



## **Cambridge National**

## **Engineering**

Unit **R101**: Engineering Principles

Level 1/2 Cambridge National Award/Certificate in Principles in Engineering  
and Engineering Business

## **Mark Scheme for January 2019**

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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.

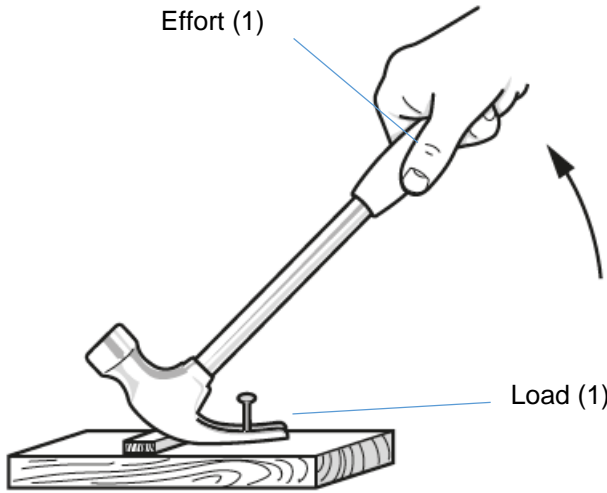
All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

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

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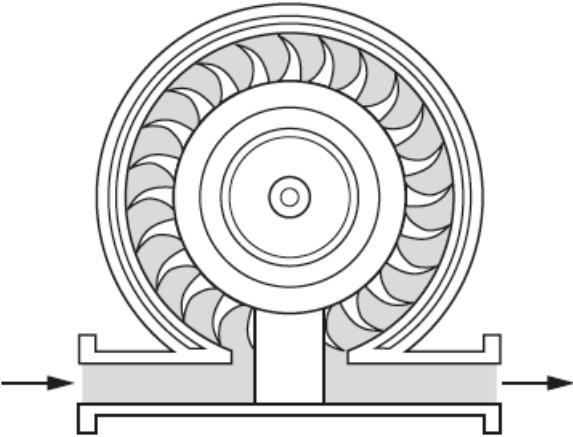
These are the annotations, (including abbreviations), including those used in scoris, which are used when Marking

Annotation	Meaning of annotation
	Blank page
	Vague
	Tick
	Unclear
	Repeat
	Benefit of doubt
	Development
	Example/Reference
	Knowledge
	Level 1
	Level 2
	Level 3

Question			Answer/Indicative content	Mark	Guidance
1	(a)	(i)	Fig.1 is correctly labelled.  	2	(2x1)
		(ii)	Class 1 Lever	1	(1x1) Class A accepted
		(iii)	Increase the length of the handle (1) Increase the effort applied to the handle (1) Decreasing the distance from the nail head to the fulcrum (1)	2	(2x1) Pull harder accepted
		(iv)	e.g. A wheelbarrow has the load and the effort on the same side of the fulcrum (1). A wheelbarrow is a class 2 lever (1)	2	Up to two marks for an explanation.  Accept other valid explanations.

Question			Answer/Indicative content	Mark	Guidance
	(b)	(i)	<p>e.g.</p> <p>Mechanical advantage is a measure of the force amplification (1) achieved by using a tool, mechanical device or machine system (1)</p> <p>The trade-off forces against movement (1) to obtain a desired amplification in the output force (1)</p> <p>The ratio of the force that performs the useful work of a machine (1) to the force that is applied to the machine (1)</p> <p>The advantage gained by the use of a mechanism in transmitting force (1)</p>	2	<p>Up to two marks for an explanation.</p> <p>Accept other valid explanations.</p> <p>Less force (1) Less effort (1) Easier (1) Greater output (1) Using a lever/crowbar to assist (1)</p>
		(ii)	<p>e.g.</p> <p>Crowbar (1) Screwdriver (1) Shovel (1) Spanner/wrench (1) Jack (1)</p>	1	<p>(1x1) BOD – hand drill (1) Pliers (1) Accept other valid example of hand tools, except hammer, that give a mechanical advantage.</p> <p>Do not award hammer as it is given in the question.</p>
			<b>Total</b>	<b>[10]</b>	
2	(a)	(i)	Coil/winding (1)	1	<p>(1x1) Copper Wire (BOD)</p>
		(ii)	<p><math>I=V/R</math> <math>12 / 60 = 0.2A</math> or <math>200mA</math></p>	3	<p>1 mark for substitution/formula seen 1 mark for correct answer 1 mark for correct unit</p>

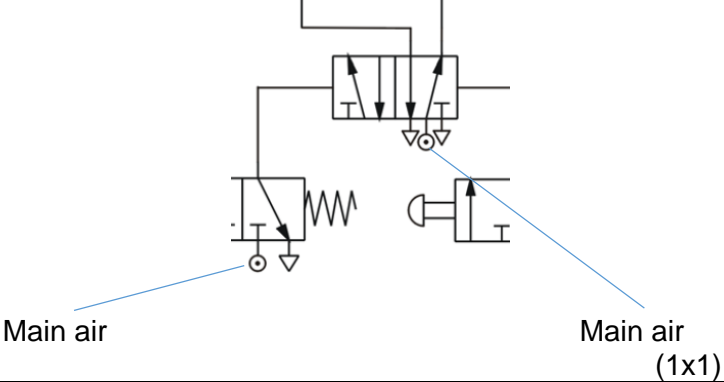
Question		Answer/Indicative content	Mark	Guidance
	(iii)	<p>Correct control device for the application e.g. Explanation of the actions of the relay when energised. E.g.</p> <p>e.g. Current flows through coil windings (1). Coil armature is pulled in/ retracts. (1) Normally open contacts are closed (1).</p> <p>e.g. Flow of current produces a magnetic field (1). Magnetic field attracts the moveable contact (1). Contacts that are normally closed will open and vice versa (1).</p>	3	<p>Up to three marks for an explanation.</p> <p>Accept other valid explanations.</p> <p>Accept similar terminology. Electro magnet (1) Magnetic field (1) Magnetic current (1) (words to look for attract switch, on to off, complete circuit)</p>
	(iv)	<p>e.g. Use a low current to switch a high current/load (1) Connect two circuits each using different voltages (1)</p>	2	<p>(2x1) Accept “use as a switch” for BOD Safety – only when related with high voltage (1) Reduce switched current (1)</p>
	(v)	<p>Motor (1) Generator (1) Solenoid (1)</p>	1	<p>(1x1) Do <b>not</b> accept ‘Relay’ as this is given in the question. Wind up torch (1), Clock not accepted</p>
<b>Total</b>			<b>[10]</b>	

Question		Answer/Indicative content	Mark	Guidance
3	(a) (i)	Intake  	1	(1x1) Intake port correctly labelled.
	(ii)	Terms inserted in this order:  ambient air pressure pressure drop suction  i.e. The pressure outside the vacuum is the <b>ambient air pressure</b> (1). The turning fan creates a <b>pressure drop</b> (1) in the area behind the fan, below the pressure level outside the vacuum generator. This creates <b>suction</b> (1) a partial vacuum, inside the vacuum generator.	3	(3x1)  Only acceptable answers.
	(b)	Vacuum can be used for transporting / lifting materials and products, and containers (1) or sealing containers (1) Vacuum can be used for holding (1) and shaping products (1). To filter the air/removing impurities from the air i.e. vacuum chamber (1) to prevent damage (1) or contamination.	3	1 mark for each valid point or, one point fully explained award up to 3 marks.  Do <b>not</b> accept "cleaning" or "removing waste" Vacuum forming (1), beginnings of explanation (1)

Question		Answer/Indicative content	Mark	Guidance
3	(c)	Hygienic / clean (1) Delicate, will not damage products (1) Vacuum can hold a variety of shapes (1)	2	(2x1) Accept other valid responses but they must be benefits to food manufacturing. Packaging so food preserved/lasts longer/fresher (1)
	(d)	Mechanical (1) Pneumatic (1) Hydraulic (1) Electrical (1)  Combinations of the above (1)	1	(1x1)  Do not accept Vacuum as this is given in the question. Solar, nuclear, BOD (1)
		<b>Total</b>	<b>[10]</b>	
4	(a)	(i) Gear <b>B</b> (1)	1	(1x1)
		(ii) To keep Gears <b>A</b> and <b>C</b> rotating in the same direction (1)	1	(1x1)
		(iii) $\text{VR} = \frac{\text{Driven}}{\text{Driver}} = \frac{17(1)}{12} = \frac{1}{1.4}$ Ratio = 1 : 1.4.. (1)	2	(2x1) Calculation (1), <b>Ration written correctly (1)</b>
	(b)	(i) e.g. A compound gear train connects gears that may share axles or shafts (1) Two gears fixed to rotate on the same axle (1)	1	(1x1) Stacked (1), Series (1), In a line (1), On top of each other (1), Next to each other (BOD)
		(ii) e.g. Lathe (1) Vehicle gearbox (1) Drill (1) Clocks/watches (1)	1	(1x1)  Accept other valid applications of compound gears. Bike (1) Wind up torch/toy (1)



Question		Answer/Indicative content	Mark	Guidance
	(c)	(i)	Advantages of using the worm gear e.g. Quiet/ smooth operation (1) Saves space (1) High Velocity ratio (1) Cannot be pushed/will not roll without the motor working (1)	1 (1x1) Will not slip (1) Increase the speed & torque (1)
		(ii)	Electrical (1) to Mechanical (1) or Chemical (1) to Electrical (1)	2 (2x1) Accept Electrical in either position, electrical to kinetic accept
		(iii)	Reverse the polarity of the supply to the motor (1)	1 (1x1) Switching, swap wires around Look for reference to swapping poles/magnets around
			<b>Total</b>	<b>[10]</b>
5	(a)	(i)	<b>A</b> Double Acting Cylinder (1) <b>B</b> 3/2 valve (1)	2 (2 x1) Component <b>A</b> accept Actuator BOD Accept two way cylinder (BOD component A)
		(ii)	e.g. When the 3/2 valve is activated/button pushed, pilot air flows from the 3/2 valve to the 5/2 (1) and activates the double acting cylinder to open/close the bus doors. (1) The cylinder piston pushes air out to exhaust through the 5/2 valve(1). The 5/2 valve will hold the DAC/ actuator in the positive (outstroke) position(1), until the other solenoid is pressed to close the bus doors. (1)	4 Award up to four marks for an explanation of the correct sequence of actions. Allow reference to solenoid in place of 3/2 valve. Button pressed air flow C to B (1) Activate cylinder/open close doors (1) Mention of exhaust (1) Air flow pushing pistons (1)
		(iii)	Component <b>A</b> is a DAC and uses one port to outstroke the piston (1) and requires air to the other port to instroke the piston (1)  The cylinder requires a separate air supply to move the piston in each direction (1) as the piston remains in position until the air is provided to move it the opposite direction (1)	2 Up to two marks for an explanation. Push/Pull (2) Input/output (2) Description of the effect of a spring (2)

Question			Answer/Indicative content	Mark	Guidance
		(iv)	Main air is the supply directly from the compressor (1)	1	Must reference either SUPPLY or SOURCE (1) (1x1)
		(v)		1	Candidates correctly label <b>any one</b> of the main air symbols.
<b>Total</b>				<b>[10]</b>	
6	(a)	(i)	<b>A</b> (fluid power) push lever (joystick) (1) <b>B</b> Electrical /switch (1) [accept button]	2	(2x1) A – mention of fluid flow or named as control valve (1) B – named as solenoid (1)  Do not accept 'Mechanical' for A
		(ii)	e.g. Digger boom/bucket (1) Hydraulic scissor lift/ lifting platform (1) Fork lift truck forks (1) Crane boom (1)	1	(1x1)  Accept other valid hydraulic applications. BOD – Bicycle brakes (1)
		(iii)	E.g. Push switch (1) Lever switch (1) Roller tip (1)	1	(1 x1) Do not accept simply 'a switch'. Accept button, Variable Resistor (BOD)

Question	Guidance	Marks	Answer
(b)*	<p>Award up to 6 marks for a discussion of benefits of using electrical systems to control pneumatic (electro-pneumatic) applications</p> <p><b>Level 3 (5 – 6 Marks)</b> Detailed discussion showing clear understanding of the how electrical systems are used to control pneumatic applications. 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 understanding of the how electrical systems are used to control pneumatic applications. 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> Basic discussion showing limited understanding of the how electrical systems are used to control pneumatic applications. 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>	6	<p>Examples and relevant points could include:</p> <ul style="list-style-type: none"> <li>• Pneumatic systems can be electrically controlled using a range of types of switches and actuators.</li> <li>• Pneumatic systems are activated using solenoids with can be remotely placed where it is convenient to have the activating switch.</li> <li>• Pneumatics can be activated using roller tip, lever switches or electrical push buttons, or with computer controlled using PLC equipment, and using interlocks for safety.</li> <li>• Electrical control/ electro-pneumatic examples include vehicle applications such as bus doors, windscreen wipers, bus step lowering systems, gearbox control, suspension systems.</li> <li>• Electro-pneumatics are used in industry in production manufacturing as electrical control can be programmed to be automated and therefore time efficient.</li> <li>• Electro-pneumatic systems can be used on portable and static equipment.</li> <li>• A disadvantage of using electro-pneumatic systems is it can be complex, and require hardware equipment to drive the electrical outputs.</li> </ul> <p><b>Bullet points max 2 marks = L1</b> <b>Knowledge points only = L1</b> <b>Few knowledge &amp; 1 development point = L2</b></p>
	<b>Total</b>	<b>[10]</b>	

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