Pearson BTEC Levels 4 Higher Nationals in Engineering (RQF)

Unit 1: Engineering Design

Unit Workbook

Engineering Design

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INTRODUCTION

- Plan a design solution and prepare an engineering design specification in response to a stakeholder's design brief and requirements
- Formulate possible technical solutions to address the student prepared design specification
- Prepare an industry-standard engineering technical design report.
- Present to an audience a design solution based on the design report and evaluate the solution/ presentation

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.

Purpose The purpose of this unit is to understand the design process in engineering, and consider the thought process that is involved for such a task. This involves listening to the clients, and developing their ideas to produce the product they want. **This workbook is to be read with the eBook, and will cover the gaps in the Learning Objectives that the eBook does not cover**. The chapters that should be read, if you wish to study from the eBook, are Chapters $1-12$, and Appendix B. Chapters 13 and 14, and Appendix A, are more directed towards manufacturing engineers, Chapters $15-17$ would be useful when studying Unit 4: Managing a Professional Engineering Project.

1. Learning Objective 1

1.1 Industry Measurement Standards

Purpose When it comes to designing, it is important that everyone is aware of the measurements, the global standard of measurements is based on the International System of Units (SI units). The seven base units shown in Table 1.1, along with their typical notations in equations. By not having a global standard, it becomes incredibly difficult to collaborate; two notable examples were the times before Europe adopted the Gregorian calendar around the 1700s, armies from allied nations would be late to reinforce because they had the wrong dates; another, more modern example, was the £100 million Martian satellite that crashed because one part of the code calculated Force in pounds, while another part calculated using Newtons.

Table 1.1: The seven base units used by SI

Unit	Measures	Equation Notations
Ampere (A)	Electrical current	I
Candela (cd)	Light intensity	I_v
Kelvin (K)	Thermodynamic Temperature	T
Kilogram (kg)	Mass	m
Metre (m)	Distance	s or d
Mole (mol)	Amount of a substance	n
Second (s)	Time	t

With these we can develop more SI units for the wide range of measurements that are taken throughout the world, some of examples of this can be seen in Table 1.2.

Table 1.2: Equations used to develop the SI unit catalogue

Measurement	Equation	Unit Equation	Unit of Measurement
Velocity	$v = \frac{ds}{dt}$	$\frac{m}{s}$	ms^{-1}
Acceleration	$a = \frac{dv}{dt}$	$\frac{ms^{-1}}{s}$	ms^{-2}
Force	$F = m \cdot a$	$kg \cdot ms^{-2}$	N (Newtons)
Work	$W = F \cdot d$	$N \cdot m = kgm^2s^{-2}$	J (Joules)

The use of SI units makes it much easier to collaborate, but sometimes numbers can be too large or too small. For example, the distance between Earth and Mars is 54.6 million kilometers or $54{,}600{,}000{,}000\ m$,

which is a difficult number to read, and long to write out every time the number needs to be mentioned. Another example of this is Avogadro's constant, the number of atoms in one mole of a substance, is $602{,}214{,}085{,}700{,}000{,}000{,}000{,}000$. With this in mind, we can add a prefix to the unit, and also convert to the "standard form", explained better in Table 1.3.

Table 1.3: Converting numbers to easier to read forms

Number	Prefix	Symbol	Standard Form
1,000,000,000,000,000	Peta-	P	10^{15}
1,000,000,000,000	Tera-	T	10^{12}
1,000,000,000	Giga-	G	10^{9}
1,000,000	Mega-	M	10^{6}
1,000	Kilo-	k	10^{3}
0.001	milli-	m	10^{-3}
0.000001	micro-	μ	10^{-6}
0.000000001	nano-	n	10^{-9}
0.000000000001	pico-	p	10^{12}
0.000000000000001	femto-	f	10^{-15}

So, we can say Avogadro's constant is $6.02 \cdot 10^{23}$. We can also mix the symbols and standard form, it is rare when talking about distances to go above kilometers, so the distance to Mars would typically be written as $54 \cdot 10^{6} km$. The likes of Mega and Giga are used when discussing material properties, while Tera and Peta are used in conjunction with analysing the likes of the national grid, and the power plant outputs. While the likes of milli, micro, nano, pico and femto are used in physics and biology. The HIV-1 virus weighs about $1 fg$, and a proton has a diameter of about $1.6 fm$.

1.2 Industry Health Standards

Purpose

It is also important to adhere to industry standards when concerned with health and safety, certain health practices and codes must be considered. For example, every workplace should complete a risk assessment every year, which can also consist of separate forms such as the Control of Substances Hazardous to Health (COSHH) and manual handling. More information on this can be found on the government website, linked below.

http://www.hse.gov.uk/

1.3 Organising the Design Process

Purpose

Without appropriate discipline and planning, the design process will just implode and fail. The design team will need a leader to help keep them on track, and it can also help to have a secretary to record the minutes and perform any administrative duties.

Time management can be the downfall to most projects, failure to keep track of time can cause the deadlines to overshoot and this can also increase expenditure. There are several methods of timekeeping, one of the most famous is the Gantt chart. This will show the project breakdown with the start and end dates and their respective time allocation. Most Gantt charts will map day by day, however, depending on the length of the project it can turn to weeks.