

# Skills for Work: Engineering Skills Intermediate 2

# Design and Manufacture



# Support Material

**E**Scotland's Colleges



## Acknowledgements

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# Engineering Skills: Design and Manufacture (Intermediate 2) F39E 11

## Introduction

These notes are provided to support teachers and lecturers presenting the Scottish Qualifications Authority Unit F39E 11, *Engineering Skills: Design and Manufacture (Intermediate 2)*.

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Further information regarding this Unit including Unit Specifications, National Assessment Bank materials, Centre Approval and certification can be obtained from:

The Scottish Qualifications Authority Optima Building 58 Robertson Street Glasgow G2 8DQ

Website: www.sqa.org.uk

#### **Class Sets**

Class sets of this pack may be purchased direct from the printer. Costs are dependent on the size of the pack and the number of copies. Please contact:

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#### Disclaimer

Whilst every effort has been made to ensure the accuracy of this support pack, teachers and lecturers should satisfy themselves that the information passed to candidates is accurate and in accordance with the current SQA arrangements documents. SFEU will accept no responsibility for any consequences deriving either directly or indirectly from the use of this pack.

## Contents

How to Use this Pack	10
Reference Section	11
What are Skills for Work Courses all about?	12
The Course in Engineering Skills (Intermediate 2)	15
Unit Outcomes, PCs and Evidence Requirements	18
Evidence Requirements for the Unit	19
Employability Skills Profile	22
Careers Scotland Support	23
Tutor Support Section	24
Introduction	25
Learning and Teaching with Under 16s	27
General Guidance on Unit Delivery	31
Unit Induction	32
Scheme of Work	33
Health and Safety Considerations	37
Signposting of Employability Skills	39
Resources	44
Lessons, Materials and Tools	46
Student Support Section	71
Tutor Note on Student Activities	72
Welcome to the Design and Manufacture Unit!	73
Employability	74
What is Design?	75
How do you design?	77
Who does design?	78
Why do the design?	78
What can be designed?	79
Project Brief	80

Project Plan	81
Produce a Design Specification	84
Manufacturing Instructions	95
Computer Aided Drawing	101
Design Review	102
Tools for Design and Manufacture	104
Safety	105
Dimensions and Tolerance	106
Manufacturing and Assembly	108
Checking that the Product is Functional	109
Project Review	111
The Project Review	112
The Project Report	113
Presentation	115
Notes	117
Unit Questionnaire	118
Glossary of Terms	119

## How to Use this Pack

None of the material in this pack is mandatory. Rather, it is intended as a guide and an aid to delivery of the Unit and aims to provide centres with a flexible set of materials and activities which can be selected, adapted and used in whatever way suits individual circumstances. It may also be a useful supplement to tried and tested materials and approaches that you have developed yourself. The pack is available on the SFEU website in Word format to enable you to customise it to your suit your own needs.

The **Reference Section** of the pack provides information on the rationale for, and ethos behind, the Skills for Work courses, the Course Rationale, the Unit Outcomes and Evidence Requirements and the Employability Skills Profile for Intermediate 2 Engineering showing where the specified employability skills and attitudes can be evidenced and assessed throughout the Course and in this unit.

The **Tutor Support Section** contains a suggested approach to teaching the Unit; advice on learning and teaching with under-16s; guidance on unit induction and unit delivery and advice on integrating the development of employability skills throughout the unit; a scheme of work with a series of suggested lesson plans and advice on Health and Safety considerations. This section also suggests resources which may be useful for tutors and students.

The Student Support Section contains guidance and instruction on manufacturer's specifications, drawings and safety instructions, guidance on Health and Safety issues, a range of student activities covering the practical outcomes of the unit and a glossary of terms used in design and manufacture.

You may wish to place material from the student notes on your own college Intranet by downloading this pack from the Skills for Work section of the SFEU website www.sfeu.ac.uk/skills\_for\_work

Activities are identified with the symbol:



# **Reference Section**

## What are Skills for Work Courses all about?

Skills for Work Courses are designed to help candidates to develop:

- skills and knowledge in a broad vocational area
- Core Skills
- an understanding of the workplace
- positive attitudes to learning
- skills and attitudes for employability.

A key feature of these Courses is the emphasis on **experiential learning**. This means learning through practical experience and learning by reflecting on experience.

## Learning through practical experience

Teaching/learning programmes should include some or all of the following:

- learning in real or simulated workplace settings
- · learning through role play activities in vocational contexts
- carrying out case study work
- planning and carrying out practical tasks and assignments.

## Learning through reflecting at all stages of the experience

Teaching/learning programmes should include some or all of the following:

- preparing and planning for the experience
- taking stock throughout the experience reviewing and adapting as necessary
- reflecting after the activity has been completed evaluating and identifying learning points.

The *Skills for Work* Courses are also designed to provide candidates with opportunities for developing **Core Skills** and enhancing skills and attitudes for **employability**.

## **Core Skills**

The five Core Skills are:

- Communication
- Numeracy
- Information Technology
- Problem Solving
- Working with Others

## Employability

The skills and attitudes for employability, including self-employment, are outlined below:

- generic skills/attitudes valued by employers
  - understanding of the workplace and the employee's responsibilities, for example time-keeping, appearance, customer care
  - self-evaluation skills
  - positive attitude to learning
  - flexible approaches to solving problems
  - adaptability and positive attitude to change
  - confidence to set goals, reflect and learn from experience.
- specific vocational skills/knowledge
  - Course Specifications highlight the links to National Occupational Standards in the vocational area and identify progression opportunities

Opportunities for developing these skills and attitudes are highlighted in each of the Course and Unit Specifications. These opportunities include giving young people direct access to workplace experiences or, through partnership arrangements, providing different learning environments and experiences which simulate aspects of the workplace. These experiences might include visits, visiting speakers, role play and other practical activities. A Curriculum for Excellence (Scottish Executive 2004) identifies aspirations for every young person. These are that they should become:

- successful learners
- confident individuals
- responsible citizens
- effective contributors.

The learning environments, the focus on experiential learning and the opportunities to develop employability and Core Skills in these Courses contribute to meeting these aspirations.

# The Course in Engineering Skills (Intermediate 2)

## **Course Rationale**

The Engineering Skills (Intermediate 2) Course has been designed to provide a basis for progression into further education or for moving directly into training in employment within an engineering sector. The overall purpose of the Course is to ensure that candidates start to develop the generic and practical skills, knowledge and understanding, and employability skills needed within an engineering sector.

The engineering sector includes the following:

Mechanical	Manufacture	Maintenance
Fabrication	Welding	Electrical
Electronic	Foundry	Automotive
Control	Transport	Aeronautical
Communications	Space	Energy Generation
Conservation	Marine	Water
Desalination	Oil/Gas	Petroleum

This Course focuses on the broad areas of Mechanical, Fabrication, Electrical, Electronic, Maintenance, Manufacture, and an element of Design. This will allow the candidates to gain transferable skills which can be applied to any of the above engineering areas.

The primary target group for this Course is school candidates in S3 and above. It may be suitable for candidates entering engineering for the first time but also for those who have completed the Engineering Skills (Intermediate 1) Course. This Course will build on the skills and knowledge developed in the Engineering Skills (Intermediate 1) Course and will introduce candidates to a wider range of engineering applications.

It is anticipated that, for this group of candidates, the Course will rely on and build on existing partnerships between schools and colleges and employers (or other agencies). This may be particularly pertinent in the case of the Engineering Skills Course due to the specialist expertise and facilities available in, for example, further education colleges and training providers. Nevertheless, the Engineering Skills Course is designed at a level and scope such that it can be delivered in schools, if the school has suitable facilities and teaching expertise. A partnership approach would still be necessary in order to provide the contact with the workplace which is an essential part of the experience for candidates. The Course is also suitable for adult candidates who are seeking to enhance their employability and develop introductory vocational skills in an engineering sector. The general aims of the Engineering Skills (Intermediate 2) Course are to:

- widen participation in vocationally-related learning for school candidates from S3 upwards
- allow candidates to experience vocationally-related learning
- provide candidates with a broad introduction to the engineering vocational sector
- encourage candidates to foster a good work ethic, including timekeeping, a positive attitude, and other relevant employability skills
- provide opportunities to develop a range of Core Skills in a vocational context
- encourage candidates to take charge of their own learning and development
- provide a range of teaching, learning, and assessment styles to motivate candidates to achieve their full potential
- facilitate progression to further education and/or training
- encourage candidates to plan their work and review their progress
- encourage candidates to develop a positive attitude to waste minimisation and environmental issues

In particular, the aims of the Engineering Skills (Intermediate 2) Course are to:

- encourage candidates to consider a career in the engineering industry
- develop an awareness of what opportunities there may be within engineering in terms of the types and range of career options
- enable candidates to develop and apply practical, technical, and communication skills as a foundation for future learning and progression
- develop the candidates' awareness of their individual strengths and weaknesses in relation to the requirements of engineering, and to reflect on how this affects their employability potential
- give candidates the technical knowledge, skills, and understanding associated with a range of skills in engineering at this level
- give candidates an introduction to the design cycle
- encourage candidates to apply their knowledge and understanding of engineering by using skills of evaluation and problem solving in a vocational context
- develop an awareness that health and safety issues are integral to the world of work generally and engineering in particular
- prepare candidates for further learning opportunities, study, and training for employment in engineering and related occupations

The Engineering Skills (Intermediate 2) Course has been designed with National Occupational Standards in mind. The standards set for first-year apprentices in the engineering industry, and the standards set out in the Intermediate 2 Course, are broadly comparable in terms of skills and tolerances.

While no formal entrance qualifications are required for this Course, it would be expected that candidates embarking on the Course would have the following:

- basic proficiency in literacy
- basic proficiency in numeracy
- some aptitude for graphical forms of communication (the reading of basic engineering drawings is developed in the Course)
- motivation to work as part of a team

This Course supports progression into appropriate further education, training, or employment. The Course provides the basis for candidates to gain an insight into engineering occupations such as Mechanical, Fabrication, Automotive, Aeronautical, Electrical, and Electronic, Marine, Control, Maintenance, and Manufacture and to use their studies to help them decide the career they wish to follow. Candidates studying this Course in Engineering and choosing a skills option, may be aiming to progress into an apprenticeship in industry. Candidates who are uncertain which trade to follow may undertake vocational courses at further education colleges.

The Intermediate 2 Course should facilitate progression to a relevant vocational Course or an appropriate National Certificate/Qualification programme.

# Unit Outcomes, PCs and Evidence Requirements

### National Unit Specification: statement of standards

### Unit: Engineering Skills: Design and Manufacture (Intermediate 2)

Acceptable performance in this Unit will be the satisfactory achievement of the standards set out in this part of the Unit Specification. All sections of the statement of standards are mandatory and cannot be altered without reference to SQA.

#### Outcome 1

Design a product from a given project brief.

### **Performance Criteria**

- a) Produce a design specification for the product in accordance with the given brief.
- b) Correctly add dimensions and manufacturing instructions to the design specification.
- c) Produce a CAD drawing of a product part of the design specification to relevant standard.
- d) Produce a hard copy of the CAD drawing.

#### Outcome 2

Identify, select, and use tools, materials and equipment to manufacture/construct the product.

#### **Performance Criteria**

- a) Identify, select, and safely use a range of relevant tools, materials and equipment.
- b) Safely and correctly manufacture/construct the product from the design specification.
- c) Correctly observe safe working practices in all practical activities.

### Outcome 3

Evaluate the results of practical tests on the product.

### Performance Criteria

- a) Identify and use dimensional checks on the completed product correctly.
- b) Test that the functional use of the completed product conforms to the given brief.
- c) Produce a report which includes a valid conclusion on the functionality of the product.
- d) Communicate the findings of the report to a specified audience.

#### Outcome 4

Review and evaluate own employability skills in practical engineering contexts.

#### Performance Criteria

- a) Review and evaluate own employability skills.
- b) Seek and record feedback on own performance in employability skills
- c) Make a judgement on own strengths, weaknesses, and learning points in relation to employability skills.
- d) Identify action points for improvement in relation to employability skills.

## **Evidence Requirements for the Unit**

Performance and written/oral evidence is required to show that all Outcomes and Performance Criteria have been achieved.

**Performance evidence** will be supported by assessor checklists. This evidence will be generated from a project consisting of practical activities carried out under supervised conditions.

The evidence may be gathered at different points throughout the Unit.

Candidates will be assessed on the practical activities in the manufacture/construction of a product in a safe manner. The product will be selected from **one** of the following project briefs:

- 1 Design a project which incorporates at least **three** component parts that will **lift** a 1kg weight to a height of 500mm and **lock** the weight at that height.
- or
- 2 Design a circuit diagram and component layout of an electrical/electronic project that will move an object from a horizontal to vertical position and give an audible and visual indication.
- or
- 3 Design a control system that will measure a physical parameter, give an audible and visual warning when the physical parameter changes and activate an output transducer.
- or
- 4 Design a project that will incorporate a minimum of any **two** from the following: Mechanical; Fabrication; Electrical; Electronic; Control.

Whichever project brief is selected, candidates are required to:

- produce a design specification suitable for manufacture
- produce a hard copy of a CAD drawing of a product part to include:
  - o two views
  - o three line types
  - o dimensions
  - o orthographic symbol
  - o title block
- select and use the correct tools, materials, and equipment, as required, to safely manufacture and assemble the product
- complete dimensional checks on the completed product
- complete functionality tests on the completed product to check for quality, robustness, fitness for purpose before submitting their work for final assessment

Where candidates choose to complete option 4 (the integrated project) they can, if appropriate, work in teams. It is essential that the project produced by such a team will be of sufficient complexity and scope to allow all members of the team to make a contribution equal to the manufacture and assembly of a project by an individual candidate.

Where this occurs the assessor must be satisfied that each individual candidate has produced evidence to demonstrate achievement of all Outcomes and Performance Criteria.

Dimensions must be within the stated tolerance of  $\pm 1$  mm, as expressed in the National Assessment Bank (NAB) material.

#### Written/Oral Evidence

Candidates are required to:

- complete an evaluation on the functionality of the project using a given pro forma checklist
- complete a short report of between 250 and 400 words, that includes a valid conclusion on the functionality of the project
- communicate the findings of the report to a peer group
- complete a self evaluation review of their own performance against the following employability skills:
  - showing health and safety awareness to include wearing PPE, safe working practices and understanding a basic risk assessment
  - o interpreting engineering drawings and specifications
  - working cooperatively with others to include seeking advice, following instructions and working in a team
  - planning and preparing for work to include selection of correct tools and equipment
  - applying time management to include working to schedule and undertaking a correct sequence of work
  - o quality checking own work
  - self review and evaluation to include identifying strengths and weaknesses, identifying learning points from practical experiences, and having a positive attitude to learning

A signed record of the review must be retained by the assessor as assessment evidence.

The National Assessment Bank (NAB) item for this Unit provides an appropriate candidate review sheet, assessor checklists and functionality pro forma. These exemplify the national standard. Centres wishing to develop their own assessments should refer to the NAB to ensure a comparable standard.

# NB Centres must refer to the full Unit Specification for detailed information related to this Unit.

# **Employability Skills Profile**

In addition to the specific, vocational skills developed and assessed in this Course, employability skills are addressed as detailed in the table below. For the purposes of the table, the Units are referred to as A, B, C and D as indicated.

### Engineering Skills (Intermediate 2)

Mechanical and Fabrication	=	Α
Electrical and Electronic	=	В
Maintenance	=	С
Design and Manufacture	=	D

Employability skills/attitude	Evidence
<ul> <li>maintaining good timekeeping and attendance</li> </ul>	А, В
<ul> <li>showing health and safety awareness</li> </ul>	A, B, C, D
selecting and using engineering tools and materials	А, В
interpreting engineering drawings and specifications	B, C, D
working cooperatively with others	C, D
planning and preparing for work	C, D
applying time management	D
awareness of environmental considerations	B, C
quality checking own work	A, B, C, D
self review and evaluation	A, B, C, D

Assessment evidence in all Units:

Assessor observation checklists of practical activities and candidate review sheets.

# **Careers Scotland Support**

# for School/College Collaboration for Scotland's Colleges in the Scottish Enterprise area



Since August 2006 Careers Scotland (SE and HI areas) has been funded by the Scottish Government to support College/School Collaboration and encourage and promote vocational educational choices for pupils in schools.

Careers Scotland (now part of Skills Development Scotland) has an important role to play in selection, recruitment and pre-entry career guidance, as well as ongoing support and pre-exit career guidance, to ensure the pupils' experience of SfW is capitalised upon in any future career planning.

Careers Scotland activity takes place locally and nationally under 4 objectives:

- Providing careers advice, guidance and employability support to pupils and their parents pre, during and post vocational education experience, focusing primarily but not exclusively on SfW pupils - demonstrating how these educational choices have implications for future career options, and support the achievement of future career goals and supporting effective transitions
- Providing targeted support to pupils at risk of becoming unemployed who would benefit from undertaking a vocational course
- Partnership working to ensure vocational study is given parity of esteem with other school and post school options, focusing on recruitment / selection and retention of pupils on vocational courses
- Capacity building through relevant shared CPD events and resource development to increase understanding of the process of uptake of vocational options and facilitate more effective support to pupils navigating these options

For further information on Careers Scotland (SE)'s involvement in school/college collaboration locally, please get in touch with your Careers Scotland Regional contact:

South East	(Edinburgh & Lothians; Forth Valley; Borders)
Stephen Benwell	01786 452043 stephen.benwell@careers-scotland.org.uk
North East	(Tayside; Grampian; Fife)
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# **Tutor Support Section**

## Introduction

The purpose of this Unit is to enable students to identify, select and use tools to carry out the design and manufacture of a product. Students will produce a project plan, design specification and CAD drawing and manufacture, assemble and test a product. Students will compile a project report and give a presentation on their project. During the practical work students will learn engineering terminology and design and manufacturing skills and will also develop work practices and behavioural attitudes that will enhance their employability skills.

Students will be working in an engineering environment and the requirement to promote and ensure safe working practices are adhered to is essential at all times.

Safe working practices should include:

- keeping the work place tidy and free from obstruction
- maintaining good working relationships with others
- maintaining a positive attitude to instruction
- using tools for their intended use only
- using measuring tools correctly
- being appropriately dressed for workshop activities
- wearing the relevant Personal Protective Equipment (PPE)

In addition to being taught the correct techniques for design and manufacture, students should be given support in all aspects of the practical activities and employability skills.

The time allocations for each Outcome are intended as a guide only. The actual time spent on each Outcome will depend on the ability and prior experience of the student.

Prior to commencing this Unit it is recommended that students should have completed the following Units in the Engineering Skills Intermediate 2 course:

- Mechanical and Fabrication
- Electrical and Electronic
- Maintenance

The Outcomes in this Unit are practical and students should be given plenty of opportunity to handle and work with tools and equipment relevant to design and manufacture. A key aspect of the practical activities is the development of student confidence and therefore students should be given adequate support in all stages of practical work.

The Unit has been designed to allow progression for those students who have already completed *Skills for Work* Intermediate 1 Units.

## Learning and Teaching with Under 16s

Scotland's Colleges have made significant progress in meeting the needs of young learners. Our knowledge of the learning process has increased significantly and provides a range of strategies and approaches which gives us a clear steer on how lecturers can add to their skill repertoire. Lecturers can, and do, provide a stable learning environment where young students develop a sense of self-respect, learn from appropriate role models and see an opportunity to progress. There are basic enabling skills for practical application which can further develop the learning process for this group of students. So what are the characteristics of effective learning and teaching which will help to engage young learners?

## Ten ways to improve the learning process for under 16s

(This list is not exhaustive!)

 Activate prior knowledge and learning – ascertain what the learner knows already and teach accordingly. Young people do have life experience but it is more limited than adult learners and they may not always be aware of how it will assist them in their current learning.

**Tips** - Question and answer; Quick Quiz; Quick diagnostic assessment on computer; present key words from the course or unit and see how many they recognise or know something about.

2. **Tune learners into the Big Picture** – the tutor knows the curriculum inside out and why each lesson follows a sequence, however the young learner does not have this information and is re-assured by being given the Big Picture.

**Tips** – Mind map or concept map; use visuals, for example wall displays of diagrams, photographs, flow charts; explain the learning outcomes in language they will understand; We Are Learning Today (WALT) targets and What I'm Looking For (WILF) targets; give clear and visible success criteria for tasks.

3. Use Advance Organisers – these are lists of the key concept words that are part of the course or unit.

**Tip** – Highlight on any text the concept words that you will be using; make a visible list and put it on display – concept words can be struck off or referred to as they occur (NB this helps with spelling and independent learning as they do not have to keep checking meaning); highlight essential learning and action points.

4. **Vary the teaching approaches**. The two main approaches are instructing and demonstrating, however try to provide opportunities to facilitate learning.

**Tips** – Ask students what they know now that they did not know before, or what they can do now they could not do before, at appropriate points in the lesson or teaching block; ensure there are problem solving activities that can

be done individually or in groups; ask students to demonstrate what they have learned; use a range of question and answer techniques that allow participation and dialogue, eg. provide hints and cues so that they can arrive at answers themselves.

5. **Preview and review of learning**. This helps to embed previous learning and listening skills and provides another opportunity to elicit learner understanding. Consolidates and reinforces learning.

**Tips** – At the beginning of each lesson, or session, review previous learning and preview what is coming up; at the end of each lesson or session, review what has taken place and what will be focussed on next time – these can both be done through question and answer, quizzes and mind mapping activities.

6. Language in the learning environment. Do not assume that the language which is used in the learning environment is always understood by young learners, some words may be familiar but do not have the same meaning when used vocationally.

**Tips** - At appropriate points ask students what words mean; explore the various meanings of words to find out if they may have come across this language in another context; by looking at the structure and meaning of words there is an opportunity for dialogue about learning and to build vocabulary.

7. **Giving instructions in the learning environment**. This is one of the most difficult tasks a tutor has to do whatever the curriculum area. With young learners this may have to be repeated several times.

**Tips** – Ask a student to repeat back what you have asked them to do before beginning a task; ask them to explain the task to one of their peers; use the KISS principle – Keep It Short and Simple so that they can absorb and process the information.

8. Effective feedback. Feedback is very important for the learner to assess their progress and to see how and what they can improve. Provide opportunities to engage in dialogue about the learning function of assessment – provide details of the learner's strengths and development needs either in written or spoken form. With younger learners identifying one or two areas for development is sufficient along with acknowledgement of what has been done well.

Essentially, learners are helped by being given a **specific** explanation of how work can be improved. You can also use summative assessment formatively, ie. as an opportunity to identify strengths, development needs and how to improve.

**Tips** – Ask students themselves to identify their own strengths and development needs – self evaluation; peer evaluation of work can be successful once they have been taught how to do it; the tutor can produce a piece of work and ask students to assess it anonymously; have a discussion about the success criteria for the task and ensure the students are clear about

them; allow learners to set criteria for success and then measure their achievements against these.

**9. Managing the learning behaviour**. Under 16s are coming into Scotland's Colleges and training establishments from largely structured and routine-driven environments in schools and early feedback from those undertaking Skills for Work courses indicates that they very much enjoy the different learning environment that colleges and other training providers offer. Remember though that these are still young learners. They will still expect tutors to provide structure and routine, and will perform best in a calm, orderly learning environment. Young students will respond to firm, fair, and consistent management. Such routines have to be established quickly and constantly reinforced.

**Tips** - Health and safety is non-negotiable and consequences of noncompliance with the regulations should be made clear and adhered to at all times; set out your expectations from day one and provide a consistent message; have clear beginnings, middles and endings for each session; be a positive role model for your students, ie. be there before they are and manage the learners with respect; always deliver what you promise; build up good relationships and get to know the learners, make the curriculum interesting and stress the relevance of the learning; set up a positive behaviour management system. By following these guidelines you will build up two-way respect, which, while sometimes challenging to achieve, can be very powerful and work to everyone's benefit.

10. **Care and welfare issues**. School/college partnerships mean increasing numbers of young learners in college. Tutors have to be aware of their professional responsibilities and mindful of young people's rights. However tutors have rights too, in terms of feeling safe and secure in working with young people and there are basic steps staff can take to minimise risks. It is essential that colleges ensure that tutors have a working knowledge of the Child Protection policies (local authority and college documentation) and follow procedures and policies diligently. School/College Liaison Officers will be familiar with these documents and can provide support and advice. There are also training sessions on Child Protection available from SFEU (see the following page).

**Tips** - Avoid one-to-one situations with young students in a closed area; do not do or say anything that could be misinterpreted; if the opportunity arises, do some observation in schools to see and discuss how teachers use the guidelines for their own protection as well as the young person's.

Most young people are a delight to work with and they will positively enjoy the experience of learning in college. However, there will inevitably be some who are disengaged, disaffected and who have not yet had an opportunity to experience success. *'Skills for Work'* is a unique educational initiative that young people can be motivated to buy into – you as the tutor are key to the success of these programmes.

## **Skills for Work Workshops**

To take this 10 point plan forward and to add to it, you can attend one of SFEU's 'Get Skilled Up' half day workshops for tutors delivering Skills for Work Courses, when we explore further the learning process and look at a range of specific teaching and learning techniques to use with the under 16 age group. To find out when the next event is visit our website <u>www.sfeu.ac.uk</u> or contact the Learning Process team at SFEU on 01786 892000.

## **Child Protection Workshops**

These are run on a regular basis by staff at SFEU in Stirling and also in colleges. For more information on these workshops please contact members of the Access and Inclusion team at <u>www.sfeu.ac.uk</u> or contact the team at SFEU on 01786 892000.

# **General Guidance on Unit Delivery**

The emphasis is on a practical approach in which the students complete practical tasks and exercises to develop design and manufacture skills. It is also designed to highlight the employability skills that are valued by employers.

The Unit should be delivered in a workshop environment. Students must wear overalls, safety footwear and other PPE (Personal Protective Equipment) as required in the workshop. They should be made aware that employability skills such as attendance, punctuality, working with others, applying time management and reviewing their progress will also be developed, supported and monitored. It is important that students evaluate their progress with employability skills and at the same time start to evaluate their practical skill development and state what they were good at and what they were not so good at in both areas.

There should be adequate time to progress design and manufacture skills whilst at the same time giving each student a good insight into engineering both locally and nationally.

Associated knowledge and skills to be developed include:

- understanding design specifications
- commonly used design and manufacture terminology
- practice in the use of CAD
- names and use of tools and equipment
- workshop practice in manufacturing and assembly

The unit is also an ideal opportunity to progress Core Skills within the context of design and manufacture:

**Numeracy Skills**: Students will be interpreting dimensioning and tolerancing and the testing of engineering parts will require numerical interpretation.

**Working with Others**: During design and manufacture students will be actively encouraged to seek advice from their tutor and work with their peers as part of a team.

**Problem Solving**: Functional checks and testing will present problems to which the students will be required to arrive at efficient and cost effective solutions.

**Communication**: Students will be interpreting a design specification and CAD drawings and will be required to follow oral and written instructions.

**IT:** Students will be provided with opportunities to research the Internet to seek additional information about design and manufacture techniques and procedures.

## **Unit Induction**

An induction session in week 1 will prepare students well for the unit and help to clarify aims and expectations, what the unit is all about and any uncertainties they may have about the unit and how it will be delivered. Induction may include the following:

- an outline of the Unit content what they're going to be doing
- how it fits in to the Engineering Skills Course
- your plans for teaching the Unit how they'll be learning the practical skills
- assessment methods and <u>schedule</u>
- where employability fits in start by asking them what they think!
- a section on health and safety
- you might also think about inviting a representative from a service provider to speak to the class about the types of employment available in their organisation, about employment and educational opportunities prospects in design and manufacture, and to reinforce the value that employers put on employability skills.
- the importance of regular attendance and good timekeeping to encourage employability skills development get them into good habits just as if they were at work and in employment!

#### Health and Safety - Note



Students need to understand their roles and responsibilities in relation to health and safety. Students may already have an appreciation of health and safety issues in one of the other course units but it should be pointed out to them that in this unit they may be dealing with a different set of potential hazards and that each practical activity will start and end with health and safety issues relevant to the practical skills covered in the lesson.

# Scheme of Work

The content of the Unit begins with the design of a product from a given project brief and includes the creation of a design specification, manufacturing instructions and a CAD drawing. After that the student will be required to correctly select and use tools and equipment to manufacture the product. This is followed by developing skills in testing and functional checking of the product and conformance to the project brief. On acquisition of the design and manufacture skills, the students are required to produce a report and communicate their conclusions to an audience.

The Outcomes should be taught in the order listed in the Unit. The review and evaluation of employability skills, however, should be integrated in all the activities undertaken in the unit.

At the beginning and throughout each Outcome of the Unit the following should be emphasised and adhered to:

Sa W	fe Working Practices in the orkshop	Th	e Care and Use of PPE
•	Workshop Safe Working Practices	•	footwear
•	Workshop Housekeeping	•	overalls
•	Health and Safety	•	eye protection
•	Accident Procedures	•	hand protection
•	Fire Alarm Procedures	•	gloves

### Outcome 1 (approximately 14 hours)

## Design a product from a given project brief.

Produce a design specification for the product in accordance with the design brief.	<ul> <li>health and safety regulations</li> <li>interpret the requirements of a project brief</li> <li>identify the main contents of a design specification</li> <li>produce a design specification</li> <li>produce a project plan</li> </ul>
Add dimensions and manufacturing instructions to the design specification.	<ul> <li>identify safe working practices and health and safety regulations relating to the manufacturing instructions</li> <li>interpret the dimensioning and tolerancing requirements of the product</li> <li>produce manufacturing instructions via an operation planning sequence</li> </ul>
Produce a CAD drawing (and hard copy) of a product part of the design specification to relative standards.	<ul> <li>safe working practices – safety and the design activity</li> <li>produce a CAD drawing</li> <li>obtain a hard copy of CAD drawing</li> </ul>

### Outcome 2 (approximately 14 hours)

# Identify, select and use tools, materials and equipment to manufacture the product

Identify, select and safely use a range of relevant tools, materials and equipment.	<ul> <li>identify and use tools by name and purpose – the safe use and recognition of tools in terms of their name and purpose</li> <li>identify and use materials by name and purpose</li> </ul>
Safely and correctly manufacture/construct the product from the design specifications.	<ul> <li>correct methods of manufacture and assembly</li> </ul>
Correctly observe safe working practices in all practical activities.	<ul> <li>safe working practices – in the manufacturing environment</li> </ul>

### Outcome 3 (approximately 7 hours)

#### Evaluate the results of practical tests on the product

Identify and use dimensional checks on the completed product correctly.	<ul> <li>safe working practices – following functional checking and testing procedures</li> <li>dimension checking</li> </ul>
Test that the functional use of the completed product conforms to the given brief.	fit for purpose testing
Produce a report which includes a valid conclusion on the functionality of the product.	<ul><li>design and project review</li><li>produce a report</li></ul>
Communicate the findings of the report to a specified audience.	<ul><li>prepare presentation</li><li>give a presentation</li></ul>

### Outcome 4 (approximately 5 hours)

# Review and evaluate own employability skills in practical engineering contexts.

Review and evaluate own employability skills.	Students will complete a Review Sheet covering:
Seek and record feedback on own performance in employability skills.	<ul> <li>showing health and safety awareness</li> </ul>
	<ul> <li>interpreting engineering drawings and specifications</li> </ul>
Make a judgement on own strengths, weaknesses and learning points in relation to employability skills.	<ul> <li>working cooperatively with others</li> </ul>
	<ul> <li>planning and preparing work</li> </ul>
	<ul> <li>applying time management</li> </ul>
Identify action points for improvement in relation to employability skills.	<ul> <li>quality checking own work</li> </ul>
	<ul> <li>self review and evaluation</li> </ul>
## Health and Safety Considerations

## General safety in the workplace

This deals with the issues of:

- General Health and Safety
- Personal Protective Equipment (PPE)
- Safe working techniques (including tool-handling)
- First Aid
- Fire Alarm
- COSHH
- Good housekeeping in the working environment
- Manual handling

Each student will require the minimum **PPE** of safety boots and overalls for most workshop activities. In some cases students may require additional equipment such as goggles, gloves, safety spectacles or ear defenders.

**Safe working techniques** will include general workshop behaviour and protocol. This will include the correct handling and transportation of tools; tool safety; workshop layout; and procedures for starting and finishing practical activities.

**First Aid** considerations should include awareness of the nearest first aid station, first aider, first aid procedures, accident and 'near miss' reporting, and avoidance of potential accidents.

**Fire Alarm** evacuation procedures should be practised and students made familiar with the audible warning sound, alarm points, location of fire fighting equipment, fire exits, assembly areas and correct conduct under alarm conditions.

The **Control of Substances Hazardous to Health** (COSHH) must be stressed if students are subjected or exposed to any chemicals, fumes, dust or irritants.

**Good housekeeping** is the welfare of all participants and the general working conditions in the workplace. This will include safety, PPE, behaviour, conduct, storage and condition of tools and equipment, walkways and handling and disposal of waste oil and scrap materials.

**Manual handling** techniques should be discussed and encouraged as a matter of good safety practice.

## **Personal Safety**

The students need to appreciate that they are responsible for their own safety and the safety of others. This will include their conduct and behaviour in all activities. Safe working practices in workshops and the safe use of tools and equipment should be emphasised.

In all the activities students are asked to perform they should be encouraged to make sound judgements on issues such as:

- the effect of their actions on fellow students
- are the tools and equipment in good usable condition?
- are they being asked to carry out an action they are unfamiliar with?
- should they seek advice from an appropriate person?

Students' personal dress should be hardwearing and give protection against grease/oil/heat etc. This clothing should not have any loose sleeves.

No jewellery of any form should be worn and neither should any piercings be worn.

### Further information on Health and Safety can be found in the SFEU Publication '*Engineering Skills: Course Guidance and Employability Skills Intermediate* 2.

## Signposting of Employability Skills

In addition to the specific vocational skills developed in this Unit, students will have opportunities to develop and apply their knowledge and understanding of the employability skills.

Throughout the pack there are numbered flags, like the one shown here, showing which specific employability skill can be highlighted and/or assessment evidence recorded when students are busy with the various activities in the Unit.



1	Maintaining good timekeeping and attendance	6	Planning and preparing for work*
2	Showing health and safety awareness*	7	Applying time management*
3	Selecting and using engineering tools and materials	8	Awareness of environmental considerations
4	Interpreting engineering drawings and specifications*	9	Quality checking own work*
5	Working cooperatively with others*	10	Self review and evaluation*

The employability skills marked with an asterisk\* are directly assessed in this Unit.

## **Guidance on Integrating Employability Skills**

Opportunities to learn and develop all of these skills are distributed throughout the course.

It is strongly advised that course teams meet together to discuss and agree a coordinated approach to the teaching and developing of the employability skills throughout the Course and to ensure that the team has a common interpretation of the skills and attitudes.

The Unit is designed to give the students the technical knowledge, skills and understanding of design and manufacture but it should also develop student awareness of what opportunities there may be within engineering in terms of the types and range of career paths and options.

It is anticipated that the development and recording of employability skills will be ongoing throughout each activity and practical assignment. It should be stressed at unit induction that that skills valued by employers such as timekeeping, attendance etc will be monitored and recorded and that all students will be encouraged to show a positive attitude. Tutors should look for every opportunity to teach about the value of developing good employability skills as well as teaching design and manufacture skills.

## Generating Evidence and Assessment Opportunities for Employability Skills

The unit is designed around practical assignments which should enable the students to develop and apply practical, technical and communication skills as a foundation for future learning and progression. As instances arise naturally within the completion of practical work or activities, job roles and career paths may be discussed so that all students are aware of progressions within the engineering sector. These discussions will also encourage an interest in engineering in general.

It is important that the students develop the ability to reflect on how they performed in the completion of tasks. In the context of this Design and Manufacture unit this will involve reflection on the development of both practical and employability skills. The skill of evaluation lets the students analyse what they did well, what they did not do so well and how they can improve. This means they will develop an awareness of their individual strengths and weaknesses.

The unit also encourages the students to apply new skills, knowledge and understanding of engineering in the completion of practical assignments by using skills of evaluation and problem-solving in a vocational context.

The following employability skills will be assessed in this unit. However, please note that it is expected that all the other employability skills are also developed throughout the unit.

- showing health and safety awareness
- interpreting engineering drawings and specifications
- working cooperatively with others
- planning and preparing for work
- applying time management
- quality checking own work
- self review and evaluation

You will find and create countless opportunities to help students develop their employability skills. Here are some ways of going about it to get you thinking!

Employability Skills	Delivery Advice	Possible Activities/Contexts
Showing health and safety awareness	Emphasise the importance of maintaining health and safety awareness at all times, of wearing appropriate PPE and the importance of <b>spotting</b> potential risks and hazards. This should lead to the application of Safe Working Practices – keeping walkways clear, correct manual handling techniques, tool and equipment safety etc.	As basic risk assessment is likely to have been covered earlier in the course, students could be given a 'spot the hazard cartoon' as a competitive quiz or a quiz on health and safety in the workshop.
Interpreting engineering drawings and specifications	Emphasise the importance of following drawings and specifications <b>accurately</b> . Tutors should take the opportunity in all tasks which involve using drawings to reinforce the importance of correct interpretation and of following instructions in the correct sequence.	Form small groups and ask each group to interpret a design specification and drawing and then present their thoughts to the rest of the class.
Working cooperatively with others	Encourage the students to support each other and emphasise the importance of <b>cooperation</b> in the manufacturing environment.	Form small groups and ask the students to give examples of teamwork. Students at the end of a <i>Skills for Work</i> course should be able to identify examples from their own experiences during the course.

Planning and preparing for work	Emphasise the <b>benefits</b> of planning and preparing for work – and the consequences of poor preparation. It is worthwhile spending a little time identifying the objectives of each session and encouraging the students to think about how they will go about it, what equipment they will need, what the sequence of the work should be etc.	Form small groups and devise a simple planning sheet to secure all tools and materials from stores; briefly outline how the job will be done and so on.
Applying time management	Encourage the concept that every project should be completed on <b>time</b> , to cost and quality. A realistic awareness of the time different stages of the design and manufacture process are likely to take will also be required for effective planning and preparation.	Form small groups and discuss projects that have over-run their time allocation, the reasons for this and the consequences.
Quality checking own work	Emphasise the importance of <b>continually</b> checking as work progresses.	In pairs, students could be asked to outline to each other if their work in progress is acceptable against specification, drawings and so on. In time this should help give them confidence in evaluating their own work.

## Resources

It is expected that this unit will be taught in an experiential manner within a fully equipped, safe and suitably arranged workshop. Resources required for individual lessons are set out in each lesson plan.

It is particularly important that, as design (CAD) and manufacturing is an integral part of the unit, any participating centre has such resources and ensures safe working practices.

## **Useful Websites**

Listed below are websites that may be of assistance to you or your students:



## • Careers, Safety and Employability

Careers Scotland http://www.careers-scotland.org.uk/home/home.asp

SEMTA http://www.semta.org.uk/

The Scottish Electrical Charitable Training Trust <a href="http://www.sectt.org.uk/">http://www.sectt.org.uk/</a>

EMTA Awards Ltd (EAL) Engineering and Technology industry awarding body <a href="http://www.eal.org.uk/">http://www.eal.org.uk/</a>

Health and Safety Executive <u>http://www.hse.gov.uk</u>

COSHH – Control of Substances Hazardous to Health <u>http://www.hse.gov.uk/coshh/</u>

Employability Framework for Scotland http://www.scotland.gov.uk/Topics/Business-Industry/Employability

### • Design and Manufacture

Qualifications and Curriculum Authority: GCSE Designing products for manufacture <a href="http://www.qca.org.uk/qca\_6651.aspx">http://www.qca.org.uk/qca\_6651.aspx</a>

British Design Innovation: project details <u>http://www.britishdesigninnovation.org/index.php?page=newlook/ddview&project\_i</u> <u>d=562</u>

Design Council: A guide for manufacturers wanting to use design for business success

http://www.designcouncil.org.uk/en/About-Design/managingdesign/Design-inmanufacturing/

BBC GCSE Bitesize: Design & Technology: Computer-aided Design (CAD) <u>http://www.bbc.co.uk/schools/gcsebitesize/design/textiles/analysisevaluationrev5.</u> <u>shtml</u>

Blueprint: The Product Design Specification (University of Hertfordshire: Manufacture Systems Engineering) http://www.ider.herts.ac.uk/school/courseware/design/pds/

#### • Tools and Materials

Wikipedia: free encyclopaedia http://en.wikipedia.org/wiki/Main\_Page

Tool-up (commercial site) <a href="http://www.toolup.co.uk/">http://www.toolup.co.uk/</a>

Encyclopaedia http://www.encyclopedia.com/

Technology Student http://www.technologystudent.com/index.htm

FENC – aims to be the leading community for vocational blended learning <a href="http://www.fenc.org.uk">http://www.fenc.org.uk</a>

## Lessons, Materials and Tools

In the following lesson plans, which are intended as a guide only, the simple practical tasks are designed to integrate basic engineering skills such as:

- producing a design specification
- producing manufacturing instructions
- producing a CAD drawing
- identification, selection and use of tools
- manufacturing a product safely
- dimensional checking of a product
- functional testing of a product
- producing a report
- giving a presentation
- employability skills

Each lesson must start with the health and safety requirements that will be applicable to that particular lesson and any additional PPE that might be required.

The types of product selected for design and manufacture is left to the discretion of each centre but must be selected from one of the following project briefs:

- Design a project which incorporates at least **three** component parts that will **lift** a 1kg weight to a height of 500mm and **lock** the weight at that height.
- Design a circuit diagram and component layout of an electrical/electronic project that will move an object from a horizontal to a vertical position and give an audible and visual indication.
- Design a control system that will measure a physical parameter, gives an audible and visual warning when the physical parameter changes and activates an output transducer.
- Design a project that will incorporate a minimum of any **two** from the following Mechanical; Fabrication; Electronic; Control

For the first project brief a suitable design could be a scissor jack design or a vertical screw jack arrangement or a rack and pinion or a pulley system design.

For option two a suitable project may be a motor and a limit switch with an object fixed to the motor shaft, As the shaft rotates the object would impact on the limit switch disconnecting the power supply and switching on the supply to an audible alarm and LED.

For option 3 a suitable arrangement may involve a heater, heat sink, thermostat and fan. Allow the heat sink to heat up and when a set temperature is reached power is supplied to a cooling fan, audible alarm and LED.

Where the last option, the integrated project brief, is selected, students may work in small teams. An example of such a project brief may be the manufacturing of a Power Supply Unit which could involve the fabrication of aluminium into a box, construction of a printed circuit board with electronic components and electrical wiring of visible indicators and accessories. Where this occurs the assessor must ensure that each individual student's contribution is equal to that of an individual project.

To illustrate how to comply with the requirements of a project brief the following lesson plans are based on the design and manufacture of a mechanical structure with a lever arm that can be rotated 180 degrees and locked into a new position.

The lessons plans can be adapted to enable other types of engineering products to be designed and manufactured.

The tools and equipment applicable to the lesson are listed. This list is for guidance only and can be supplemented as necessary.

During the practical activities the use of tools and equipment for design, manufacturing and functional checks will provide opportunities to discuss the varying roles and responsibilities within the design and manufacturing industry. This could include the design and manufacturing processes used by local engineering firms.

## **Practical Tips**

It is expected that as each basic practical skill is demonstrated, good practice will be emphasised. Good trade specific hints or tips should Also be included in the lesson. It is also recommended that some or all of the following should be integrated with the range of practical activities:

- The use of employed apprentices attending college to aid workshop sessions
- The use of various speakers/experts/tradespersons to aid employability skills and knowledge of local industry
- The use of ICT eg. PowerPoint, Word
- The use of appropriate websites

## **Produce a Design Specification**

#### **Objectives:**

- Health and safety regulations and employability to establish a level of knowledge and understanding of relevant design regulations and employability skills
- Interpret the requirements of a project brief
- Identify the main contents of a design specification
- Produce a design specification
- Produce a project plan

#### Resources:

- Tutor project brief
- Student Support Section materials
- Project plan pro forma example

#### Learning and teaching process:

- use group discussion to discuss the design activity and to determine the level of student knowledge of health and safety issues relating to design regulations. Discuss the need for designers to incorporate safety into their designs and use this opportunity to promote awareness of employability skills such as applying time management, particularly relating to the project plan.
- form small discussion groups to interpret the project brief
- identify the main contents of a design specification
- produce a project plan using the example as a guide



#### Activities

- Products you can design
- Your project plan
- What is in a design specification?



# **Project Plan (Example of a Completed Planning Sheet)** Total Time: 40 hours (20 x 2 hour blocks)

Action		•	•		_	•	-	•		40		40	40		45	40	47	40	40		01-1-1-
	1	2	3	4	5	6	1	ø	9	10	11	12	13	14	15	16	17	18	19	20	Status
Read Project																					
Brief																					
Make Plan																					
Produce																					
Design Spec																					
Produce CAD																					
drawing																					
Gather																					
materials																					
Make parts																					
Assemble																					
Dimensional																					
Checks																					
Test																					
											ļ										
Review																					
Кеер																					
Records																					
Produce																					
Report																					
•																					
Presentation																					
Employability																					
Skills																					

## Answer to Activity: Products you can design

You can find six product types in the table of letters below – you are to circle the words that you can identify as a product.

w	Y	L	V	Q	D	Z	М	т	Р
С	Α	М	Е	R	Α	н	К	Е	J
S	J	Q	I	С	Q	Q	J	L	U
D	Y	L	I	J	н	L	Р	Е	J
D	L	L	Q	Р	Р	L	W	V	Y
Т	L	J	R	к	0	U	Q	I	К
Р	Α	Е	Z	D	Z	D	Z	S	X
G	U	I	Т	Α	R	D	R	I	н
X	Р	Е	н	В	X	S	J	0	R
В	I	С	Y	С	L	Е	D	N	I

Camera, drill, ipod, television, bicycle and guitar

## **Illustrative Project Drawings**

The drawings which follow are of the illustrative mechanical structure project with rotating lever arm, bills of material and operation planning sheets (which give the manufacturing instructions).



















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## **Dimensions and Manufacturing instructions**

### **Objectives:**

- Identify safe working practices and health and safety regulations relating to manufacturing instructions.
- Interpret the dimensioning and tolerancing requirements of the product.
- Produce manufacturing instructions and an operation planning sequence sheet.

#### Resources:

- Tutors project brief
- Student Support Section materials
- Operation Planning Sequence Sheet (manufacturing instructions)
- Measuring tools and equipment

## Learning and teaching process:

- use a group discussion to highlight the health and safety regulations and precautions relating to the manufacturing environment
- state and demonstrate correct methods/techniques of using measuring tools
- allow students to practise measuring on simple tasks
- complete time taken (planned) on operations planning sheet



- Produce Manufacturer's Instructions
- The Operation Planning Sequence



## **Operation Planning Sequence** Date:

Sheet 1 of 2



Sequence Number	Operation Description	Machine used	Tooling Used	Time Taken (planned)
001	Mark out required lengths of material from stock (Leave 5 mm excess to allow squaring off)	-	rule, scriber	
002	Cut lengths of stock material	-	hacksaw	
003	Mark off ends of material lengths to size	-	rule, scriber, square, centre punch	
004	File ends square	-	bench vice, files, square	
005	Mark off position of pivot and locking holes on lever arm	-	rule, scriber, square, centre punch	
006	Drill holes on lever arm	pillar drill	Ø6.2mm drill bit, machine vice	
007	Mark off Ø6.2 hole positions on one of the pivot/lock bars	-	rule, scriber, square, centre punch	
008	Drill Ø6.2 holes	pillar drill	Ø6.2mm drill bit, machine vice	
009	Use the drilled holes as a template to mark and drill holes on the other pivot bar (to ensure alignment)	as before	as before	

## Operation Planning Sequence (cont'd)

Date:			Sheet 2 of	2
Sequence Number	Operation Description	Machine used	Tooling Used	Time Taken (planned)
010	Mark out hole positions for M6 threaded holes on pivot/lock bars	-	rule, scriber, square, centre punch	
011	Drill and tap M6 to required depth	pillar drill	M6 drill and tap set, tapping wrench, cutting compound, bench vice	
012	Mark out position of Ø6.2 holes on one of the base lengths	-	rule, scriber, square, centre punch	
013	Drill holes	pillar drill	Ø6.2mm drill bit, machine vice	
014	Use the drilled holes as a template to mark and drill holes on the base length (to ensure alignment)	as before	as before	
015	Drill countersink	pillar drill	countersinking bit, machine vice	
016	Use base lengths as a template to mark holes on base cross piece	-	centre punch	
017	Drill and tap M6 to required depth on base cross piece	as before	as before	
019	Cut external thread on cross bars		M6 die set, cutting compound, bench vice	

## Produce a CAD drawing

## Objectives:

- Safe working practices safety and the design activity
- Produce a CAD drawing of a product part
- Obtain a hard copy of the CAD drawing
- Review the design of the product

### **Resources**:

- CAD facilities
- Tutor's project brief
- Student Support Section materials
- Design specification

## Learning and teaching process:

- use group discussion to emphasise the need to consider safety issues in design work
- state and demonstrate correct methods/techniques of using CAD
- correct method of producing a hard copy of drawing



## Activities

- CAD drawing requirements
- Design review



## Identification and use of tools and materials and the manufacture and assembly of a product



#### **Objectives:**

- Identify and use safe working practices in the manufacturing environment
- Identify and use tools by name and purpose the safe use and recognition of tools in terms of their name and purpose. Emphasis should be on the correct use for each tool.
- Identify and use materials by name and purpose
- Correct methods of manufacture and assembly

### Resources:

- Tutor's project brief
- Student Support Section materials
- CAD drawing
- Operation Planning Sequence Sheet (manufacturing instructions)
- Bill of Materials
- Materials
- Tools:
  - o rule
  - o scriber
  - o hacksaw
  - o square
  - o centre punch
  - o bench vice
  - o files
  - o pillar drill
  - o tap set
  - o die set

## Learning and teaching process:

- use group discussion to emphasise the need to follow safety instructions specifically to the manufacturing environment
- identify listed tools by name and purpose
- state and demonstrate correct methods/techniques of using listed tools
- allow students to practise tool usage on simple tasks



## Activities

- Tools practice
- Hazards and Safety

Identification and use of dimensional checks and functional testing



## **Objectives:**

- Safe working practices following functional checking and testing procedures
- Dimension checking
- Fit for purpose test

#### **Resources**:

- Tutor's project brief
- Student Support Section materials
- Measuring tools

### Learning and teaching process:

- use group discussion to emphasis the importance of complying with tolerance requirements
- state and demonstrate correct methods/techniques of testing



Fit for purpose tests

Produce a report and give a presentation on the project

## Objectives:

- Interpret correctly the requirements of a project review
- Produce a project report
- Prepare and give a project presentation

## **Resources**:

- Tutor's project brief
- Student Support Section materials
- Visual aids

## Learning and teaching process:

- use group discussion to emphasis the importance of the review process
- form small groups to discuss how to produce the report
- form small groups to discuss tips on giving the presentation



## Activities

- Project review
- Project report
- Project presentation



## **Practical Activity Checklist**

Checklist to monitor each student's progress in completing the lessons.

Student Name	Lesson 1	Lesson 2	Lesson 3	Lesson 4	Lesson 5	Lesson 6

## **Student Support Section**

## **Tutor Note on Student Activities**

This section includes both student notes and activities. These materials are not mandatory but are offered to centres as a flexible set of materials and activities which can be selected, altered and used in whatever way suits individual centres and their particular situation. For example, in the case of the student activities you might want to talk through the instructions with the learners and then give the instructions out on paper as reminders. You are encouraged to adapt and use the materials creatively in ways which will best engage your students.

It is not intended that the *Student Support Section* is issued to students as a complete pack. Rather the materials are designed to be issued in small sections only, to reinforce practical workshop activity. Handout materials and activity sheets should be issued at an appropriate time – (which could be before, during or after the topic has been fully covered with the students).

This *Student Support Section* focuses on the trade specific aspects of the unit. Further information and activities on the following aspects, which should be incorporated into learning and teaching throughout the unit, can be found in the SFEU publication: *Engineering Skills: Course Guidance and Employability Skills Intermediate 2:* 

- health and safety
- employability skills.

Online research and practical activities will provide students with a more **blended** approach to teaching and learning. School students will be familiar with this approach. For students returning to study, you may need to spend time supporting them in the use of electronic resources. Useful online videos are available that will reinforce the learning of the design and manufacture activities.
# Welcome to the Design and Manufacture Unit!

The purpose of this Unit is to introduce you to design and manufacture techniques and to give you some experience in handling the tools and equipment which you will use when you are carrying out design and manufacture. The unit is designed to be mainly practical but also has an emphasis on helping you develop employability skills.

In this unit you'll use tools and equipment to design and manufacture a product. Your tutor will give you a brief or outline of the type of product you'll have to design and manufacture. You will learn to make up a design <u>specification</u>, manufacturing instructions and a <u>CAD</u> (Computer Aided Design) drawing.

You will learn to manufacture a product **safely** by following safe working practices and following safety instructions.

The skills and practices you learn during this unit will help you to decide if you would like to make a career in <u>design</u> and manufacture.

Listen to your tutors – they have the experience, knowledge and skills in maintenance which they want to pass on to you. They are there to help you and will welcome your questions.



# Employability

This unit is also designed to help you develop employability skills. All designers, engineers and crafts people, such as electricians, plumbers and motor mechanics have specific **practical skills** but they also have **employability skills**.

Employability skills are valued by employers because they mean that their employees:

- understand the workplace and their responsibilities as employees, for example timekeeping, appearance, customer care, working safely
- can think about the work they've done and how they did it and decide what they could do to improve it
- are keen to learn
- try to work out solutions to problems instead of walking away from them or leaving them to someone else
- have confidence to set goals, reflect and learn from experience.

These employability skills are an important part of this Design and Manufacture Unit and to get the most out of the unit you should:

- $\checkmark$  follow health and safety instructions
- interpret engineering drawings and specifications accurately
  - co-operate with your tutor and class-mates
- ✓ plan and prepare your work
- manage your time well
- ✓ chec

check your work as it develops

 try to identify your own strengths and weaknesses and take action to improve your work and your skills.

# What is Design?

Design is an **activity** which can be applied to products, services or processes.

In this Unit you'll design a **product.** A product is something you can make or **manufacture.** 

Design begins with the need to make a new product. Many things bring about this need to design a new product:

- a customer asks for a new product
- the marketing or sales team work out that a new product is needed
- problems with the old product e.g. no spare parts
- new technologies and materials
- new manufacturing processes and machines

Design is a thinking activity and can start off with many ideas which are reduced to one final design and then made into a physical product.



The main design activities are:



#### Ideas

Many ideas will be rejected before you choose the idea you think will work best.



In industry only 2% of ideas end up being a product.

When you have chosen your best idea, a **preliminary design** is done. This is a rough working of the chosen idea and may include how the product should work, materials to be used, initial drawings etc and this will help you to review whether you have the basis of your design or whether you have to make some changes.

A **prototype** is a trial product. It can take the form of a model of the product, a computer reproduction or a first attempt at the real product. It helps you decide if the design is OK or if further changes to it are needed. It's important to be sure of your design because any product alterations are much more expensive when the product is being made.

A **final design** is reached when you are sure that the product needs no further changes, that it will work to the <u>design specification</u>, and you are confident that the product can be made and duplicated in the workshop by the manufacturing team.

### **Cost of Alterations**

The graph below shows you how changes made later on in the manufacturing stage are more expensive than those changes made at the design stage:



### How do you design?

You can do design by using a computer software package called CAD – Computer Aided Design. The designer forms a drawing on the screen using either a light pen or mouse or keyboard. Lines are told where to fit by using coordinates or the points can be highlighted on the screen and the computer will draw the line between the points. You'll create a CAD drawing and will have to show:

- two views
- three line types
- dimensions
- orthographic symbol
- title block

#### Who does design?

Designers carry out the design activity and they must ensure that their designs:

- are high quality
- error free
- safe
- easy to understand
- make the manufacturing easy
- are produced at low cost

## Why do the design?

Designers need to ensure that their designs can be copied and manufactured so that each product is as identical as it can be.

#### What can be designed?







# Activity: Products you can design

You can find six product types in the table of letters below - circle the words that you can identify as a product:

w	Y	L	V	Q	D	Z	М	т	Р
С	Α	М	Е	R	Α	Н	K	Е	J
S	J	Q	Ι	С	Q	Q	J	L	U
D	Y	L	Ι	J	н	L	Ρ	Е	J
D	L	L	Q	Р	Р	L	W	V	Y
Т	L	J	R	К	0	U	Q	Ι	Κ
Р	Α	Е	Z	D	z	D	Z	S	X
G	U	I	т	Α	R	D	R	Ι	Н
X	Ρ	Е	н	В	X	S	J	0	R
В		С	Υ	С	L	E	D	Ν	Ι

# **Project Brief**

Your tutor will give you a **project** <u>brief</u> that will outline the type of product you'll be asked to design and manufacture.

The project can be a mechanical, electrical, electronic, control based project or a combination of these activities, called an integrated project. You may be asked to do the project individually or as part of a team if it is to be an integrated project.

Every project brief will ask you to:

- produce a design specification
- make a CAD drawing
- use the correct tools and equipment to make the product safely
- check the dimensions of the completed product
- test the completed product
- produce a short report
- give a presentation to your classmates

# Take time to read the project brief at the beginning and ask your tutor if there is something you don't understand.



# Project Plan

Every project needs a **project** plan to help you complete the project on time.

There is an old saying:

If you fail to plan then you will plan to fail.

From your previous work in the other units, you should be able to estimate how long it will take you to make each part.

Allow some time for problems, like having to remake something.

Look at the example of a completed planning sheet. Each box in the chart represents a period of time – in this case it is a 2 hour block.

Notice on the chart how some of the actions overlap. This is when one action depends on another, or you do one thing while waiting for another to be completed.



### Activity: Your project plan

Complete the given pro-forma planning sheet.

You can look at the sample planning sheet as a guide

# Keep records throughout the project to make your <u>report</u> and <u>presentation</u> easier for you!



As you progress through the work and complete each stage, tick the status box on the sheet.



**ct Plan** Total Time: 40 hours (20 x 2 hour blocks)



Action																					
To do	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	Status

Action	1	2	2	4	5	6	7	0	0	10	11	12	12	14	15	16	17	10	10	20	Status
LO UO		2	3	4	5	0	1	0	9	10		12	13	14	15	10	17	10	19	20	Sidius
brief																					
Make plan																					
Produce																					
design specification																					
Produce CAD																					
drawing																					
Gather																					
materials																					
Make parts																					
Assemble																					
Dimensional checks																					
Test																					
Review																					
Keep Records																					
Produce Report																					
Presentation																					
Employability Skills																					

# Project Plan (Example of a Completed Planning Sheet) Total Time: 40 hours (20 x 2 hour blocks)

# **Produce a Design Specification**

You have to produce a **design specification** from a **project brief** given to you by your tutor.

What is in the design specification will depend on the type of product you will design and manufacture. These support notes are based on a project brief to design and manufacture a mechanical structure that has a rotating arm that can be moved 180 degrees and locked into its new position. This design is for illustration purposes **only** and will show you the approach you'll need to take for your project to be a success.





# Activity: What is in a design specification?

Fill in the table with what you think might be in your design specification:

De	sign Specification
1	
2	
3	
4	
5	

### EMPLOYABILITY

Have you been applying time management correctly?

# **Design Specification**

#### What is in a **design specification**?

A design specification will contain:

- function and purpose of product what it will do
- technical process eg. drill, cut, form, manufacture, machine, weld, buy-in part
- sequence of operation eg. how it will work
- what the product will look like
- what it is made of eg. mild steel
- size its dimensions eg. length, width, height
- material list eg. fasteners
- appearance eg. shape, colour

Example of a design specification:

Design Specification	Project:
	Mechanical structure that can allow the rotation of a lever arm and lock in a new position
1 Function of product	Rotate lever arm and lock in position
2. Technical process	Mark out, file, cut, drill and so on ( see operation planning sequence sheet)
3. Operation	Move lever arm and lock in place with locking pin
4. Bill of material	See component part list detailing material needs drawing number 00090
5. What will the product look like	See drawing number 00080
6. Product dimensions	See drawing numbers 00010,00020,00030, 00040,00050 and 00060

The <u>drawings</u> of the **example** project of a mechanical structure with rotating lever arm, bills of material and operation planning sheets (which give you the manufacturing <u>instruction</u>s) are attached as a guide for you.















	Ü	PART NAME	DRN ND.	QUANTITY	[		
	1	LEVER ARM	00010	1 OFF			
	5	PIVDT/LDCK BAR	00020	2 OFF	1		
	ю	BASE	00030	2 DFF			
	4	BASE (Cross Piece)	00040	2 OFF	1		
	IJ	CRDSS BAR	00050	1 OFF			
	6	LOCKING PIN	00060	1 OFF	1		
	7	M6 NUT	N/A	8 OFF			
	8	M6 X 40 CAP SCREV	N/A	4 OFF			
	6	M6 X 20 COUNTERSUNK HEAD	N/A	4 DFF			
			Tole	rances unless oth	nerwise stated ± 0.5mm	All Dimensions in mm	
			DRN	ANDN	DATE MAT	FR N/A CHKD	
			SCALI	E N/A TITLE CD	MPDNENT LIST	DRN 00090	
				-			٦

# **Manufacturing Instructions**

Before you are ready to begin the manufacture and <u>assembly</u> of your chosen product you need <u>manufacturing</u> instructions.





# Activity: Produce Manufacturer's Instructions

Fill in the table with what you think a manufacturing instruction might be:

	Manufacturing instructions
1	
2	
3	
4	
5	

#### **Operation Planning Sequence**

The manufacturing instructions are shown on the operation planning sequence sheets. You need to work out how much **time** you have to complete each operation. You should be able to do this from your experience gained in the previous engineering skills units you have already completed.





### **Activity: The Operation Planning Sequence**

On your Operation Planning Sequence sheets, fill in the time you think you will take to carry out each instruction.

# **Operation Planning Sequence**

Date:

Sheet 1 of 2

Sequence Number	Operation description	Machine used	Tooling used	Time taken (planned)
001	Mark out required lengths of material from stock (Leave 5 mm excess to allow squaring off)	-	rule, scriber	
002	Cut lengths of stock material	-	hacksaw	
003	Mark off ends of material lengths to size	-	rule, scriber, square, centre punch	
004	File ends square	-	bench vice, files, square	
005	Mark off position of pivot and locking holes on lever arm	-	rule, scriber, square, centre punch	
006	Drill holes on lever arm	pillar drill	Ø6.2mm drill bit, machine vice	
007	Mark off Ø6.2 hole positions on one of the pivot/lock bars	-	rule, scriber, square, centre punch	
008	Drill Ø6.2 holes	pillar drill	Ø6.2mm drill bit, machine vice	
009	Use the drilled holes as a template to mark and drill holes on the other pivot bar (to ensure alignment)	as before	as before	

# **Operation Planning Sequence (cont'd)**

Date:

Sheet 2 of 2

Sequence Number	Operation description	Machine used	Tooling used	Time taken (planned)
010	Mark out hole potions for M6 threaded holes on pivot/lock bars	-	rule, scriber, square, centre punch	
011	Drill and tap M6 to required depth	pillar drill	M6 drill and tap set, tapping wrench, cutting compound, bench vice	
012	Mark out position of Ø6.2 holes on one of the base lengths	-	rule, scriber, square, centre punch	
013	Drill holes	pillar drill	Ø6.2mm drill bit, machine vice	
014	Use the drilled holes as a template to mark and drill holes on the base length (to ensure alignment)	as before	As before	
015	Drill countersink	pillar drill	Countersinking bit, machine vice	
016	Use base lengths as a template to mark holes on base cross piece	-	Centre punch	
017	Drill and tap M6 to required depth on base cross piece	as before	as before	
019	Cut external thread on cross bars		M6 die set, cutting compound, bench vice	

# Your Operation Planning Sequence

Date:

Sheet 1 of 1

6, 7

Sequence Number	Operation description	Machine used	Tooling used	Time taken (planned)
001				
002				
003				
004				
005				
006				
007				
008				
009				

Sequence Number	Operation description	Machine used	Tooling used	Time taken (planned)
010				
012				
013				
014				
015				
016				
017				
019				
020				

# **Computer Aided Drawing**

Before you start drawing using CAD you should know what the drawings tell you!

### Drawings show you:

- each part of the <u>equipment</u>
- what they look like
- how these parts are assembled
- how these parts work
- how the equipment works
- where the part is located
- the drawing projection
- title
- drawing number
- dimensions
- scale if appropriate
- tolerance
- material



# Activity: CAD Drawing Requirements



You have to draw part of the product using CAD - use the checklist below to make sure you have completed this activity correctly.

CAD drawing requirements	Tick when complete
1. two views	
2. three line types	
3. dimensions	
4. projection symbol	
5. title block	
6. made a hard copy of the drawing	

# **Design Review**

**Design** <u>review</u> is an **ongoing process** and is when we look back at what we did.

We use the review to confirm the quality of the proposed design.

Examples of design review questions we might ask are:

- What improvements could we make?
- Are the dimensions correct?
- Does the design meet the requirements of the design specification?

The **records** you keep will help you to evaluate the work and the progress.

You will keep a note of the problems you had and how you solved them.

You will record your own progress so that you are able to evaluate yourself.





# Activity: Design Review

Now complete a design review by filling in this table:

Question	Your answer and review notes
Have you met the needs of the project brief?	
Does the final design meet the design specification?	
Do you think you could you make any improvements to the design?	
Did you finish the design and CAD drawings on time?	
How satisfied are you with the quality?	
Have you checked the drawings?	

9, 10

# **Tools for Design and Manufacture**

The type of tools and equipment you'll need for design and manufacture will depend on the type of project you are asked to do. For the **mechanical structure with the rotating lever project** the tools you'll need for the manufacture are:

- rule
- scriber
- hacksaw
- square
- centre punch
- bench vice
- files
- pillar drill
- tap set
- die set



#### **Activity: Tools practice**

Your tutor will allow you to practise with the tools you'll use for your project.



2.9

# Safety





During the manufacture of your product it is essential that you follow the safety instructions from your tutors to prevent injury to you, your classmates and your tutors.

Everyone in the workplace is responsible for their own safety and the safety of others who might be affected by their work. This means that, no matter how new and inexperienced you are to any workplace or engineering workshop **you** have a responsibility for safety.

The successful and safe completion of any practical work starts with everyone thinking about health and safety and what steps must be taken to ensure that the workplace is a safe and secure environment.

#### Always:

- 'think safety'
- act responsibly
- plan your work
- keep your work area tidy
- ask questions if you are not sure.

#### EMPLOYABILITY

Have you been showing health and safety awareness?

# **Dimensions and Tolerance**

Mechanical parts have dimensions and <u>tolerances</u> that define their shape and geometry. Parts must go together into assemblies and fit properly with each other. In order for the parts to fit together you have to get the dimensions and tolerances correct not only for each part but also for how they fit together.



A **dimension** is the size of something in more than one direction eg. length, width or height.

**Tolerance** is the difference between maximum and minimum limits of size or the amount you can allow a variation or difference by

#### Example

A dimension should be 10cm with an allowable tolerance of 5mm







Think of some hazards and safety issues you will meet during the making of your product and fill in the table:

	Hazards and Safety Issues
In the workshop	
Using tools	
Processes eg. drilling, wiring etc.	
Behaviour	
The product itself	

# Manufacturing and Assembly



Activity

You are now ready to manufacture the parts and then assemble these parts of your project safely and correctly.




### **Checking that the Product is Functional**

You now have to test your product by:

- measuring the dimensions
- carrying out a 'Fit for Purpose' test
- checking that the product complies with the design specification.

Remember - you'll have to make checks and tests of your work at different stages during the:

- design
- making of the parts
- assembly of the parts

You will be checking for different things at each stage and should consider:

- Size is the product greater than the minimum allowable size and less than the maximum allowable size?
- Fit are any parts too tight or too loose?
- Appearance does the product look good?
- **Touch** is the surface smooth?
- Functionality does it do what it is supposed to do?



Scottish Further Education Unit

#### Fit for Purpose test for Mechanical Structure Project

Fit for purpose test	Yes/No
Does the product have a stable mechanical structure?	
Does the product have a rotating lever arm?	
Can the product be locked with the arm in the new position?	
Are the dimensions correct?	



#### Activity

Activity

#### Fit for purpose test for your project

Fit for purpose test	Yes/No



4.9

### **Project Review**

#### How do you know if your project was a success?

You can think of your project as a triangle:



Quality: did your project:

- work as it was supposed to?
- was it made to the design specification?
- does the product look good?

#### Time:

- were stages completed according to the timing in the plan?
- was your project completed on time overall?

#### Cost: was your project

- completed at a realistic cost?
- completed with the materials provided with no or little scrap?

### The Project Review

The review is all about looking back at what you did. You ask questions about all aspects of the job, and about yourself.





#### Activity

Fill in the review table:

Question	Your answer
How satisfied were you with your project plan?	
How satisfied were you with your design specification?	
How satisfied were you with your CAD drawing?	
Does the completed work match the design specification?	
How satisfied are you with the quality of your finished product?	
Did the product work?	
Did you work safely?	
Did you finish on time?	
What mistakes were made?	
Did you use the tools correctly?	
How satisfied were you with the testing and functionality checks?	
What improvements could you make to your product?	

### The Project Report



Having completed the review you will now be able compile the project report.

The main body of the report will be between **250 and 400 words** long.

The report is just a summing up of all the things you did, and because you have kept the records eg. notes, drawings and forms it will be easy to put the report together.

#### What to include in your report:

#### Main Body

- front cover
- title
- introduction
- did the work go according to your plan?
- was the work carried out safely?
- were the right tools used?
- did the finished product meet the design specification?
- test results
- conclusions
  - did the product work
  - what went well
  - what did not go so well
  - overall was the project a success?

#### Appendices

- your project specification
- your plan
- your CAD drawing
- your manufacturing instructions
- picture of product
- any references you may have used



#### Activity: Project Report

Now complete your project report using the guidelines above

# EMPLOYABILITY Have you been carrying out self review and evaluation?

### Presentation



The **presentation** will allow you to demonstrate your project, display the product and tell an audience:

- how you did it
- the problems you encountered, and
- how you solved them.

The material you collected for the **review** and **report** will help.

You can use **pictures** and presentation equipment to make the presentation interesting.

You could use a PowerPoint presentation as a slide show



#### **Presentation Hints and Tips**

- ask your tutor how long your presentation should be
- ask when and where the presentation will take place
- practise how long it will take to deliver the presentation time yourself
- stick to your script or your presentation notes- don't try and change it during the presentation
- speak slowly and take your time -, don't rush
- make sure any pictures you have are large enough to be seen
- display your product and show how it works
- answer any questions
- if you don't know an answer, don't bluff or waffle! Just say you don't know the answer and offer to follow it up later.



#### Activity



#### **Project Presentation**

You must now prepare and give your project presentation. Make some planning notes here. Some things to think about are given to start you off.

	Notes
Date and time of presentation	
Length of presentation	
Who's involved	
Method eg. PowerPoint, slideshow etc	

### **Unit Questionnaire**

This questionnaire is designed to help your lecturer find out how you feel about this unit.

You don't need to put your name on this questionnaire.

*Instructions*: Please complete this form by placing  $\checkmark$  in the most appropriate box.

Ur	Unit Title:			
Lecturer's Name:			Date:	
		Strongly Agree	Agree	Disagree
1	The induction to this unit was helpful.			
2	My teacher/lecturer helped me through this unit.			
3	The resources and equipment were suitable.			
4	All Health and Safety information and practices were effective.			
5	My teacher/lecturer prepared me well for assessments.			
6	I was given constructive feedback.			
7	I was kept informed of my progress regularly.			
8	I enjoyed this subject.			

Please add any comments about things you think would make this unit better:

Thank you for completing this questionnaire.

### **Glossary of Terms**

Term	Meaning
Assembly	when you put parts together
Brief	a summary of what you have to do
Computer Aided Drawing (CAD)	a drawing completed on a computer
Design	thinking of an idea of how something will work
Design Specification	a way to show how something will work and be made
Dimensions	the size(s) of something
Drawings	a diagram or sketch of something
Equipment	a collection of parts that work together
Fit for purpose	when something works the way it should all the time
Functionality	the way something works
Instruction	the way you must do something
Manufacturing	making something
Manufacturing Instructions	these show or explain how to make something
Materials	what something is made of
Part	a small piece of equipment
Plan	what you need to do and when you need to do it by
Presentation	a talk to an audience
Procedure	a way of doing something
Product	something that has been made
Project	a task you have to do
Report	a written account of something
Review	a way to sum up how things went
Schedule	a timetable or plan of something that is going to be done
Specification	lists detail of equipment such as size, weight, type
Test	when you check something works correctly
Tolerance	the difference between the maximum and minimum size allowed

## These boxes are for you to add any other terms that you use during the course: