

# Unit 12: Applications of Mechanical Systems in Engineering

<b>Unit code:</b>	<b>D/600/0262</b>
<b>QCF Level 3:</b>	<b>BTEC National</b>
<b>Credit value:</b>	<b>10</b>
<b>Guided learning hours:</b>	<b>60</b>

## ● Aim and purpose

This unit aims to give learners knowledge of the components and systems commonly used in lubrication systems, transmissions and plant equipment.

## ● Unit introduction

Mechanical engineering is a term that covers a wide range of activities. Mechanical systems are found in land, sea and air transport, power generation, manufacturing plant and domestic products. The design, manufacture and maintenance of such systems is the concern of engineers and technicians who must be able to apply a blend of practical and theoretical knowledge to ensure that these systems work safely and efficiently.

Moving parts usually require some form of lubrication and learning outcome 1 examines lubricant types and lubrication systems. Pressurised systems often require seals and gaskets to contain the lubricants and other working fluids. Rotating parts require bearings and mechanical systems incorporate fixing devices to hold the various components in position. A range of seals, bearings and fastenings is examined in learning outcome 2.

A prime purpose of mechanical systems is to transmit motion and power. There are many ways in which this can be achieved and learning outcome 3 examines a range of power transmission systems and components. In learning outcome 4 learners are introduced to a range of plant equipment and systems. This includes an overview of hydraulic and pneumatic systems, steam plant, refrigeration and air conditioning plant and mechanical handling equipment.

The general aim of this unit is to broaden and extend learners' practical knowledge of mechanical engineering systems and provide a foundation for continuing work in related units.

## ● Learning outcomes

**On completion of this unit a learner should:**

- 1 Know about the purposes and uses of lubricants and lubrication systems
- 2 Know about the uses and applications of a range of engineering components
- 3 Know about the uses and operation of mechanical power transmission systems
- 4 Know about the uses and operation of plant equipment and systems.

# Unit content

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## 1 Know about the purposes and uses of lubricants and lubrication systems

*Lubricant purposes and types:* purpose eg reduction of frictional resistance, reduction of wear, heat dissipation, prevention of corrosion, prevention of contamination; types eg mineral, vegetable and synthetic oils and greases, graphite, compressed gases, cutting fluids

*Lubrication systems and maintenance:* operation of lubrication systems eg gravity feed, forced feed, splash lubrication, capillary action, grease cups and nipples, grease packing, compressed air/gas bearings; maintenance eg replenishment and renewal of lubricants, safe storage and handling

*Applications:* eg automobile engine, automobile transmission, machine tool, pump, compressor

## 2 Know about the uses and applications of a range of engineering components

*Seals, packing and bearings:* seals eg rotary lip seals, mechanical seals, piston rings; packing eg packed glands, gaskets, shims; bearings eg plain journal, thrust, ball, roller (such as parallel or tapered), needle

*Fastenings:* screwed fastenings eg metric bolts, studs and set screws, self-tapping screws, locking devices; rivets eg snap head, pan head and countersunk heads, bifurcated and pop rivets

*Applications:* eg automobile engine, automobile transmission, other automotive sub-system, machine tool, pump, compressor, other mechanical system involving rotation and fluid containment, component assembly, maintenance and replacement

## 3 Know about the uses and operation of mechanical power transmission systems

*Cams and linkage mechanisms:* cams and followers eg radial plate cams, cylindrical cams, face cams, knife-edge followers, flat plate followers, roller followers; linkage mechanisms eg slider-crank and inversions, four-bar linkage and inversions, slotted link quick return motion, Whitworth quick return motion

*Belt, chain and gear drives:* belt drives eg flat, V-section, synchronous, tensioning device; chain drives eg roller (such as single, duplex, triplex), morse rocker-joint, tensioning devices; gear trains eg gear types (such as spur, helical, herring bone, bevel, spiral bevel, hypoid), simple, compound, worm, combinations, epicyclic

*Transmission shafts, clutches and brakes:* transmission shafts and couplings eg sections (such as solid, hollow), flanged couplings, splined couplings, angle couplings (such as Hooke universal, constant velocity); clutches eg dog, flat plate, conical, centrifugal, fluid couplings; brakes eg friction (such as internal expanding, external contracting), disc, dynamometers (such as friction, fluid, electromagnetic)

## 4 Know about the uses and operation of plant equipment and systems

*Actuation and handling systems:* pneumatic and hydraulic actuation systems eg system layout for automated plant and process operations, system components; safety and maintenance; mechanical handling systems eg belt conveyers, roller conveyers, workshop gantry cranes, workstation jib cranes

*Steam, refrigeration and air conditioning plant service systems:* steam power generation plant eg system layout for power generation and process operations, system components, feed water treatment, safety and maintenance; refrigeration systems eg system layout for vapour compression and absorption systems, refrigerants, system components, safety and maintenance; air conditioning systems eg system layout for full summer and winter cycle air conditioning, system components, safety and maintenance

## 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:
<b>P1</b> describe the purpose and application of three different types of lubricant [IE4]	<b>M1</b> compare and contrast the operation and use of flat plate clutches, centrifugal clutches and fluid couplings in mechanical power transmission systems	<b>D1</b> justify the use of a particular lubricant and lubrication system in a given engineering application
<b>P2</b> describe the operation and maintenance of three different lubrication systems	<b>M2</b> compare and contrast the operation and use of pneumatic and hydraulic actuation systems.	<b>D2</b> justify the choice of engineering components in a given engineering application.
<b>P3</b> describe the operation of one seal, one type of packing and two different types of bearing, giving a typical application for each one		
<b>P4</b> describe two different types of screwed fastening and two different types of rivet giving a typical application for each one [IE4]		
<b>P5</b> describe the operation of two different types of cam and follower and two different types of linkage mechanism [IE4]		
<b>P6</b> describe the arrangement and operation of two different kinds of belt drive, two different kinds of chain drive and two different kinds of gear train [IE4]		

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:
<b>P7</b> describe the arrangement and operation of two different kinds of transmission shaft and coupling, two different kinds of clutch and two different kinds of brake		
<b>P8</b> describe, with the aid of diagrams, the general layout and operation of a pneumatic actuation system, a hydraulic actuation system and a mechanical handling system		
<b>P9</b> describe, with the aid of diagrams, the general layout and operation of a steam power generation plant, a refrigeration system and an air conditioning system.		

**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.

<b>Key</b>	IE – independent enquirers CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators
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# Essential guidance for tutors

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## Delivery

The learning outcomes of this unit can be delivered in any order, although it may be best to leave learning outcome 4 until last. When delivering learning outcome 1 it would be appropriate to start with an overview of the reasons for lubrication in mechanical systems. Some time can then be spent on lubricant types, their origins, additives, uses and classification. When explaining the function and maintenance of lubricating systems it will be useful to present items of equipment and view their applications in motor vehicles or workshop machinery if available. Much useful trade literature is available from the major oil companies and equipment suppliers.

A similar approach can be adopted when delivering learning outcome 2. Initial overviews of the purpose and uses of seals, packing, bearings and fastenings can be followed by an examination of exemplar items. Time can then be spent in explaining their specific function and applications. If facilities are available, practical assembly and replacement exercises can enhance understanding of component use.

The content of learning outcome 3 is quite wide ranging and the order of delivery is a matter of personal preference. Coverage of cam types, followers and input and output motions should be qualitative. It is not necessary to enter into cam profile design procedures as these are time consuming and may be covered in other units. The emphasis should be on the identification of the different types and their typical applications. The same applies to the delivery of linkage mechanisms which are covered in detail in *Unit 11: Further Mechanical Principles and Applications*.

The range of transmission shafts, shaft couplings, clutches, brakes, belt, chain and gear drives is quite extensive but, wherever possible, explanation of their functions and applications should be accompanied by the presentation of exemplar items of equipment. Descriptive printed material will be of value in the delivery of this outcome, reinforced by the viewing of typical applications in motor vehicles, workshop equipment and video footage where possible.

When delivering the pneumatic and hydraulic system content for learning outcome 4 the emphasis should be on system layout, major system components and the comparison of operation and usage. It is not necessary to enter into the detailed description of components such as valve types and their symbolic representation. Similarly, with mechanical handling systems and steam, refrigeration and air conditioning plant the emphasis should be on function and layout. An industrial visit will be of value to reinforce delivery of this outcome.

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
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"><li>• introduction to unit, scheme of work and method of assessment</li><li>• introduce the different types of lubricant and explain their purpose and applications</li><li>• explain the operation of lubrication systems and their maintenance.</li></ul> <p><i>Individual learner research:</i></p> <ul style="list-style-type: none"><li>• investigating lubricants and lubrication systems.</li></ul> <p><i>Practical/group activity:</i></p> <ul style="list-style-type: none"><li>• investigate and examine lubricating systems equipment in workshop machinery.</li></ul>
<p>Preparation for and carrying out <b>Assignment 1: Applications of Lubricants and Lubrication Systems</b> (P1, P2 and D1).</p>
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"><li>• describe the purpose and use of the different types of seals, packing and bearings</li><li>• explain the function and applications of seals packing and bearings</li><li>• explain the use of screwed fastening and rivets.</li></ul> <p><i>Individual learner research:</i></p> <ul style="list-style-type: none"><li>• investigating seals, packing and bearings.</li></ul> <p><i>Practical/group activity:</i></p> <ul style="list-style-type: none"><li>• disassembling and mechanical systems and replacing seals, packing and bearings.</li></ul>
<p>Preparation for and carrying out <b>Assignment 2: Applications of Engineering Components</b> (P3, P4 and D2).</p>
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"><li>• identify the different types of cam and describe the purpose and typical applications of cams and linkage mechanisms</li><li>• identify and explain the function of belt drives, chain drives and gear trains.</li></ul>
<p>Preparation for and carrying <b>Assignment 3: Applications of Cams and Drives</b> (P5 and P6).</p>
<p><i>Whole-class teaching:</i></p> <ul style="list-style-type: none"><li>• identify and explain the function of a range of transmission shafts, clutches and brakes.</li></ul> <p><i>Individual learner research:</i></p> <ul style="list-style-type: none"><li>• investigating transmission systems.</li></ul> <p><i>Practical/group activity:</i></p> <ul style="list-style-type: none"><li>• examine mechanical power transmission systems in automotive or workshop equipment applications.</li></ul>
<p>Preparation for and carrying out <b>Assignment 4: Applications of Brakes and Clutches</b> (P7 and M1).</p>

## Topic and suggested assignments/activities and/assessment

### *Whole-class teaching:*

- explain the function of pneumatic and hydraulic actuation systems and explain relevant safety and maintenance
- explain the function and use of mechanical handling systems.

### *Group activity:*

- investigate and examine the layout of pneumatic, hydraulic and mechanical handling systems, the major system components and compare their usage and operation.

### *Whole-class teaching:*

- explain the function and operation of steam power generation plant, refrigeration systems and air conditioning systems.

### *Individual learner research:*

- investigating plant equipment and systems.

### *Industrial visit:*

- visit local company to view steam, refrigeration and air conditioning plant service systems.

Preparation for and carrying out **Assignment 5: Plant Equipment and Systems** (P8, P9 and M2).

Feedback, unit revision and close.

## Assessment

Criteria P1, P2 and D1 could be achieved through an individual assignment. This should contain tasks to describe the purpose and application of three different types of lubricant (P1) and the operation and maintenance of three different lubrication systems (P2). To achieve D1, learners should be able to fully justify the use of a particular lubricant and lubrication system in a given engineering application. This might be the lubrication system of a vehicle engine or transmission, a machine tool, pump or compressor. Alternatively, a mechanical system required to operate in a hostile service environment such as extremes of temperature may be considered.

A second assignment could be used to assess P3, P4 and D2. This would require learners to describe the operation and application of one type of seal, one type of packing and two different types of bearing (P3). Another task would need to cover two different types of screwed fastener and two different types of rivet (P4). The applications should be general, rather than product specific, to demonstrate an understanding of purpose. Diagrams and sketches could be used to complement the descriptions. To achieve D2 learners should be able to fully justify the choice of bearings, seals, packing and fastenings in a given engineering system. This again might be a sub-system of a vehicle, a machine tool or any mechanical system where rotation and the containment of fluid is involved.

Criteria P5 and P6, which relate to learning outcome 3 on mechanical power transmission systems, could be achieved through a third assignment. This should require learners to describe methods of transmitting/ converting motion from one form to another by means of two different types of cam and follower and two different linkage mechanisms. It will also need to include two different kinds of belt drive, two different kinds of chain drive and two different kinds of gear train. As with the previous assessment, learners should be encouraged to illustrate the descriptions with diagrams and freehand sketches.

Criteria P7 and M1 relate to learning outcome 3 and could be achieved through a fourth assignment. This should contain tasks requiring learners to describe the arrangement and operation of two different kinds of transmission shaft coupling, two different kinds of clutch and two different kinds of brake (P7). To achieve M1, learners should compare and contrast the operation of manually operated and automatic friction clutches and fluid couplings. The comparisons should be of a general nature, although they may be accompanied by typical applications to illustrate usage.

A final time-constrained assignment could be used to assess P8, P9 and M2. This should contain tasks requiring learners to describe, with the aid of diagrams, the general layout and operation of pneumatic and hydraulic actuation systems (P8), a steam generation plant, a refrigeration system and an air conditioning system (P9). Learners will also need to provide a reasoned comparison of the operation and use of pneumatic and hydraulic actuation systems to achieve merit criterion M4. As with the previous assessment, the comparison should be general in nature but may be accompanied by typical applications to illustrate usage.

### 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 and D1	Applications of Lubricants and Lubrication Systems	Learners need to describe lubricants and the operation of lubrication systems to a new apprentice.	A series of three written tasks in which learners provide description of three lubricants and the operation of lubrication systems. They are also asked to justify the use of a lubricant for a given application.
P3, P4 and D2	Applications of Engineering Components	Learners need to investigate different components in order to find the best to use for a particular application.	A series of three written tasks in which learners describe the application of seals, packing, bearings and fasteners and justify their use for a given system.
P5 and P6	Applications of Cams and Drives	Learners need to investigate mechanical power transmission systems.	Two written tasks in which learners describe the use of cams, linkage mechanisms and chains and drives.
P7 and M1	Applications of Brakes and Clutches	Learners need to investigate transmission shafts, clutches and brakes.	Two written tasks in which learners describe the operation of shaft couplings, clutches and brakes.
P8, P9 and M2	Plant Equipment and Systems	Learners have been asked to produce a report on some new plant equipment and systems that their company is interested in using.	A time-controlled task in which learners produce written descriptions and accompanying diagrams of actuation systems and steam, refrigeration and air conditioning systems. They should also carry out a comparison of pneumatic and hydraulic systems.



## 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
		Mechanical Principles and Application
		Further Mechanical Principles and Applications
		Electro, Pneumatic and Hydraulic Systems and Devices

### Essential resources

Centres should have access to a range of engineering components, demonstration equipment and engineering and motor vehicle workshops.

### Employer engagement and vocational contexts

Centres should actively seek links with local engineering companies and establish what form of help they will be able to provide. Links or assistance could include focussed site visits and/or sector-related work experience, visiting speakers, materials or samples and loan of or assistance with specialist equipment.

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](http://www.warwick.ac.uk/wie/cei)
- Learning and Skills Network – [www.vocationallearning.org.uk](http://www.vocationallearning.org.uk)
- Network for Science, Technology, Engineering and Maths Network Ambassadors Scheme – [www.stemnet.org.uk](http://www.stemnet.org.uk)
- National Education and Business Partnership Network – [www.nebpn.org](http://www.nebpn.org)
- Local, regional Business links – [www.businesslink.gov.uk](http://www.businesslink.gov.uk)
- Work-based learning guidance – [www.aimhighersw.ac.uk/wbl.htm](http://www.aimhighersw.ac.uk/wbl.htm).

### Indicative reading for learners

#### Textbooks

Darbyshire A – *Mechanical Engineering BTEC National Option Units* (Elsevier, 2008) ISBN 075068657X

Neale M J – *Lubrication and Reliability Handbook* (Newnes, 2000) ISBN 0750651547

## 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 ...
<b>Independent enquirers</b>	analysing and evaluating information relating to different mechanical systems and technology when investigating lubrication systems, engineering components, transmission systems and plant equipment.

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 ...
<b>Team workers</b>	collaborating with others when working in groups to examine and investigate different mechanical systems
<b>Self-managers</b>	organising time and resources and prioritising actions.

## ● Functional Skills – Level 2

Skill	When learners are ...
<b>English</b>	
Reading – compare, select, read and understand texts and use them to gather information, ideas, arguments and opinions	researching and investigating mechanical systems and technology
Writing – write documents, including extended writing pieces, communicating information, ideas and opinions, effectively and persuasively	describing the function and operation of different mechanical systems and technology.