© International Baccalaureate Organization 2021

All rights reserved. No part of this product may be reproduced in any form or by any electronic or mechanical means, including information storage and retrieval systems, without the prior written permission from the IB. Additionally, the license tied with this product prohibits use of any selected files or extracts from this product. Use by third parties, including but not limited to publishers, private teachers, tutoring or study services, preparatory schools, vendors operating curriculum mapping services or teacher resource digital platforms and app developers, whether fee-covered or not, is prohibited and is a criminal offense.

More information on how to request written permission in the form of a license can be obtained from https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/.

© Organisation du Baccalauréat International 2021

Tous droits réservés. Aucune partie de ce produit ne peut être reproduite sous quelque forme ni par quelque moyen que ce soit, électronique ou mécanique, y compris des systèmes de stockage et de récupération d'informations, sans l'autorisation écrite préalable de l'IB. De plus, la licence associée à ce produit interdit toute utilisation de tout fichier ou extrait sélectionné dans ce produit. L'utilisation par des tiers, y compris, sans toutefois s'y limiter, des éditeurs, des professeurs particuliers, des services de tutorat ou d'aide aux études, des établissements de préparation à l'enseignement supérieur, des fournisseurs de services de planification des programmes d'études, des gestionnaires de plateformes pédagogiques en ligne, et des développeurs d'applications, moyennant paiement ou non, est interdite et constitue une infraction pénale.

Pour plus d'informations sur la procédure à suivre pour obtenir une autorisation écrite sous la forme d'une licence, rendez-vous à l'adresse https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/.

© Organización del Bachillerato Internacional, 2021

Todos los derechos reservados. No se podrá reproducir ninguna parte de este producto de ninguna forma ni por ningún medio electrónico o mecánico, incluidos los sistemas de almacenamiento y recuperación de información, sin la previa autorización por escrito del IB. Además, la licencia vinculada a este producto prohíbe el uso de todo archivo o fragmento seleccionado de este producto. El uso por parte de terceros —lo que incluye, a título enunciativo, editoriales, profesores particulares, servicios de apoyo académico o ayuda para el estudio, colegios preparatorios, desarrolladores de aplicaciones y entidades que presten servicios de planificación curricular u ofrezcan recursos para docentes mediante plataformas digitales—, ya sea incluido en tasas o no, está prohibido y constituye un delito.

En este enlace encontrará más información sobre cómo solicitar una autorización por escrito en forma de licencia: https://ibo.org/become-an-ib-school/ib-publishing/licensing/applying-for-a-license/.

Diploma Programme
Programme du diplôme
Programa del Diploma

Design technology
Higher level and standard level
Paper 2

Wednesday 10 November 2021 (afternoon)

Candidate session number

1 hour 30 minutes

Instructions to candidates

- Write your session number in the boxes above.
- Do not open this examination paper until instructed to do so.
- Section A: answer all questions.
- Section B: answer one question.
- Answers must be written within the answer boxes provided.
- A calculator is required for this paper.
- The maximum mark for this examination paper is **[50 marks]**.

8821 – 6203

23 pages

© International Baccalaureate Organization 2021

International Baccalaureate®
Baccalauréat International
Bachillerato Internacional

Section A

Answer **all** questions. Answers must be written within the answer boxes provided.

1. Forceps are tools used for grasping or holding objects. Most forceps have mechanisms consisting of multiple parts, see **Figure 1**.

Some designers have developed alternative mechanisms for forceps that rely on the elasticity of the material for the transfer of force, movement or energy. These are often produced as one part.

"Oriceps" are forceps inspired by origami (the Japanese art of paper folding), see **Figure 2** and **Figure 3**.

Figure 1: Forceps designed using a traditional mechanism that has multiple parts

Figure 2: "Oriceps" use an origami-inspired design

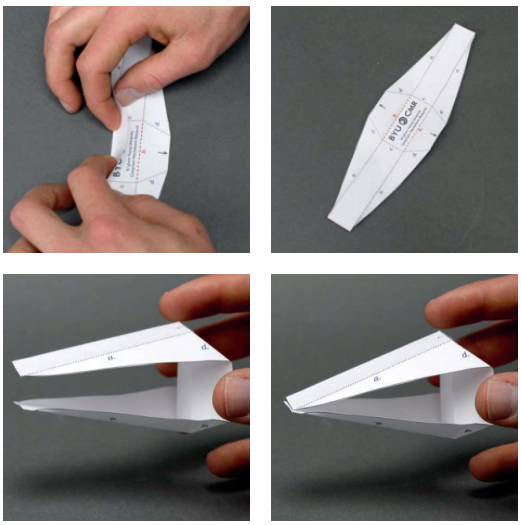
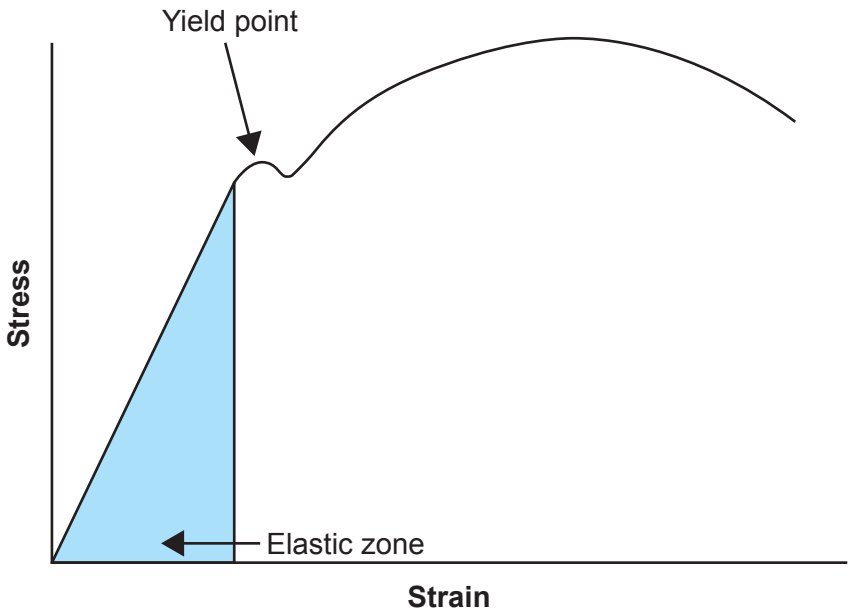


Figure 3: "Oriceps" in use

(This question continues on the following page)

(Question 1 continued)

Figure 4: An example of a stress / strain graph



(a) (i) Define *elasticity*. [1]

. . . . . .

. . . . . .

. . . . . .

(ii) **Figure 4** shows an example of a stress / strain graph.

Describe what happens when the stress on a material causes it to exceed its yield point. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(b) (i) Describe how biomechanical data would have been used in the development of the forceps in **Figure 1**. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(ii) Outline **one** way how products that are produced as a single part can reduce manufacturing costs. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(c) (i) Outline how design for disassembly can help extend the lifespan of products with multiple parts. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(ii) Explain how finite element analysis (FEA) can be used to test products with multiple parts. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

Designed by George Nelson in 1958, the Nelson Swag Leg Desk is named after “swaging”, a manufacturing process that allowed the legs to be curved easily. The lightweight desk features walnut sides, four coloured hardwood dividers, laminate surface and legs shaped from chrome steel tubes, see **Figure 5**.

The desk is designed to be flat-packed and assembled by the consumer.

Figure 5: The Nelson Swag Leg Desk

(d) (i) State **one** possible joining method used to attach the legs to the other parts of the desk. [1]

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 1 continued)

(ii) Outline the percentile range used to calculate the reach from the front of the desk to the coloured dividers. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(e) (i) Outline **one** reason why the Nelson Swag Leg Desk achieved classic design status. [2]

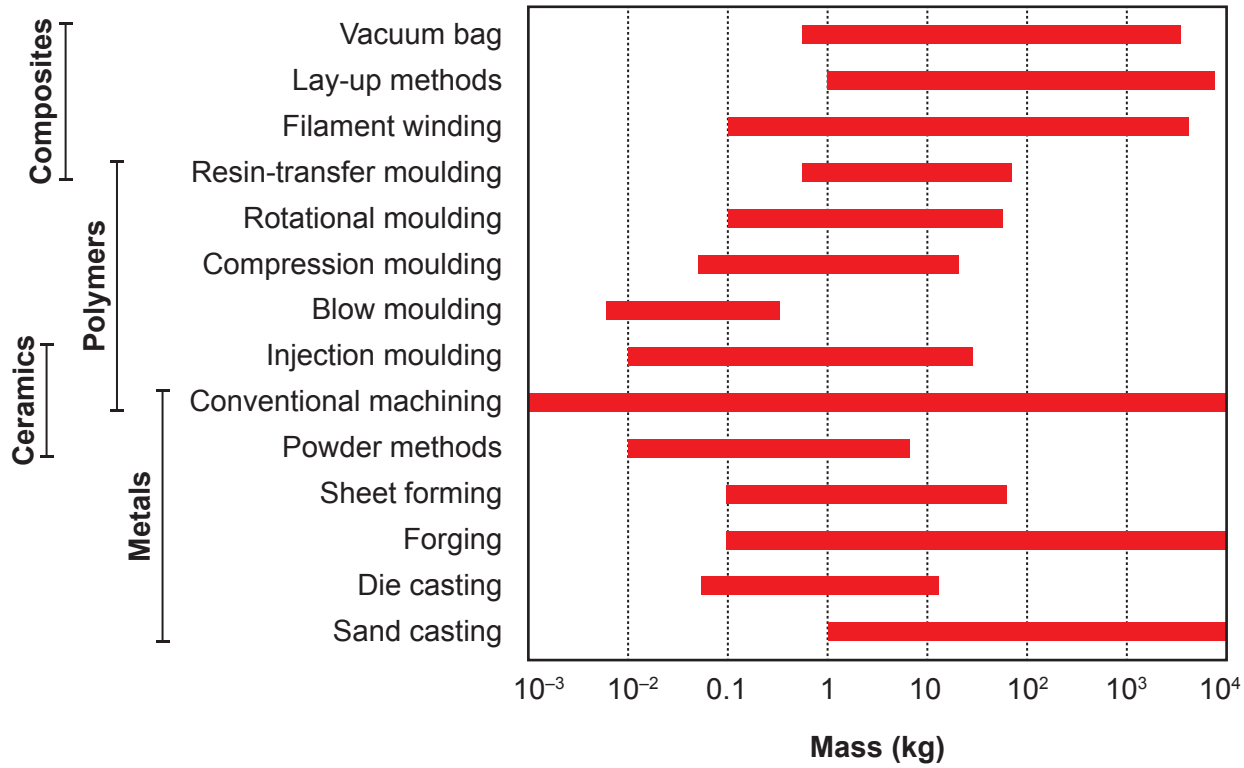
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

(ii) Suggest **one** reason why the depletion of hardwood reserves may have political implications. [3]

. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .
. . . . . .

2. To select suitable manufacturing processes for products, designers use process selection charts such as the one shown in **Figure 6**.

Figure 6: Process selection chart



(a) List **two** materials in **Figure 6** that can be shaped using resin-transfer moulding. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

(b) List **two** suitable processes in **Figure 6** for a ceramic component with a mass of 10 kg. [2]

. . . . . .
. . . . . .
. . . . . .
. . . . . .

3. Explain how the molecular structure of thermoplastics is affected by heat. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

4. The choice of production systems can be based on criteria such as time, cost and impact on the environment.

Explain **one** reason why designers would consider impact on the environment as a criterion for selecting manufacturing processes. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

Please **do not** write on this page.

Answers written on this page
will not be marked.

Section B

Answer **one** question. Answers must be written within the answer boxes provided.

5. The Aria asthma inhaler was designed to address the disposable nature of the existing asthma inhaler, see **Figure 7**. Once the canister runs out it is thrown away.

The design team developed four refillable inhalers. Each targets a different audience; Aria Youth, Aria Contemporary, Aria Sport and Aria Heritage, see **Figure 8** and **Figure 9**.

The Aria asthma inhaler is supported by a smartphone app which offers information on weather and air quality, as well as giving personalised recommendations based on an individual's use, see **Figure 10**.

Figure 7: Existing inhaler with disposable cartridge

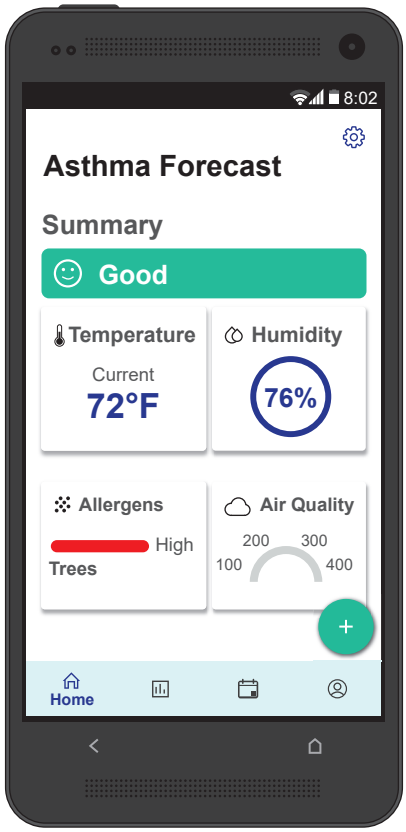
Figure 8: Four versions of the Aria asthma inhaler

Figure 9: The Aria asthma inhaler in use

(This question continues on the following page)

(Question 5 continued)

Figure 10: The Aria smartphone app



(a) Outline how data modelling could have been used in the development of the Aria smartphone app in **Figure 10**. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 5 continued)

(b) Explain **one** way how disposable products can have a negative impact on the environment. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 5 continued)

(c) Explain **two** ways how the design team have addressed the problem of disposability through the design of the Aria asthma inhaler. [6]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 5 continued)

(d) Rogers' characteristics of innovation impact on the rate of consumer adoption of an innovation.

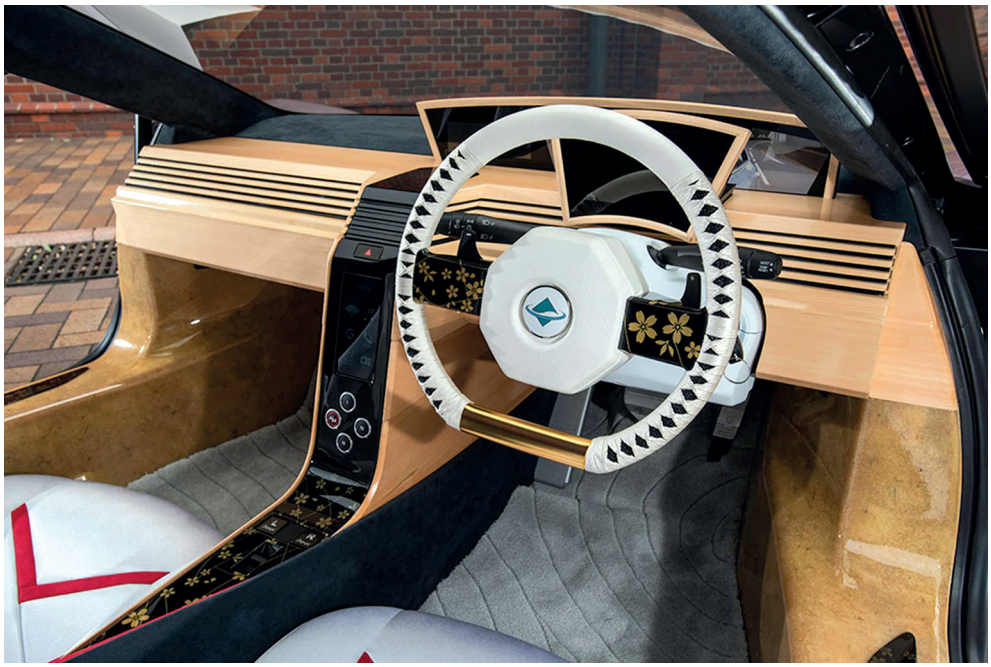
Explain the role of relative advantage, compatibility **and** observability on the rate of adoption of the Aria asthma inhaler. [9]

6. The Nano Cellulose Vehicle (NCV) is a concept car made from nano cellulose, a new material that can be made from unused biomass or locally sourced wood, see **Figure 11**. Nano cellulose can be manufactured into parts that are five times as strong as steel, yet one fifth of the weight.

There were a number of drivers (reasons) for the invention of the NCV.

Figure 11: Nano Cellulose Vehicle (NCV)

Figure 12: Interior of the NCV



(This question continues on the following page)

(Question 6 continued)

(a) List **two** forms of graphical modelling used by car designers. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(b) Explain **one** driver for invention of the NCV in **Figure 11**. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 6 continued)

(c) A lack of alertness of car users is a major factor in road traffic accidents.

Explain how light **and** sound could be used by designers of the NCV in **Figure 12** to improve the alertness of the user. [6]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 6 continued)

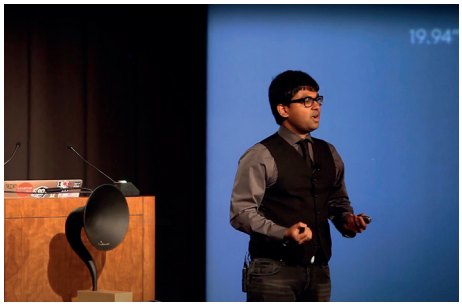
(d) Explain how the use of nano cellulose impacts the pre-production, utilization **and** disposal stages of the NCV's life cycle. [9]

7. The Gramovox® bluetooth speaker design is based on gramophones from the 1920s, see **Figure 13**. For the prototype, stereolithography (SLA) was used to 3D print the S-curve horn.

Pavan Bapu the founder of Gramovox®, is an entrepreneur and a product champion, see **Figure 14**. He crowdsourced funding for manufacture through Kickstarter and promoted the concept through live online broadcasts and newspaper interviews. He was inspired to develop the Gramovox® bluetooth speaker after seeing a 1920s gramophone in a shop window.

Figure 13: Gramovox® bluetooth speaker

Figure 14: Pavan Bapu, founder of Gramovox®



(a) Outline **one** physical property that makes hardwood a suitable choice for the base of the Gramovox® bluetooth speaker in **Figure 13**. [2]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 7 continued)

(b) Explain how retro-styling has been used in the design of the Gramovox® bluetooth speaker. [3]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 7 continued)

(c) Explain Pavan Bapu's role as entrepreneur **and** product champion in the success of the Gramovox® bluetooth speaker. [6]

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

. . . . . .

(This question continues on the following page)

(Question 7 continued)

(d) Explain the benefit of using freehand sketches, physical models **and** CAD solid models in the development of the horn of the Gramovox® bluetooth speaker. [9]

References:

Figure 1 AfroBrazilian, 2012. Liston Bone Cutting Forecep curved 01. [image online] Available at: https://commons.wikimedia.org/wiki/File:Liston_Bone_Cutting_Forcep_curved_01.jpg. Attribution-ShareAlike 3.0 Unported (CC BY-SA 3.0) https://creativecommons.org/licenses/by-sa/3.0/deed.en [Accessed 10 September 2020].

Figure 2 BYU_CMR, 2018. Oricepts: Origami Inspired Foreceps. [image online] Available at: https://www.thingiverse.com/thing:2988740 [Accessed 10 September 2020].

Figure 3 BYU_CMR, 2018. Oricepts: Origami Inspired Foreceps. [image online] Available at: https://www.thingiverse.com/thing:2988740 [Accessed 10 September 2020].

Figure 5 Nelson Swag Leg Desk image provided by Herman Miller.

Figure 7 InspiredImages, 2016. Asthma Ventolin Inhaler. [image online] Available at: https://pixabay.com/photos/asthmaventolin-breathe-inhaler-1147735/ Pixabay.com [Accessed 10 September 2020].

Figure 8 [*Four design styles of Aria Inhalers*] 2019. [image online] Available at: https://www.trendhunter.com/trends/aria-inhaler [Accessed 10 September 2020].

Figure 9 [*An Aria Inhaler*] 2019. [image online] Available at: https://www.trendhunter.com/trends/aria-inhaler [Accessed 10 September 2020].

Figure 11 Images provided with permission from Ministry of the Environment, Government of Japan.

Figure 12 Images provided with permission from Ministry of the Environment, Government of Japan.

Figure 13 Gramovox, 2013. Gramovox Bluetooth Gramophone. [image online] Available at: https://www.kickstarter.com/projects/gramovox/gramovoxtm-bluetooth-gramophone [Accessed 10 September 2020].

Figure 14 Technori, 2015. Pavan Bapu Presents Gramovox. [video online] Available at: https://www.youtube.com/watch?v=-Mp5m8klziA [Accessed 10 September 2020]. Source adapted.

All other texts, graphics and illustrations © International Baccalaureate Organization 2021