



GCE

Design and Technology

H404/02: Problem Solving in Design Engineering

Advanced GCE

Mark Scheme for June 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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Annotations

Annotation	Meaning
	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 (not used on level Qs)
	Benefit of doubt
	Noted but no credit given
L1	Level 1 response
L2	Level 2 response
L3	Level 3 response
L4	Level 4 response
ECF	Error carried forward
RE	Rounding error
highlighter	A line is highlighted next to relevant part if only part is answering Q

Subject Specific Marking Instructions

INTRODUCTION

Your first task as an Examiner is to become thoroughly familiar with the material on which the examination depends. This material includes:

- the specification, especially the assessment objectives
- the question paper
- the mark scheme.

You should ensure that you have copies of these materials.

You should ensure also that you are familiar with the administrative procedures related to the marking process. These are set out in the OCR booklet Instructions for Examiners. If you are examining for the first time, please read carefully Appendix 5 Introduction to Script Marking: Notes for New Examiners.

Please ask for help or guidance whenever you need it. Your first point of contact is your Team Leader.

Question		Answer	Mark	Guidance	
				Content	Levels of Response
1*		<ul style="list-style-type: none"> • The environment in which the pump will be working. • Location of the pump in relation to the villages. • The cost of manufacturing the pumps. • The costs involved in transporting the pumps to the location from place of manufacture. • The materials which are to be used for the pump with reference to: <ul style="list-style-type: none"> i) Costs ii) Material properties iii) Manufacturing processes used iv) Availability of the material v) Suitability of the material for the pump • Candidates may mention the different parts of the pump and the different materials. • Ergonomic considerations with reference to: <ul style="list-style-type: none"> i) Height of handle ii) Effort required to operate the handle (with reference to majority of people using it being women and children) • Understanding that the pump will be extracting Ground Water and a 	14	<p>Candidates may extract information from the Resource Booklet. Any such lifted information can be used in support of the critical evaluation but no marks should be awarded simply for duplicating text.</p> <p>There is no analysis or evaluation in Level 1.</p> <p>If candidate has made no improvements then cannot score more than a level 2.</p>	<p>Level 4 [11-14 marks]</p> <p><i>A comprehensive discussion of the issues a design engineer would need to consider.</i></p> <p>Comprehensive understanding of a wide range (at least 3) of issues that a design engineer would need to consider when developing a new water pump for use in a remote village.</p> <p>Information in RB is used effectively to fully exemplify the points being made.</p> <p>Well-constructed narrative in relation to question with clear and supported evaluative comments.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 3 [7-10 marks]</p> <p><i>A good critical discussion of the issues a design engineer would need to consider.</i></p> <p>Good understanding of a range (at least 2) of issues that a design engineer would need to consider when developing a new water pump for use in a remote village.</p> <p>Information in RB is used for the</p>

need for the Engineers to have a geographical understanding of the location of Ground water and the issues that this can bring.

- A recognition that the pump will require routine maintenance throughout its life and that this should be aimed to be kept to a minimum to reduce costs.

most part effectively to exemplify points being made although one or two opportunities are missed.

Well-constructed narrative in relation to question although one or two opportunities missed to develop response. Evaluative comments are clear but not always supported.

There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.

Level 2 [4-6 marks]

A **sufficient** critical discussion of the issues a design engineer would need to consider.

Sufficient understanding of issues (at least 2) that a design engineer would need to consider when developing a new water pump for use in a remote village.

Informative in RB is used to exemplify some points being made although much more could have been done to exploit the stimulus material available.

Reasonable narrative in relation to the question although response at times lacks depth and cohesion. Evaluative comments lack clarity and are unsupported.

The information has some relevance and is presented with

					<p><i>limited structure. The information is supported by limited evidence.</i></p> <p>Level 1 [1-3 marks]</p> <p><i>A limited discussion of the issues a design engineer would need to consider.</i></p> <p>Limited knowledge and next to no understanding of issues that a design engineer would need to consider when developing a new water pump for use in a remote village.</p> <p>Use of information from the RB is used in a simplistic way and adds limited value to the points being made.</p> <p>Limited narrative in relation to question. Response is basic and unstructured with no evaluative comments.</p> <p><i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i></p> <p>0 marks = No response or no response worthy of credit.</p>
	Question	Answer	Mark		Guidance

2	6	Candidate who took the Piston rod into account:
<p>Dimensions of the cylinder: 100mm x 300mm. [1] [1]</p> $V = \pi r^2 h$ $V = \pi \times 0.05^2 \times 0.3$ $V = 2365 \text{ cm}^3$ $V = \frac{2365}{1000} = 2.365$ $V = 2.365 \text{ ltrs} \quad [1] \quad [1]$		<p>Three marks for volume of cylinder in mm³ or cm³ taking into account the volume of the piston rod. (One mark for volume of cylinder. One mark for volume of piston rod. One mark for subtracting the two values).</p>
<p>Volume of water in the cylinder accounting for the Piston Rod.</p> $V = (\pi r^2 h) - (\pi R^2 h)$ $V = (\pi \times 0.05^2 \times 0.3) - (\pi \times 0.019^2 \times 0.3) \quad [1]$ $V = 2.635 - 0.3 \quad [1]$ <p>Total Volume = 2.1 ltrs (2.0 ltrs if sub-calcs not rounded)</p>		<p>One mark for transposing the correct values from the RB to the equation.</p>
<p>Therefore one cycle of the pump will move either:</p> <p>2.065 (or 2.0) ltrs of water if accounted for piston rod or 2.365 ltrs if piston rod was ignored.</p>		<p>One mark for dividing the total volume by the required container volume.</p>
<p>Number of cycles required:</p>		<p>One mark for correct answer.</p>
<p>Maximum volume of the container / the volume of each cycle. [1] [1]</p>		Max 6 marks
<p>i.e. If piston rod accounted for: Number of cycles = $20 / 2.1 = 9.5$ therefore 10 complete cycles. [1]</p>		Candidate who did not take the Piston rod into account:
<p>If Piston rod not accounted for: Number of cycles = $20 / 2.4 = 8.3$ therefore 9 complete cycles. [1]</p>		<p>One marks for volume of cylinder in mm³ or cm³.</p>
		<p>One mark for transposing the correct values from the RB to the equation.</p>
		<p>One mark for dividing the total volume by the required container</p>

Question	Answer	Marks	Guidance
			<p>volume.</p> <p>One mark for correct answer.</p> <p>Max 4 marks.</p> <p>Where an incorrect answer is given working out should be used to credit appropriate marks.</p> <p><i>*Allow error carried forward (ECF) where correct working out is shown</i></p> <p>Award marks for any other correct method.</p>

3		6	
	<p>Calculating the total area A required:</p> $A = \frac{E}{(rxHxPR)} \quad [1]$ <p>Photovoltaic panel yield $r = 0.15$</p> <p>Performance ratio $PR = 0.75$</p> <p>Solar irradiation $H = 2100 \text{ KWh m}^{-2} \quad [1] \quad [1]$</p> $A = \frac{1890}{(0.15 \times 2100 \times 0.75)} \quad [1]$ <p>Total area = 8m^2</p> <p>Number of photovoltaic panels:</p> <p>Area of a single panel = $1.0 \times 0.5 = 0.5\text{m}^2 \quad [1]$</p> <p>Total number of panels needed =</p> <p>Total area required / single panel area</p> $8\text{m}^2 / 0.5\text{m}^2 = 16 \quad [1]$		<p>Award six marks as follows:</p> <p>One mark for rearranging formula in terms of A.</p> <p>Two marks for extracting the correct information from the RB. or One mark for extracting 2 correct pieces of information from the RB.</p> <p>One mark for 1890 into these to workout total area in m^2 with correct answer.</p> <p>One mark for calculating the area of a single solar panel from the data in the resource booklet</p> <p>One mark for division of the total area by the area of each panel leading to correct answer.</p> <p>Where an incorrect answer is given working out should be used to credit appropriate marks.</p> <p><i>*Allow error carried forward (ECF) where correct working out is shown</i></p> <p>Award marks for any other correct method.</p>

Question	Answer	Mark	Guidance
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				Content	Levels of Response	
4		<p>Reference to Stakeholders:</p> <ul style="list-style-type: none"> Initial outlay of the system. Fitting by specialists. Maintenance of the system. Reference to that fact it is more technical and could go wrong requiring intervention. Also a requirement for there to be a manual method of pumping the water as backup. The motor and mechanical maintenance. Possibility of using a storage method to keep excess energy or sell. Cleaning PV panel. Security - chance of valuable PV panels being stolen. Any other valid suggestion. <p>Reference to Users:</p> <ul style="list-style-type: none"> Less labour intensive. Would produce the required water quicker. Limited to daytime use unless suitable storage method was used. Excess energy created could be used for lighting etc. Chance of 'leaving the tap running'. Any other valid suggestion. 	14	<p>Candidates may extract information from the Resource Booklet. Any such lifted information can be used in support of the critical evaluation but no marks should be awarded simply for duplicating text.</p> <p>There is no analysis or evaluation in Level 1.</p>	<p>Level 4 [11-14 marks]</p> <p><i>A comprehensive critical evaluation that considers the positive and negative uses of photovoltaic panels for powering water pumps in areas affected by water scarcity.</i></p> <p>Comprehensive understanding of the suitability of photovoltaic panels for powering water pumps in areas affected by water scarcity.</p> <p>Analysis of suitability of photovoltaic panels is consistently and appropriately aligned with identified stakeholder needs.</p> <p>Information in RB is used effectively to fully exemplify the points being made.</p> <p>Well-constructed response in relation to question with a clear and developed narrative.</p>	
					<p>Level 3 [7-10 marks]</p> <p><i>A good critical evaluation that considers the positive and negative uses of photovoltaic panels for powering water pumps in areas affected by water scarcity.</i></p> <p>Good level of understanding of the suitability of photovoltaic panels for powering water pumps in areas affected by water</p>	

						<table border="1"> <tr> <td>scarcity.</td> </tr> <tr> <td>Analysis of suitability of photovoltaic panels is appropriately aligned with identified stakeholder needs but one or two opportunities are missed to make connections.</td> </tr> <tr> <td>Information in RB is used for the most part effectively to exemplify points being made although one or two opportunities are missed.</td> </tr> <tr> <td>Well-constructed response in relation to question although one or two opportunities missed to develop narrative.</td> </tr> <tr> <td>Level 2 [4-6 marks]</td> </tr> <tr> <td><i>A sufficient critical evaluation that considers the positive and/or negative uses of the use of photovoltaic panels for powering water pumps in areas affected by water scarcity.</i></td> </tr> <tr> <td>Sufficient understanding of the suitability of photovoltaic panels for powering water pumps in areas affected by water scarcity.</td> </tr> <tr> <td>Analysis of suitability of photovoltaic panels is reasonably aligned with identified stakeholder needs but there are significant opportunities missed to make connections.</td> </tr> <tr> <td>Informative in RB is used to exemplify some points being made although much more could have</td> </tr> </table>	scarcity.	Analysis of suitability of photovoltaic panels is appropriately aligned with identified stakeholder needs but one or two opportunities are missed to make connections.	Information in RB is used for the most part effectively to exemplify points being made although one or two opportunities are missed.	Well-constructed response in relation to question although one or two opportunities missed to develop narrative.	Level 2 [4-6 marks]	<i>A sufficient critical evaluation that considers the positive and/or negative uses of the use of photovoltaic panels for powering water pumps in areas affected by water scarcity.</i>	Sufficient understanding of the suitability of photovoltaic panels for powering water pumps in areas affected by water scarcity.	Analysis of suitability of photovoltaic panels is reasonably aligned with identified stakeholder needs but there are significant opportunities missed to make connections.	Informative in RB is used to exemplify some points being made although much more could have
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					<p>been done to exploit the stimulus material available.</p>
					<p>Reasonable response in relation to the question although narrative at times lacks depth and cohesion.</p>
					<p>Level 1 [1-3 marks]</p>
					<p><i>A limited examination of the use of photovoltaic panels for powering water pumps in areas affected by water scarcity.</i></p>
					<p>Limited knowledge and next to no understanding of the suitability of photovoltaic panels for powering water pumps in areas affected by water scarcity.</p>
					<p>Isolated statements made in relation to photovoltaic panels resulting in only weak alignment with stakeholder needs.</p>
					<p>Use of information from the RB is used in a simplistic way and adds limited value to the points being made.</p>
					<p>Limited response in relation to question. Narrative is basic and unstructured.</p>
					<p>0 marks = No response or no response worthy of credit.</p>

Question			Answer	Mark	Guidance	
					Content	Levels of Response
5			<p>Issue 1:</p> <ul style="list-style-type: none"> • Candidates should identify the input components used (LDRs) and recognised that an analogue input will be received into the microcontroller. • Correct use of symbols used for the flow chart if used. • Correct use of coding if used. • Explanation/annotation for the critical parts of the program. • Use of ADC or analogue command to produce a number value representing light level. • Clarity of how the light level from the two LDRs is compared and decisions reached. • Clarity of how the motor is rotated CW or CCW depending on result of light level comparison. • Understanding of how two outputs are used to control the motor driver IC. • Correct use of output and input pins in the program. <p>Issue 2:</p> <p>Candidates should identify the need to use a compound gear train.</p> <p>Candidates must produce a sketch (might be a schematic) which shows</p>	16	<p>Candidates can draw on practice experience of iterative designing and product analysis to support their response to this question.</p> <p>The candidate is expected to demonstrate their understanding of the process involved through a series of annotated sketches and/or notes. There may be variations to the process as indicated but to get into L3 candidates must demonstrate a clear understanding of the end to end process.</p> <p>Note: if a candidate only completes one of the issues fully they can only be awarded half marks. Each issue should be worth 8 marks.</p>	<p>Level 4 [13-16 marks]</p> <p><i>A comprehensive demonstration of technical solutions to overcome the two issues identified.</i></p> <p>Comprehensive understanding of technical design and technology principles to overcome the two issues identified. Both solutions are well-developed.</p> <p>Information in RB is used effectively to fully exemplify the points being made.</p> <p>Sketches if used will be clear and supported with relevant notes.</p> <p>The process will be end to end and clear in the way it is explained.</p> <p>Level 3 [9-12 marks]</p> <p><i>A good demonstration of technical solutions to overcome the two issues identified.</i></p> <p>Good understanding of technical design and technology principles to overcome the two issues identified. Both solutions will be covered but one of the solutions may be underdeveloped.</p> <p>Information in RB is used for the most part effectively to exemplify points being made although one or two opportunities are missed.</p>

how the gears connect and which clearly indicates input/output shafts.

$$\text{Gear ratio} = \frac{\text{Product of Driven}}{\text{Product of Driver}}$$

Identification of correct gears to produce appropriate ratios:

$$160 / 20 = 8:1$$

$$80 / 20 = 4:1$$

$$160 / 40 = 4:1$$

e.g.

Using 160t / 20t to give 8:1, then 80t / 20t to give 4:1

$$\text{Gear ratio} = \frac{(160 \times 80)}{(20 \times 20)} = 32:1$$

On the second issue, if an attempt is made at a gear system (compound or gear train) then Level 1 should be awarded.

Sketches if used will for the most part be clear and supported with relevant notes although one or two opportunities for clarity may be missed.

The process will be end to end and for the most part be clear in the way it is explained.

Level 2 [5-8 marks]

A **sufficient** demonstration of technical solutions to overcome the two issues identified.

Sufficient understanding of technical design and technology principles to overcome the two issues identified or a comprehensive answer on one issue and no attempt on another. Solution/s may be covered but may be underdeveloped.

Informative in RB is used to exemplify some points being made although much more could have been done to exploit the stimulus material available.

Sketches if used will be adequate and supported with notes, some of which may be relevant.

The process may not necessarily be end to end with some knowledge gaps evident.

Level 1 [1-4 marks]

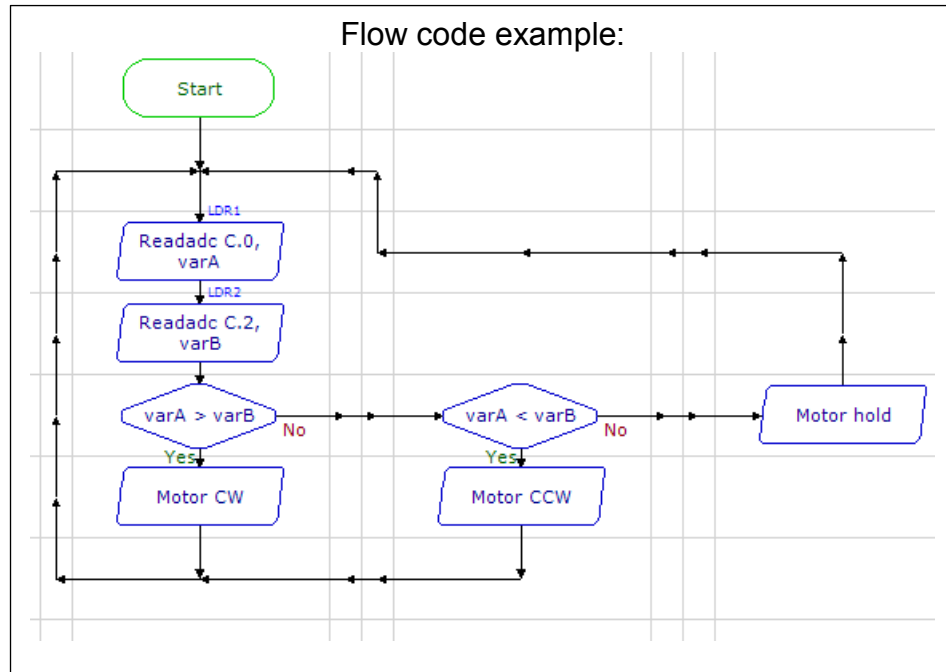
A **limited** demonstration of

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					<p><i>technical solutions to overcome the two issues identified.</i></p>
					<p>Use of information from the RB is used in a simplistic way and adds limited value to the points being made</p>
					<p>Sketches if used will be unclear with only basic notes to accompany them.</p>
					<p>The end to end process may not exist and if anything is basic in nature.</p>
					<p>0 marks = No response or no response worthy of credit.</p>



Code example:

```

symbol LDR1 = b0
symbol LDR2 = b1
symbol motor1a = b.0
symbol motor1b = b.1
    
```

Main:

```

readadc c.2, LDR1
readadc c.0, LDR2
    
```

```

if LDR1 = LDR2 then goto motor_hold
if LDR1 < LDR2 then motor_turn_CW
if LDR1 > LDR2 then motor_turn_CCW
goto main
    
```

Motor_hold:

```

Low motor1a
Low motor1b
goto main
    
```

Motor_turn_cw:

```

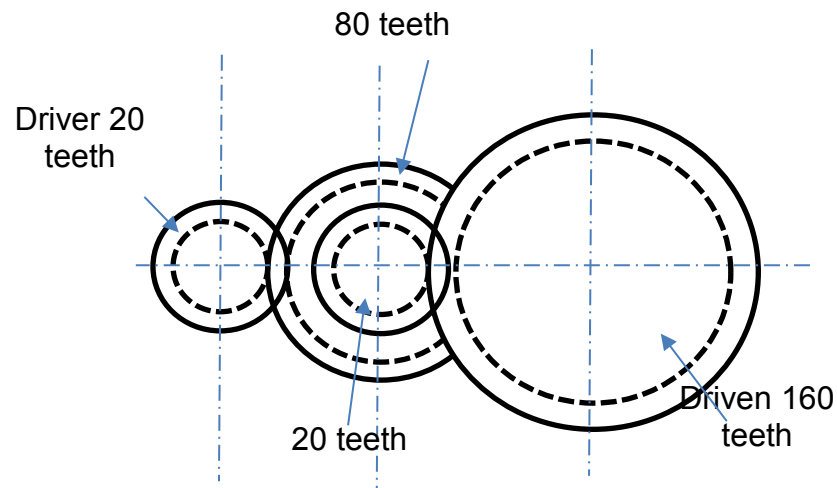
High motor1a
Low motor1b
goto main
    
```

Motor_turn_ccw:

```

High motor1b
Low motor1a
goto main
    
```

Issue 2



Question			Answer	Mark	Guidance	
					Content	Levels of Response
6*			<p>Marks should be awarded for both positive and negative points for the chosen design:</p> <p>Analysis of the chosen trolley including but not limited to:</p> <ul style="list-style-type: none"> Materials; Aluminium won't corrode, lightweight, strong – Expensive to purchase and manufacture. Materials; Steel Axle would corrode over time, would require a bearing to efficient use, would require maintenance. – Strong axle which could handle the loads being applied. Tyre type: Solid tyre would mean no punctures and minimum maintenance once in operational use. Solid tyre would not act as a shock absorber, meaning the uneven ground could cause issues once load is applied. Wheel diameter is small, same issues with uneven ground. Unit weight; lightweight product, would be able to be used by the perceived market (reference to women and 	14	<p>Candidates may extract information from the Resource Booklet. Any such lifted information can be used in support of the critical evaluation but no marks should be awarded simply for duplicating text.</p> <p>There is no analysis or evaluation in Level 1.</p> <p>To gain a level 3 mark, candidate should have mentioned improvements.</p>	<p>Level 4 [11-14 marks]</p> <p><i>A comprehensive evaluation of the trolley design with recommendations made for improvement.</i></p> <p>Comprehensive understanding of the how the trolley design could be improved.</p> <p>Analysis of product and recommendations for improvement are consistently and appropriately aligned with identified task.</p> <p>Information in RB is used effectively to fully exemplify the points being made.</p> <p><i>There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.</i></p> <p>Level 3 [7-10 marks]</p> <p><i>A good evaluation of the trolley design with recommendations made for improvement.</i></p> <p>Good understanding of the manufacturing process for the trial batch. All details covered but some evidence underdeveloped.</p>

- children)
- Max load; some reference to the weight of water required for a family per day is 40kg. Well within the range of the trolley. Could be used to collect more if required.
 - Suitability for chosen water container; containers could be stacked on top of each other, although this would limit the trolley to carrying two containers at a time. Trolley is not wide enough to put two next to each other without the stability being affected.
 - Trolley lifting bed; depth of the trolley bed is smaller than the water container, may make it unstable.

Reference to modifications that would be made:

Modification should be in line with the product evaluation in 4(a), e.g. Solid tyres are too small for the terrain; reference should be made to using larger solid tyres, or possible use of other types of tyres i.e. airless tyres etc.

Mark should be awarded for the improvements to the design with reference to what has been improved.

Analysis of product and recommendations are appropriately aligned with identified task but one or two opportunities are missed to make connections.

Information in RB is used for the most part effectively to exemplify points being made although one or two opportunities are missed.

There is a line of reasoning presented with some structure. The information presented is in the most part relevant and supported by some evidence.

Level 2 [4-6 marks]

*A **sufficient** evaluation of the trolley design with recommendations made for improvement.*

Sufficient understanding of the manufacturing process for the trial batch. All details may not be covered and the details that are covered may be underdeveloped.

Analysis of product and recommendations are reasonably aligned with identified task but there are significant opportunities missed to make connections.

Informative in RB is used to exemplify some points being made although much more could have been done to exploit the stimulus material available.

						<p><i>The information has some relevance and is presented with limited structure. The information is supported by limited evidence.</i></p> <p>Level 1 [1-3 marks]</p> <p><i>A limited demonstration of the trolley design with recommendations made for improvement.</i></p> <p>Limited knowledge and next to no understanding of the manufacturing and assembly process for the trial batch.</p> <p>Isolated statements made in relation to product and improvements resulting in only weak alignment with specified task.</p> <p>Use of information from the RB is used in a simplistic way and adds limited value to the points being made</p> <p><i>The information is basic and communicated in an unstructured way. The information is supported by limited evidence and the relationship to the evidence may not be clear.</i></p>
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