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Examiners' report

DESIGN AND TECHNOLOGY: DESIGN ENGINEERING

H404
For first teaching in 2017

H404/02 Summer 2019 series

Version 1

Contents

Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates. The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report. A full copy of the question paper can be downloaded from OCR.

Paper 2 series overview

General Comments

In the first series of the newly formed A Level H404-2 Problem –solving paper we are very pleased with the responses that we received from a cohort that seems to have a good understanding across the specification.

This report seeks to give pragmatic advice to centres that will be helpful as they prepare their next cohort for this style of examination.

Basic concept

This new style of examination has an allowed time of 1 hour 45 minutes.

The examination has a resource booklet that is inherently linked to the details of the examination paper and the question within.

The recommended reading time for the resource booklet is 35 minutes, although it does appear that candidates have used this time in various ways throughout the examination.

The total mark for the paper is 70.

The marks given for each question are shown in the brackets [ ].

Quality of the extended response will be assessed in the questions marked with an asterisk (*).

Candidates often used sub-headings when responding to specific bullets points, this proved a very useful strategy for them to use.

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]**

This question was answered well by a vast number of candidates. To be able to identify the issues is a skill that a Design Engineer candidate should be familiar with and this was evident in most responses.

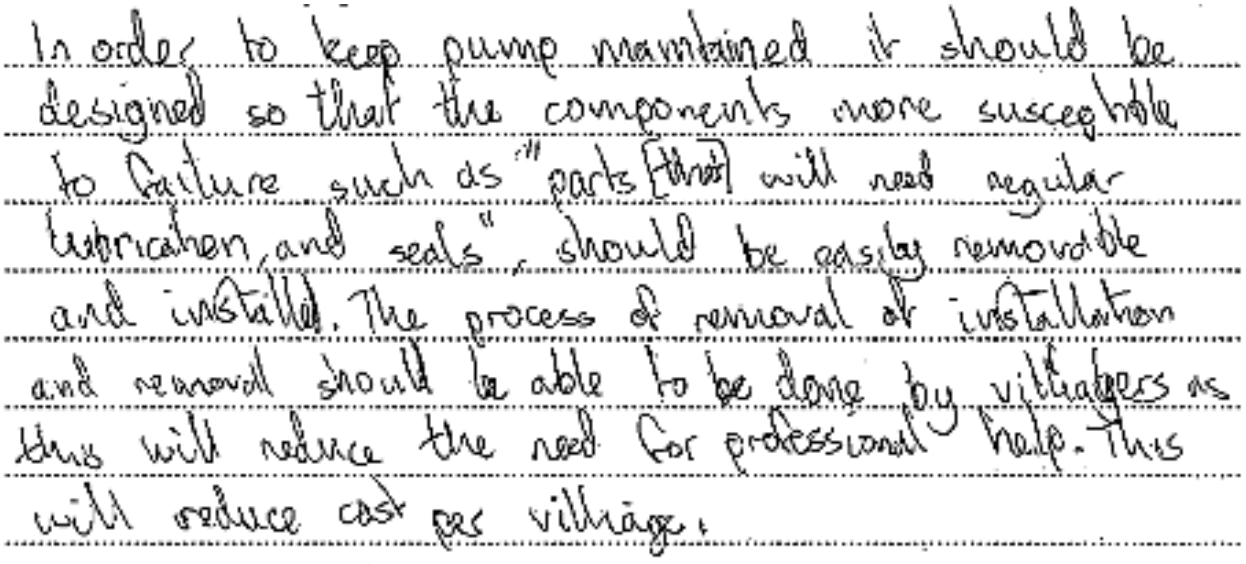
Most candidates used the resource booklet effectively, taking the relevant information out of it and presenting it in a way that highlights the issues faced. The best responses were able to use the resource booklet to support their answers and not just copy out sections.

Level 4 answers gave a comprehensive discussion on the issues faced when developing a new water pump, covering a wide range of different aspects which were both directly and indirectly related to the water pump itself.

Exemplar 1 is a useful example of a Level 4 response.

Care should be taken with an extended response question that the candidate enters a discussion of the issues and not simply produce a list the issues. The extended response question is there for the candidate to demonstrate their ability to articulate the issues being raised.

Exemplar 1


In order to keep pump maintained it should be designed so that the components more susceptible to failure such as "parts [that] will need regular lubrication, and seals", should be easily removable and installed. The process of removal or installation and removal should be able to be done by villagers as this will reduce the need for professional help. This will reduce cost per village.

In order to keep pump maintained it should be designed so that the components more susceptible to failure such as "parts that will need regular lubrication and seals" should be easily removable and installed. The process of removal of installation and removal should be able to be done by villagers as this will reduce the need for professional help. This will reduce cost per village.

Whilst groundwater is "usually safer to drink than surface water", "there may be contamination of the water with heavy metals and bacteria. The ~~pre~~ pump should therefore provide an on-pump water quality testing capabilities. This will mean that once every set time period, water quality could be checked by users, reducing chance of contamination. This will reduce amount of workers required to come and check water. This will result in higher set up costs but will reduce maintenance costs so over time may be

cheaper. Another way of avoiding this issue is to provide in-house Gilrahan. Research is being done into graphene water filtration and is being shown to remove heavy metals and some forms of bacteria such as E-coli. The graphene is becoming abundant as more advanced manufacturing processes are made, so may be affordable..

The cast iron handle of pump will become very hot and uncomfortable to touch in high temperatures at equator. A less material that is durable but absorbs less heat should be chosen, such as PP which could be manufactured as sleeves to go over current handle

Question 2

2 The WHO supplies the India MkIII hand-operated water pump shown in **Fig. 3** of the Resource Booklet. It also donates the DP4b water containers shown in **Fig. 10** of the Resource Booklet to villagers to transport fresh water. Each water container holds 20 litres of water.

Using the information on **page 5** of the Resource Booklet, calculate how many **complete cycles** of the pump handle will be required to fill **one** 20 litre container with water. Show your working.

The formula for calculating the volume of a cylinder is $V = \pi r^2 h$

Number of complete cycles of the pump handle .....

[6]

Most candidates were able to extract the required data from the resource booklet for the cylinder volume.

A large number of candidates did not spot the requirement to remove the volume of the internal cylinder from the total volume. This would have given them a different answer and although was rewarded in the marks they did not gain full marks.

Many candidates also calculated the volume of the cylinder from the information given in latter pages of the resource booklet. This was not required as the cylinder volume was given to them in the question (**one** 20 Litre container).

Candidates should try to methodically present their workings to make sure clear access is available to marks if the final answer is incorrect.

Final answers should always be written in the space provided.

Question 3

3 A design team is investigating whether the use of a solar-powered water pump would be more of a viable solution.

It is looking into the use of the RB500 photovoltaic panels shown in **Fig. 6** of the Resource Booklet. A number of these panels could be used together in a photovoltaic array to provide the required energy output.

It has been determined that an annual energy output of 1890 kilowatt-hours (kWh) is required for the pump to work efficiently.

Calculate the minimum number of photovoltaic panels of the type shown that would be required to produce the energy output needed for the water pump.

Use the equation below and information on **page 6** of the Resource Booklet. Show your working.

$E = A \times r \times H \times PR$

Where:

E = annual energy output from photovoltaic array (kWh)

A = total photovoltaic array area (m^2)

r = photovoltaic panel yield

H = annual average solar irradiation ($kWh\,m^{-2}$)

PR = performance ratio, coefficient of losses.

Minimum number of photovoltaic panels required .....

[6]

Majority of candidates achieved near maximum marks for this question.

Candidates were able to retrieve the correct technical data from the resource booklet to answer the question correctly.

Some candidates had difficulty rearranging the formula to make A the subject.

Candidates should try to methodically present their workings to make sure clear access is available to marks if the final answer is incorrect.

Final answers should always be written in the space provided.

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]**

This question was answered well by a large number of candidates. On this question some candidates chose to use bullet points to aid their response to great effect.

The higher scoring candidates were able to identify with a range of stakeholders associated with the installation of the photovoltaic panels, and not just those that will be using them directly.

They were also able to produce a critical evaluation, covering the advantages and disadvantages of employing the system for all stakeholders involved.

Higher scoring candidates were able to structure their answer covering all the required elements and using the resource booklet to support their evaluation with 'facts' and technical data.

Level 4 answers had a comprehensive demonstration of a critical evaluation, taking into account a range of stakeholders and being able to show the advantages **and** disadvantages.

Some candidates did not refer to the different stakeholder with their response simply giving a personal opinion about the idea being effective or not.

In some cases, the technical detail in the resource booklet was used poorly, giving the candidate incorrect information to support their evaluation.

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]**

The variety of this question seemed to appeal to most candidates, with some being able to produce very detailed response to the two issues in the question.

Issue 1:

Out of the two issues this one received the better responses. Most candidates where able to produce a simple Flow Chart using the correct symbols to highlight the required actions of the program.

The higher achieving candidates where able to identify the need for storing the data from the two LDRs in the micro-controller's registry and using it to compare against each other to produce a response.

They were also able to label the correct symbols and pins for the inputs and outputs in the micro-controller which was shown in the resource booklet.

Some candidates identified the output requirements to run the motor driver in the circuit to give the correct orientation of the motor.

A Level 4 response produced a clear Flow Chart or written program that covered all the required elements of the question, it may or may not have contained some annotation depending on the clarity of the text in the Flow Chart, an example of a Level 4 response can be seen in Exemplar 2.

A few candidates chose to write the program out using a programming language, where this was attempted the candidates achieved some impressive responses. Care should be taken when writing out a program that each line is annotated so the examiner can clearly see the candidate understands the coding.

There were a small number of candidates that did not know the basic symbols for a Flow Chart.

Issue 2:

A lot of candidates identified the need for a compound gear train in their response and arrived at a combination that satisfied the requirement.

A Level 4 answer was able to clearly demonstrate the compound gear train in both diagrammatic and mathematical format, an example can be seen in Exemplar 3.

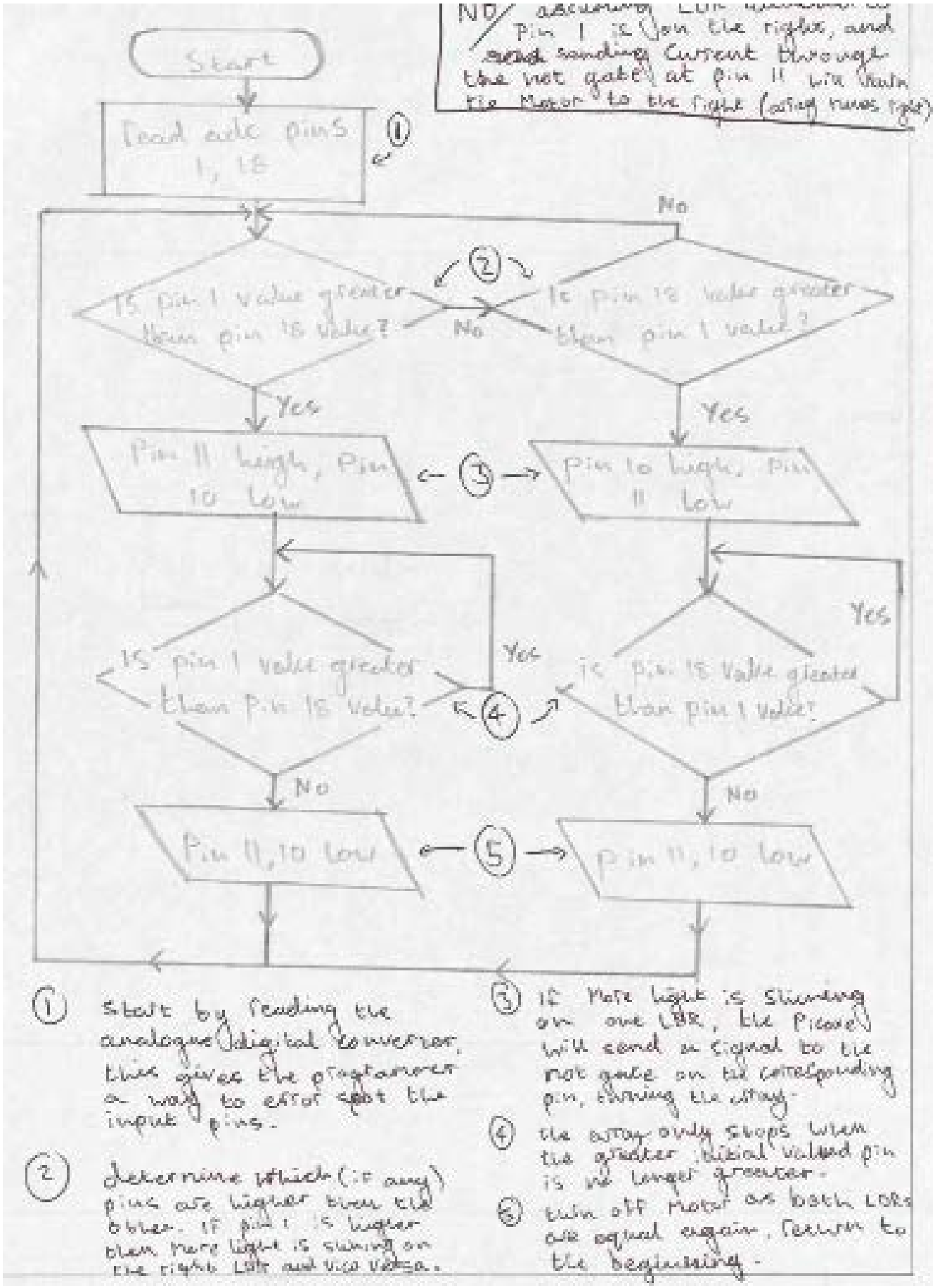
There were some candidates who produced a gear train which did not allow for the correct gear ratio required.

It is advised that when answering these types of questions that the candidates clearly labels the input and output shafts. There were some who did not do this making it difficult for the examiner to award the required marks.

It was also evident in some cases that candidates got the equation for the gear ratio incorrect meaning their gear selection did not achieve the required 32:1 ratio.

Candidates should take care when presenting their work and it should be communicated in a clear and methodical manner. A number of candidates produced poor quality sketching which made the communication of their response difficult.

Exemplar 2

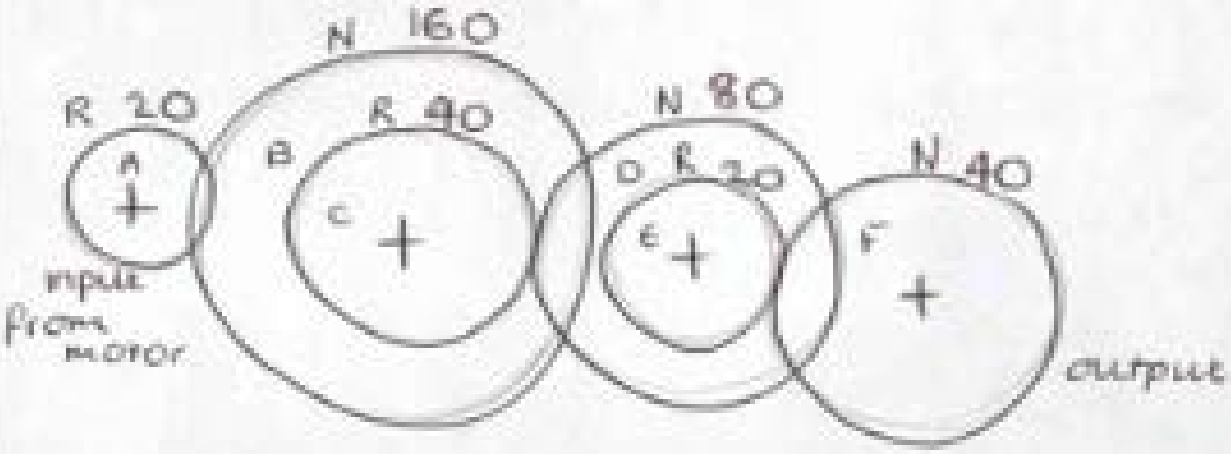


Exemplar 3

Issue 2:

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

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



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

The driven gears
B → 160 teeth
D → 80 teeth
F → 40 teeth

Driver Gears
A → 20 teeth
C → 40 teeth
E → 20 teeth

- compound gear trains work by having multiple gears on the same drive shafts.

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]**

This question was answered particularly well. Product analysis is a skill that all Design Engineering candidates should be familiar with and it showed in the responses.

The best responses were able to use the resource booklet and make comparisons between the suitability of the trolley to not only the environment it will be used, but against the primary user and the water container also given in the resource booklet. The better responses also made suggested improvements to any areas that they deemed as insufficient in the current design.

Candidates made some clear and factual comments regarding the material selection of the trolley.

Level 4 responses were able to evaluate the trolley and its use against the environment (terrain, climate), user (how it could improve their lives) and interaction with the container (suitable size, material). They were able to make suitable and viable suggestions on how it the trolley could be improved giving examples of other materials or design features.

Some candidates used diagrams in the question to good effect.

This was an extended response question, therefore candidates are expected to produce a concise and detailed critical evaluation of the trolley. The use of short sentenced bullet points is not appropriate for a response of this type.

A small number of candidates did not identify the properties of a certain materials.

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