OCR
Oxford Cambridge and RSA

Friday 15 October 2021 – Morning

A Level in Design and Technology: Design Engineering

H404/02 Problem Solving in Design Engineering

Time allowed: 1 hour 45 minutes

8949050899

You must have:
- the Resource Booklet

You can use:
- a ruler (cm/mm)
- a scientific calculator
- geometrical instruments

H4040 2

Please write clearly in black ink. **Do not write in the barcodes.**

Centre number | | | | | | Candidate number | | | | |

First name(s) _____

Last name _____

INSTRUCTIONS
- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. You can use extra paper if you need to, but you must clearly show your candidate number, the centre number and the question numbers.
- Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Each question tells you which part of the Resource Booklet to refer to.

INFORMATION
- The total mark for this paper is **70**.
- The marks for each question are shown in brackets **[ ]**.
- Quality of extended response will be assessed in questions marked with an asterisk (*).
- This document has **16** pages.

ADVICE
- Read each question carefully before you start your answer.

Answer **all** the questions.

Before responding to the questions in this paper you must spend time reading and familiarising yourself with the Resource Booklet.

1* Since the First Industrial Revolution, technology has been advancing at an increasing pace. For many years this progress has had an adverse impact on the environment in which we live.

Discuss the impact that technological progression has had on the environment.

You **must** use your own examples of the effects that technological progression has had on the environment to support your answer.

Refer to information on **pages 2 and 3** of the Resource Booklet for additional support. **[14]**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

2 Design engineers play an important role in the design of future technological products. They have a responsibility to ensure that these products do not have a negative impact on the environment.

With reference to a product of your choice, critically examine the ways in which a design engineer can reduce the impact that their designs have on the environment at the different stages of the product lifecycle.

Refer to information on **page 3** of the Resource Booklet. **[14]**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

3 An engineering company is developing a wave energy converter (WEC) to generate renewable electricity from the kinetic energy of waves on the sea. The name given to the prototype WEC is 'The Snake'.

The Snake WEC is described on **pages 4 and 5** of the Resource Booklet.

The Snake is a modular product aimed at entrepreneurs who are interested in venturing into the renewable energy industry.

The design engineers have **two** issues to overcome.

Issue 1

When on the sea, the movement of The Snake segments creates reciprocating motion of a pushrod shown in **Fig. 4** of the Resource Booklet. A mechanical system is required to convert this motion into rotary motion to turn the generator axle. This mechanical system should also multiply the frequency of the motion by three, meaning that for each complete reciprocation of the pushrod, the generator shaft should rotate three times.

A mechanical system is required to convert the input reciprocating motion of the pushrod to an output rotary motion and also multiply the frequency by three.

Issue 2

The first batch of segments of The Snake will be sold as prototype units and each will contain a microcontroller system to record the total number of reciprocations of the pushrod. This data will be collected by engineers using a wireless technology, as they pass near to the segments in a boat. The data will be used for product development.

A system diagram and a program flowchart are required, showing how an identified sensor will detect the movement of the pushrod and record the total number of reciprocations before transmitting this data through an identified wireless technology.

Use sketches and/or notes to determine suitable technical solutions that overcome the **two** issues identified.

Refer to information on **pages 4 and 5** of the Resource Booklet. **[16]**

Issue 1

Issue 2

4 **(a)** During the development of The Snake prototype WEC described on **pages 4 and 5** of the Resource Booklet, the design engineers used destructive testing techniques on materials in order to select a suitable material for the pushrod.

They chose to use the Brinell Hardness Test which is described on **page 6** of the Resource Booklet.

When one material was tested, the following results were obtained:

Force applied (kN)	**Indenter diameter (mm)**	**Indentation diameter (mm)**
10	10	0.60

The engineers require a material with a Brinell Hardness Number (BHN) between 3900 MPa and 5600 MPa.

Determine, by calculation, whether the material being tested is suitable for the pushrod.

State Yes or No **and** show your working.

Refer to information on **page 6** of the Resource Booklet.

Suitable? .....

[3]

(b) During use at sea, The Snake described on **pages 4 and 5** of the Resource Booklet is tethered to a fixed buoy by a rope as shown in **Fig. 3**. The design engineers responsible for this part of the design are investigating the use of a polymer rope made from recycled plastic.

Data for the rope under investigation is given in **Fig. 6** on **page 7** of the Resource Booklet.

(i) Calculate the diameter of the polymer rope in mm. Give your answer to the nearest mm and show your working.

Diameter of polymer rope ..... mm

[3]

(ii) Tests have been carried out to determine that the average tensile force in the polymer rope will be 4200 N.

Calculate the tensile stress (in N/m^2) in the polymer rope when the tensile force is 4200 N. Give your answer in N/m^2 and show your working.

Tensile stress in polymer rope ..... N/m^2

[3]

(iii) When the polymer rope is under tension it will stretch.

Calculate the extension of the polymer rope in m when the stress is at the value you calculated in **part b(ii)**. Give your answer to **3** decimal places and show your working.

Extension of the rope ..... m

[3]

5* The Snake WEC described on **pages 4 and 5** of the Resource Booklet is a prototype product in the renewable energy generator market. This prototype product should create interest among entrepreneurs who are looking to venture into the renewable energy generation industry.

The stakeholders of The Snake are concerned about its commercial viability and have asked for feasibility studies to be carried out on the following factors:

- how well the product performs
- technical difficulty of manufacture and materials selection
- costs and profit
- timescales involved
- balancing supply and demand.

Choose any **three** factors from the list above. Critically evaluate the ways in which they influence the commercial viability of The Snake.

Use information on **pages 4, 5 and 7** of the Resource Booklet. **[14]**

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

END OF QUESTION PAPER

PLEASE DO NOT WRITE ON THIS PAGE