Unit 5: Mechanical Principles and Applications

Unit code: F/600/0254
QCF Level 3: BTEC National
Credit value: 10
Guided learning hours: 60

Aim and purpose

This unit gives learners the opportunity to extend their knowledge of mechanical principles and to apply them when solving engineering problems.

Unit introduction

The use and application of mechanical systems is an essential part of modern life. The design, manufacture and maintenance of these systems are the concern of engineers and technicians who must be able to apply a blend of practical and theoretical knowledge to ensure that systems work safely and efficiently. Science underpins all aspects of engineering and a sound understanding of its principles is essential for anyone seeking to become an engineer.

The selection and use of engineering materials builds on the principles laid down by the scientists Hooke and Young. The laws of motion, put forward by Sir Isaac Newton, underpin the design of dynamic engineering systems ranging from domestic appliances through motor vehicles to spacecraft. Similarly, the design of internal combustion engines and gas turbines is based on the principles and laws that were put forward by Boyle, Charles and Joule.

This unit aims to build upon the knowledge gained at GCSE and BTEC First Diploma level. Learning outcome 1 will introduce learners to the behaviour of loaded engineering materials and the analysis of a range of static engineering systems that will include the application of Hooke's Law and Young's modulus. Learning outcome 2 will extend learners' knowledge of dynamic systems through the application of Newtonian mechanics. It will also consider the storage and transfer of energy that is often involved in the operation of mechanical systems. Learning outcomes 3 and 4 seek to lay the foundation for future work in applied thermodynamics and fluid mechanics. In particular, they will deal with the effects of heat transfer, the expansion and compression of gases and the characteristic behaviour of liquids at rest and in motion.

This unit provides a basis for further work in the areas of mechanical principles, engineering thermodynamics, fluid mechanics and other related applications of engineering science.

Learning outcomes

On completion of this unit a learner should:

1 Be able to determine the effects of loading in static engineering systems

2 Be able to determine work, power and energy transfer in dynamic engineering systems

3 Be able to determine the parameters of fluid systems

4 Be able to determine the effects of energy transfer in thermodynamic systems.

Unit content

1 Be able to determine the effects of loading in static engineering systems

Non-concurrent coplanar force systems: graphical representation eg space and free body diagrams; resolution of forces in perpendicular directions eg $F_x = F\cos\theta$, $F_y = F\sin\theta$; vector addition of forces, resultant, equilibrant, line of action; conditions for static equilibrium ($\Sigma F_x = 0$, $\Sigma F_y = 0$, $\Sigma M = 0$)

Simply supported beams: conditions for static equilibrium; loading (concentrated loads, uniformly distributed loads, support reactions)

Loaded components: elastic constants (modulus of elasticity, shear modulus); loading (uniaxial loading, shear loading); effects eg direct stress and strain including dimensional change, shear stress and strain, factor of safety

2 Be able to determine work, power and energy transfer in dynamic engineering systems

Kinetic parameters: eg displacement (s), initial velocity (u), final velocity (v), uniform linear acceleration (a)

Kinetic principles: equations for linear motion with uniform acceleration ($v = u + at$, $s = ut + ½at^2$, $v^2 = u^2 + 2as$, $s = ½(u + v)t$)

Dynamics parameters: eg tractive effort, braking force, inertia, frictional resistance, gravitational force, momentum, mechanical work ($W = Fs$),
power dissipation (*Average Power* $= W/t$, *Instantaneous Power* $= Fv$),
gravitational potential energy ($PE = mgh$), kinetic energy ($KE = ½mv^2$)

Dynamic principles: Newton's laws of motion, D'Alembert's principle, principle of conservation of momentum, principle of conservation of energy

3 Be able to determine the parameters of fluid systems

Thrust on a submerged surface: hydrostatic pressure, hydrostatic thrust on an immersed plane surface ($F = \rho gAx$); centre of pressure of a rectangular retaining surface with one edge in the free surface of a liquid

Immersed bodies: Archimedes' principle; fluid eg liquid, gas; immersion of a body eg fully immersed, partly immersed, determination of density using floatation and specific gravity bottle methods

Flow characteristics of a gradually tapering pipe: eg volume flow rate, mass flow rate, input and output flow velocities, input and output diameters, continuity of volume and mass for incompressible fluid flow

4 Be able to determine the effects of energy transfer in thermodynamic systems

Heat transfer: heat transfer parameters eg temperature, pressure, mass, linear dimensions, time, specific heat capacity, specific latent heat of fusion, specific latent heat of vaporisation, linear expansivity; phase eg solid, liquid, gas; heat transfer principles eg sensible and latent heat transfer, thermal efficiency and power rating of heat exchangers; linear expansion;

Thermodynamic process equations: process parameters eg absolute temperature, absolute pressure, volume, mass, density; Boyle's law ($pV = constant$), Charles' law ($V/T = constant$), general gas equation ($pV/T = constant$), characteristic gas equation ($pV = mRT$)

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria					
To achieve a pass grade the evidence must show that the learner is able to:		**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**		**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**	
P1	calculate the magnitude, direction and position of the line of action of the resultant and equilibrant of a non-concurrent coplanar force system containing a minimum of four forces acting in different directions	**M1**	calculate the factor of safety in operation for a component subjected to combined direct and shear loading against given failure criteria	**D1**	compare and contrast the use of D'Alembert's principle with the principle of conservation of energy to solve an engineering problem
P2	calculate the support reactions of a simply supported beam carrying at least two concentrated loads and a uniformly distributed load	**M2**	determine the retarding force on a freely falling body when it impacts upon a stationary object and is brought to rest without rebound, in a given distance	**D2**	evaluate the methods that might be used to determine the density of a solid material and the density of a liquid.
P3	calculate the induced direct stress, strain and dimensional change in a component subjected to direct uniaxial loading and the shear stress and strain in a component subjected to shear loading	**M3**	determine the thermal efficiency of a heat transfer process from given values of flow rate, temperature change and input power		
P4	solve three or more problems that require the application of kinetic and dynamic principles to determine unknown system parameters [IE1, IE4]	**M4**	determine the force induced in a rigidly held component that undergoes a change in temperature.		
P5	calculate the resultant thrust and overturning moment on a vertical rectangular retaining surface with one edge in the free surface of a liquid				
P6	determine the up-thrust on an immersed body				

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P7 use the continuity of volume and mass flow for an incompressible fluid to determine the design characteristics of a gradually tapering pipe		
P8 calculate dimensional change when a solid material undergoes a change in temperature and the heat transfer that accompanies a change of temperature and phase		
P9 solve two or more problems that require application of thermodynamic process equations for a perfect gas to determine unknown parameters of the problems [IE1, IE4].		

PLTS: This summary references where applicable, in the square brackets, the elements of the personal, learning and thinking skills applicable in the pass criteria. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key			
	IE – independent enquirers	RL – reflective learners	SM – self-managers
	CT – creative thinkers	TW – team workers	EP – effective participators

Essential guidance for tutors

Delivery

Although the unit content can be delivered in any order, it might be advisable to follow the order of the learning outcomes. Revision of previous work on the polygon of forces may be necessary in learning outcome 1 before applying the principles of vector addition and force resolution to non-concurrent coplanar force systems. Likewise, the conditions for static equilibrium may need to be revised before applying them to the calculation of simply supported beam reactions. Practical demonstrations using force boards and balanced beam apparatus could be used to support the theoretical concepts.

After defining elasticity, the validity of Hooke's law might also be demonstrated as a practical exercise before introducing learners to the concepts of stress, strain and the elastic constants. If available, use should be made of tensile testing equipment and a suitable extensometer to determine modulus of elasticity and tensile strength. Where appropriate, the calculation of stress should be accompanied by determination of the factor of safety in operation. Learners should however be made aware that the presence of stress concentrations could affect its validity.

The revision of motion parameters should be followed by derivation of the equations for uniform linear motion using distance versus time and velocity versus time graphs. Newton's laws of motion are an essential introduction to the understanding of momentum and inertia, leading to the application of D'Alembert's principle in the solution of dynamic problems. In its simplest form, D'Alembert's principle states that if the internal inertial reaction to the acceleration or retardation of a body (ie the product ma given by Newton's second law) is imagined to be an external force, then the body can be treated as though it were in static equilibrium under the action of a system of external forces. A free body diagram can then be drawn to aid the solution of a dynamic problem. The diagram might also contain frictional resistance F_f and some component of weight $mg \sin\theta$, if the body is on an incline. The resultant force F (tractive effort or braking force) is then the vector sum of these three, ie $F = ma + F_f + mg \sin\theta$.

The application of D'Alembert's principle is thus the application of Newton's second and third laws of motion with the inertial reaction ma, considered as an external force. Problems should be set which involve consideration of inertia, friction and gravity when calculating tractive effort, braking force, work and power. These might include the motion of a vehicle on an incline, the operation of a lift or hoist, or the motion of a machine slide or worktable.

The relationship between work done and the form of energy stored should be clearly explained when deriving expressions for gravitational potential energy and kinetic energy. A clear distinction should be made between the principle of conservation of momentum and the principle of conservation of energy together with their applications. If time and facilities permit, the use of dynamics trolleys and timers can be used to demonstrate the principle of conservation of momentum. Problems involving bodies in collision, separation of space vehicles and the operation of pile drivers and drop hammers might be used to illustrate application of the two principles. Dynamics problems that have been previously solved using the equations of motion, D'Alembert's principle and Newton's laws might be revisited and solved using energy considerations. Learners will then be aware that this is an alternative and equally valid approach to the solution of dynamics problems and will be able to compare and evaluate the two methods.

On starting learning outcome 3, revision of previous work on hydrostatic pressure will lead to calculation of thrust on immersed plane surfaces. The depth of the centre of pressure for a rectangular retaining wall with one edge in the free surface of the liquid should be derived from first principles using integration. This can then be applied in the solution of problems such as those involving retaining walls, sluice gates and lock gates. Knowledge of the second moment of area is not required for this level of problem. This could be followed by an explanation of Archimedes' principle and calculation of up-thrust on immersed bodies. The determination of density by floatation and use of a specific gravity bottle should be explained and if possible, demonstrated. Finally, steady incompressible flow through tapering pipes can be considered with problems to determine flow velocities, flow rates and pipe dimensions using the equations for continuity of volume and mass flow.

It will be beneficial to revise and define the Celsius and absolute scales of temperature and the concept of absolute zero of temperature before starting the heat transfer content of learning outcome 4. This could begin with the definition of linear expansivity and the calculation of dimensional change that accompanies a change in temperature for a substance whose movement is unrestricted. Learners should be made aware that thermal stress would be induced where a body is constrained in some way. If time and facilities exist it may be beneficial to include a practical investigation to determine the linear expansivity of a material. The definition of specific heat capacity and specific latent heat of fusion and vaporisation could follow, with the solution of problems involving the calculation of sensible and latent heat transfer and heat transfer rates.

The remaining content of learning outcome 4 is concerned with the expansion and compression of gases. This essentially involves an explanation of the gas laws and, if possible, their experimental verification. The general gas equation $pV/T = constant$, can be derived from a consideration of expansion according to Boyle's and Charles' laws leading to statement of the characteristic gas equation $pV = mRT$. Learners should also be made aware that this could be manipulated to give expressions for the density and specific volume of a gas. It is sufficient at this stage to quote the value of the characteristic gas constant R for a given gas without reference to the universal gas constant or the specific heat capacities of the gas.

Learners should be made aware of the limitations of the gas equations when applied to real gases and particularly to vapours. Problems might include the expansion and compression of a gas in an engine cylinder bringing in the calculation of initial and final volumes from bore, stroke and compression ratio data, making use of all of the ranged equations.

Note that the use of 'eg' in the content is to give an indication and illustration of the breadth and depth of the area or topic. As such, not all content that follows an 'eg' needs to be taught or assessed.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • introduction to unit content, scheme of work and method of assessment • introduce and discuss rules and sign convention for resolution of forces • demonstrate analytical solution of concurrent coplanar force systems • explain that a non-concurrent coplanar force system can be reduced to a single resultant force an a resultant couple • demonstrate analytical solution of non-concurrent coplanar force systems. *Individual activity*: • analytical solution of concurrent and non-concurrent coplanar force systems.
Whole-class teaching: • define and discuss simply supported beams and types of support • demonstrate calculation of support reactions for simply supported beams carrying concentrated and uniformly distributed loads. *Individual activity*: • solution of simply supported beam problems.
Whole-class teaching: • define and discuss direct stress and strain, elastic behaviour and modulus of elasticity • define ultimate tensile strength and factor of safety • demonstrate calculation of direct stress and strain in engineering components and associated dimensional changes • define and discuss shear stress and strain, shear strength and shear modulus • demonstrate calculation of shear stress and strain in engineering components • demonstrate solution of problems on engineering components subjected to combines direct and shear loading. *Individual activity*: • solve problems on engineering components subjected to direct loading, shear loading and combined loading.
Preparation for and carrying out **Assignment 1: Static Systems** (P1, P2, P3 and M1).

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • discuss displacement v. time and velocity v. time graphs for uniform linear motion and derive associated equations of motion • explain Newton's laws of motion and derive expression for inertial resistance • explain and discuss the characteristics of dry frictional resistance, coefficient of kinetic friction and calculation of dry frictional resistance • explain the concept of dynamic equilibrium and application of D'Alembert's principle • define and derive expressions for work done, average power and instantaneous power disipation • demonstrate solution of dynamic problems involving application of the equations for uniform linear motion, Newton's laws and D'Alembert's principle. *Individual activity*: • solve dynamic problems involving application of the equations for uniform linear motion, Newton's laws and D'Alembert's principle.
Whole-class teaching: • explain and discuss the principle of conservation of momentum and demonstrate its application in the solution of problems involving the direct impact of moving bodies • define and derive expressions for gravitational potential energy and kinetic energy • explain and discuss the principle of conservation of energy • demonstrate solution of dynamic problems involving application of the principles of conservation of momentum and conservation of energy. *Individual activity*: • solve dynamic problems involving application of the principles of conservation of momentum and conservation of energy.
Preparation for and carrying out **Assignment 2: Dynamic Systems** (P4, M2 and D1).
Whole-class teaching: • describe and discuss properties of fluids and derive expression for pressure at depth • describe and demonstrate pressure measurement using piezometers and manometers • derive expression for thrust on an immersed plane surface and position of centre of pressure on a rectangular retaining surface with one edge in the free surface of a liquid • demonstrate solution of problems involving pressure at depth and thrust on an immersed surface. *Individual activity*: • solve problems involving pressure at depth and thrust on an immersed surface.
Whole-class teaching: • recap density, relative density and specific weight • explain and discuss Archimedes' principle • demonstrate calculation of up-thrust on fully immersed and partially immersed objects • explain and demonstrate experimental methods of determining density of solids and liquids. *Individual or small-group activity*: • solve problems involving application of Archimedes' principle and apply experimental procedures to determine the density of solids and liquids.

Topic and suggested assignments/activities and/assessment
Whole-class teaching: • derive expressions for volume and mass flow rate for steady pipeline flow • derive and discuss the continuity of volume and continuity of mass equations for steady flow • demonstrate solution of problems involving calculation of flow velocities and flow rates in branched and tapering pipes. *Individual activity*: • solve problems involving steady flow in branched and tapering pipes.
Preparation for and carrying out **Assignment 3: Fluid Systems** (P5, P6, P7 and D2).
Whole-class teaching: • define and discuss scales of temperature, specific heat capacity and specific latent heat of fusion and vaporisation • describe and discuss the working of typical heat exchangers eg boilers and water heaters • define and discuss power rating and thermal efficiency • describe and define linear expansivity (coefficient of linear expansion) • discuss the effect of heat transfer on the dimensions of a material and the occurrence of thermally induced stress • demonstrate solution of problems involving calculation of heat transfer, power rating, thermal efficiency, dimensional changes and thermal stress. *Individual activity*: • solve problems involving relating to heat transfer and its effects of heat transfer.
Whole-class teaching: • state and explain Boyle's law and Charles' law relating to the expansion and compression of gases and define an ideal gas • derive the general and characteristic gas equations • demonstrate solution of problems involving expansion and compression of gases. *Individual activity*: • solve problems involving expansion and compression of an ideal gas.
Preparation for and carrying out **Assignment 4: Thermodynamic Systems** (P8, P9, M3 and M4).
Feedback on assessment, unit evaluation and close.

Assessment

Ideally, the assessment of this unit will be achieved through application of the mechanical principles covered to the relevant engineering settings. This could be achieved through integration with other engineering principles units, practical work that provides learners with opportunities to produce individual evidence for assessment against the criteria, and individual project/assignment tasks. Whichever approach is taken it is important to ensure that the criteria are achieved autonomously. Where centres consider a test/examination is necessary to achieve authentic evidence then they need to ensure that the test items are set in a way to enable the criteria to be met in full. Centres also need to consider how such an assessment will provide opportunities to meet the merit and distinction criteria and how to provide learners with further learning and assessment should they initially fail to achieve in the test/examination.

If learners make an arithmetic error within the solution to a problem, it is for the centre to decide the significance of such an error, assess the work accordingly and provide suitable feedback. For example, if a learner has chosen the correct approach and manipulated the necessary formulae and data correctly but has made and carried through a minor arithmetic error, then the final 'inaccurate' solution to the problem may be deemed to be good enough to meet the criterion. However, if the final solution to the problem is so obviously wrong that it should have prompted further checks for accuracy, then the solution could be deemed to be unacceptable and reassessment considered. The incorrect application of units and/or dimensions are a typical cause of such major errors, which can lead to relatively large scale errors of the magnitude 103 or greater.

The criterion P1 requires the solution of a single non-concurrent force system that contains a minimum of four active forces. It will be expected that two of these forces will be set to act in directions other than the horizontal and vertical. This will necessitate the resolution of forces in perpendicular directions, eg the use of $Fx = F \cos\theta$ and $Fy = F \sin\theta$, as the first step in the solution to the problem. A typical problem might be an engineering component under the action of at least four non-concurrent forces whose magnitudes and directions are given. One of the forces might be its own weight but at least two of them should act in directions other than the horizontal and vertical. Learners would be expected to produce space and free body diagrams, resolve forces horizontally and vertically and take moments of the forces about some suitable reference point. The magnitude and direction of the resultant force and the position of its line of action could then be found through vector addition, application of Pythagoras' theorem and consideration of the resultant turning moment.

P2 will use similar skills to those required for P1 but in this case they will be applied to a simply supported beam carrying two point loads, as a minimum, and a uniformly distributed load. These specifications will provide centres with a variety of loading possibilities that can be used for assessment purposes. During the delivery phase for this part of the unit a greater range of loading may be considered but centres need only work with the minimum for assessment purposes. Neither the content or criteria stipulate that the point loads should be anything other than perpendicular to the beam. During delivery however, it may be useful to demonstrate the resolution of forces applied at an angle to the beam and calculation of the magnitude and directions of the support reactions.

The assessment for criterion P3 will require a task to calculate the direct stress, direct strain and the accompanying dimensional change in a directly loaded component. It will also require a task to calculate the shear stress and shear strain in a component or material subjected to shear loading. Centres should consider how the tasks set for P3 could be extended to incorporate an opportunity to achieve M1. This might involve consideration of the factor of safety in operation for an angled joint that is bolted or riveted such that the fastenings are subjected to both tensile and shearing forces.

It will require the setting of at least three dynamic system tasks to ensure that the range of kinetic and dynamic principles is applied to achieve P4. Centres should not fragment the application of kinetic and dynamic principles to the extent that they over simplify the problems. It is the interrelationships between the kinetic and dynamics principles that are as important as the use of any single equation. The principles applied in P4 can be directly linked to M2, although achievement of M2 will require a further task to be set to consider the impact of a freely falling body. Suitable examples of this type of problem are listed in the delivery section of these guidance notes. A final task to achieve the distinction criterion D1 will be required to enable learners to consider and solve an engineering problem using the two alternative approaches (ie D'Alembert's principle and the principle of conservation of energy), and compare the two methods.

The criteria P5 and P6 both involve the calculation of hydrostatic forces. P5 may be achieved by calculating resultant thrust and overturning moment on a rectangular retaining surface, examples of which are listed in the delivery section. P6 may be achieved by calculating the up-thrust on a totally immersed body using Archimedes' principle. There are no links to the merit criteria from these two areas of the unit but an understanding of fluid principles is needed to achieve D2, which requires learners to evaluate the methods used to determine the density of solids and liquids. The criterion P7 examines the learner's basic understanding of fluid flow. It may be achieved by considering the design of a gradually tapering pipe to suit given dimensional and flow constraints.

The criteria P8 and P9 have been designed to assess the thermodynamics aspects of the unit. P8 will require tasks to determine the dimensional change in an engineering component that accompanying a change in temperature, and the sensible and latent heat transfer that accompanies a change of temperature and phase in a substance. P9 will require tasks involving the range of thermodynamic process equations applicable to the expansion and compression of an ideal gas. The area of work covered by P8 – the effects of heat transfer – is extended in the merit criteria M3 and M4.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, P3, M1	Static Systems	Problems involving engineering components subjected to static force systems.	A written report containing an introductory explanation to each step in the sequence of calculations and findings.
P4, M2, D1	Dynamic Systems	Problems involving force, work and power in dynamic engineering system.	A written report containing an introductory explanation to each step in the sequence of calculations and findings.
P5, P6, P7, D2	Fluid Systems	Problems involving hydrostatic thrust and fluid dynamics. Experimental methods used to determine density.	A written report containing an introductory explanation to each step in the sequence of calculations and findings, and an evaluation of the methods used to determine density.
P8, P9, M3, M4	Thermodynamic Systems	Problems involving heat transfer and dimensional change in thermodynamic systems and involving the expansion and compression of gases.	A written report containing an introductory explanation to each step in the sequence of calculations and findings.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Engineering sector suite. This unit has particular links with the following unit titles in the Engineering suite:

Level 1	Level 2	Level 3
	Applied Electrical and Mechanical science for Technicians	Further Mechanical Principles and Applications
		Principles and Applications of Fluid Mechanics
		Principles and Applications of Thermodynamics
		Advanced Mechanical Principles and Applications

This unit provides some of the underpinning knowledge for the SEMTA Level 3 NVQ in Mechanical Manufacture, Level 3 NVQ in Engineering Maintenance and Level 3 NVQ in Engineering Technical Support.

Essential resources

There are no essential resources required for this unit. Centres should wherever provide access to laboratory facilities with a sufficient range of investigation and demonstration equipment wherever possible. In particular, tensile testing equipment, dynamics trolleys, linear expansivity apparatus, apparatus to determine density and apparatus for verification of Boyle's and Charles' laws would be of significant value.

Employer engagement and vocational contexts

The use of vocational contexts is essential in the delivery and assessment of this unit. Some of the work can be set in the context of learners' work placements or be based on case studies of local employers. Industrial visits will enhance delivery of the unit. Engineering companies with design, testing and development departments will be able to explain the relevance of mechanical science to their work.

There are a range of organisations that may be able help centres engage and involve local employers in the delivery of this unit, for example:

- Work Experience/Workplace learning frameworks – Centre for Education and Industry (CEI, University of Warwick) – www.warwick.ac.uk/wie/cei
- Learning and Skills Network – www.vocationallearning.org.uk
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – www.stemnet.org.uk
- National Education and Business Partnership Network – www.nebpn.org
- Local, regional business links – www.businesslink.gov.uk
- Work-based learning guidance – www.aimhighersw.ac.uk/wbl.htm

Indicative reading for learners

Textbooks

Boyce A, Cooke E, Jones R and Weatherill B – *BTEC Level 3 National Engineering Student Book* (Pearson, 2010) ISBN 9781846907241

Boyce A, Cooke E, Jones R and Weatherill B – *BTEC Level 3 National Engineering Teaching Resource Pack* (Pearson, 2010) ISBN 9781846907265

Bird J – *Science for Engineering* (Newnes, 2003) ISBN 0750657774

Bolton W – *Engineering Science* (Newnes, 2006) ISBN 0750680830

Darbyshire A – *Mechanical Engineering BTEC National Option Units* (Newnes, 2003) ISBN 0750657618

Tooley M and Dingle L – *BTEC National Engineering* (Butterworth-Heinemann, 2002) ISBN 0750651660

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	solving problems that require the application of kinetic and dynamic principles to determine unknown system parameters solving problems that require application of thermodynamic process equations for a perfect gas to determine unknown system parameters.

Although PLTS are identified within this unit as an inherent part of the assessment criteria, there are further opportunities to develop a range of PLTS through various approaches to teaching and learning.

Skill	When learners are …
Self-managers	organising their time and resources and prioritising actions when solving problems
Reflective learners	inviting feedback and dealing positively with praise, setbacks and criticism
Creative thinkers	trying out alternative solutions to problems.

Functional Skills – Level 2

Skill	When learners are …
ICT – Develop, present and communicate information	
Enter, develop and format information independently to suit its meaning and purpose including: • text and tables • images • numbers • records	presenting calculations and findings for set assignments
Mathematics	
Understand routine and non-routine problems in a wide range of familiar and unfamiliar contexts and situations	understanding the settings and contexts of mechanical, fluid and thermodynamic system problems
Identify the situation or problem and the mathematical methods needed to tackle it	identifying relevant data and calculating system parameters
Select and apply a range of skills to find solutions	selecting and applying appropriate methods and procedures to solve mechanical, fluid and thermodynamic system problems
Use appropriate checking procedures and evaluate their effectiveness at each stage	checking the validity of calculations and findings
Interpret and communicate solutions to practical problems in familiar and unfamiliar routine contexts and situations	presenting calculations in a logical sequence with statements of intent and correctly stated units
Draw conclusions and provide mathematical justifications	justifying selection and use of formulae and presenting findings and conclusions
English	
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	presenting solutions to problems, justifying of methods used and communicating findings and conclusions.