

## **Cambridge National**

# **Principles in Engineering and Engineering Business**

**R101/01: Engineering principles**

Level 1/2 Cambridge National Certificate/Award

**Mark Scheme for January 2021**

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

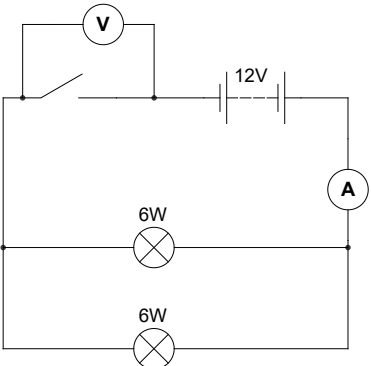
Mark schemes should be read in conjunction with the published question papers and the report on the examination.

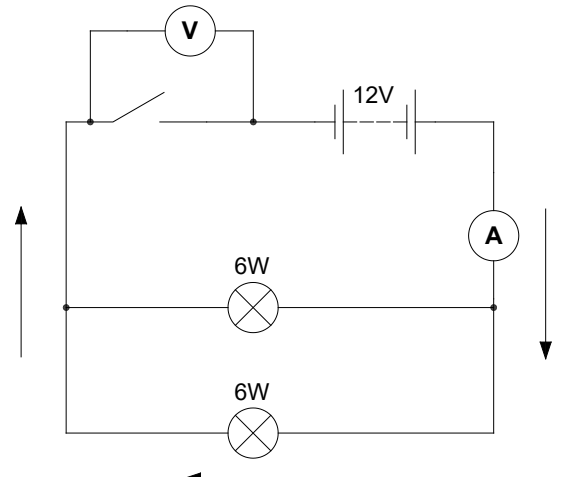
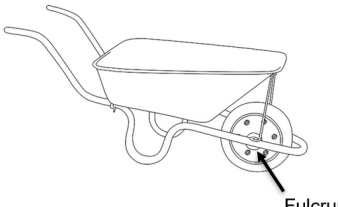
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## Annotations

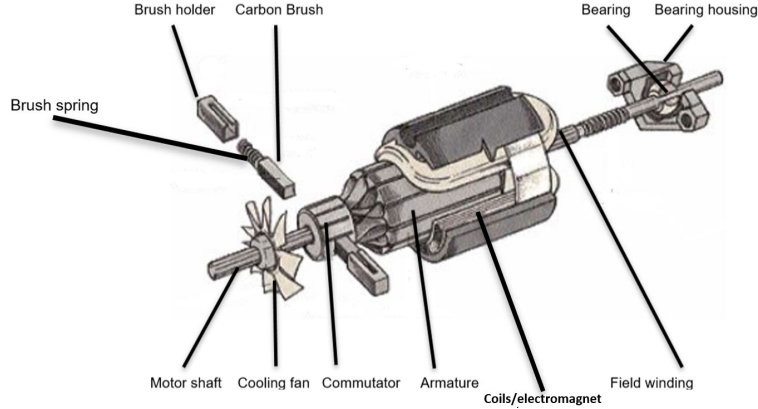
Annotation	Meaning of annotation
<b>BP</b>	Blank Page – this annotation must be used on all blank pages within an answer booklet (structured or unstructured) and on each page of an additional object where there is no candidate response.
✓	Tick - 1 Tick for each mark awarded. Do not use ticks for question 4(b)*
<b>SEEN</b>	Noted but no credit given, or no response for whole part-question  Use 'Seen' and <b>NR</b> - No Response (bottom right of screen) where there is no response for whole part-question. Typing NR also works.
<b>REP</b>	Repetition - Repeated answer or knowledge point - no additional credit/marks awarded
<b>BOD</b>	Benefit of doubt given
<b>K</b>	Knowledge - used for question 4(b)* only
<b>DEV</b>	Developed knowledge point - used for question 4(b)* only
<b>L1</b>	Level 1 response (i.e. in the range of 1-2 marks) used for question 4(b)*
<b>L2</b>	Level 2 response (i.e. in the range of 3-4 marks) used for question 4(b)*
<b>L3</b>	Level 3 response (i.e. in the range of 5-6 marks) used for question 4(b)*
<b>VG</b>	Too vague, not worthy of credit/marks
No other annotations should be used. <b>Do not</b> use crosses ✗	

Subject Specific Marking Instructions

Question			Answer/Indicative content	Mark	Guidance
1	(a)	(i)	 <p>Correct symbol for Voltmeter (1)                  Correct placement in circuit (across switch) (1)</p> <p>(2x1)</p>	2	
		(ii)	<p>Open 12 V (1)                  Closed 0 V (1)</p> <p>(2x1)</p>	2	
		(iii)	<p>Parallel (1)</p> <p>(1x1)</p>	1	

		(iv)	 <p>Arrow(s) pointing clockwise + to - (1)</p>	1	Any arrow in a clockwise direction will be accepted
	(b)		<p>The sum of the <b>current</b> in each branch of the circuit equals the current leaving the power supply.                  The <b>voltage is the same</b> across all <b>parallel</b> components.                  1 mark for each correct term in the correct order                  (4x1)</p>	4	
			<b>Total</b>	<b>[10]</b>	
2	(a)	(i)	<p>1 mark for each correct labelling of the fulcrum (at the point of pivot, or very near) (1)</p>  <p style="text-align: right;">(1x1)</p>	1	

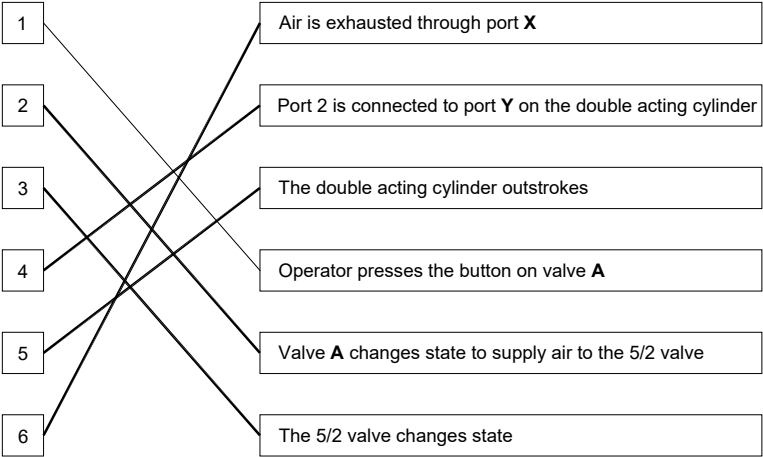
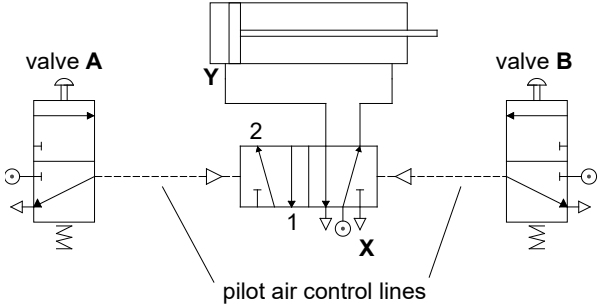
	(ii)	The fulcrum is the point of the lever that pivots or rotates. (1)  (1x1)	1	Allow similar definition.
	(iii)	Less effort will be required to lift the load/ it will be easier to move the load. (1)  (1x1)	1	
	(iv)	Answers will include an explanation of the relationship between the load and the fulcrum eg:- The closer the load to the fulcrum, the less effort will be required (1) such as a class 1 lever (1). A class 2 lever has the load between the effort and the fulcrum to use less effort for heavy loads (1) If levers are lengthened (1) the weight/load is moved (1) and it reduces the effort(1).  (3x1)	3	Allow similar answers. Award marks for correct examples of class 1, 2 or 3 levers.
(b)	(i)	The belt can slip under load (1) The belt will wear under load (1)  (1x1)	1	
	(ii)	Using a chain drive (1) Use gears (1)  (1x1)	1	
	(iii)	$\frac{\text{Distance moved by Driven pulley}}{\text{Distance moved by Driver pulley}} = \frac{80}{160} = 0.5 : 1$  (1x1)	1	No marks for formula. 1 mark for correct answer 1 mark for 0.5 (acceptable without ratio) Give BoD if 1:2
	(iv)	$\frac{\text{Driver}}{\text{Driven}} = 60 = 2:1 = 60/2 = 30 \text{ rpm.}$  (1x1)	1	Award marks for correct answer only even without the working out
		<b>Total</b>	<b>[10]</b>	

<p>3</p>	<p>(a)</p>	<p>(i)</p>	 <p>Any two correctly labelled components (2x1)</p>	<p>2</p>	<p>Allow 1 mark BOD for label to outer casing (surrounding the field coil).</p> <p>Allow 'magnet' in place of coils/electromagnet as BoD.</p>
		<p>(ii)</p>	<p>Example answers stating the function of the component e.g.</p> <ul style="list-style-type: none"> <li>• The brush holder holds the carbon brush onto the commutator (1)</li> <li>• The carbon brush supplies current to the commutator (1)</li> <li>• The bearing allows the motor to spin without friction (1)</li> <li>• The bearing housing supports the bearing (1)</li> <li>• The motor shaft allows the motor to drive the output (1)</li> <li>• The cooling fan keeps the motor cool as the current creates heat (1)</li> <li>• Draws hot air – fan expels/directs hot air from the heating element (1)</li> <li>• The commutator collects current from the brushes and provide a current to the magnetic field and continually reverses the flow of electrons (1)</li> </ul>	<p>1</p>	<p>Award any one correct answer from the list. Allow variations in terminology.</p>

		<ul style="list-style-type: none"> <li>The armature makes a coil inside the field windings (1)</li> <li>The field windings create a magnetic field to spin the motor (1)</li> <li>The casing protects the user from electrical components (1)</li> </ul> <p style="text-align: right;">(1x1)</p>		
		(iii) $500 / 230 \text{ V} = \mathbf{2.17(1) \text{ A}}$ (1)	<b>2</b>	1 mark for the correct answer including decimal places (allow rounding to 2.2 for BOD), 1 mark for the correct units No mark for formula
		(iv) The hair dryer motor converts <b>electrical</b> energy to <b>mechanical</b> energy, to turn a fan. An electrical current is passed through the heater element coils. The coils have <b>resistance</b> which creates <b>heat</b> energy.	<b>4</b>	1 mark for each correct answer in the correct position in the statements. Allow kinetic for mechanical, allow heat/thermal energy
		(b) Chemical to mechanical/kinetic (1) Chemical to electrical (1) Chemical to heat (1) Light to electrical (1) Kinetic/mechanical to electrical (1) Potential to kinetic (1) Chemical to light (1)	<b>1</b>	Accept valid combinations. Do not allow repeat of correct answers in part (iii).
		<b>Total</b>	<b>[10]</b>	
<b>4</b>	<b>(a)</b>	Excavator (1) Waterwheel (1) Archimedes screw (1) Relief valve (1) Fluid flywheel (1) Dam (1) Hydraulic jack/ram (1) Water turbine generator (1)	<b>1</b>	Accept valid examples
		(1x1)		



	<b>(b)</b>	<p>Answers could include examples such as below e.g.:</p> <p>A water turbine is a device for converting water/fluid power into mechanical power. (1) The mechanical power can be used to perform work or generate other energy (1). A mechanical valve can be used to control/ restrict or direct the flow of water (1).</p> <p>A pump is a device for converting the rotary motion of an impeller (1) to produce a flow of water or increase the water pressure. (1) The pump could be driven by water or electro-mechanically. (1)</p> <p style="text-align: right;">(3x1)</p>	<b>3</b>	Accept valid examples.	
	<b>(c)</b>	<b>(i)</b>	<p>Torque or torsion (1)</p> <p style="text-align: right;">(1x1)</p>	<b>1</b>	
	<b>(c)</b>	<b>(ii)</b>	<p>Valid description of connecting the crankshaft /flywheel to a gearbox or similar output. i.e.</p> <p>The crankshaft could be connected to a clutch (1) bolted to the flywheel (1). The clutch engages with a gearbox which is bolted (1) to an engine crank case.</p> <p>The crankshaft is connected to a fluid flywheel/ torque converter(1). The torque converter is connected to the gearbox (1) and when hydraulic pressure is created by the turning motion of the engine crankshaft, the gearbox gears can be selected. (1)</p> <p style="text-align: right;">(3x1)</p>	<b>3</b>	Allow mechanical or fluid examples.
	<b>(c)</b>	<b>(iii)</b>	<p>A hydraulic pump could be driven from a gearbox power take off, using gears (1), or a drive shaft (1) or could be driven by an auxiliary pulley (1)</p> <p style="text-align: right;">(2x1)</p>	<b>2</b>	<p>Allow other examples. Award "Hoses" BOD</p> <p>Allow description of generator powered pump.</p>
			<b>Total</b>	<b>[10]</b>	

<p><b>5</b></p> <p><b>(a)</b></p> <p><b>(i)</b></p>	 <p>(4x1)</p>	<p><b>4</b></p>	<p>1 mark for one line correct                  2 marks for two lines correct                  3 marks for three lines correct                  4 marks for four or five lines correct</p>
<p><b>(ii)</b></p>	<p>Valve <b>B</b> is pressed to instroke the piston.</p> <p>(1x1)</p>	<p><b>1</b></p>	
<p><b>(iii)</b></p>	<p>Remove valve <b>B</b> as it is no longer required (1)                  Replace the 5/2 valve with a 3/2 valve (1)</p> <p>(1x1)</p>	<p><b>1</b></p>	
<p><b>(iv)</b></p>	 <p>pilot air control lines</p>	<p><b>1</b></p>	<p>Either pilot air control line identified, 1 mark</p>

	<b>(b)</b>	<p>This can include any description which is correct example shown below eg;                  Pressure is created using a compressor (1) which draws air from the atmosphere (1). The compressor compresses the air and supplies this under pressure to the system (1).</p> <p style="text-align: right;">(3x1)</p>	<b>3</b>	<p>Allow other descriptions e.g.                  The air drawn in is forced into a small area.</p>												
		<b>Total</b>	<b>[10]</b>													
<b>6</b>	<b>(a)</b>	<table border="1" style="margin-left: auto; margin-right: auto;"> <thead> <tr> <th>Description</th> <th>Fluid power component</th> </tr> </thead> <tbody> <tr> <td>Receiver</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>Shuttle Valve</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>Relay</td> <td></td> </tr> <tr> <td>Non-return valve</td> <td style="text-align: center;">✓</td> </tr> <tr> <td>Alternator</td> <td></td> </tr> </tbody> </table> <p style="text-align: right;">(3x1)</p>	Description	Fluid power component	Receiver	✓	Shuttle Valve	✓	Relay		Non-return valve	✓	Alternator		<b>3</b>	
Description	Fluid power component															
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	<b>(b)</b>	<p>Control valve / joystick / lever (1)                  Pump (1)</p> <p style="text-align: right;">(1x1)</p>	<b>1</b>	<p>Allow push-button control valve as BoD.</p>												

Question	Guidance	Marks	Answer
(c)*	<p>Award up to 6 marks for a discussion of function and application of a double acting cylinder as a mechanism to move a load.</p> <p><b>Level 3 (5 – 6 Marks)</b> Detailed discussion showing clear understanding of the function and application of a double acting cylinder as a mechanism to move a load, Understanding of the how the system is used to include the instroke function, and / or hold the actuator will be demonstrated, with an appropriate example.</p> <p>Specialist terms will be used appropriately and correctly. The information will be presented in a structured format. The candidate can demonstrate the accurate use of spelling, punctuation and grammar.</p> <p><b>Level 2 (3 – 4 Marks)</b> Adequate discussion showing an understanding of the function and application of a double acting cylinder as a mechanism to move a load, with comparison of using a single acting actuator or other mechanical means. The response may give an appropriate example application.</p> <p>There will be some use of specialist terms, although these may not be used appropriately. The information will be presented for the most part in a structured format. There may be occasional errors in spelling, punctuation and grammar.</p> <p><b>Level 1 (0 – 2 Marks)</b></p>	6	<p>Examples and relevant points could include:</p> <ul style="list-style-type: none"> <li>• Fluid power includes pneumatics and hydraulics. Both systems use actuators controlled by valves to perform a task.</li> <li>• Control systems may be manually or electrically operated and are often electronically controlled in manufacturing.</li> <li>• Actuators/cylinders are used to push, contract, hold, press, stamp or lift.</li> <li>• Single action actuators include a return spring that is used to return the cylinder piston after the outstroke.</li> <li>• Double acting cylinders use an air or fluid supply to outstroke the piston and a separate supply to instroke, and either exhaust the supplied air, or return fluid to a reservoir.</li> <li>• Double acting cylinders are used in hydraulic applications to lift/move heavy loads as the action can be controlled very slowly by the operator. A vehicle crushing machine is one example of hydraulic double acting cylinder used to compress / crush. Other examples include a hydraulic lift which requires the cylinder to be able to outstroke to lift and instroke to lower. Single acting cylinders are often used in pneumatics for lighter operations or loads to press, stamp and push, pack and may operate a higher speed in manufacturing. The return spring is required to return the piston to the rest</li> </ul>

		<p>Basic discussion showing limited understanding function and application of a double acting cylinder as a mechanism to move a load.</p> <p>There will be little or no specialist terms. Answers may well be ambiguous or disorganised. Errors of spelling, punctuation and grammar may be intrusive.</p> <p><b>0</b> = a response that is irrelevant and/or not worthy of a mark. Annotate with 'Seen' at the end of the response.</p>		<p>position for the next operation, such as on a production line.</p> <ul style="list-style-type: none"> <li>• A double acting cylinder exerts force in both directions, whereas a single acting cylinder can only provide force on the outstroke. The more force, the more control.</li> <li>• In summary, double acting cylinders allow more control of movement in both directions, than the single acting cylinder, whether used in hydraulics or pneumatics.</li> </ul>
		<b>Total</b>	<b>[10]</b>	

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