



Rewarding Learning

General Certificate of Secondary Education
2024

Centre Number

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Candidate Number

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Engineering and Manufacturing

Unit 3

assessing

Materials, Processes and Systems



[GEM31]

GEM31

THURSDAY 6 JUNE, MORNING

TIME

2 hours.

INSTRUCTIONS TO CANDIDATES

Write your Centre Number and Candidate Number in the spaces provided at the top of this page.

You must answer the questions in the spaces provided.

Do not write outside the boxed area on each page or on blank pages.

Questions which require drawing or sketching should be completed using an H.B. pencil.

All other questions must be completed using black ink only.

Do not write in pencil or with a gel pen.

Answer **all** questions in Sections **A** and **B**.

Questions 1, 2, 3, 4 and 5 of Section A refer to the pre-release material, a copy of which has been provided for you.

Quality of written communication will be assessed in Question **5**.

You may use a calculator for this paper.

INFORMATION FOR CANDIDATES

The total mark for this paper is **100**.

Figures in brackets printed down the right-hand side of pages indicate the marks awarded to each question or part question.

14168



28GEM3101

Answer **all** questions

Section A

Questions in this section refer to the pre-release material.

- 1 (a) The mechanism shown in **Fig. 1** is used in the scroll saw to control the motion of the saw blade.

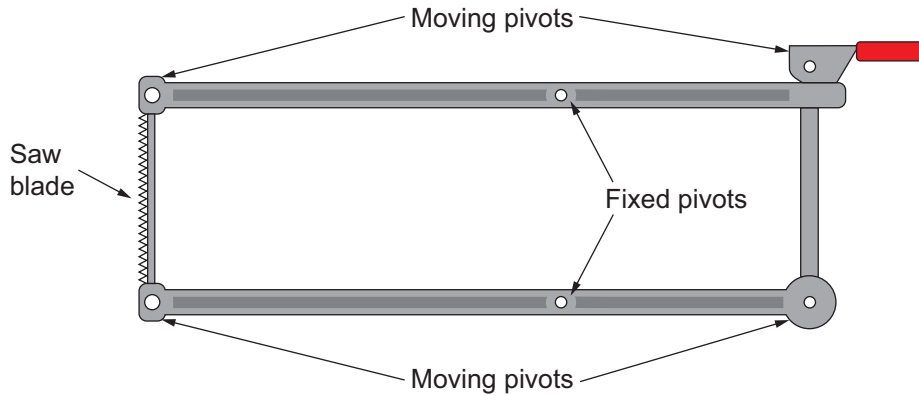


Fig. 1

- (i) State the type of mechanism shown in **Fig. 1**.

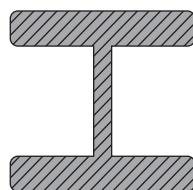
_____ [1]

- (ii) Explain why aluminium alloy has been used to manufacture the mechanism in the scroll saw shown in **Fig. 1**.

_____ [2]



- (b) The cross section of the top and bottom members of the mechanism is shown below in **Fig. 2**.



Source: CCEA

Fig. 2

- (i) The cross section shown in **Fig. 2** has been used in the design of the mechanism shown in **Fig. 1** to increase its stiffness.
Explain the meaning of the term stiffness.

[2]

- (ii) A range of fixtures are used in the manufacture of the scroll saw.

What is the function of a fixture?

[1]

[Turn over



- (c) Parts of the scroll saw are made using the process of pressure die casting. Produce an annotated sketch, showing the main features of the pressure die casting process.

[4]





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(Questions continue overleaf)

14168

[Turn over



28GEM3105

2 (a) The electronic components of the scroll saw have been encased in a nylon housing.

(i) State **one** property of nylon which makes it a suitable material for the casing for the electronic components.

_____ [1]

(ii) Name the most suitable process that could be used to produce the nylon housing for the electronic components.

_____ [1]

(iii) State **two** safety precautions which the user should employ when using the scroll saw.

1. _____ [1]

2. _____ [1]

(b) The results of a tensile test shows stress / strain curves for materials used in the manufacture of the scroll saw as shown in **Fig. 3**.

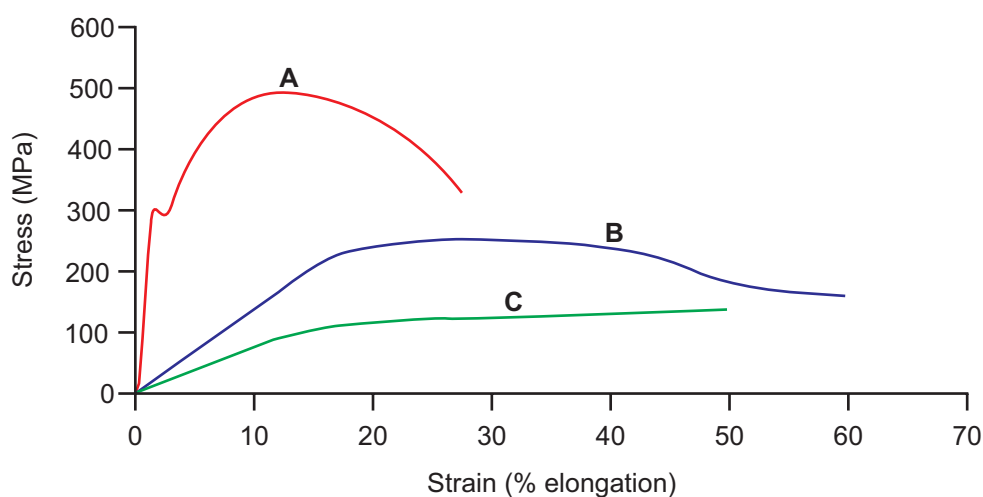


Fig. 3

Source: CCEA



- (i) Complete **Table 1** below by suggesting materials used in the manufacture of the scroll saw that would produce the stress / strain curves shown in **Fig. 3**.

Table 1

Stress / Strain curve	Material
A	
B	
C	

[3]

- (ii) The samples used in the tensile tests were all equal length and cross section. If the initial length of the samples was **80 mm**, what was the length of sample **B** at the point of fracture?

Answer _____ mm [1]

[Turn over



- 3 (a) The company has calculated it spends £8000 on energy, £470 on materials and £430 on labour costs to produce a batch of 2000 aluminium alloy saw tables for the scroll saw.

In order to reduce costs the company changes the material to a low melting point aluminium alloy which will reduce energy costs by 15% but will increase material costs by 20%, labour costs remain at £430.

By how much will the cost of each saw table be reduced?

Show your working out in the space below.

Answer _____ [7]



- (b) The company manufactures the scroll saw table using the pressure die casting process from 5 kg blocks of aluminium alloy as raw material. Each saw table casting has a volume of 120 cm^3 .

Given that aluminium alloy has a density of 2.7 g/cm^3 , calculate how many scroll saw tables can be produced from one 5 kg block.

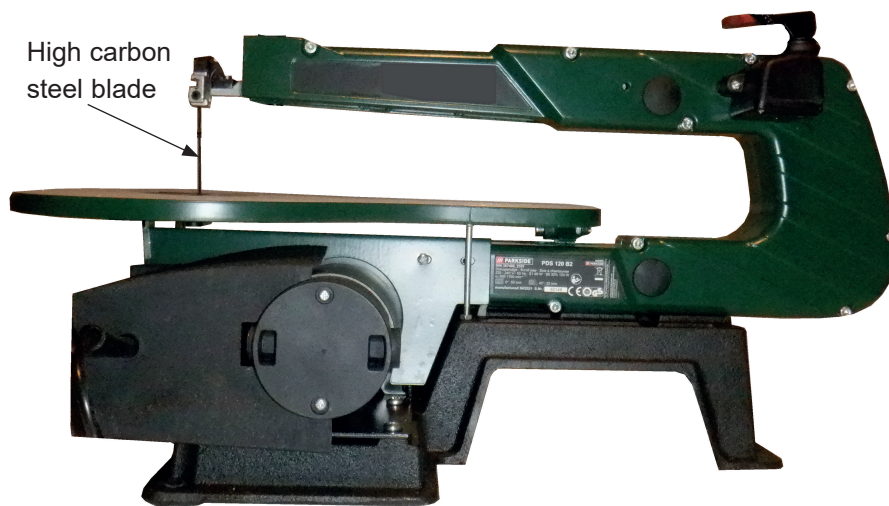
Show your working out in the space below.

Answer _____ Scroll saw tables [3]

[Turn over



- 4 **Fig. 4** shows the high carbon steel blade fitted to the scroll saw.



Source: CCEA

Fig. 4

In the space provided, use 2D, assembly and exploded annotated sketches, with appropriate terminology, to show how the scroll saw blade may be fitted to the top and bottom members of the scroll saw.

Marks will be awarded for:
Detail contained in the sketches
Quality of sketches
Annotation

[4]
[4]
[4]





Show your response to Question 4 in the space below.

[Turn over

14168



28GEM3111

- 5** Discuss the advantages and disadvantages that a manufacturer of scroll saws should consider before implementing computer-aided design (CAD), computer-aided manufacturing (CAM) and robotics into their production system.

Quality of written communication will be assessed in this question.

[illegible]



[10]

[Turn over

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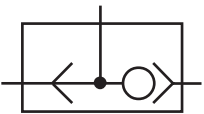
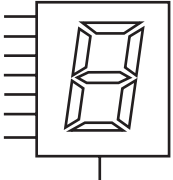


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Section B

- 6 (a) Complete **Table 2** by inserting the correct name for each symbol or component.

Table 2

Symbol or Component	Symbol or Component Name
	
 <i>Source: CCEA</i>	
 <i>Source: CCEA</i>	
 <i>Source: CCEA</i>	

[4]



(b) Shape-memory alloys (SMAs) are smart materials.

- (i) Explain the key features of shape-memory alloys (SMAs) and give **one** application for their use.

Explanation

[2]

Application

[1]

- (ii) Smart materials are used in industrial projects. Briefly explain **two** benefits of using smart materials.

1.

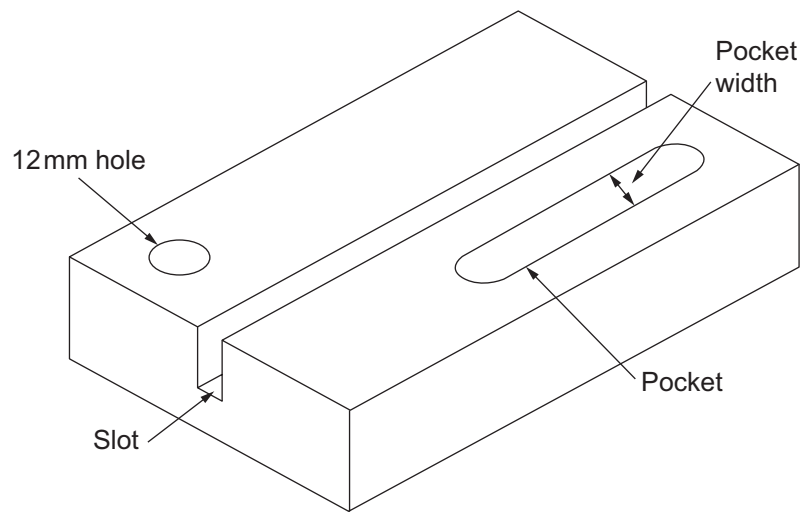
2.

[2]

[Turn over



- 7 **Fig. 5** shows an aluminium block of a component part for a project to be machined in a school workshop.



Source: CCEA

Fig. 5

- (a) (i) Suggest a suitable school workshop machine which could be used to produce the slot in the aluminium block.

_____ [1]

- (ii) Explain with reference to hand tools how the 12 mm hole would be marked out ready for drilling.

_____ [2]

- (b) (i) Suggest a suitable tool which could measure the depth of the pocket.

_____ [1]

- (ii) Suggest a suitable tool which could measure the width of the pocket.

_____ [1]



(c) Tolerances and quality control charts are used when manufacturing products.

(i) Give **two** reasons for the use of tolerances in the manufacture of a product.

1. _____

2. _____

_____ [2]

(ii) Explain how a quality control chart could be used in the design and manufacture of a product.

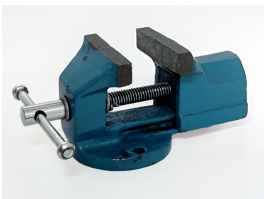

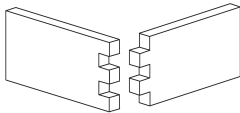
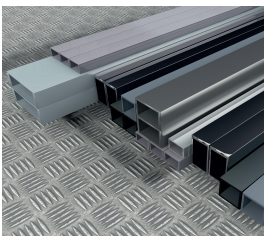
_____ [2]

[Turn over



- 8 (a) Complete **Table 3** by inserting the correct material forming process, joining method or the type of joint for each image shown.

Table 3

Product	Material	
 <p>Source: © Getty images</p>	Cast iron	Material forming process
 <p>Source: © Getty images</p>	Steel	Joining method
 <p>Source: CCEA</p>	Oak	Type of joint
 <p>Source: © Getty images</p>	Aluminium alloy	Material forming process

[4]



(b) Give **two** reasons why cast iron is a suitable material for the metalwork vice shown in **Table 3** opposite.

1. _____

2. _____

_____ [2]

(c) The cast iron metal work vice shown in **Table 3** is to be manufactured using mass production.

Give **two** characteristics associated with mass production.

1. _____

2. _____

_____ [2]

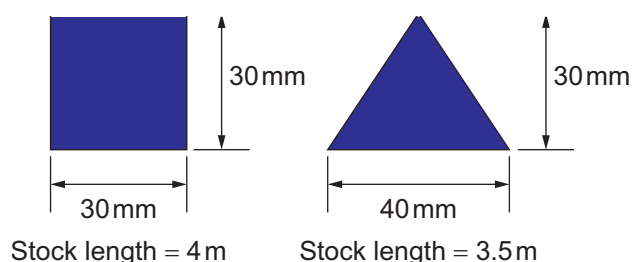
[Turn over



- 9 **Fig. 6** shows a typical garden railing made from mild steel. The vertical railings are available in solid bar in either a square section or triangular section but in different stock lengths as shown.



Source: © Getty images



Source: CCEA

Fig. 6

- (a) Using the information from **Fig. 6**, calculate the difference in cm^3 between the volume of mild steel in one stock length of square section material compared to the volume of mild steel in one stock length of triangular section material.

Difference in volume _____ cm^3 [3]



- (b) A length of square section mild steel 4 m long is to be cut into 500 mm lengths using a circular saw.

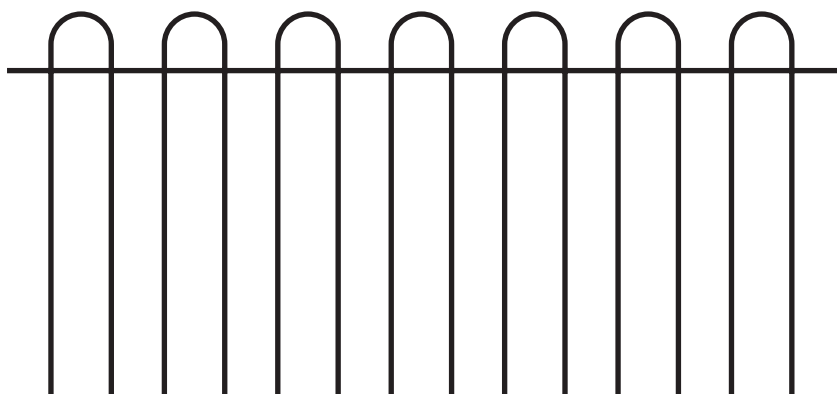
Given that a 3 mm length of material is lost with each saw cut, calculate the length of material left over after the maximum number of 500 mm lengths has been cut.

Left over material _____ mm [3]



- (c) The company manufactures the hoop top railing panels shown in **Fig. 7** using 10 mm round mild steel bar costing £32.00 per 6.4 m length.

After cutting each length of round mild steel bar, a piece of material 896 mm long was left over.



Source: CCEA

Fig. 7

- (i) Calculate the cost per metre for the round mild steel bar.

Answer _____ [1]



(ii) Calculate the percentage of left over material from each 6.4 m length.

Answer _____ % [1]

(iii) Calculate the cost of the left over material.

Answer _____ [1]

[Turn over



10 Fig. 8 shows a design for a children's play park frame.



Source: © Getty images

Fig. 8

- (a)** The manufacturing processes to be used to manufacture the play park frame and the anticipated loads when in use after installation require a ductile material.
- (i)** Explain the meaning of ductility as a mechanical property of a material.

[2]

The manufacture of the play park frame involves heat treatments to reduce brittleness in the welded joints.

- (ii)** Explain the meaning of brittleness as a mechanical property of a material.

[2]



When installed in the park any load applied to the play park frame under normal use should be within the elastic limit of the material.

(iii) Explain the term elastic limit.

[2]

(b) Outdoor play park frames such as the one shown in **Fig. 8** are usually galvanised before being painted.

Explain the process of galvanising which would be used on the outdoor play park frame.

[3]

[Turn over



11 A company that designs and manufactures circuit boards made reference to pick and place machines, new and emerging technologies and computer-aided engineering (CAE).

(a) Briefly outline **two** advantages that pick and place machines offer manufacturers.

[2]

(b) Explain the impact that new and emerging technologies in the design and manufacture of products can have on reducing energy costs.

[2]

(c) Explain how computer-aided engineering (CAE) is used in manufacturing.

[2]





THIS IS THE END OF THE QUESTION PAPER



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For Examiner's use only	
Question Number	Marks
1	
2	
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11	

Total Marks	
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Examiner Number

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Engineering and Manufacturing

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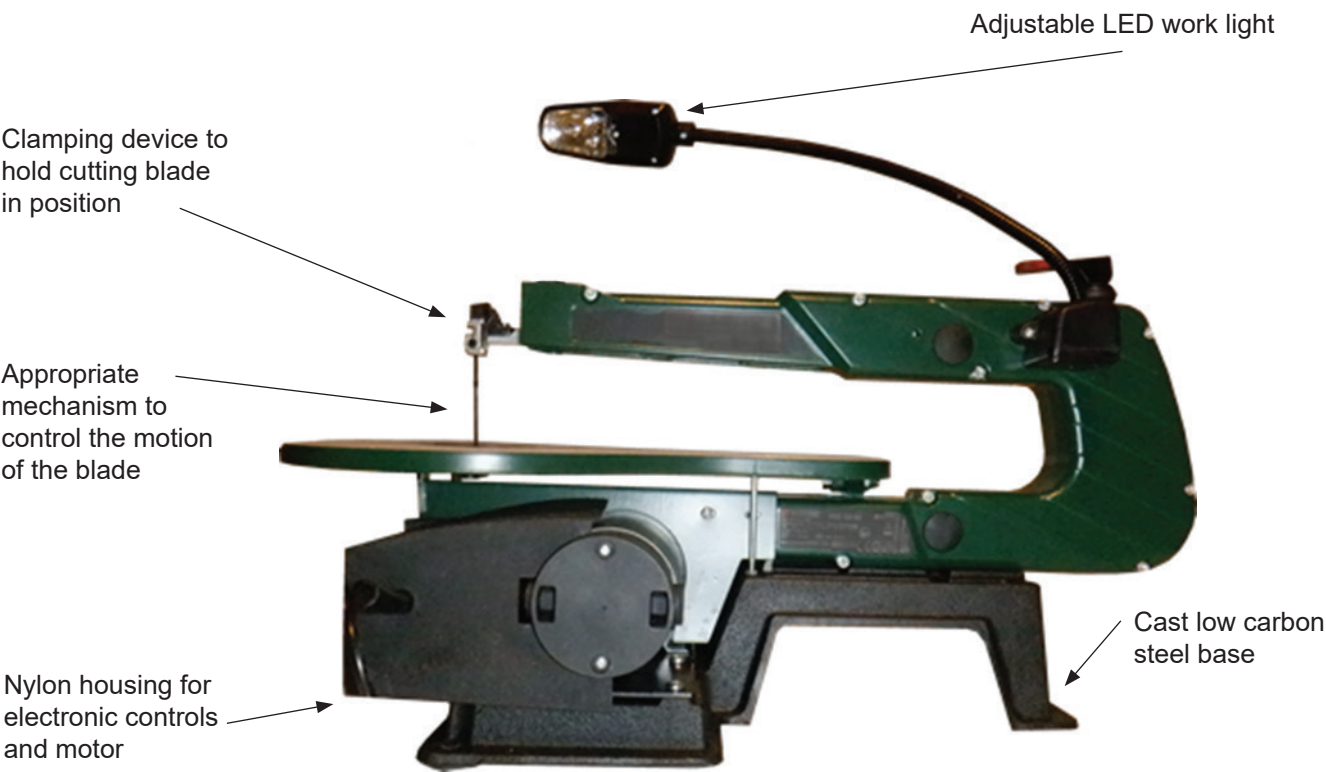
Materials, Processes and Systems

[GEM31]

THURSDAY 6 JUNE, MORNING

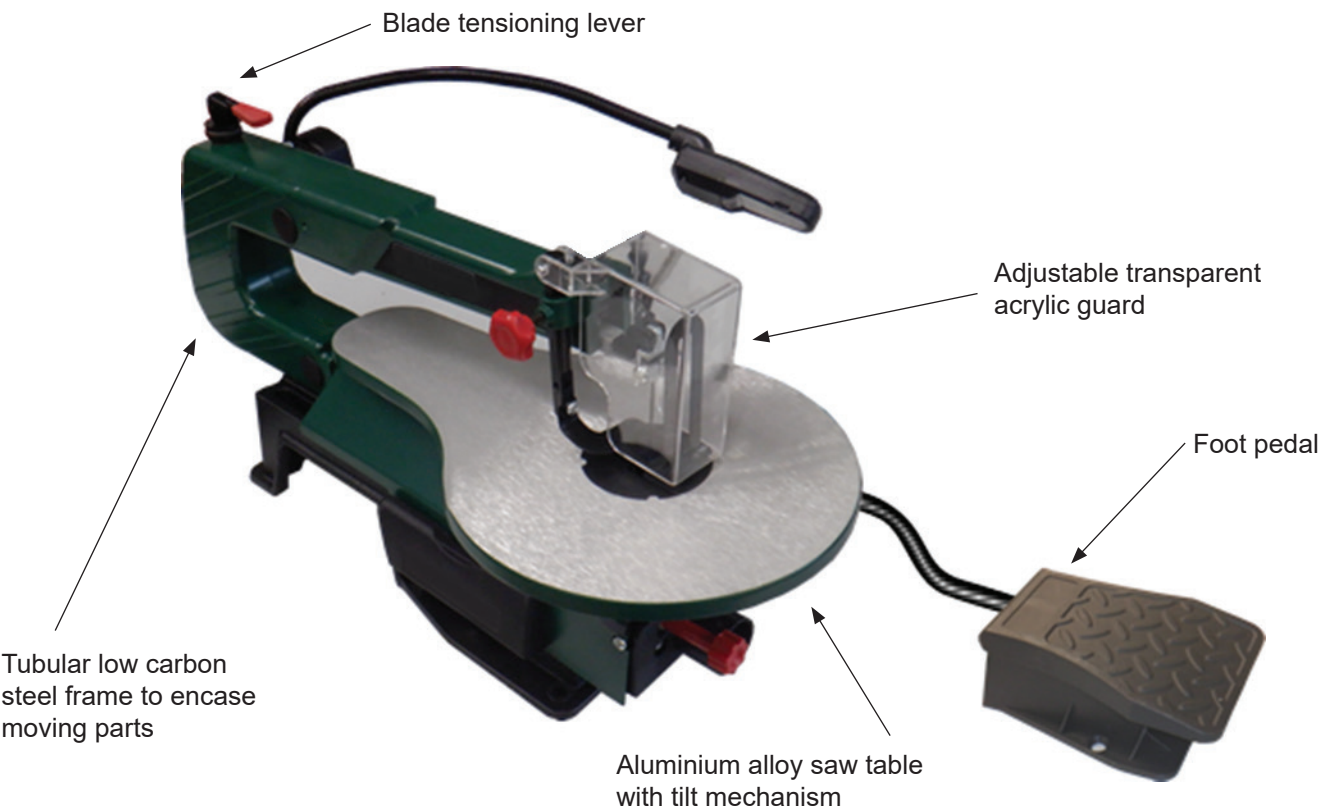
**PRE-RELEASE
MATERIAL**

Fig. 1 and Fig. 2 show an electric scroll saw.



Source: Chief Examiner

Fig. 1



Source: Chief Examiner

Fig. 2

Product features include:

- Reciprocating mechanism;
- Die cast aluminium alloy saw table with tilt mechanism;
- Simple method to fit and remove cutting blades;
- Variable speed electric motor;
- Foot pedal and manual speed control;
- Robust construction with a low carbon steel base and frame;
- Dimensions Height (400 mm) – Length (650 mm) – Width (300 mm); and
- Adjustable transparent acrylic guard for the blade.

Pre-release investigation:

You should investigate the possible impact and use of the following where appropriate, in the design and production of the electric scroll saw:

- Materials and components: including application, properties, processes, form, supply and types of finish;
- Manufacturing processes: including CAD, CAM, robotics, casting and the use of jigs and fixtures;
- Quality control and quality assurance;
- Product safety; and
- Costing: including direct and indirect costs incurred in the manufacture of the electric scroll saw.

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