OCR
Oxford Cambridge and RSA

Friday 12 June 2020 – Morning

A Level in Design and Technology: Design Engineering

H404/02 Problem Solving in Design Engineering

Time allowed: 1 hour 45 minutes

You must have:
- the Resource Booklet

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

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 Personal fitness is a growing market, led by trends which are affected by social, economic and marketing issues. It is important that companies who manufacture exercise equipment are able to monitor and predict these trends as they happen.

Discuss the **social, economic and marketing** issues that would be considered when designing a piece of fitness equipment.

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

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2* A manufacturer of exercise equipment has approached its design team with a concept to make its products more appealing to the gym user.

It has proposed that a charging system is installed on its rowing machines so that the user is able to charge their mobile electronic devices by making use of the rowing machine's kinetic energy.

The rowing machine is the Rowmatic-1 shown on **page 4** of the Resource Booklet.

Critically evaluate the issues a designer would need to consider when developing a charging system for a rowing machine used in a gym.

Refer to information on **pages 4 and 5** of the Resource Booklet. **[14]**

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3 The designers of the rowing machine charging system described in **Question 2** wish to develop a working prototype.

A generator is going to be used to convert the rower's kinetic energy into electrical power. The proposed device is the TB-401/10 generator shown on **page 5** of the Resource Booklet.

The average user on the Rowmatic-1 rowing machine produces an output of 600 rpm at the flywheel.

The prototype is being designed specifically to **charge the iPhone with the charging specification shown in Fig. 8 of the Resource Booklet**.

The design engineers have two issues to overcome.

Issue 1

It is necessary to transfer rotary motion from the flywheel in the rowing machine to the TB-401/10 generator's input pulley.

A suitable rotary speed of the generator pulley must be produced so that the required charging current is produced by the average user.

A drive system is required to transfer the rotary motion from the flywheel to the generator at an appropriate speed.

Issue 2

In order to charge properly, mobile devices require a 5 V output from the charging system.

The generator will maintain a steady 5 V output only if its pulley rotates at a minimum of 1000 rpm.

An annotated system diagram is required, describing an electronic system to monitor the speed of the generator pulley and to switch off the electrical output if the speed drops below 1000 rpm. Appropriate sensor(s) and output device(s) must be identified.

Use sketches and/or notes to determine suitable technical solutions that overcome the **two** issues identified. All of the information you need is on **pages 4 and 5** of the Resource Booklet. **[16]**

Issue 1

Issue 2

4 A company is developing the Bike-ease roof-mounted bicycle rack described on **pages 6 and 7** of the Resource Booklet.

The Bike-ease roof-mounted bicycle rack mechanism uses a pneumatic cylinder as shown in **Fig. 9a and Fig. 9b** of the Resource Booklet.

Design engineers need to choose a suitable pneumatic cylinder for this design.

(a) Calculate the **extended length** (to the nearest mm) of the pneumatic cylinder shown in **Fig. 9a**. Show your working.

Use the data in **Fig. 9a and Fig. 9c** of the Resource Booklet.

Extended length of pneumatic cylinder ..... mm

[3]

(b) Calculate the horizontal distance labelled H on **Fig. 9a** (to the nearest mm), through which the bicycle clamp moves as the Bike-ease roof-mounted bicycle rack is raised. Show your working.

Use the data in **Fig. 9a, Fig. 9b and Fig. 9c** of the Resource Booklet.

Distance H ..... mm

[4]

(c) The pneumatic cylinder shown in **Fig. 9a** needs to exert a minimum instroke force of 1100 N to begin lifting the bicycle into the vertical position. Compressed air at a pressure of 0.6 N mm^{-2} is being used in this system.

The list of pneumatic cylinders available for use is shown in **Fig. 10** on **page 7** of the Resource Booklet. The cylinders are labelled A to D.

Determine by calculation which pneumatic cylinder from those shown in **Fig. 10** would be suitable for this design. Show your working.

Justify your answer.

Chosen pneumatic cylinder .....

Why chosen .....

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[7]

5* This question refers to the development and introduction to market of the Bike-ease roof-mounted bicycle rack shown on **page 6** of the Resource Booklet.

During the development and introduction to market of the Bike-ease roof-mounted bicycle rack, design engineers will use a variety of digital design tools.

Discuss the **advantages** to design engineers of using digital design tools during the development and introduction to market of a product such as the Bike-ease roof-mounted bicycle rack.

Refer to information on **page 6** of the Resource Booklet. **[12]**

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END OF QUESTION PAPER

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