of TWO matrices (2x2 only).
- 47.26 Calculate the product of TWO 2x2 matrices.
- 47.27 Solve a pair of linear simultaneous equations using matrices.
- 47.28 Evaluate a 2x2 determinant.
- 47.29 Solve a pair of linear simultaneous equations using determinants.

Differential Calculus

47.30 Derive, from first principles, the differential coefficients for function such as $y = ax^n + b$

47.31 Use the notations dy/dx , and d^2y/dx^2 or $f'(x)$ and $f''(x)$ for derived expressions noting that other variables, such as V, A, h and r, may be used for Volume, Area, height and radius.

47.32 Differentiate, by rule, a range of functions and combinations of functions noting that the constants may be positive, negative or fractional numbers.

Range of functions:

- i $y = ax^n \pm b \sqrt[n]{x}$ -where a,b,m, and n are constants
- ii $y = a \sin(b\theta + a)$ -similarly for other trigonometric functions
- iii $y = a \ln(bx)$ -similarly for functions involving $\log_{10}x$ and e^x
- iv $y = ab^x$

47.33 Differentiate, by rule, functions of functions, products and quotients of functions for the range given in 47.32.

47.34 Obtain the first and second derivatives for the range of functions given in 47.32.

47.35 Determine turning points for the range of functions given in 47.32 and identify these as local maxima, local minima or points of inflection.

47.36 Solve problems involving maximum and minimum values.

47.37 Identify and use the first and second derivatives of a displacement / time function as velocity and acceleration respectively, for linear and angular motions.

Integral calculus

47.38 Determine the indefinite integrals of functions for the range given in 47.32 including integrals of the form $f'(x) / f(x)$, $f'(x) [f(x)]^n$, integration by substitution and integration by parts.

47.39 Evaluate definite integrals of functions for the range given in 47.32 between various limits.

47.40 Solve problems involving definite integration by partial fractions of functions of the type given in 47.32.

47.41 Evaluate the area under a curve from the range in 47.32 as the integral between given limits.

47.42 Express and evaluate, by integration, the area between two curves from the range in 47.32.

47.43 Define and calculate the mean and root mean square values of the functions in 47.32 ii).

47.44 Calculate the centroid, first and second moments of area of plane figures.

Differential equations and Laplace transforms

47.45 Solve, by direct integration, equations of the form

$$\frac{dy}{dx} + bx + c = 0$$

47.46 Solve, by assuming a solution of the form $\theta = Ae^{bt}$, an

$$\text{equation of the form } \frac{d\theta}{dt} = k\theta$$

47.47 Solve differential equations arising from practical situations.

47.48 Define Laplace transformation and inverse transformation.

47.49 Use Laplace transforms and inverse transforms to solve first and second order differential equations for functions of t when $f(t) = k, t^n, e^{kt}, \sin \omega t, \cos \omega t, \sinh \omega t, \cosh \omega t$, and combinations of these.

Progressions and series

47.50 Define arithmetic progressions (AP's) and geometric progressions (GP's) as progressions having a common difference and common ratio between successive terms respectively.

47.51 Evaluate the sum of n terms of an arithmetic progression using the formula

$$S_n = \frac{n[2a + d(n-1)]}{2}, \text{ where } a \text{ is the first term, } d \text{ is the}$$

common difference and n is the number of terms.

47.52 Evaluate the sum of n terms in a geometric progression using the formula

$$S_n = \frac{a(1-r^n)}{(1-r)}, \text{ where } a \text{ is the first term, } r \text{ is the common}$$

ratio and n is the number of terms.

47.53 Deduce general expressions for the n^{th} term of simple arithmetic and geometric progressions.

47.54 Expand the general binomial expression $(a+b)^n$ for any positive integer value of n.

47.55 Write a single specified term from the expansion given in 47.54.

47.56 Use the binomial series to expand expressions such as $(1+x)^n$ for $-1 < x < 1$

47.57 Use the binomial series to estimate the effects on the subject of a formula, involving power laws, when there are small percentage errors in the variables.

- 47.58 Describe the concept of convergence of a series to a limit.
- 47.59 Define the radius of convergence of a power series.
- 47.60 Use the ratio test to determine the radius of convergence of series expansions for functions such as e^x , $\sin x$, $\log_e (1+x)$ and $(1+x)^n$

Complex waveforms

- 47.61 State that any periodic waveform can be regarded as the sum of the fundamental and harmonically related sinusoidal components.
- 47.62 Define the terms fundamental, second and third harmonic.
- 47.63 Show graphically the effects of adding second and third harmonics to a fundamental waveform.
- 47.64 Show graphically the effect of changing the amplitude and phase of the second harmonic component.
- 47.65 Derive an expression for a waveform comprising the fundamental and harmonic components of specified amplitudes.
- 47.66 Write an expression for a waveform comprising the fundamental with second and third harmonic components of specified amplitudes.

Probability

- 47.67 Define probability (p) and show that $0 \leq p \leq 1$.
- 47.68 Define complementary probability (q) and show $p + q = 1$.
- 47.69 Calculate the values of probability in simple cases.
- 47.70 Define mutually exclusive events, independent events and dependent events.
- 47.71 Perform calculations related to simple cases of total and compound probability.
- 47.72 Define the classical probability P of an event A occurring as $P(A) = n(A) / n(S)$, where $n(A)$ is the number of ways A can occur and $n(S)$ is the total number of ways that possible events can occur.
- 47.73 Solve simple problems using the multiplication law for probability of independent events.
- 47.74 Solve simple problems using the addition law for probability of independent events.

Test specification for written question paper
047 Advanced Mathematics

This is a written examination paper lasting three hours with ten questions. Candidates must answer **all** questions.

The examination paper will cover the knowledge specifications:

Topic	Approximate % examination weighting
Trigonometry	20
Geometry	
Algebra	
Complex numbers	10
Differential calculus	30
Integral calculus	
Differential equations and	
Laplace transforms	
Progressions and series	10
Complex waveforms	10
Probability	10
Matrices and determinants	10

048 Computer Aided Draughting 2 Practical Assignments

Introduction

The aim of this unit is to build on the elements of computer aided draughting acquired at diploma level and to introduce candidates to 3D construction, surface modelling and solid and regional modelling. Although this unit is based on AutoCAD version 12 plus the Advanced Modelling Extension (or later versions), centres may use any software having an equivalent specification.

Practical competences

The candidate must be able to do the following:

Co-ordinate systems

- 48.1 Use the UCS Command to define User Co-ordinate systems by all available methods, select a current UCS and delete a UCS.
- 48.2 Use the system variable THICKNESS to give an extrusion thickness to a 2D entity.
- 48.3 Use 3D points in absolute, relative and polar co-ordinates.

3D construction

- 48.4 Use 2D drawing entities on different User Co-ordinate Systems to produce 3D drawings.
- 48.5 Use the 3D drawing entities to produce 3D drawings.
Entities: LINE, 3DPOLY, 3DFACE
- 48.6 Use the procedure for making the edges of 3D faces invisible.

Surface modelling

- 48.7 Produce surfaced models using ruled surfaces, tabulated surfaces, surfaces of revolution, and edge-defined surface patches.
Surfaces: RULESURF, TABSURF, REVSURF, EDGESURF
- 48.8 Use the system variables for the control of surface mesh density.
Variables: SURFTAB1, SURFTAB2
- 48.9 Modify 3D drawings using 2D editing commands on different User Co-ordinate Systems.
- 48.10 Use the command PEDIT to fit a spline curve to a 3D polyline.
- 48.11 Edit the vertices of a polygon mesh created by a surface command PEDIT.
- 48.12 Use the command PEDIT to fit surfaces to polygon meshes.
Surfaces: Bezier, quadratic b-spline, cubic b-spline

Display control

- 48.13 Use the command PLAN to display a plan view of the current UCS, a named UCS and the World Co-ordinate System.
- 48.14 Use multiple view ports in the construction of a 3D drawing.
View ports: VPORTS, VIEW PORTS
- 48.15 Select 3D viewpoints VPOINT to display a 3D model from various points in space.
- 48.16 Use the command DVIEW to view a 3D model from various points in space.
- 48.17 Use the command DVIEW to apply perspective projection to a 3D model.
- 48.18 Use clipping planes to create cut-away and section views of a 3D model – DVIEW.
- 48.19 Vary the perspective view applied by using different lens values in the ZOOM option and in the DVIEW command.
- 48.20 Perform hidden line removal on a 3D view of a drawing – HIDE.

Blocks

- 48.21 Create blocks of 3D models – BLOCK.
- 48.22 Insert blocks of 3D models into drawings with any specified orientation in space INSERT.

Solid modelling and materials selection

- 48.23 Create solid primitives.
Primitives: box, cone, cylinder, wedge, taurus, sphere
- 48.24 Use solid commands to edit solid primitives.
Commands: extrude, revolve, subtract, union, interfere
- 48.25 Apply editing commands to solid models.
Commands: eg fillet, chamfer, scale
- 48.26 Assign appropriate materials to solid models and render. Save as GIF file.
- 48.27 Assign mass properties to the solid model and save as MPR file.

Regional modelling

- 48.28 Construct a 2D regional drawing from a 2D constructed drawing.
- 48.29 Use solid commands to edit 2D regional models.
Commands: extrude, revolve, subtract, union, interfere
- 48.30 Apply editing commands to regional models.
Commands: eg fillet, chamfer, scale

48.31 Produce hidden view and wire frame view using PAPERSPACE.

Plotting 3D drawings.

48.32 Produce plots from 3D drawings including views with perspective and with hidden lines removed.

48.33 Produce plots from surface and solid models.

048 Computer Aided Draughting 2 Practical Assignments

Practical assignment 048/1: 3D Construction and Visualisation – Computer

1 Competence reference

48.1-48.6, 48.7, 48.13-48.19, 48.20-48.22, 48.32

2 Preparation

2.1 Location of test

The centre, under supervision.

2.2 Requirements

An AutoCAD manual, a computer set up and running AutoCAD version 12 (or later version) with a mouse and a laser printer.

A copy of section 3 and sections 6.1, 6.2, 6.3, 6.4 and 6.5.1 and 6.5.2.

2.3 Instructor notes

Candidates are required to produce an orthographic drawing of a computer (see section 6) and three 3D views of the computer (see sections 6.1, 6.2 and 6.3).

The time allowed for this assignment is 3 hours.

After the assignment is completed, hard copies of the three stored perspective view and the orthographic and 3D drawing must be produced for marking purposes with hidden lines removed. This can be done by either the instructor or candidate. If done by the candidate, the instructor must ensure no further changes or additions are made to the drawings.

3 Candidates' instructions

- 3.1 This assignment must be completed within three hours. In this assignment you are required to create a 3D model and various views of a computer.
- 3.2 Create a new drawing called COMPUTER using the default prototype drawing.
- 3.3 Set appropriate drawing limits.
- 3.4 Produce the model of the computer as shown in sections 6.1, 6.2, 6.3 and 6.4, according to the instructions given in section 6.5, using 3D faces and other appropriate techniques. Invisible edges must be used where 3D faces meet in order to produce the surface model of the computer similar to that shown in sections 6.1, 6.2, 6.3 and 6.4. Create the circular supporting pins (see paragraph 6.5.2) by giving an extrusion thickness to the entity.
- 3.5 Create the slots on the disk drive and the panel on the front of the computer as surface details using the overall dimensions provided. The particular sizes of the details on these features are left to your discretion (see paragraph 6.5.1).

In a similar way create the features on the back panel of the computer as surface details using the provided dimensions (see paragraph 6.5.2).
- 3.6 Set three perspective views corresponding as closely as possible to those shown in sections 6.1, 6.2 and 6.3. Select an appropriate position for the 'clipping plane' used to show the internal details of the computer as shown in section 6.3.

Save these views with the names VIEW-A, VIEW-B and VIEW-C respectively.
- 3.7 Plot or print plot the views to file, with hidden lines removed, with the names VIEW-A, VIEW-B and VIEW-C. Save the drawing using the name COMPUTER.
- 3.8 Set two new views showing the front view and side view of the computer illustrated in section 6.4. Using paperspace position these views together with a plan view of the original computer you created as shown in section 6.4.

Enter your name on the drawing.
- 3.9 Save the orthographic drawing showing the three views of the computer using the name C2. Plot or print plot this drawing to file, with hidden lines removed, with the name C2.
- 3.10 Hand in your work to the instructor.

4 Marking

Marking must be carried out on both the hard copies and the stored drawing (see paragraph 2.3).

- 4.1 All entities present. []
- 4.2 All entities on electronic file drawn to the correct size and with the correct orientation. []
- 4.3 Supporting pins drawn with an extrusion thickness setting. []
- 4.4 3D face edges invisible where appropriate. []
- 4.5 A suitable perspective view, similar to that in section 6.1 selected. []
- 4.6 A suitable perspective view, similar to that in section 6.2 selected. []
- 4.7 A suitable perspective view, similar to that in section 6.3 selected. []
- 4.8 A suitable ‘clipping plane’ selected for the view shown in section 6.3. []
- 4.9 An orthographic drawing of the computer produced showing the elevations in the positions shown in 6.4. []
- 4.10 Completed within three hours. ()

Notes: In 4.4, a few minor edges inadvertently left in the drawing are acceptable. In 4.5 to 4.7, the perspective views selected by the candidate must have similar angles, distance and lens length as those shown in sections 6.1 to 6.3 but exact replicas are not necessary.

5 Assignment completion

The candidate will have satisfactorily completed this assignment if success is recorded in all items marked with a [].

A period of at least seven days must elapse before an unsuccessful candidate may retake this assignment.

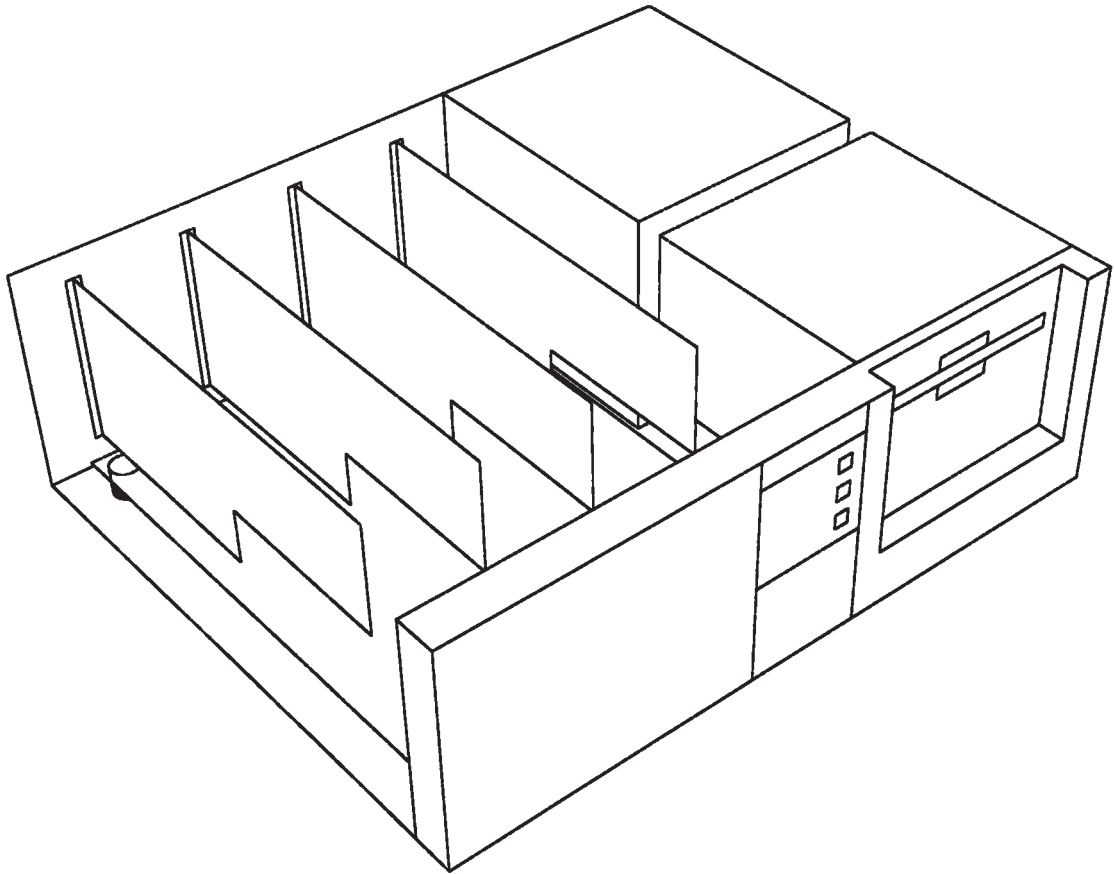
6 Assignment documentation

One complete set consisting of the following:

- 6.1 Required perspective drawing (View A)
- 6.2 Required perspective drawing (View B)
- 6.3 Required perspective drawing (View C)
- 6.4 Required orthographic drawing
- 6.5.1 Drawing instructions
- 6.5.2 Drawing instructions.

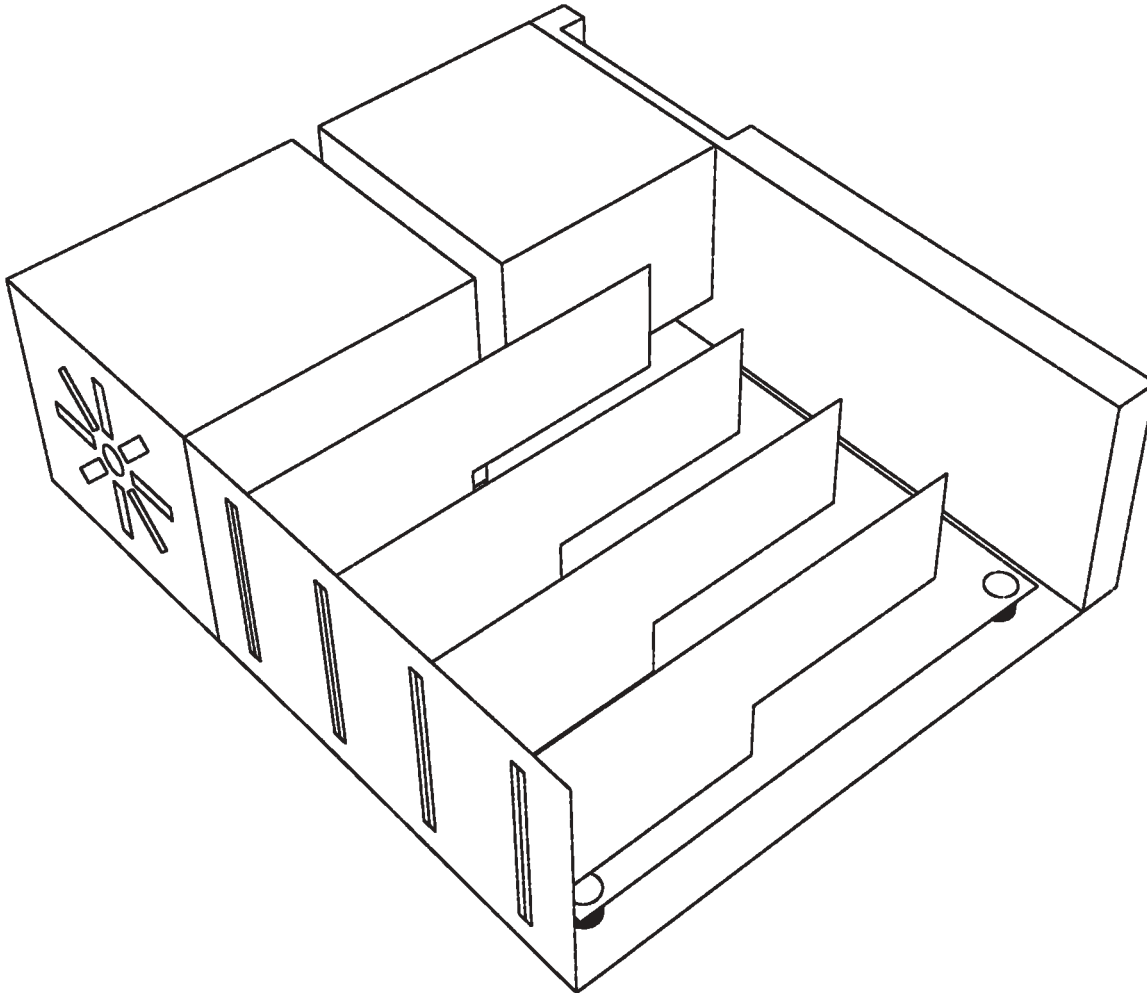
6 Assignment documentation

6.1 View A



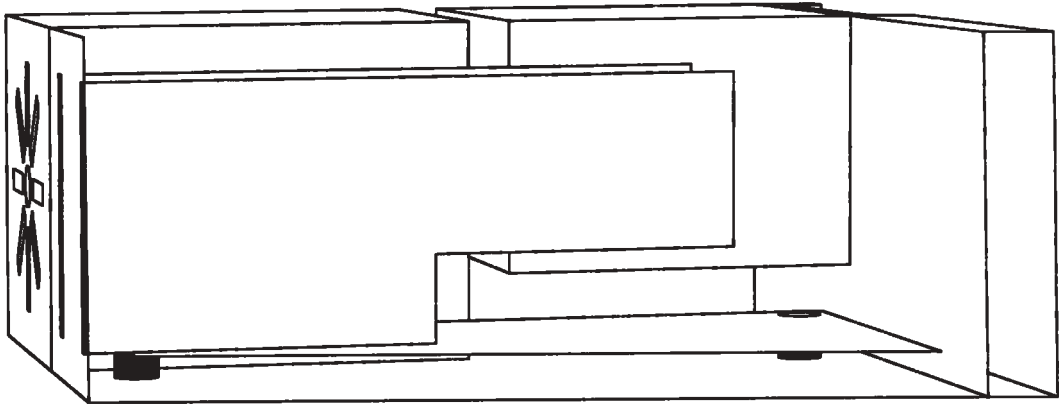
6 Assignment documentation

6.2 View B



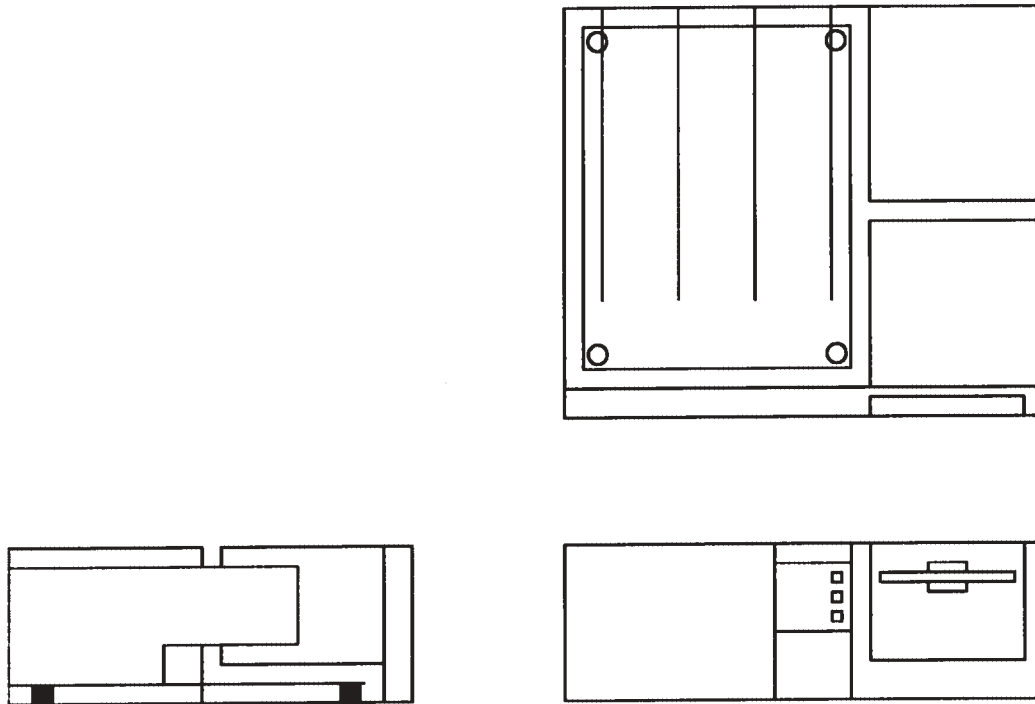
6 Assignment documentation

6.3 View C



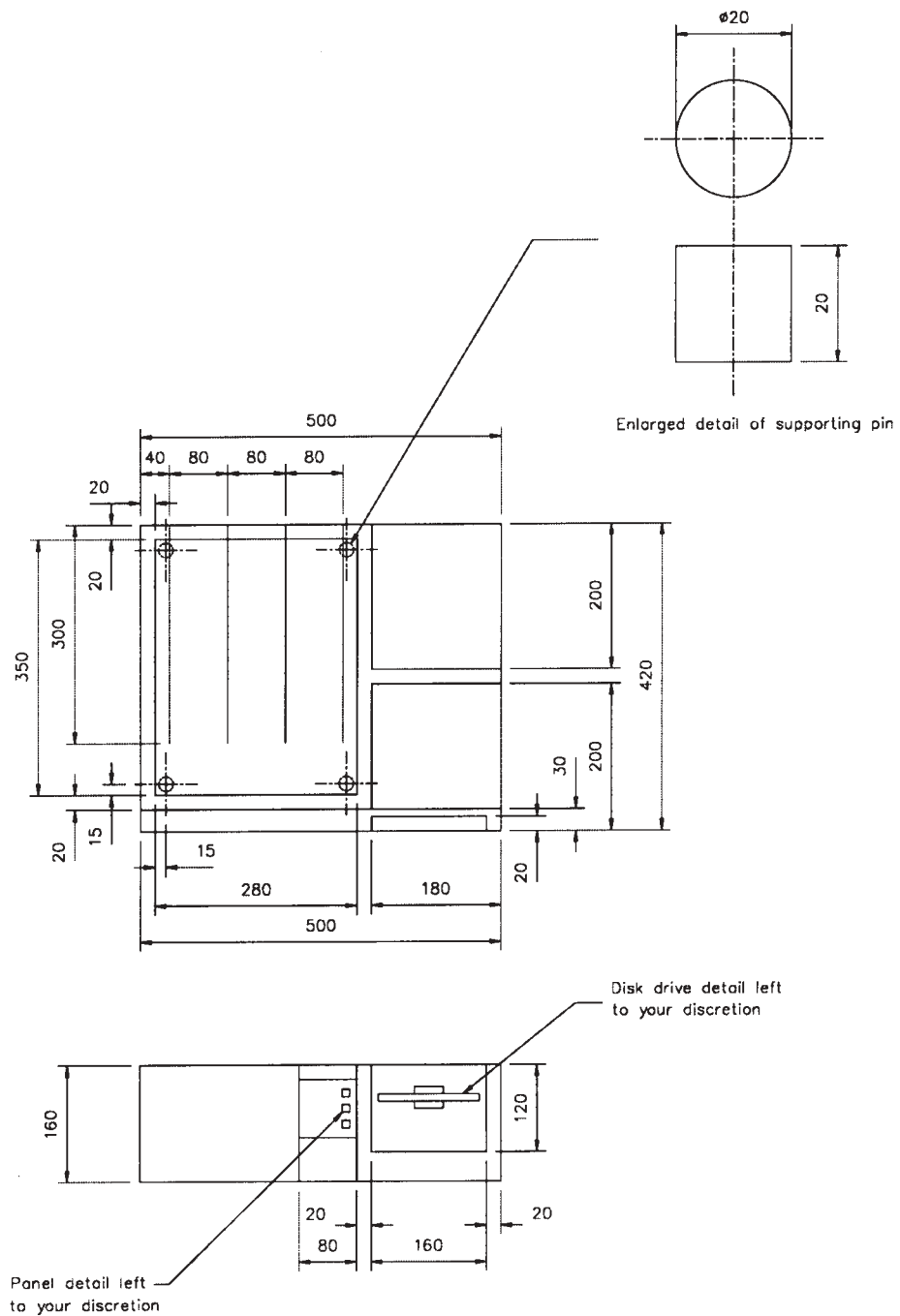
6 Assignment documentation

6.4 Orthographic drawing



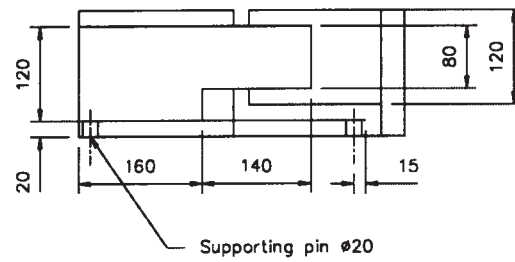
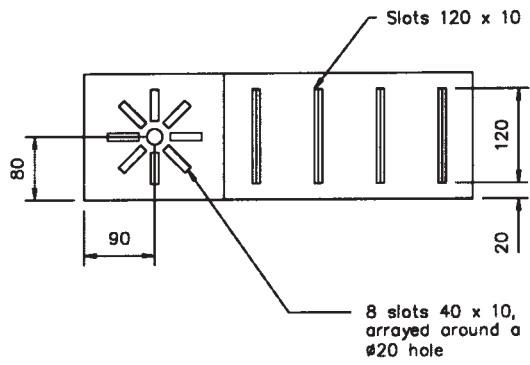
6 Assignment documentation

6.5.1 Drawing instructions



6 Assignment documentation

6.5.2 Drawing instructions



048 Computer Aided Draughting 2 Practical Assignments

Practical assignment 048/2: Surface Modelling

1 Competence reference

48.1-48.4, 48.7-48.12, 48.13-48.15, 48.20, 48.33

2 Preparation

2.1 Location of test

The centre, under supervision.

2.2 Requirements

An AutoCAD manual, a computer set up and running AutoCAD version 12 (or later version) with a mouse and a laser printer. A copy of section 3 and sections 6.1 and 6.2.

2.3 Instructor notes

Candidates are required to produce the surface model of the micrometer shown in section 6.1 according to the instructions given in section 6.2.

The time allowed for this assignment is three hours.

After the assignment is completed, hard copies of the stored view must be produced for marking purposes.

This should show the 3D views of the object with hidden lines removed. This can be done by either the instructor or candidate. If done by the candidate, the instructor must ensure no further changes or additions are made to the drawings.

3 Candidates' instructions

- 3.1 In this assignment you are required to produce a surface model of a micrometer. You have 3 hours to complete this assignment.
- 3.2 Create a new drawing called MODEL using the default prototype drawing.
- 3.3 Set appropriate drawing limits for the object concerned.
- 3.4 Produce a surface model of a micrometer as shown in section 6.1 according to the instructions given in section 6.2. For some parts of the model, there may be several equally appropriate methods of generating the surface. Whichever method is used, a similar mesh density to that shown in section 6 should be used.
- 3.5 Enter your name on the drawing.
- 3.6 Set a 3D view corresponding as closely as possible with that shown in section 6.1. Save this view with the name VIEW-A.
- 3.7 Plot or print plot the view to file with the name MODEL-1. Save the drawing using the name MODEL.
- 3.8 Produce hard copy of the stored view showing the 3D views of the object with hidden lines removed. Hand it in to the instructor.

4 Marking

Marking must be carried out on both the hard copy and the stored drawing. Because there is more than one way of producing a 3D surface model, the results must be marked against the criteria of 4.2 to 4.4 and only compared with the view given in section 6.1 for general shape and mesh density.

- | | | |
|-----|--|-------|
| 4.1 | All entities present. | [] |
| 4.2 | The defining framework/basic structure is dimensionally correct. | [] |
| 4.3 | The types of surfaces used provide satisfactory representation of the shape shown. | [] |
| 4.4 | Mesh densities similar to those shown in section 6.1 used. | [] |
| 4.5 | A 3D-view, similar to that in section 6.1 selected. | [] |
| 4.6 | Completed within 3 hours. | () |

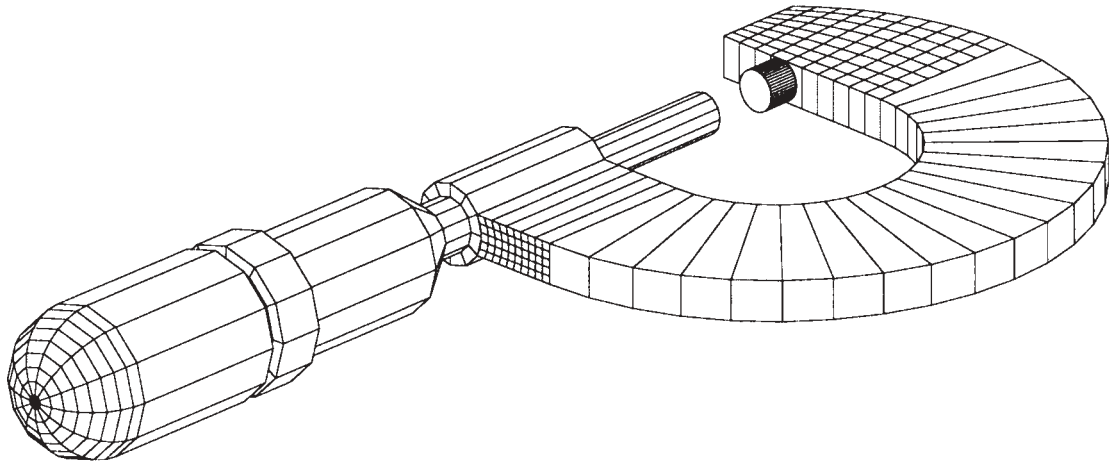
5 Assignment completion

The candidate will have satisfactorily completed this assignment if successful in all the items marked with a [].

A period of at least seven days must elapse before an unsuccessful candidate may retake this assignment.

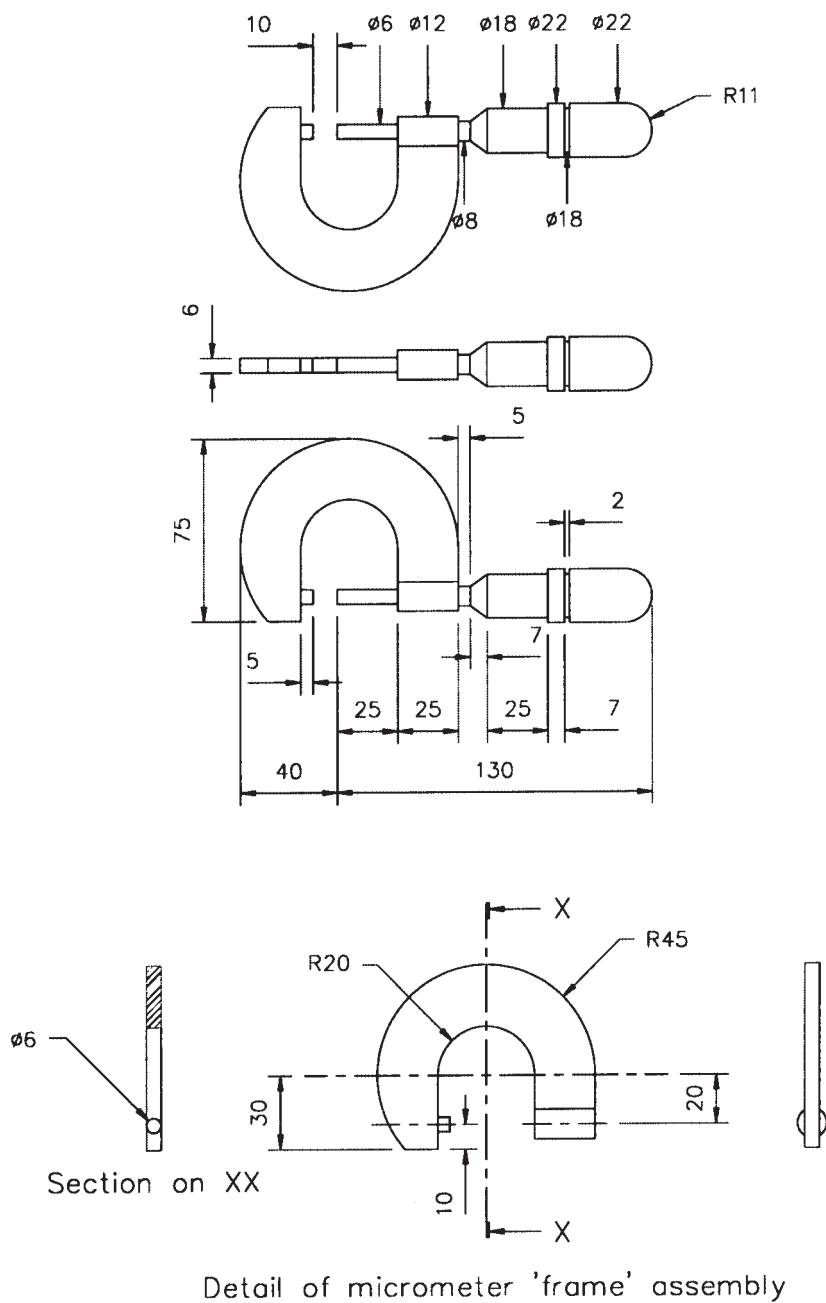
6 Assignment documentation

6.1. Required drawing



6 Assignment documentation

6.2 Drawing instructions



Detail of micrometer 'frame' assembly

048 Computer Aided Draughting 2 Practical Assignments

Practical assignment 048/3: Solid Modelling – Flanged Pipe Coupling

1 Competence reference

48.23-48.27

2 Preparation

2.1 Location of test

The centre, under supervision.

2.2 Requirements

An AutoCAD manual, a computer running AutoCAD version 12 (or later version) with a mouse and a laser printer.

A copy of section 3 and section 6.

2.3 Instructor notes

Candidates are required to produce a solid model and two views (see section 6.1 and 6.2, view A, sliced view and view B, a sectional view) from an orthographic view of a flanged pipe coupling.

Instructors may either produce the orthographic view (see section 6.3) and give copies on disk or in user network area to candidates or require candidates to produce the orthographic view prior to the assignment.

The time allowed for this assignment is 3 hours.

3 Candidates' instructions

- 3.1 You are required to produce a solid model and two views (see section 6.1, view A, sliced view and section 6.2, view B, a sectional view) from an orthographic view of a flanged pipe coupling. You have 3 hours to complete this assignment.
- 3.2 Create a new drawing called COUPLING using the default prototype.
- 3.3 Set appropriate drawing limits.
- 3.4 Use profile drawing of sectional detail for the flanged coupling provided (see section 6).
- 3.5 Produce the solid model of flanged coupling from the drawing instructions (section 6.3).
- 3.6 Produce one of the sliced views on the required drawing as shown in view A. Save this view under the name VIEW-A.
- 3.7 Produce the sectional drawing and match view B. Save this new view with the name VIEW-B.
- 3.8 Apply materials bronze or copper to view A and render.
- 3.9 Save the rendered view as SOLID.GIF.
- 3.10 Print or plot view A and view B to file with the names VIEW-A and VIEW-B and **also** save the drawings.
- 3.11 Extract the mass properties of the sliced view, save as SOLID.MPR and print.
- 3.12 Hand in your work to your instructor.

4 Marking

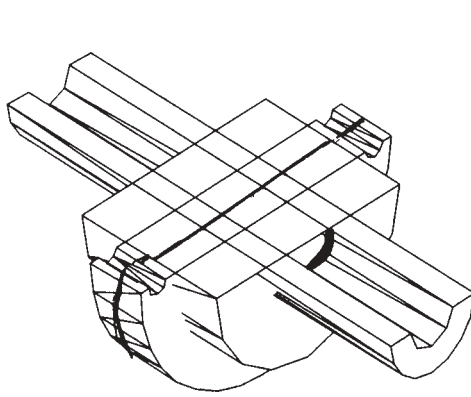
- | | | |
|------|---|-------|
| 4.1 | Assignment completed in 3 hours. | () |
| 4.2 | A new drawing called COUPLING created using the default prototype. | [] |
| 4.3 | Appropriate limits set. | [] |
| 4.4 | Profile drawing of sectional detail for flanged coupling used. | [] |
| 4.5 | The solid model of flanged coupling produced from drawing instructions. | [] |
| 4.6 | Sliced view on required drawing produced. | [] |
| 4.7 | Sectional drawing produced and view B matched. | [] |
| 4.8 | Materials, bronze or copper, applied to view A and rendered. | [] |
| 4.9 | Rendered view saved as SOLID.GIF. | [] |
| 4.10 | View A and view B printed or plotted. | [] |
| 4.11 | Mass properties of the sliced view extracted, saved as SOLID.MPR and printed. | [] |
| 4.12 | Work handed in to instructor. | [] |

5 Assignment completion

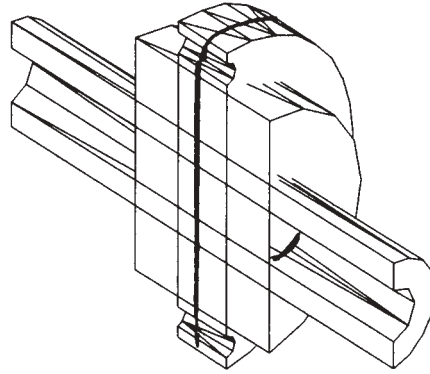
- The candidate will have satisfactorily completed this assignment if successful in all the items marked with [].
- A period of several days must elapse before an unsuccessful candidate may retake this assignment.

6 Assignment documentation

6.1 Required drawing – View A



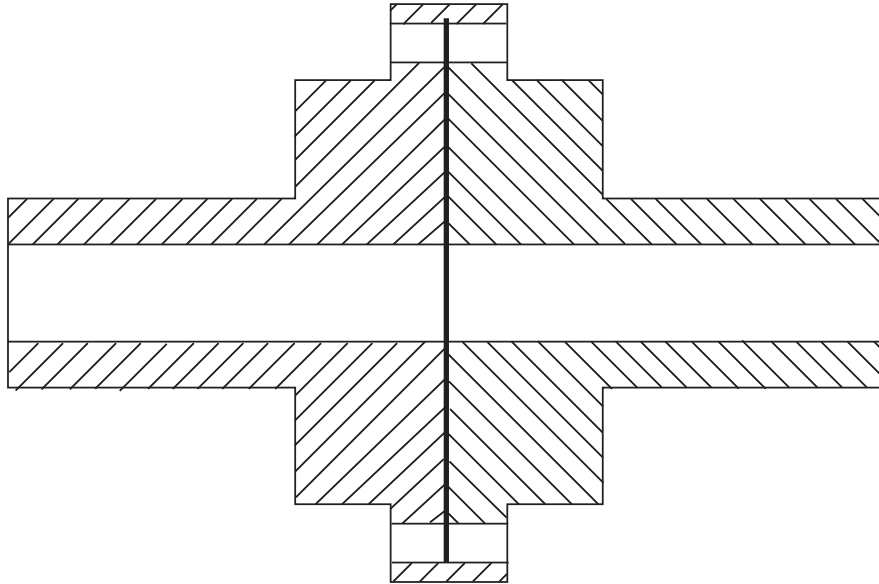
Sliced View (ROTATED AT 90 DEGREES)



Sliced View (SW ISOMETRIC)

6 Assignment documentation

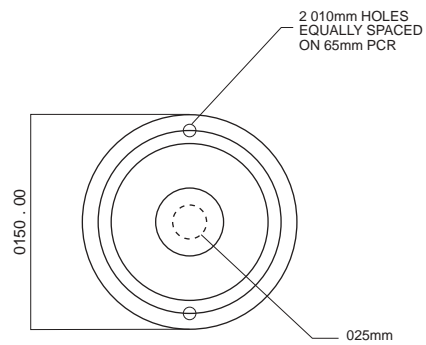
- 6.2 Required drawing – View B: Solid section view of flanged pipe coupling (after hatching)



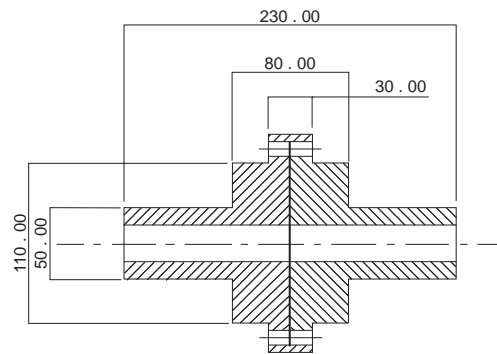
6 Assignment documentation

6.3 Drawing instructions

Instructions for flanged coupling



Sectional detail of flanged pipe coupling



048 Computer Aided Draughting 2 Practical Assignments

Practical assignment: 048/4 Regional Modelling – Link Mount

1 Competence reference

48.28-48.31

2 Preparation

2.1 Location of test

The centre, under supervision.

2.2 Requirements

An AutoCAD manual, a computer running AutoCAD version 12 (or later version) with a mouse and a laser printer

A copy of section 3 and section 6.

2.3 Instructor notes

Candidates are required to produce two views of a regional model of a link mount (see section 6, view A, south west isometric view and front elevation and view B, both south west elevations – one hidden, one wire framed).

Instructors may either produce the orthographic view (see section 6.3) and give copies to candidates on disk or user network area or require candidates to produce the orthographic view prior to the assignment.

The time allowed for this assignment is 3½ hours.

3 Candidates' instructions

- 3.1 You are required to produce two views of a regional model of a link mount (see section 6, view A, south west isometric view and front elevation and view B, both south west elevations – one hidden, one wire framed). You have 3½ hours to complete this assignment.
- 3.2 Create a new drawing called REGION.DWG.
- 3.3 Set appropriate drawing limits.
- 3.4 Use the orthographic profile of the link mount provided (see section 6.3).
- 3.5 Produce required drawing view A of south west isometric view and front elevation.
- 3.6 Produce required drawing view B of both south west elevations – one hidden, the other wire framed.
- 3.7 Print or plot view A and view B to file with the names VIEW-A and VIEW-B and **also** save the drawings.
- 3.8 Extract mass properties of both views, save as VIEWA.MPR and VIEWB.MPR and print.
- 3.9 Hand in your work to the instructor.

4 Marking

- | | | |
|-----|--|-----|
| 4.1 | Assignment completed in 3½ hours. | () |
| 4.2 | A new drawing created called REGION.DWG. | [] |
| 4.3 | Appropriate drawing limits set. | [] |
| 4.4 | An orthographic profile of the link mount used. | [] |
| 4.5 | Required drawing produced, view A of south west isometric view and front elevation. | [] |
| 4.6 | Required drawing produced, view B of both south west elevations – one hidden, the other wire framed. | [] |
| 4.7 | View A and view B printed or plotted and drawings saved to file. | [] |
| 4.8 | Mass properties of both views extracted, saved as VIEWA.MPR and VIEWB.MPR and printed. | [] |
| 4.9 | Work handed to the instructor. | [] |

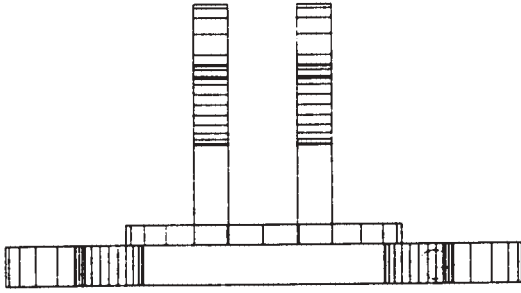
5 Assignment completion

The candidate will have satisfactorily completed this assignment if successful in all the items marked with [].

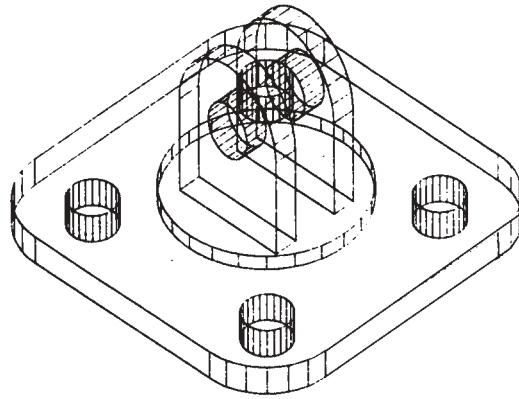
A period of several days must elapse before an unsuccessful candidate may retake this assignment.

6 Assignment documentation

6.1 View A



FRONT ELEVATION

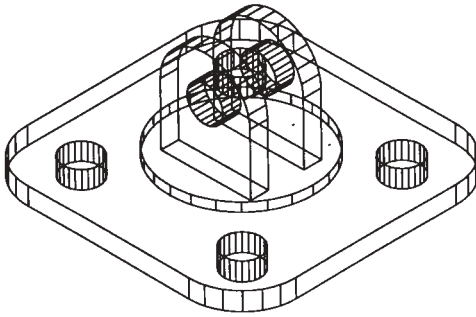


SOUTH WEST ISOMETRIC VIEW

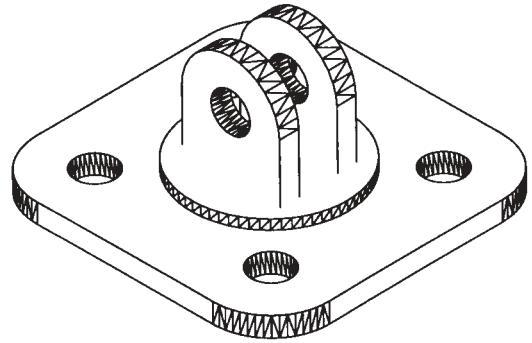
6 Assignment documentation

6.2 View B

REQUIRED DRAWING – LINK MOUNT



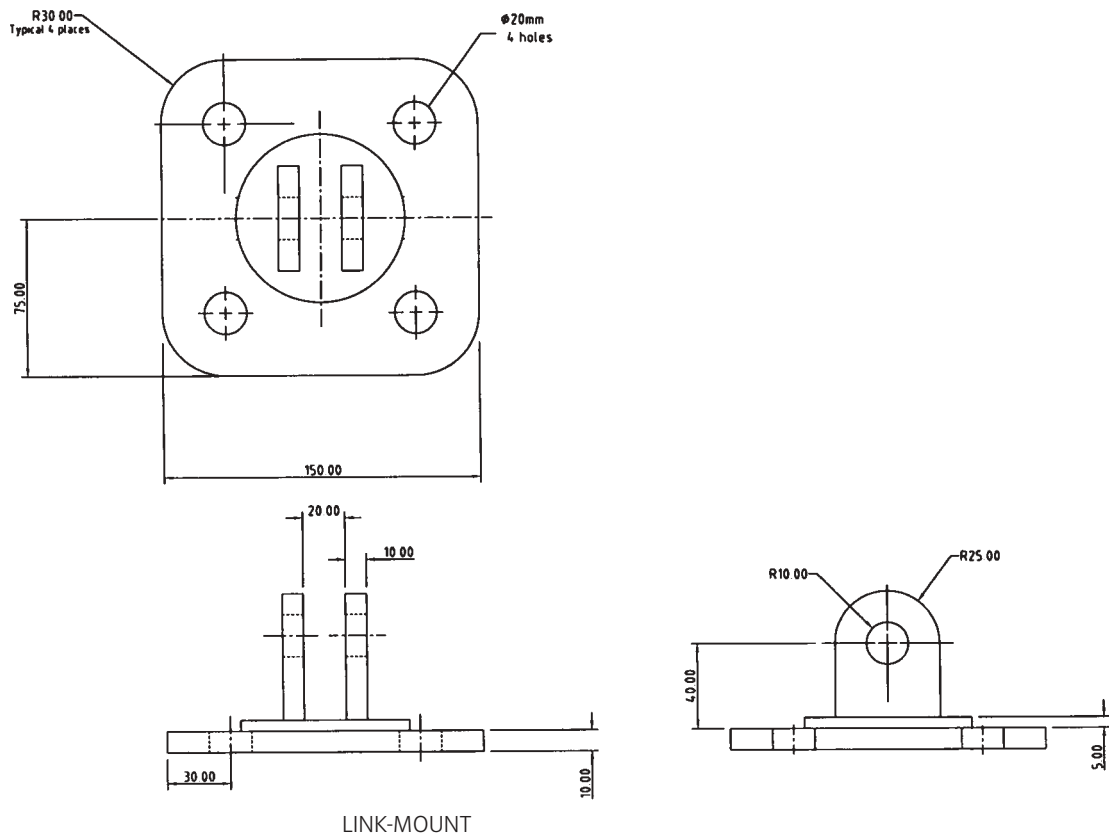
WIRE FRAMED MODEL



HIDDEN REGIONED MODEL

6 Assignment documentation

6.3 Drawing instructions



Appendix A

Practical assignments

Two assessment methods are used in the 2565 Technician Awards in Engineering programme – written questions and practical assignments.

Practical assignments

Some of the units or components in the Advanced Diploma level of this programme have a related practical assignment or assignments. These assignments may call on skills covered in other sections but reference is only made to the competences covered by the marking criteria. Wherever relevant the option is given for you to use local names, local currencies, alternative measurements and paper sizes, or to design an alternative assessment. **Where this option is taken the assignment must be of a comparable standard** to ensure consistency between centres using this programme. The assignment must be documented and available for the visiting verifier. ALL assignments must be successfully completed.

The assignments may be administered at any time convenient to the instructor and to the candidate.

The practical assignments in this publication are intended to be photocopied.

Instructor notes

It is essential that you read these before attempting to administer the practical assignment. Practical assignments usually require you to prepare material for the assignment.

Candidate instructions

Make sure every candidate has a copy of these before beginning the practical assignment.

Marking

The marking is based on performance criteria or outcomes related to the practical assignment, to which the answer will always be either 'yes – the candidate achieved this' or 'no – the candidate did not achieve this'. Credit is given for those performance competences for which the answer is 'yes – the candidate achieved this'.

Supervision

All assignments require supervision and you must make sure that the results reflect only the individual candidate's own work. You must keep all assessment documentation and material in a file for each candidate until the results have been agreed by the visiting verifier and until confirmation of result has been received from City & Guilds.

Records, results and certification

Successful completion of the related practical assignments for each unit needs to be recorded and then sent to City & Guilds. We suggest that you keep a record of each individual's achievements which may then be transferred to the entry forms. A model is given at the end of this section but you may use any form of record keeping that is convenient and accessible.

In order to gain certification, results for successfully completed practical assignments must be sent to City & Guilds. Results for practical assignments are entered onto Form S which is then countersigned by the visiting verifier and sent to us.

An advantage of this programme is that candidates who successfully complete the practical assignments for a single unit may, if they wish, claim a Certificate of Unit Credit. This may be beneficial for those candidates who only wish to complete part of this programme. Send these claims to us at any time provided the visiting verifier has countersigned the Form S.

Candidates wishing to gain the full award (Certificate, Diploma or Advanced Diploma) must successfully complete all the relevant practical assignments. We recommend that their practical results are sent at the time of, or shortly before, the date of the written examinations.

Visiting verifier

The operation of this programme requires the appointment of a visiting verifier. **The visiting verifier must countersign the results of the practical assignments on Form S.** The visiting verifier should also be able to inspect records and candidates' work to verify the results before submission.

Advanced Technician Diploma in Applied Mechanical Engineering – Manufacturing

Candidate assessment record

***Candidates must complete these assignments**

Candidate's name and number

Centre name and number

Assessment reference	Date completed	Instructor signature	Instructor name
030/1 Engineering project*			
035/1 Operate a CAM system*			
035/2 Write a programme*			
048/1 Construction and visualisation			
048/2 Surface modelling*			
048/3 Solid modelling*			
048/4 Regional modelling*			

Advanced Technician Diploma in Applied Mechanical Engineering – Plant Technology Candidate assessment record

*Candidates must complete these assignments

Candidate's name and number

Centre name and number

Assessment reference	Date completed	Instructor signature	Instructor name
030/1 Engineering project*			
039/1 Steam generation*			
039/2 Calculate heat transference*			
041/1 Investigating an hydraulic system*			
041/2 Investigating a pneumatic system*			
048/1 Construction and visualisation			
048/2 Surface modelling*			
048/3 Solid modelling*			
048/4 Regional modelling*			

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