HM Government

T-LEVELS

8730-031
T Level Technical Qualification(s) in Engineering and Manufacturing (Level 3)
Core: Exam paper 1

If provided, stick your candidate barcode label here.

Date of exam: TBC
Duration: 2 hours 30 minutes

Candidate name (first, last)

First

Last

Candidate enrolment number

Date of birth (DDMMYYYY)

Gender (M/F)

Assessment date (DDMMYYYY)

Centre number

Candidate signature/declaration*

- If additional answer sheets are used, enter the additional number of pages in this box. ➡
- Before taking the examination, **all candidates** must check that their barcode label is in the appropriate box. Incorrectly placed barcodes may cause delays in the marking process.
- Please ensure that you staple additional answer sheets to the back of this answer booklet, clearly labelling these with your full name, enrolment number, centre number and qualification number in BLOCK CAPITALS.
- All candidates need to use a **black/blue** pen. **Do not** use a pencil or gel pen, unless otherwise instructed.
- If provided with source documents, these documents **will not** be returned to City & Guilds and will be shredded. Do not write on the source documents.
- *** I declare that I had no prior knowledge of the questions in this examination and that I will not divulge to any person any information about the questions.**

You should have the following for this examination

- a pen with blue or black ink
- a calculator
- source document: 8730-031 Formula sheet

General instructions

- π should be used as 3.14
- Show all your workings.
- Give your answers to three significant figures, unless otherwise stated.
- The marks for questions are shown in brackets.
- This examination contains **21** questions. Answer all questions.

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- Answer the questions in the spaces provided. Answers written in margins or on blank pages will not be marked.
- Cross through any work you do not want to be marked.

This exam has been split into two sections. Below details the types of questions and marks available for each section. Please allow time for each section accordingly.

Section A is made up of **67** marks and includes **18** short answer and medium answer questions.

Section B is made up of **33** marks and includes **3** extended response questions.

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

Section A

1 Describe what is meant by fan in and fan out in signal processing. (2 marks)

2 Name **two** different types of smart material and for each give a typical application. (4 marks)

3 Define the following terms used in engineering:

(a) Reliability (1 mark)

(b) Accuracy (1 mark)

(c) Precision (1 mark)

4 A robotic delivery vehicle of mass 500 kg is being used to move wagons containing materials around a factory. The wagon and materials have a combined mass of 125 kg.
The robotic delivery vehicle, which is initially travelling at 2.4 m s^{-1}, collides with the stationary wagon and the two become fixed together and move as a single mass.

Calculate the common velocity after the collision. (4 marks)

5 Complete the table below, stating a different item of equipment to carry out each measurement. (3 marks)

Measurement	Equipment used
Checking that the diameter of a hole is 8 ± 0.5 mm	
Checking that the separation between two metal parts is 1.5 ± 0.1 mm	
Deviation from concentricity of a shaft	

6 The input into a gearbox is 300 revolutions per minute (rpm). The output from the gearbox is 2700 rpm. The gearbox contains two gears.

The output gear has 18 teeth. How many teeth does the input gear have? (2 marks)

7 The shape in Figure 1 must be accurately measured before manufacturing.
Calculate the length of side KL. (3 marks)

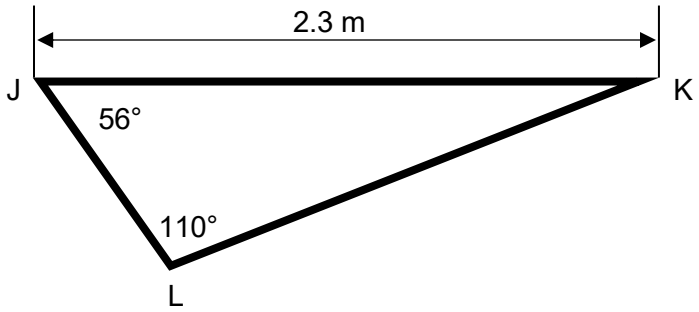

Figure 1 – Not to scale

8 A pneumatic cylinder with a movable piston contains 0.9 m^3 of air at a pressure of 6 MPa.
Calculate the volume of the air if the pressure exerted within the cylinder is reduced to 1.2 MPa.
Assume that the temperature remains constant. (2 marks)

9 The triangle in Figure 2 is a structural part that needs to be manufactured.
The designer of the part has specified that cot $a = 1.73$

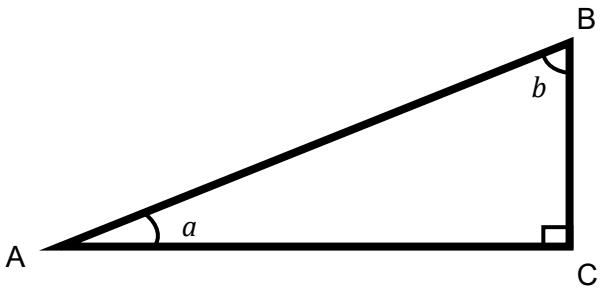

Figure 2 – Not to scale

(a) Determine the angles a and b. (3 marks)

(b) Show that the ratio of lengths BC to AB is approximately 0.5 (2 marks)

10 A company wants to chemically etch stainless steel labels with its logo and product details, such as the ones shown in Figure 3. Describe how the etching process would be carried out. (4 marks)

Figure 3

Source: www.brunelengraving.co.uk

11 When a sample selected at random from a batch of products was inspected, it was found that:

- 89% of the products contained no defect and were satisfactory,
- 9% of the total quantity of products contained crack defects,
- 6% of the total quantity of products contained porosity defects.

Some of the products contained both types of defect.

Calculate the probability that a product selected at random contains only one defect. (3 marks)

12 A test was carried out to evaluate the usable life of a machine tool. This involved recording the number of defective parts produced by the machine each hour.
The first defective part was produced in hour 5. The number of defects in subsequent hours increased geometrically. The number of defects produced in the hour 8 was 64.

Calculate the common ratio that multiplies the number of defects in each successive batch.
(3 marks)

13 In a circuit, three components each change the amplitude of the output, D, in sequence by different values:

- Component 1 causes the amplitude to increase by the cube of its value (D^3).
- Component 2 causes the amplitude to be divided by the square of its value (D^2).
- Component 3 multiplies the resultant output by its square root ($D^{\frac{1}{2}}$).

Determine the simplest form of the equation to represent how the output signal is affected by the three components. (3 marks)

14 A tool moves in a straight line in a machine. At time t seconds, its position relative to a fixed point in the machine, x mm, is given by the function

$$x = 2t^3 + 2\cos(3t)$$

Determine the difference in the velocity of the tool between $t = 1.0$ and $t = 2.5$ seconds, to two decimal places. (5 marks)

15 A steel bar is being used to provide rigidity inside an industrial oven. It was fixed in position at both ends inside the oven when the temperature was 20°C. When in use, the oven operates at 130°C and any expansion or contraction of the steel bar is prevented.

Calculate the maximum stress experienced by the bar as a result of the change in temperature.

Additional information: For steel, $\alpha = 12 \times 10^{-6}\ °C^{-1}$ and $E = 205\ GN\ m^{-2}$ (6 marks)

16 A designer requires a circuit to have a time constant (T = RC) of 0.5 ± 0.05 seconds.
Determine if the time constant of the arrangement shown in Figure 4 would be acceptable.

(5 marks)

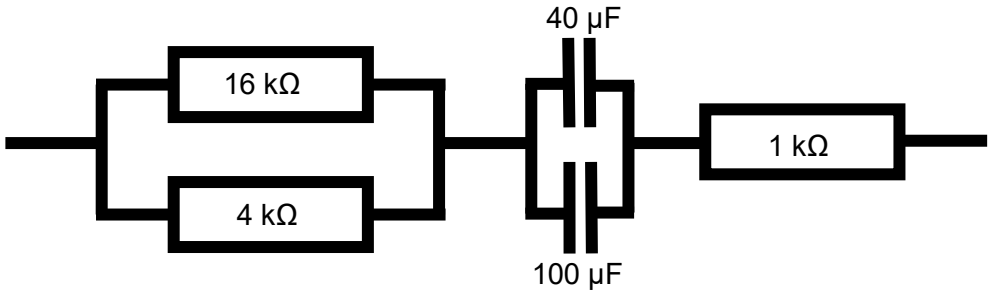

Figure 4

17 A company manufactures hard hats from a metal alloy, such as the one shown in Figure 5. The design specifies that the metal should have a crystalline structure. Due to a manufacturing issue, the metal has been produced with an amorphous non-crystalline structure.

Explain how this will affect the performance of the hard hat when it is subjected to an impact.

(4 marks)

Figure 5

Source: www.forestry-suppliers.com

18 A company is planning to build a new factory to mass produce electronic circuit boards for phones. Each of the assembly operations will be carried out by dedicated robotic arms. The factory will work seven days a week, 24 hours a day in order to meet demand. New phone designs will be manufactured each year.

Explain why programmable logic controllers (PLCs) would be used to control the robotic arms, rather than dedicated integrated circuits. (6 marks)

Section B

19 A company is making a chain for a ship's anchor that a ship will use when at sea. They are using a ferrous metal.
The company has three potential processing techniques that could be used to make the links in the chain:

- Casting
- Forging
- Welding bent pieces together.

The chain also needs to be protected from corrosion.

Suggest which of the three processing techniques would be suitable chain and a method to improve its corrosion resistance, justifying your suggestions compared to the alternatives.

(9 marks)

20* A manufacturing company is considering using a renewable source of power for a new factory. The factory will have a number of electrically-powered machining processes which are expected to operate continuously. The factory is in a high altitude rural location with no nearby river and limited access by road.

Evaluate the different power sources available and suggest the most suitable for the needs of this company. (12 marks)

21* A company has been asked to develop a wheelchair that will be used by an athlete in the Paralympics. The wheelchair needs to be manually powered and will be used for long distance racing on roads and track, and must be manufactured as a one-off.
Discuss the factors that are most important when selecting the materials to make the wheelchair and recommend a suitable main material for the frame, justifying your choice. (12 marks)

End of Assessment

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