Pearson BTEC Levels 4 and 5 Higher Nationals in Engineering (RQF)

Unit 2: Engineering Maths (core)

Unit Workbook 3

in a series of 4 for this unit

Learning Outcome 3

Analytical and Computational Methods

Contents

INTRODUCTION

Use analytical and computational methods for solving problems by relating sinusoidal wave and vector functions to their respective engineering applications.

Sinusoidal waves:

Sine waves and their applications.

Trigonometric and hyperbolic identities.

Vector functions:

Vector notation and properties.

Representing quantities in vector form.

Vectors in three dimensions.

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.

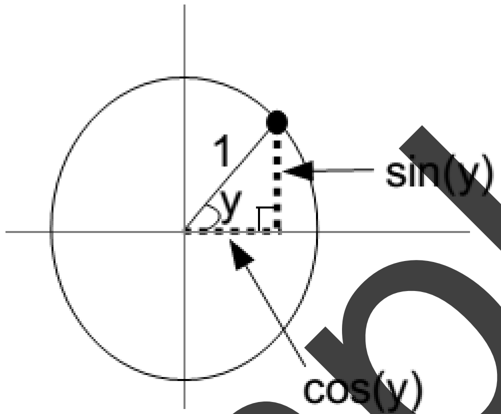
Video

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.

3.1 Sinusoidal Waves

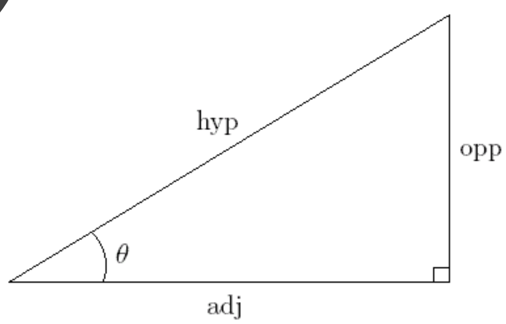
3.1.1 Trigonometric and Hyperbolic Identities

So far you have been used to thinking of trigonometry as the analysis of right-angled triangles. The graph below uses a unit circle to define the sine and cosine functions. You will notice that the triangle is contained within the circle.

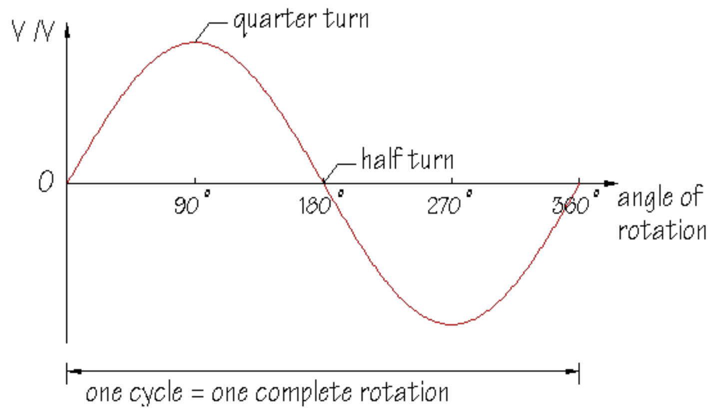


If you imagined this circle to be an electrical generator, spinning anti-clockwise with the dot starting at 3 o' clock, then measurement of the height of the dot versus time would trace out a very familiar sine wave. The mains electricity supply has a sinusoidal nature and this is produced by a circular generator at the power station. For this reason we can say that ***trigonometric functions such as sin, cos and tan are CIRCULAR functions***.

A quick reminder about the common circular functions…



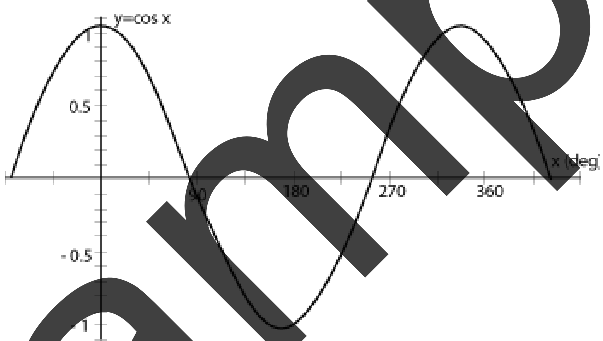
$$\sin(\theta) = \frac{opp}{hyp}; \quad \cos(\theta) = \frac{adj}{hyp}; \quad \tan(\theta) = \frac{opp}{adj}$$



If we say $\sin(90^o) = 1$ then what this means, in relation to the sine wave above, is that the sine function reaches an amplitude of 1 at 90^o. This is reading the function from the bottom up and then left. What if we were to read the function from the left first of all and then across and to the bottom? This could be expressed mathematically as…

$$sin^{-1}(1) = 90$$

By the same token we could look at a cosine wave…



Here we can say…

$$cos(0) = 1$$

and we can inverse this as…

$$cos^{-1}(1) = 0$$

These inverse trigonometric functions are very useful to us because they allow the release of variables which are 'trapped' inside circular functions. When sin^{-1} directly meets sin then the two disappear (handy). The same goes for cos^{-1} directly meeting cos.

Worked Example 1

An instantaneous signal voltage (v_s) is described by the equation…