Pearson BTEC Level _ Higher Nationals in Engineering (RQF)

Unit 23: Computer Aided Design and Manufacture

Unit Workbook 2

in a series of 2 for this unit

Learning Outcome 2, 3 & 4

Producing 3D Models, Manufacturing Simulations & Accurate Components using CAD/CAM

Contents

INTRODUCTION

Produce 3D solid models of a component suitable for transfer into a CAM system.

1. *Solid modelling:*
    - Extrude, cut, fillet, chamfer, holes, sweep, revolve, lines, arcs, insert planes, properties of solid models e.g. mass, centre of gravity, surface area.
2. *Geometry manipulation:*
    - Mirror, rotate, copy, array, offset.
3. *Component drawing:*
    - Set-up template, orthographic and multi-view drawings, sections, scale, dimensions, drawing.
    - Attributes e.g. material, reference points, tolerances, finish.

Use CAM software to generate manufacturing simulations of a component.

1. *Insert solid model:*
    - Set-up, model feature and geometry identification, stock size, material.
2. *Manufacturing simulation:*
    - Operations, e.g. roughing and finishing, pockets, slots, profiling, holes, tool and work change positions, tool sizes and IDs, speeds and feeds, cutter path simulations, program editing.

Design and produce a dimensionally accurate component on a CNC machine using a CAD/CAM system.

1. *CNC machine types:*
    - Machining centres, turning centres, MCUs e.g. Fanuc, Siemens and Heidenhain.
2. *Data Transfer:*
    - Structured data between CAD and CAM software e.g. datum position and model orientation; file types e.g. SLDPRT, Parasolid, STL, IGES, DXF; transfer to CNC machine e.g. network, USB, ethernet.
3. *Inspection:*
    - Manual inspection e.g. using Vernier gauges, bore micrometres.
    - Automated inspection e.g. co-ordinate measuring machine (CMM), stages of inspection throughout manufacturing process.

GUIDANCE

This document is prepared to break the unit material down into bite size chunks. You will see the learning outcomes above treated in their own sections. Therein you will encounter the following structures;

Purpose Explains *why* you need to study the current section of material. Quite often learners are put off by material which does not initially seem to be relevant to a topic or profession. Once you understand the importance of new learning or theory you will embrace the concepts more readily.

Theory Conveys new material to you in a straightforward fashion. To support the treatments in this section you are strongly advised to follow the given hyperlinks, which may be useful documents or applications on the web.

Example The examples/worked examples are presented in a knowledge-building order. Make sure you follow them all through. If you are feeling confident then you might like to treat an example as a question, in which case cover it up and have a go yourself. Many of the examples given resemble assignment questions which will come your way, so follow them through diligently.

Question Questions should not be avoided if you are determined to learn. Please do take the time to tackle each of the given questions, in the order in which they are presented. The order is important, as further knowledge and confidence is built upon previous knowledge and confidence. As an Online Learner it is important that the answers to questions are immediately available to you. Contact your Unit Tutor if you need help.

Challenge You can really cement your new knowledge by undertaking the challenges. A challenge could be to download software and perform an exercise. An alternative challenge might involve a practical activity or other form of research.

Video Videos on the web can be very useful supplements to your distance learning efforts. Wherever an online video(s) will help you then it will be hyperlinked at the appropriate point.

1.1.2 Geometry Manipulation

In many cases, there are shortcuts to reaching the finished part. A common example is the 'pattern' feature, which enables, as its name suggests, a pattern to be created from existing sketch entities, bodies or features, rather than drawing multiple, identical features all individually. Even the 'mirror' feature is an example of a geometry manipulation feature which effectively provides a shortcut for CAD users.

Challenge

1. Create the following solid model:

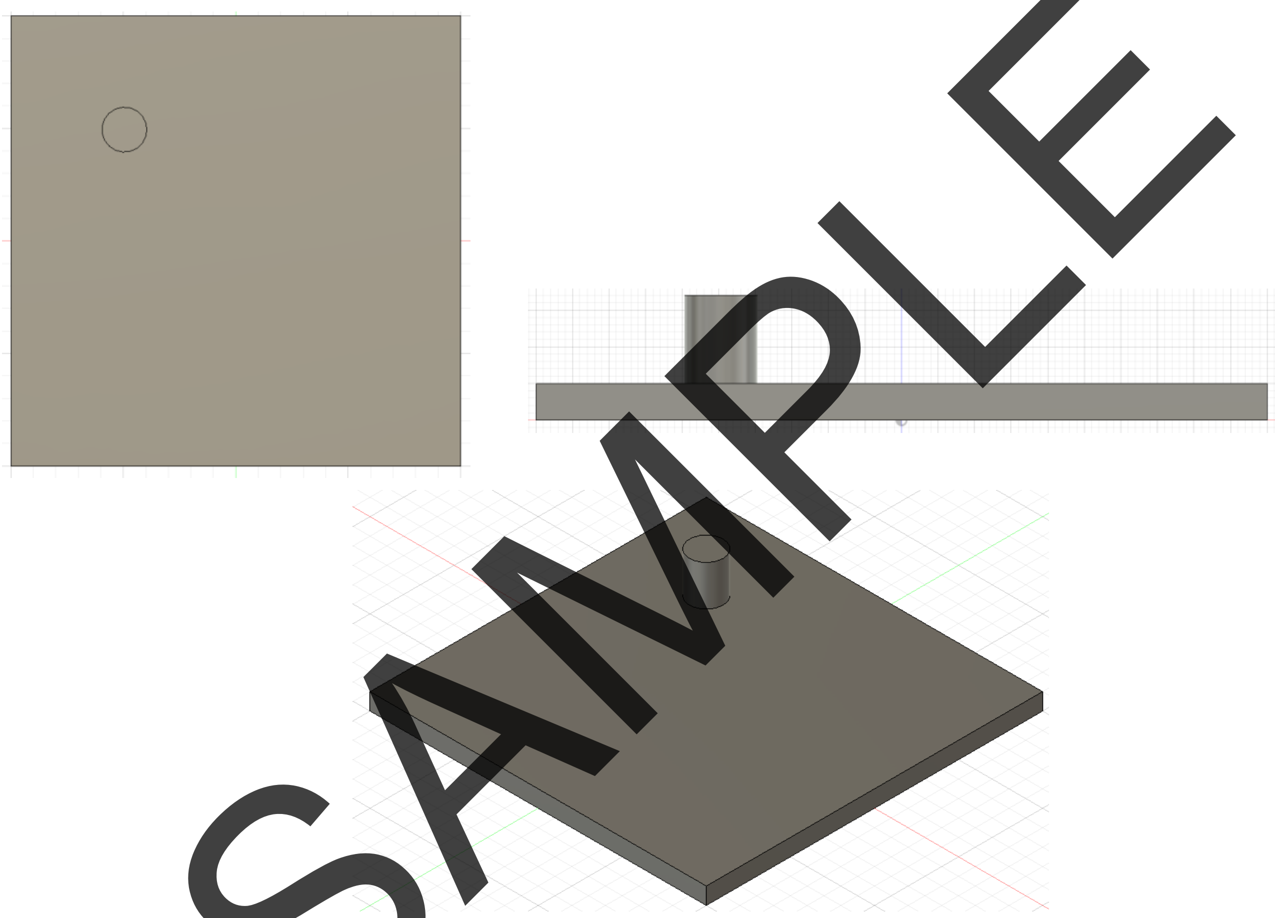

Figure 1.3: *Example Solid Model Plate*

From this drawing, there is a lot of information that can be gleaned before even looking at the part itself, in the bottom right-hand corner there are a number of boxes containing important information, this is referred to by several different names, but we shall call it the title block.

Much of this information is self-explanatory, such as 'Created by: J.Bloggs' and 'Title: Base Plate Insert', clearly this drawing was generated by a person called J.Bloggs and the part is called Base Plate Insert. There are other areas of technical interest, such as 'Rev: A'. The purpose of this section is to inform the reader of which revision this drawing is at. The revision of a drawing is essentially the version that it currently sits at, usually this starts at A and logically just continues through the alphabet, with every change that is made to the drawing. For example, this part 'CS-0011-PT Rev. A', may have been used in the field and whilst under this constant use, it has been found that the diameter of the 130mm diameter flange needs to be reduced to 120mm for some clearance reasons. The part would then be changed, and the drawing then up-issued to revision B, a revision table may also be populated on the drawing, commonly in one of the top corners.

Many companies employ some standard tolerance and finish notes which are stated in the title block and a common note to add is 'Break all sharp edges and deburr' or something similar. Also often added are 'scale' and 'page size' notes in to the title block.

When we look at the views of the part itself, it is always useful to include an isometric view as this gives an overall representation of the part. The standard in the UK is to use 3rd angle orthographic projection as the style to represent the part. This is essentially just a way of looking at a 3D object and representing it in 2D.

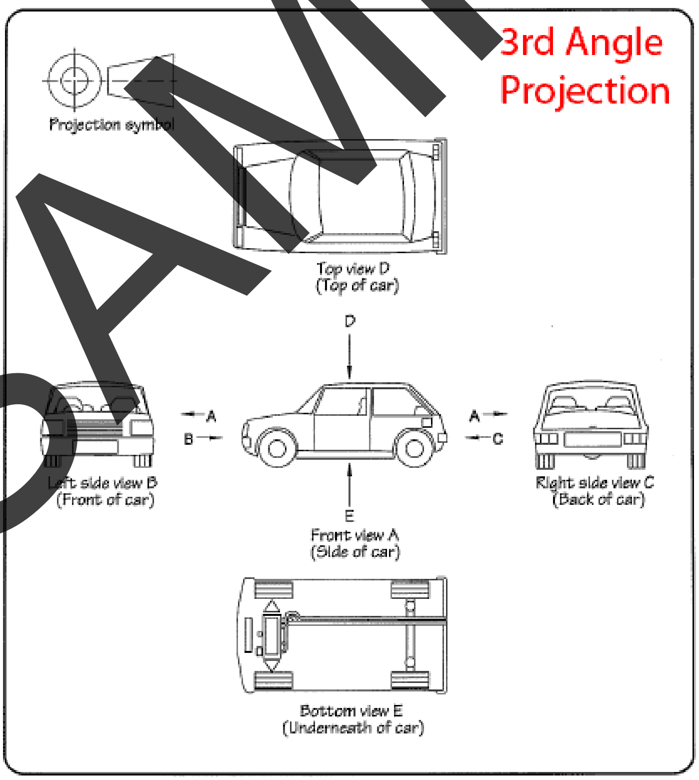

Figure 1.6: *3rd Angle Orthographic Projection*

The meaning of this symbol is 'surface finish' and by looking at the value attributed to this note, we can ascertain the specific surface finish that is required for this surface. In this case it states '3.2', which in the case of surface finish notes, means that the required finish value is 3.2 micrometres. (The surface/texture finish of parts is covered in BS 1134).

The purpose of this surface finish value is to ensure that the surface performs as it is required. For example, a rough finish will mean that a seal or O-ring will not seal properly, therefore a low value for the surface finish is required, possibly 0.4 micrometres.

At a professional company, there will often be an Engineering System Coordinator who is responsible for setting up the templates for all engineering drawings. These templates contain important information and basic layout for every drawing that is created by the Design Engineer. It is important in a company for all drawings to follow the same layout in order to maintain standards of work and ease of understanding engineering drawings.

Challenge

Create your own Base Plate Insert part and subsequent drawing, using the same dimensions as in the example drawing, fill out the title block with your own information.

Video

The best way to learn how to master CAD is to practice.

The following video tutorials offer help on getting started with Fusion 360:

https://www.youtube.com/watch?v=A5bc9c3S12g&vl=en

https://www.youtube.com/watch?v=HXRMzJWo0-Q

https://www.youtube.com/watch?v=zS8dYA_Iluc

1.2 Manufacturing Simulations

1.2.1 Import Solid Model

A finished and approved 3D model must be imported into the CAM area of the relevant software or into separate CAM software itself.

As an example, let us look again at Fusion 360. Although different software packages will have different interfaces and features, the main steps and functions will be similar, if not the same.

The first step is to enter the CAM area of the software and make a new setup. One must then define the type of operation to be performed, usually milling or turning. It is then necessary to define the work coordinate system, followed by the stock (the raw billet or piece of blank material to be machined). Within the Fusion 360 software, the material is defined in the 3D modelling area, otherwise this will be defined as part of the CAM setup.

Fusion 360, like many modern CAM software packages, includes automatic feature and geometry identification. This is an incredibly useful feature, which means that the software system can help you as the designer to create a working simulation without having to define every single small detail.

1.2.2 Manufacturing Simulation

There are many different operations that can be performed on a workpiece, and these are all options to be selected in the CAM software. A common place to start in milling is with 2D adaptive clearing which essentially removes the bulk of excess material leaving you with a basic outline of the part, other operations are then performed to increase detail level. There are various specific operations available such as slot, thread, pocket, hole. Whilst there are also a number of alternatives available for CNC turning such as thread, chamfer, face and groove.

To add another operation in Fusion 360, one simply selects the operation and then select the appropriate tool for that operation. In order to select this appropriate tool, one must have an appreciation and understanding of how each tool is best used.

For a common, basic example we will look at a flat end milling piece which is a standard tool, used to remove relatively large amounts of material. This is commonly selected when the 2D adaptive clearing function is activated and a suitable sized tool will also be used, this depends on the geometry and size of the workpiece.

Video

The following videos offer step-by-step tutorials on getting started with Fusion 360 CAM:

https://www.youtube.com/watch?v=iqnvzxuXFTQ

https://www.youtube.com/watch?v=Bd6-BQUCbVA

https://www.youtube.com/watch?v=6FzbZNhey2w&list=PL40d7srwyc_OmRH4UQ_E-6UB-GbhPdjc8

1.3 Producing Accurate Components

1.3.1 CNC Machine Types

There are several different types of CNC machines available, depending on their general setup and arrangement. Let us first consider a 'machining centre', this is quite simply a term given to describe most CNC machines which include an automatic tool-changer and clamp the workpiece in place. The actual tool itself is rotating, whilst the workpiece is not.

A 'turning centre' is a similar concept to the term, 'machining centre' but is specifically concerned with turning operations, clearly. Turning centres can often perform a variety of drilling and milling operations as well.

A very important term within the CNC world is 'MCU', this stands for Machine Control unit and this is essentially the heart of a CNC system. Its role is to read the coded instructions, decode these coded instructions, implement interpolations and then finally to generate axis motion commands. Additionally, it must also receive feedback signals from each axis and implement auxiliary control functions, like the coolant control and tool change. This MCU is also how the user interacts with the CNC process, to change code, pause a process etc. An example of this MCU can be seen below:

Figure 1.9: *Haas MCU*

There are various different brands offering high-end MCUs, such as Haas, Siemens, Fanuc, Bosch Rexroth and Heidenhain. Most offer a complete package, including machine centre and MCU.

A Vernier or calliper can either be a digital or analogue and are generally sensitive up to 0.01mm, an example of this measurement device can be seen below.

Figure 2.1: *Digital Vernier*

The Vernier has two sets of jaws for either measuring around the outside of material or in the middle of material, such as an internal bore dimension. Another similar measurement device is the Micrometre and can either be digital or analogue as well. A typical example is as follows:

Figure 2.2: *Digital Micrometre*

A micrometre is typically more sensitive than a Vernier, usually up to 0.001mm in fact, and so is therefore more often used for thin items or parts that require inspection of highly tolerance dimensions. A similar item to the micrometre, is the bore micrometre, which is exclusively used to measure internal bore diameters at high precision. Different sized bore micrometres are available, depending on the size range of the bore, see below for a typical example:

Figure 2.3: *Digital Bore Micrometre*