Pearson BTEC Level _ Higher Nationals in Engineering (RQF)

Unit 37: Virtual Engineering

Unit Workbook 1

in a series of 1 for this unit

Learning Outcomes 1, 2, 3 & 4

Virtual Engineering

Contents

INTRODUCTION

Explore the capabilities and limitations of computer-based models in meeting design fundamentals and their use in solving problems in engineering.

- *Engineering Design Fundamentals:*
  - Standardisation and regulatory compliance (BS, ASTM, ISO).
  - Capabilities & limitations of computer-based models.
- *Design, Analysis and Simulation tools:*
  - 2D and 3D CAD.
  - Finite Element Method.
  - Computational Fluid Dynamics (CFD).
- Interpretation of results and determining faults:

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 Engineering Design Fundamentals

Within any organisation, a design engineer has a key role to play in delivering a product or service to the end customer. They have the responsibility of researching and developing new ideas and/or modifying existing products in order to make improvements. When implementing a new design process the design engineer must listen to the requirements of the customer, whilst considering the limitations and requirements of manufacturers, suppliers, fitters, software, testing procedures and end users. The purpose of a design engineering process is to produce a product/service that is fit for purpose and fulfils the original requirements of the customer.

1.1.1 Standards & Regulatory Compliance

In order to ensure that all engineering products meet certain levels of quality and are safe to use and operate, there are sets of standards that have been refined over time to provide engineering laws and practical constraints, representing good practice across the entire spectrum of engineering.

There are currently different sets of standards depending on the discipline of engineering and the country in which the are being applied. Generally, in Europe engineering companies conform to EN (European Norms) standards. In the U.K. some companies comply with EN standards and some with British Standards (BS), whilst others comply with a mix of both. In America there are a set of standards known as ANSI (American National Standards Institute), whilst ASTM (originally the American Society for Testing & Materials) and ISO (International Organisation for Standardisation) are both standards organisations which operate globally.

1.1.2 Capabilities & Limitations of Computer-Based Models

In order to comply with regulations, companies often use computer-based models to test their designs before they actually go into production. Imagine a boat manufacturer requires a bow post to be designed for a new boat, and in order for their product to pass regulations this bow post must be capable of withstanding a certain ‘pull force’. Rather than just designing a bow post, having it manufactured and then immediately having it physically tested, the company can perform virtual tests on a computer model of the post to determine if the design is likely to pass or fail the physical test. In doing a virtual test, this gives the designer valuable information about whether or not their design is fit for purpose. If the design fails this virtual test then the designer can make changes to material, design or method of fixing/manufacture and then retest the design until it passes. Alternatively, if the part that has been designed is over-engineering then potentially some costs could be saved by removing excess material, simplifying the design or using a less expensive material.

Of course, a design engineer can use manual calculations to predict the physical performance of a product they are designing; however, this can be very labour intensive, may take a lot of time and is susceptible to human error. Using computer-based models increases speed, accuracy, reliability, adaptability and reduces the space required for storing records. Although there are many advantages to computer-based models, there are several limitations; computer systems have zero IQ and are therefore only able to perform specific tasks that they are programmed for, computer systems are also unable to make decisions requiring human evaluation skills, finally a computer is unable to use common-sense or logic as a human is able to.

1.2 Design, Analysis and Simulation Tools

Depending on the industry or the context in which an engineer is operating they may need to use different computer-based design, analysis and simulation tools.

1.2.1 2D and 3D CAD

Within a professional company, when there is a requirement for a new product it is highly likely that it will be designed using Computer Aided Design (CAD), without this it will be difficult to communicate the details of the design to a supplier. Whilst a detailed drawing can be produced by hand, it is far quicker to use CAD and it also makes it easier to rectify mistakes or make changes to designs. There is a full explanation of capabilities and limitations in the previous section.

There is a plethora of different CAD software packages that can be used for professional design, as such there are also many different file formats but generally they can usually be transferred from one package to another.

2D CAD is used to produce technical drawings and is frequently utilised in the production of building layouts, floorplans and electrical schematics. 3D CAD is generally used to produce three-dimensional models of parts and assemblies that can be manipulated in 3D space and then used to produce 2D manufacturing drawings for manufacture. It is used by engineers, product designers and architects to produce a vast plethora of different products and structures.

CAD has developed massively since it's conception in the early 1980's and is continuing to improve by offering a better user experience through more intuitive operations and ease of access.

1.2.2 Finite Element Method

The finite element method, sometimes referred to as finite element analysis (FEA) is used in order for engineers to predict the behaviour of systems and parts, typically in the areas of heat transfer, electromagnetic potential, fluid flow and structural analysis. These systems can be static or dynamic and one, two or three dimensional. To predict the behaviour of a system, the finite element methods looks at it in terms of a number of algebraic equations rather than the system as a whole. The problem is divided into a large number of much simpler parts, known as 'finite elements' and brought together at the end of the process to give an overall answer.

With regards to structural analysis, FEA is used very frequently in functions such as calculating the failure point of parts and structures when put under load. In order to make a simulation of a structure, a 'mesh' is created which consists of a huge number of small elements, which when added together make up the structure overall.

These individual elements produce known values at each corner and these points are called nodal points or nodes. When each individual element and node has been worked out, the mesh can be converged, and an overall result obtained. If a more precise overall result is required then the mesh can be refined, which is essentially reducing the size of each individual element to reduce errors in calculations.