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Exemplar Candidate Work

DESIGN AND TECHNOLOGY

H404
For first teaching in 2017

H404/02 Summer 2019 examination series

Version 1

Contents

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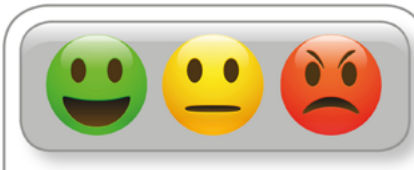

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Introduction

These exemplar answers have been chosen from the summer 2019 examination series.

OCR is open to a wide variety of approaches and all answers are considered on their merits. These exemplars, therefore, should not be seen as the only way to answer questions but do illustrate how the mark scheme has been applied.

Please always refer to the specification https://www.ocr.org.uk/qualifications/as-and-a-level/design-and-technology-h004-h006-h404-h406-from-2017/ for full details of the assessment for this qualification. These exemplar answers should also be read in conjunction with the sample assessment materials and the June 2019 Examiners' report or Report to Centres available from Interchange https://interchange.ocr.org.uk/Home.mvc/Index

The question paper, mark scheme and any resource booklet(s) will be available on the OCR website from summer 2020. Until then, they are available on OCR Interchange (school exams officers will have a login for this and are able to set up teachers with specific logins – see the following link for further information http://www.ocr.org.uk/administration/support-and-tools/interchange/managing-user-accounts/).

It is important to note that approaches to question setting and marking will remain consistent. At the same time OCR reviews all its qualifications annually and may make small adjustments to improve the performance of its assessments. We will let you know of any substantive changes.

Question 1

1* Water scarcity is a major concern for parts of the developing world. The World Health Organisation (WHO) is one organisation that is helping by fitting water pumps to extract groundwater in those rural areas worst affected.

Discuss the issues that a design engineer would need to consider when developing a new water pump for use in a remote rural village.

Refer to information on **pages 2, 3 and 4** of the Resource Booklet. **[14]**

Exemplar 1 — 14 marks

Water ~~Scar~~ scarcity already effects every ~~extinct~~ continent and around 2·8 billion people for at least one ~~not~~ month each year therefore a new water pump must be accessible to as many people as possible. Design engineers would need to consider how quickly the pump could be installed and implemented into an area ~~th~~ that would maximise the number of people that could use it. Esp More than 1·2 billion people lack access to clean drinking water also suggest the need to for a pump that would be able to provide for a large majority of people quickly. Water scarcity occurs in areas of flooding and increased pollution. Designers would need to ensure pump water could not be contaminated with pollution or sludge when flooding occurs. Designers must ~~reach~~ research effective ways to prevent cross-contamination to ensure pump water. The pump should be made using materials that will make are durable to intense sunlight and salt water to ensure the pump ~~will~~ can remain in use for as long as possible. Use of concrete to firmly secure the pump to the ground. Pumps may be placed in low-earning areas and if materials such as steel used, then there is the possibility that people could try and ~~steal~~ steal the pump to sell for scrap-metal. So designers would need to consider how to secure the pump to the ground to prevent theft. Designers would need to consider how to ensure the pump is always connected to a natural water supply. Physical water scarcity means a lack of natural water sources so they would need to investigate using technology where water resources ~~lie~~ lie in order to place the pump in a location that will achieve maximum water output throughout the year. Location is another important issue since villagers should not require having to walk many miles in order to get access to clean drinking water. Therefore, a compromise may need to be made between location

of the pump and proximity to villages. Designers should ensure the pump has features to ensure clean water is not wasted, economic water scarcity. This will ensure as many people as possible have clean water. Many people without water also may also have poor sanitation so designers may need to consider if the pump could also have connections that lead to some kind of wash area so people are able to cleanse their body and hands, thus improve hygiene. WHO state that in 2004, 16% of people in Sub Saharan Africa had access to readily accessible water, this is through a household connection. Therefore, the pump could be designed with multiple outlets for people to implement household connections of water into their homes. Diseases can occur in stagnant water, e.g. malaria so designers would need to ensure their pump leaves no stagnant water for diseases to form in. The pump should be well protected. Lack of financial resources means the pump must be easy to maintain so should not have complicated mechanisms that could fail or

1) use materials that are not suitable to move water continuously. Designers should pay attention to water quality equally, if not more than quantity. Information should be provided with the pump to ensure hygienic maintence of the pump. In order to prevent young girls and women from needing to carry water for over large distances, pump should be located close to homes. Pump could be designed to have a built in decontaminated system to purify raw collected rainwater. water storage tank could be implemented so clean water stored seperately, reducing risk of contamination with untreated water which can contain faeces and harmful chemicals, causing health issues to people. Storage tank should have large capacity to store water during dry seasons. Pump preferably links to ground water since safest to drink and provides reliable water source during droughts. Pipes ~~many~~ need to be dug down which take time and be quite expensive. Inclusion of simple water monitoring system will allow people to check if pump water is safe enough to drink. Human powered pump good since no additional systems needed. Teach villages how to lubricate pump in order to maintain pump.

Exemplar 2 7 marks

When designing a new water pump for a remote rural village design engineers need to think about:

Water scarcity in the village. Physical water scarcity is a result of inadequate natural water resources to supply the demand. In relation to this design engineers will need to think about the placement for the pump, ensuring that it is both available to the village and within a location where natural resources of water can be used to help meet the demand of water.

Also, the economic water scarcity is a result of poor management of the resources of water. Design engineers will need to consider the future management of the pump because they want to build a pump that will supply water readily to the village for many years. Others needing to maintain constantly - using components and materials that will have a long use life

The risk of contamination to the water is another issue design engineers will need to consider because for the remote village this may be their only source of water and if it becomes contaminated this can cause disease to spread and possibly kill villagers. Engineers will need to consider ways of keeping the pump clean and not cause any risk to the village.

As most pumps are designed to be used around the equator "where the climate is arid and temperatures are high" design engineers need to consider the issue of possible evaporation and if any is lost to the ground

Additionally, pumps will be built in remote rural villages, possibly where the land is unprepared making it difficult to build the pump there. Design engineers will need to consider the land in which

it will be built and how they can work with it to ensure a suitable and sustainable pump can be built there.

Examiner commentary

The response in Exemplar 1 demonstrates a good all-round understanding of the issues that a Design Engineer would have to consider when designing a product. Including not only direct factors but also considering indirect factors.

With this question being an extended response, it was important that candidates did not simply list the points being made but were able to construct a coherent discussion around the issues, giving clear examples wherever possible.

Throughout this response there were references to the information in the Resource Booklet. The candidate expanded on the information using their own knowledge and learning throughout the course.

The structure of the question enables candidates to comment on a variety of different focus areas. A Level 4 response would involve candidates' giving an area of focus followed up with a suitable example. In the exemplar answer the candidate has mentioned a suitable material (a non-ferrous metal) and given reasons as to why a material of this type would be suitable for this application.

Candidates are also encouraged to think of the wider implications (moral, social and economical) of design and not just the direct issues related to designing the product. In this response the candidate has discussed the wider issues, i.e. education of the villagers and ongoing maintenance of the pump, long after the designer's job is completed.

Exemplar 2 shows a Level 3 response. In the response although the candidate has identified several issues, like in the first example, however the depth and understanding that they have demonstrated is not at the same level as the previous example. For this response to have achieved a Level 4 response it would have needed to have expanded on their points. For example, when discussing the issue of the materials which the pump would be manufactured, it would be prudent for the candidate to mention a suitable material that would be used. Within the extended responses the candidate could have used this opportunity to demonstrate their knowledge in the areas in question.

Question 4

4 Due to the large initial cost of developing a solar-powered water pump, the WHO is reluctant to commission the design work without further research.

Critically evaluate the use of photovoltaic panels for powering water pumps in areas affected by water scarcity. Your response should consider the needs of stakeholders and users of the system.

Refer to the information on **pages 2, 3 and 6** of the Resource Booklet. **[14]**

Exemplar 1 — 12 marks

The operating temperature range for the photovoltaic cell is well within the range of temperatures it will experience when in use, since the maximum operating temperature is 85°C as compared to a maximum daily temperature of 41°C. The on average, there a seven hours of sunlight per day and whilst this may not be alot, with sufficient panels it should be long enough for the photovoltaic cells to produce and store sufficient energy to operate the pump.

It would be in the stakeholders interest to educate the users of the system on how it works and be made aware of safety issues, as these will be the people are using the system. If they understand how it works, it is more likely that the system will last longer as care will have been given to it. In the previous question, it was calculated 16 panels would be required to operate a similar pump. This would take up a large area, an area that would need to be pre-prepared for the installation of the solar panels, increasing the cost to the stakeholder.

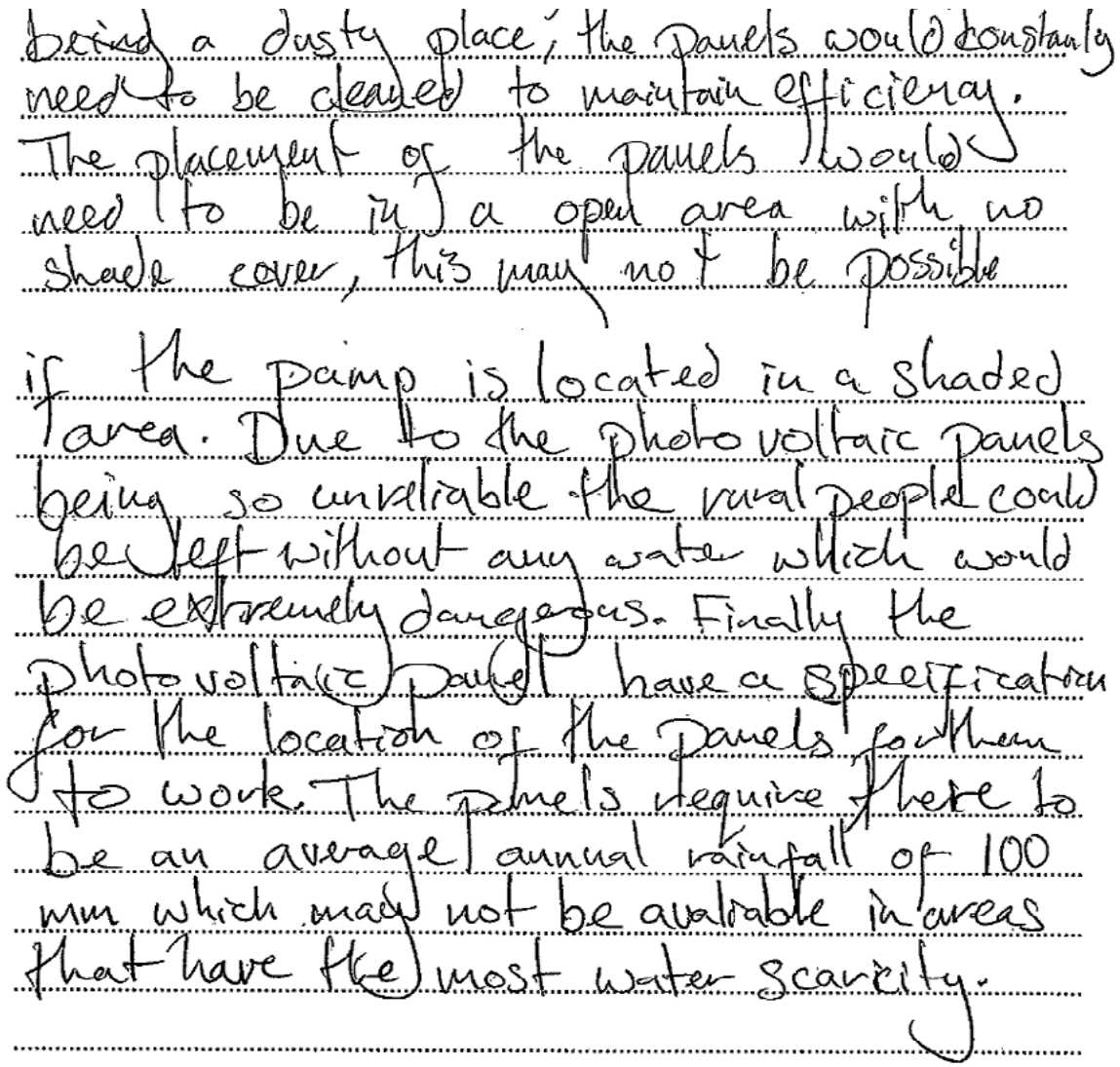
The system should not be too complicated to use either, as users will tend to have had little education, so a simple system would be ideal.

Infrastructure already in place used to source water is not maintained properly, so stakeholder should consider why this would be different for the use of photovoltaic cells, if at all it would be as users have thus far shown a dist

disinterest in the upkeep of it and sanitation of the system as long as it works.
Each of the cells is relatively heavy at 8.78kg, and this could make installation and transport of the cells cumbersome and expensive for the stakeholder.
There is also very little rainfall annual rainfall at 100mm, and this presents a problem in that the cells will have to be cleaned regularly of any dust / dirt that accumulates on the surface will not be washed away, preventing the cell from operating as efficiently as possible.
Consideration should also be given to the cost of installing a new pump that operates from photovoltaic cells as the cost for drilling to the depth of the water is already very high.

Exemplar 2 — 6 marks

Photovoltaic panels have an expensive start up cost and require constant maintenance. The panels once installed require constant check ups to increase the life span of the panel, due to the village being very remote this would be very difficult to do. Due to the sun moving throughout the day the panels would need to be re-aligned throughout the day to ensure the pump keeps running. As well as this, due to the sun not being in the sky at night there would be no way of using the system. Furthermore, the villagers would need to have training & on how to use the new machine, this may prove to be difficult as such a technological advancement may not make sense, and due to Africa


behind a dusty place, the panels would constantly need to be cleaned to maintain efficiency. The placement of the panels would need to be in a open area with no shade cover, this may not be possible if the pump is located in a shaded area. Due to the photovoltaic panels being so unreliable the rural people could be left without any water which would be extremely dangerous. Finally the photovoltaic panels have a specification for the location of the panels for them to work. The panels require there to be an average annual rainfall of 100 mm which may not be available in areas that have the most water scarcity.

Examiner commentary

In this question candidates were asked to produce a critical evaluation on the use of the Photovoltaic Panels for powering the water pumps. The key element of the question was to take into consideration the needs of the stakeholders involved. Many candidates did not consider these needs in their responses, choosing to give a personal account of whether the current system would benefit the users of these panels rather than looking at the wider effect of the stakeholders involved.

A Level 4 response needed to have considered the viewpoints from several different stakeholders i.e. WHO, manufacturers, installation teams, maintenance teams and users, given a balanced evaluation of the potential investment from the WHO.

In the first exemplar response the candidate has identified different factors that would affect the stakeholders and evaluated the suitability of the proposal in relation to their needs and requirements as well as the eventual users of the system. As this question did not require an extended response candidates could have chosen to produce detailed bullet points to satisfy the answer. However, this exemplar shows that the candidate has structured their response and may have produced a plan to support this.

Although the question is to evaluate the suitability of the system, there was no requirement for the candidate to state whether they would consider the system to be a viable option; instead they should have made suggestions as to whether the stakeholders are likely to consider it a viable option. These considerations may have differed and the top candidates where able to identify this and justify their response accordingly.

In the second exemplar the candidate has been given less than half marks. Although they have made a few decent responses the level at which those responses are aimed is much lower than the previous exemplar. The candidate has not expanded on their points; for example, when responding about the inefficiency of Solar Panels at night and them not producing electricity for a higher level response it would be expected that they would mention the need store the unused electricity throughout the day for use during the night. It is this depth that would have achieved a high level response. They have also made some comments that are not backed up with the facts of the Resource Booklet. In their response they have mentioned about 'constant daily check-ups' of the panels, whereas in the Resource Booklet it is stated that they need very little maintenance.

The Resource Booklet does contain valuable information which the candidates could and should use within their response, however like in this example response, candidates should be careful that they interpret the information correctly.

Question 5

5 A decision has been made to proceed with the design of the solar-powered water pump.

The design team has been given two immediate issues to overcome.

Issue 1

The efficiency of the photovoltaic array will vary throughout the day depending on the position of the sun in the sky. In order to improve the efficiency it has been suggested that the photovoltaic array should move so that it always faces the sun.

A system has been designed to do this which uses a motor, connected through a gearbox, to move the array. The system is controlled by a PICAXE microcontroller. **Page 7** of the Resource Booklet explains the operation of the system.

A program flowchart or code with annotation is required for the PICAXE microcontroller so that the photovoltaic array will move to follow the sun across the sky.

Issue 2

Spur gears need to be used for the gearbox to move the photovoltaic array.

A gear ratio of 32:1 is required.

Due to the remote area it is working in, the design team has a limited selection of spur gears available shown on **page 7** of the Resource Booklet.

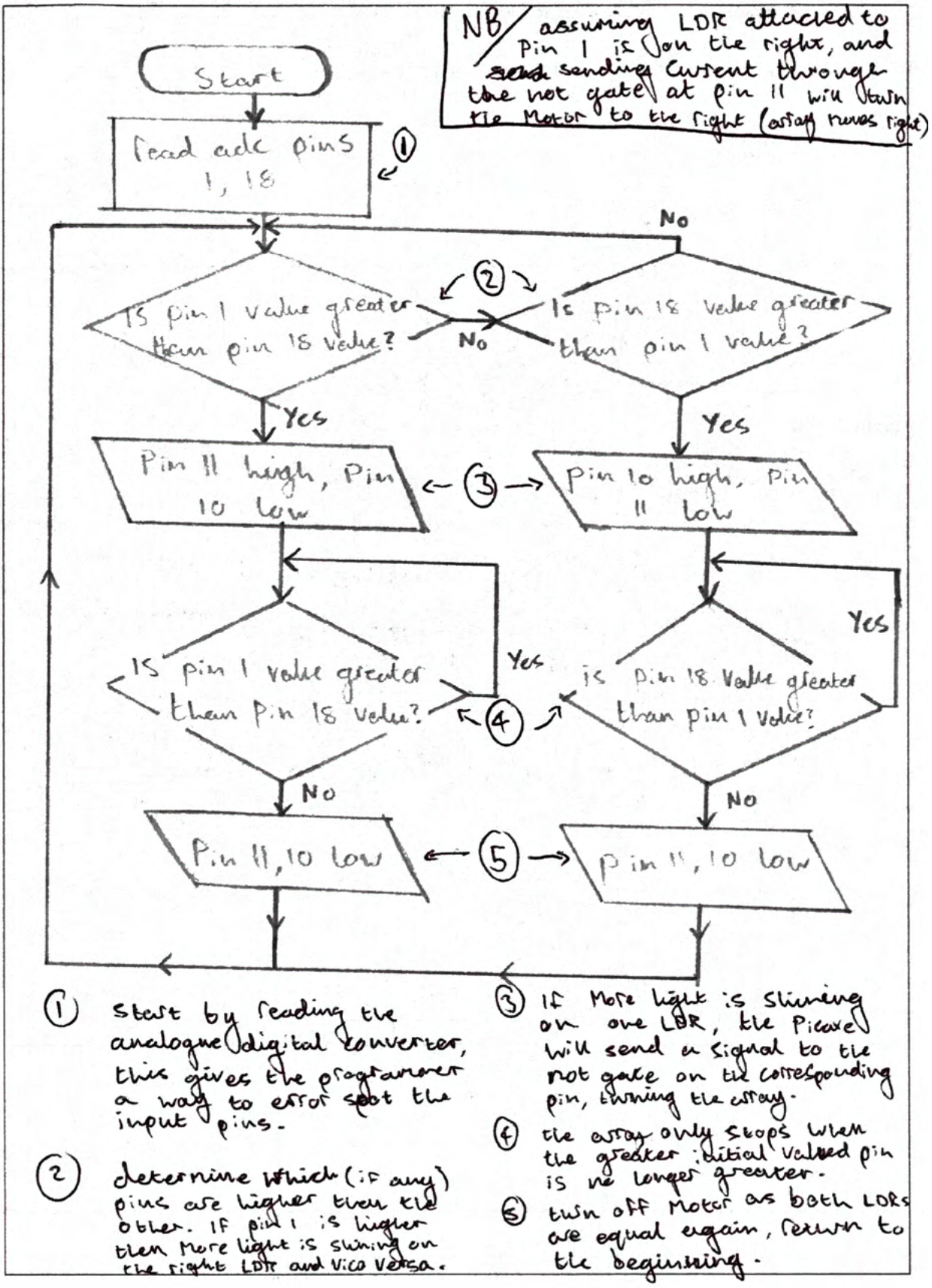
A gear system is required using only the available spur gears that would produce the required gear ratio.

Use sketches and/or notes to determine suitable technical solutions that overcome the **two** issues identified. All of the information you need is on **page 7** of the Resource Booklet. **[16]**

Exemplar 1 – 4

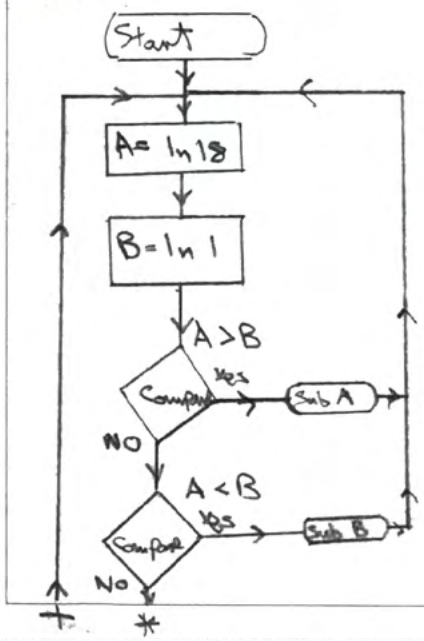
16 marks

Exemplar 1



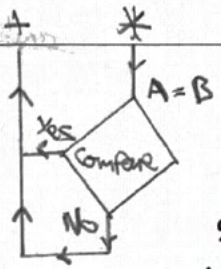
Exemplar 2

Issue 1:

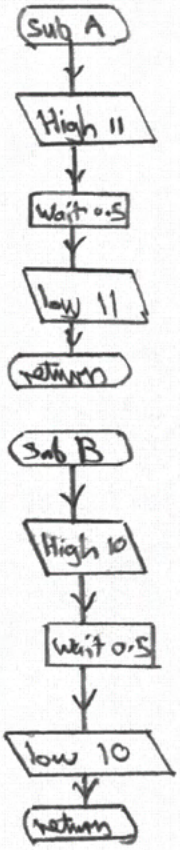


Variables A and B are given the input value of the 2 LDR's respectively.

The values are compared to each other.



If A and B are equal then the panel is aligned to the incoming radiation and so no action is taken so both Yes and no routes join on returns to the start.



In the case of A > B the motor turns anticlockwise with a pulse lasting 0.5 seconds and then flowchart returns back to where sub A route was called from

In the case of A < B the motor turns clockwise with same pulse of 0.5 seconds and then flowchart returns back to where sub B was called from.

. . . continues

Exemplar 2 *continued*

After each section the flowchart is directed back to the start to get another pair readings which are compared and the cycle starts again. This allows for constant and fine adjustment to the angle of the panel as it is in a constant feedback loop of taking a reading, moving the panel, take another reading, readjust the panel etc.

Exemplar 3

Issue 1:

```
SET PIN 14 (IN) POWER IN
SET PIN 15 (OUT) POWER OUT
SET PIN 1 (IN) LDR1
SET PIN 18 (IN) LDR2
SET PIN 11 (OUT) CL Motor
SET PIN 10 (OUT) COCL Motor
```

Tells the micro controller where the power is coming from and where this going

turning pins on variables to LDR inputs

Turn motor Clockwise

Turn motor counter clockwise

out pins

Setting each Pin

```
turn.clockw():
    PIN 11.High()
    PIN 10.Low()

turn.coclock():
    Pin 11.low()
    Pin 10.High()

measure.LDR():
    LDR1 = Pin 1.voltage
    LDR2 = Pin 18.voltage
```

Steps to turn motor clock wise

Counter clockwise

Measuring the LDR voltages and putting them with variables.

... continues

Exemplar 3 *continued*

```
void loop():
WHILE measure.LDR():
    WHILE LDR1 > LDR2:
        turn.clockwise()
    OR WHILE LDR2 > LDR1:
        turn.coclock()
    If LDR1 = LDR2:
        delay(6000)
        loop()
```

(If LDR1 is to the ~~left~~ right of LDR2 on the left)

↑ Checks which value is higher and turns accordingly.

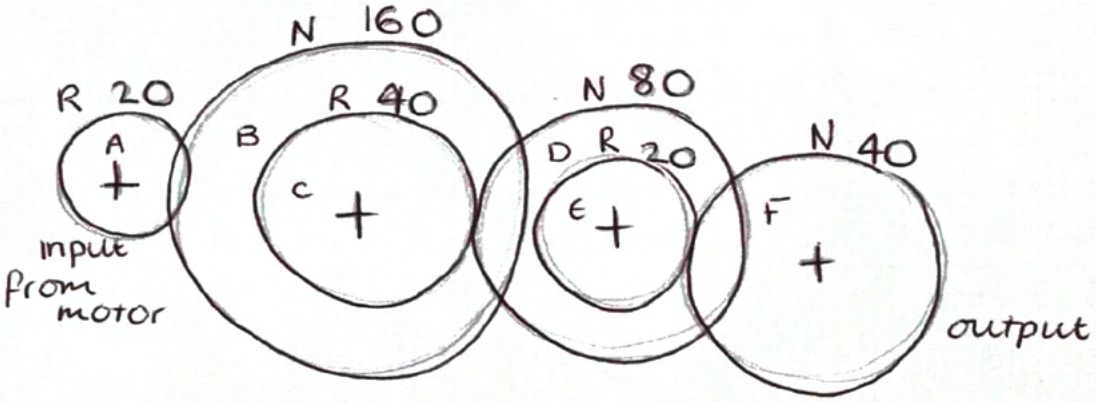
↑ When the LDRs are the same, the microcontroller waits a minute, then checks again to see any changes and to see if it needs to rotate.

Exemplar 4

Issue 2:

32 : 1 ratio $VR = \frac{Driven}{Driver}$

$$\frac{160 \times 80 \times 40}{40 \times 20 \times 20}$$



* Compound gear train allows the use of the spur gears to achieve the required gear ratio.

Examiner commentary

This question was split into two very distinct parts. Each issue carried its own solution independent of one another were given 8 marks independent to each other. These marks were then added together to give the total mark for the question and the response level. The exemplars are taken from four separate papers and demonstrate the variety of ways which the question could have been answered. The responses shown are from candidates who achieved full marks in their response.

To gain a Level 4 response, candidates were required to solve the problem within the constraints given in the question. Issue 1 was to create a program in the form of a flowchart or written program.

The key element to achieving a Level 4 response was to consider the information given in the Resource Booklet regarding the circuit diagram. Within this the candidates should have realised that there was a requirement for 2 LDRs on the input and each motor requiring two outputs. This should have been acknowledged in the flowchart/code they produced.

The better responses also referred to the LDR being required to store the analogue value in the registry and then referred to it being called on when needed. The program should have been identified as a closed loop system so that the program can run throughout the day.

Candidates who used a flowchart for their response should have used the correct symbols throughout, and while the text within the symbols did not have to be directly relatable to the coding to be used, it should give a general understanding of the function; Exemplar 1 is a good example of this.

Those candidates who used coding benefited from writing some annotation beside each line, showing an understanding of what was happening. While a perfect line of code was desirable it was by no means required, so long as the candidate showed a good grasp for the process they were trying to achieve; Exemplar 2 gives a good example of how this can be done.

For a Level 4 response on Issue 2 the exemplar shows how the candidate has identified the ratios of the given gears in the Resource Booklet and applied them to a compound gear train to achieve the required ratio. The response is clear and well-constructed to clearly show their design.

For both responses there was more than one correct method the candidates could have used so it is important that the candidates clearly showed their response.

Question 6

6* During the course of a day the average family will require two containers of water of the type shown in **Fig. 10** of the Resource Booklet. Traditionally, these are collected by the women and children of the families and are sometimes carried over large distances.

The WHO is working with a company that specialises in producing heavy-duty trollies for industrial applications. The company has proposed a trolley design shown in **Fig. 11** of the Resource Booklet that could be used by families to transport water from the water source to their homes.

Critically evaluate the design of the trolley in **Fig. 11** of the Resource Booklet making suggestions for improvement for the task specified. **[14]**

Exemplar 1 — 13 marks

The wheels of the trolley do not look sturdy. This is important as the terrain in africa and other places is very rocky and uneven, therefore the wheels need to be strong, durable and sturdy. Therefore, a suggestion would be to add thicker/wider wheels to the trolley to enable it to navigate rough terrain. The carrying bed size is too small at only 380 x 250MM, the base of the container is 280 x 280. Therefore one side will be overhanging by 30 mm. This could make it fall off, therefore increase the base bed size so it can comfortably carry the container. The axel material is steel. Steel has a very weak resistance to corrosion. Since the trolley will be exposed to an array of weather conditions steel would not be an appropriate material Stainless steel is a much more suitable material as it is corrosion resistant. Strong. The handle is extendable, this is a very good feature as it means that women and children of different sizes will be able to use the trolley, thus keeping the user audience as wide as possible. However, The handle has no grip on it, due to the extended periods of use, this could cause great discomfort to the user. Therefore, another possible suggestion is the addition of rubber grips to the handles to allow the user

to hold dem better. The frame is aluminium. Aluminium has a good strength to weight ratio, thus making it a suitable material for moving heavy water containers. Aluminium is also corrosion resistant. Since the trolley will be exposed to an array of weather conditions, this increases the trolley's life-span thus benefitting the user and stops dem from having to buy another one. The carrying bed is made from ABS plastic, which is strong and durable, thus making it a good material for the bed as it can take heavy loads. The tyres are solid, this is a big design flaw as they won't absorb any impact. Due to the rocky surfaces, solid tyres will get worn out very quickly and thus need replacing often. A possible suggestion would be to instead add tyres like a bike with an air tube, this will absorb some impacts and won't wear out as quickly. Also, The tyres have no grips on them, this means they won't be good for in wet conditions or in sandy places with loose surfaces as they will slip. Therefore The tyres should be fitted with grips to provide better motion.

END OF QUESTION PAPER

The wheels are very thin, which means they could sink in on sandy surfaces. Pressure $= \frac{F}{A}$, so the smaller the contact area, the greater the pressure, thus making them more likely to sink. If they sink, the trolley will become very difficult to use. Therefore, wider wheels and tyres should be used to prevent it from sinking.

6	The unit cost of the trolley is £39. This is a relatively cheap cost, thus meaning more people are likely to be able to afford one. The adjustment height of the handle is 1090 – 1400 mm. This means that the user must be over 1.5 m tall.

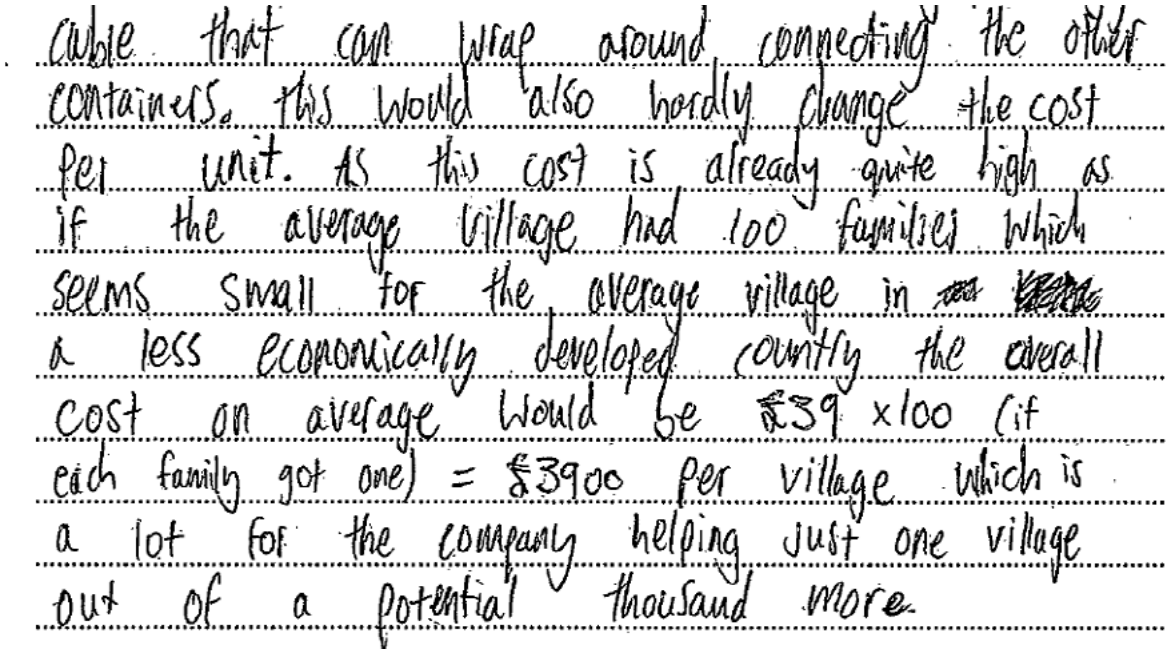
Exemplar 2

6 marks

carrying bed increase - method of attaching

As the average family will require two containers this does not mean the ~~carrier~~ trolley should not fascilitate for larger families, so there should be enough room to fit at least three containers on the trolley so > 840mm in height if the containers are stored on there side, as the ~~carrier~~ trolley can reach up to 1400mm it has the vertical capacity to store upto to 5 containers, yet this would go over the max load capacity as if each container weighed 20kg that would be 10kg over the 90kg limit. However the ability to carry 4 containers is very impressive as this is enough for two average sized families. The carrying bed size is a little too small as if they were stored on their side it would need to fit 330mm x 280mm so as the bed is only 250mm, 30mm will have to hang of the side, therefore they should increase this size. They should also add in a method of attatching the containers to the trolley or at least something in place to stop them moving about as it would be incredibly difficult for the people carrying / pulling the trolley as if the containers were not fitted on them they would have to balance them for a possibly long journey back to their home, which would be extremely difficult especially on the rough terrains within these countries. An improvement for this could be little clips that the container sits into on the bed and then a tight bungy

Terrain


cable that can wrap around connecting the other containers. this would also hardly change the cost per unit. As this cost is already quite high as if the average village had 100 families which seems small for the average village in a less economically developed country the overall cost on average would be £39 x100 (if each family got one) = £3900 per village which is a lot for the company helping just one village out of a potential thousand more.

Examiner commentary

The second of the extended response questions required the candidate to critically evaluate the design of the trolley within the Resource Booklet.

Once again with this being an extended response, candidates were expected to construct a coherent discussion and not just produce a list of points.

Exemplar 1 is a Level 4 response, in this response the candidate has shown a clear understanding of what would be required in the design of the trolley for the application for which it was intended. The candidate has demonstrated a clear understanding of materials being able to offer alternatives to the current design. They were able to ascertain the users of the trolley and apply their understanding of ergonomics, as well as identifying other aspects of the design which may require attention.

As well as being critical in areas of the design, they have also been able to highlight the positives in the design, this being important when producing a balanced evaluation. Another important aspect is the ability to suggest an improvement to the areas they have acknowledged needing development. A good example of this can be seen in the exemplar, in the response the candidate has commented on both size and structure of the wheel design. Not only have they mentioned the negatives of the design as it is, they have also suggested possible improvements.

In Exemplar 2, while the candidate has mentioned some of the key elements their response doesn't cover the points in enough depth. They have also only focused on a few areas of the design and usage of the trolley. This makes for a superficial answer and doesn't demonstrate that the candidate has thought about other areas involved in the design. It would have been better for the candidate to have mentioned multiple areas for improvements with examples than answer in the format they have chosen.

The ideal response from a candidate would be one where they are analysing the design aspects alongside the intended application, referring to the improvements that they would make. Using the Resource Booklet is critical to producing a quality response.

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