

CAMBRIDGE NATIONALS

Examiners' report

ENGINEERING MANUFACTURE

J832, J842

R109 January 2023 series

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Introduction

Our examiners' reports are produced to offer constructive feedback on candidates' performance in the examinations. They provide useful guidance for future candidates.

The reports will include a general commentary on candidates' performance, identify technical aspects examined in the questions and highlight good performance and where performance could be improved. A selection of candidate answers is also provided. The reports will also explain aspects which caused difficulty and why the difficulties arose, whether through a lack of knowledge, poor examination technique, or any other identifiable and explainable reason.

Where overall performance on a question/question part was considered good, with no particular areas to highlight, these questions have not been included in the report.

A full copy of the question paper and the mark scheme can be downloaded from OCR.

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R109 series overview

R109 is an un-tiered, externally examined, mandatory component of J832 and J842, these being the Award and Certificate respectively, in Engineering Manufacture. This component assesses candidates' knowledge and understanding of engineering materials and processes. The paper requires short and extended written responses and includes synoptic assessment and assessment of the quality of written communication.

Candidates seemed well prepared for this exam and there was good demonstration of knowledge and understanding across the whole specification. Candidates used their time appropriately and virtually all candidates completed the paper within the allocated time. Very few candidates used extra pages/ continuation sheets but where they were used these extra pages were usually clearly and accurately labelled indicating the question that the additional response referred to.

A number of centres enabled candidates to make use of the Equality Act by using exam access arrangements, most obviously through use of word-processed answer sheets. Compared with previous sessions, a greater proportion of candidates' word-processing answers were answered on the question paper where it was most suitable to do so and used word-processed sheets to support their longer written responses, most commonly Question 6 (c)*. There was, however, still a small proportion of candidates who answered every question on the word processor even when it may have been quicker, simpler and less cognitively demanding to answer on the paper. For future sessions, it would benefit candidates with exam access arrangements if they were well-practised in which types of questions are best answered on the paper and which to use word-processing for. This will not only save these candidates time but will also reduce potential for errors when working across two answer sheets. Some candidates organised their word-processed responses well and produced answer sheets that were very clear and easy to follow which question their response referred to. This was however not always the case; centres could help candidates who answer using a word processor by training them to make good use of line spacing and white space to help candidates to organise their responses so that it is clearer and easier for the candidate to produce and check their responses.

Although a number of centres made use of modified papers for visually impaired candidates, some centres had copied standard papers onto A3 with a view to better help candidates with visual difficulties. Unfortunately, it is well documented that although copying onto A3 does increase the font size it actually disadvantages visually impaired candidates because these candidates generally do not have wide enough field of view to see the whole page. Centres entering visually impaired students owe it to these students to give them the best possible chance by arranging for, practising candidates with, and using modified papers.

A wide range of marks were given in this paper. In many cases it was clear that some candidates had transferred synoptic knowledge and understanding gained practically in the centre assessed units or from wider afield. Indeed some candidates had a clear and in-depth practical knowledge/experience of the processes and manufacturing methods they were writing about. There were also clear differentials between candidates who had learned subject content from across the whole of the specification relating to R109 and those who had not. It should be borne in mind that direct questions can be asked of any of the unit content that is shown with an "i.e.". The success of candidate responses can be generalised as follows:

Candidates who did well on this paper generally did the following:	Candidates who did less well on this paper generally did the following:
<ul style="list-style-type: none"> • had detailed knowledge and understanding of engineering manufacture especially with respect to properties and uses of materials • read the question carefully, understood what the question was asking and responded accordingly • showed broad knowledge drawn from across the whole of the R109 specification statements • demonstrated an understanding and familiarity with the different command verbs, e.g. identify, give, describe, explain and discuss • gave broad and balanced responses that incorporated several points in conjunction with key vocabulary, which were often developed, when answering the longer written answer questions • used the guidance, where given, in the response lines to help make sure they answered all parts of the question. 	<ul style="list-style-type: none"> • lacked basic knowledge and understanding of materials, for example confusing mechanical properties with characteristics of the materials or confusing processes with machines • had not read the question carefully enough, answering what they thought they had read instead of what the question was actually asking • limited the marks available to them by not offering an answer to questions • found it difficult to apply what they had learned to different scenarios and instead gave responses that were simply a repeat or rewording of what was given in the stem of the question • repeated the same single point in different ways when answering the longer written responses • limited the marks available to them by not answering all aspects of the question by not using the additional guidance, where given, in the response lines.

Assessment for learning



Centres can train their candidates to deconstruct questions, paying attention to locating the command verbs; the exact meaning of command verbs and the demand that the command verb requires in the response.

The last point for example can be taught explicitly by instead of asking the candidate for the answer to a question, to ask for an example of what the response would look like. This can be done for a variety of command words with increasing demand, e.g. name/state, suggest, describe, explain, evaluate, etc. while keeping the remaining stem of the equation the same as far as possible.

This report covers every question in the paper. The higher tariff (4 mark plus, written response) questions have the biggest influence on improving candidate performance in this component, so the exemplars given concentrate on these questions and do not appear until towards the end of the report.

Question 1 (a)

1 Many different materials are used in engineering.

(a) Draw lines to link the material type to the correct example.

One has been completed for you.

Material type	Example
Composite	Iron
Alloy	Carbon fibre
Non-ferrous metal	Tungsten carbide
Ceramic	Brass
Ferrous metal	Titanium

[3]

This question was designed to be a straight forward introduction to the exam in order to settle candidates and as such the question was generally answered very well.

Assessment for learning



Centres can help candidates with this type of question by encouraging the use of rulers and straight lines between the boxes. This will make it easier for the candidate to decipher where the line is going to when they check their responses and makes the intended response clearer especially in the event of a response being changed.

Question 1 (b), (c) and (e)

(b) **Circle** **one** destructive test from the list below that can be carried out on metals.

conductivity testing

crack detection

tensile testing

[1]

(c) Describe what is meant by 'hardness' in a metal.

.....
.....
..... **[2]**

(e) Give **one** use of tungsten carbide.

..... **[1]**

These questions required candidates to show knowledge, either by circling an answer or writing a one or two word response. Because they are simply showing knowledge without application they were generally answered well, although Question 1 (e) drew a considerable proportion of no responses, maybe indicating lack of knowledge of use of tungsten carbide.

Question 1 (d)

(d) The ductility of a metal can be increased by using the normalising process.

Explain what ductility means and how normalising affects the structure and ductility of the metal.

.....
.....
.....
..... **[3]**

This 3-mark question was designed to test recall of a property (ductility) and the much higher level skill of explaining how normalising affects the microstructure and ductility of a metal. As might be expected, many candidates were able to give a definition of ductility, approximately half of the candidates were able to state how normalising affects the ductility of a metal but only very few candidates were able to describe the changes to the microstructure and how that increases ductility.

Question 2 (a) (i), (ii) and (iii)

2 (a) Fig. 1 shows a safety helmet with visor worn by lifeboat crew.

The visor is made of polycarbonate. The shell of the helmet is made of acrylonitrile butadiene styrene (ABS).

Fig. 1



(i) State the property that makes polycarbonate, but not ABS, suitable for the **visor**.

..... [1]

(ii) State **two** properties of ABS that makes it suitable for use in safety helmets.

1

.....

2

.....

[2]

(iii) The polycarbonate raw material is available in sheet or powder form.

State the most appropriate method of manufacturing the visor from these different forms of raw material.

Polycarbonate sheet

Polycarbonate powder

[2]

These knowledge and understanding questions required knowledge and understanding in the context of a given application. The majority of candidates were able to answer these questions well although for Question 2 (a) (i) some gave other properties for the visor that are true for ABS not realising that the visor must be transparent.

Question 2 (b) and (c)

- (b) Tow ropes on lifeboats are manufactured from nylon because they require high elasticity.

State the meaning of 'elasticity'.

.....
..... [1]

- (c) Place a tick (✓) in the correct column in the table below to show if the material is a thermoplastic or thermosetting plastic.

Polymer material	Thermoplastic	Thermosetting plastic
polycarbonate		
ABS		
nylon		
phenol-formaldehyde		

[4]

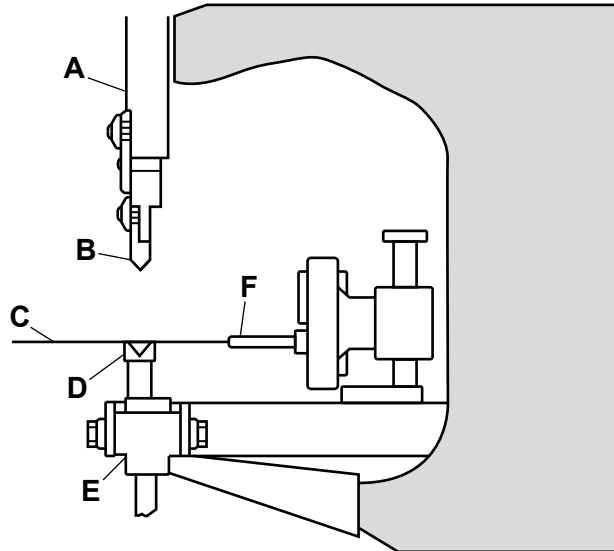
These two questions were generally answered well.

Question 3 (a) (i), (ii) and (iii)

3 (a) Fig. 2 is an end view of a press brake machine, used to shape metal.

Parts of the machine are identified with labels.

Fig. 2



(i) State the letters in Fig. 2 that label the following parts of the press brake machine.

Part of the press brake machine	Letter
Die	
Punch	
Hydraulic ram	

[3]

(ii) State **two** safety features, other than PPE, that you would find near a press brake machine.

1

2

[2]

(iii) Describe the safety precautions that should be taken before operating a press brake machine.

.....

.....

.....

..... [2]

These questions required candidates to show knowledge, either by writing a one or two word response, selecting a word from a list or selecting letters from diagrams. Because they are simply showing knowledge without application they were generally answered well, although the following were notable:

Question 3 (a) (ii) had a small number of candidates give items of PPE or precautions as an incorrect response.

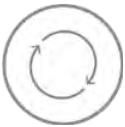
Question 3 (a) (iii) had a small number of candidates list different items of PPE, which were not given more than 1 mark.

Assessment for learning



Centres can help candidates with this type of question by training their students to clearly circle their intended response, to only circle or give the required number of responses and, possibly more importantly, if a response is changed, to be very clear about which answer is the intended one.

Assessment for learning



Because these type of questions are knowledge and recall based, centres can help their candidates by training them in recall of, for example, definitions of properties, uses of certain types of material, parts of machines, machines for different process, etc. There are many articles online that can provide ideas for training candidates to recall.

Question 3 (b)

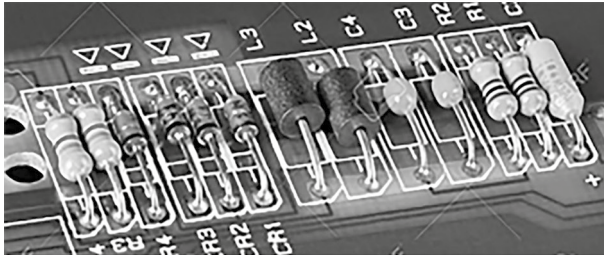
(b) Fig. 3 shows three examples of metals that require a joining method.

Next to each example below, state the most appropriate joining method from the following:

brazing **soldering** **welding**

Each method can be used once, more than once or not at all.

Fig. 3



components to a printed circuit board

.....



aluminium tubing in cycle frames

.....



copper pipes

.....

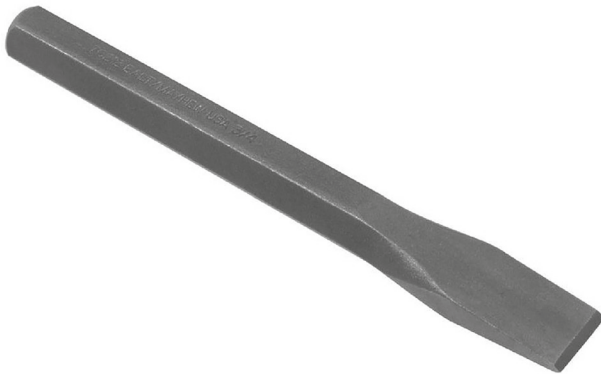
[3]

Candidates simply selected each word once and so tended to gain just 2 of the 3 marks.

Question 4 (a) (i)

4 (a) Fig. 4 shows a cold chisel.

Fig. 4



(i) The stages of manufacture for the chisel are given below.

Put the stages into the correct sequence by drawing lines to connect the sequence number to the correct stage.

One has been completed for you.

Sequence	Stage
1	Grind cutting edge onto the chisel
2	Heat to an orange colour and quench in water
3	Cut a 20 cm length from the hexagonal stock using a hacksaw
4	Hammer into shape on an anvil
5	Heat one end of the stock material in a furnace
6	Allow chisel to cool

[4]

The majority of candidates were able to answer this question well.

Question 4 (a) (ii) and (iii)

(ii) The next stage in manufacturing the chisel is to temper the cutting edge.

Describe how the cutting edge of the chisel is tempered after it has been cleaned.

.....
.....
.....
..... [2]

(iii) Explain why the cutting edge of the chisel should be tempered.

.....
.....
.....
..... [2]

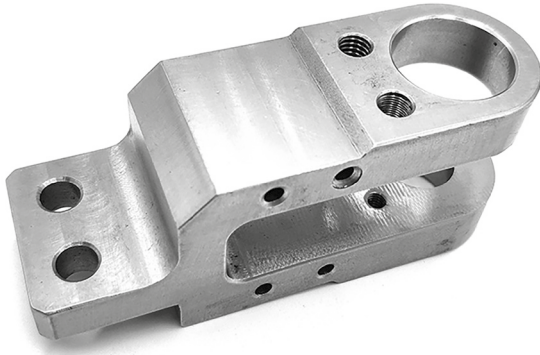
In general candidates did not answer these questions well. Indeed questions about heat treatment of metals have not been answered well in previous sessions of R109/01. With (ii), just to increase accessibility of marks, a mark was given for reference to cooling, irrespective of the type/method of cooling. The other mark was for stating the temperature or colour that the metal needed heating before cooling and this was given only very rarely, the most common incorrect response being that the metal was heated to a red colour. For (iii) a mark was given for stating that tempering increases the toughness of the metal and while many candidates gained this mark, very few candidates gained a mark for explaining that this increased the metal's ability to withstand impact without breaking.

Question 5 (a) (i) and (b) (i)

5 Computer Numerical Control (CNC) machines can be used to manufacture a wide variety of products.

(a) The item shown in **Fig. 5** was manufactured from a single piece of aluminium.

Fig. 5

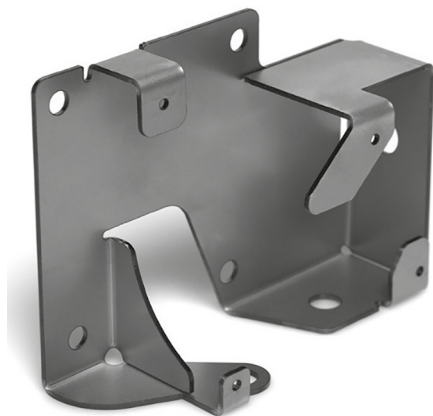


(i) Name **one** CNC machine that would be suitable to manufacture the item shown in **Fig. 5**.

..... [1]

(b) **Fig. 6** shows an item manufactured from sheet aluminium.

Fig. 6



(i) Name **one** CNC machine that could be used to produce the bends in the sheet.

..... [1]

These knowledge and understanding questions required knowledge and understanding in the context of a given application. Generally Questions 5 (a) (i) and 5 (b) (i) were answered very well, however a significant proportion of candidates did not take into account the forms of the raw material in the context of the question and suggested some form of additive manufacturing method.

Question 5 (a) (ii) and (b) (ii)

- (ii) State how it is possible to produce many different shaped aluminium products using the same CNC machine.


.....
 [1]

- (ii) State how it is possible for this machine to produce different shaped bends.

.....
 [1]

Questions 5 (a) (ii) and 5 (b) (ii) were also well answered although fewer candidates got these marks than for parts (i). Many candidates simply stated that the machine had multiple axes when using different axes. Tools or coding were required for these marks.

Assessment for learning



It is probably worth noting here for these short and the longer written responses below that “efficiency” is most likely too vague to be given marks. If candidates use the word efficiency in any responses they would be best to clarify exactly what they mean, e.g. time efficient or even better to say exactly what they mean, e.g. manufacture can be completed more quickly.

Question 5 (b) (iii)

- (iii) Give **two** reasons why the manufacturer would choose to produce the holes by CNC punching instead of CNC laser cutting.

1

2 [2]

Most candidates gained 1 mark for this question by stating that punching was quicker than laser cutting. Candidates could have gained the second mark by explaining why laser cutting was quicker or relating their response to the heating effect of laser cutting. The most common response to not gain credit here was reference to accuracy.

Question 5 (c)

(c) Fig. 7 shows a connector manufactured from hexagonal aluminium stock.

Fig. 7



Name **one** CNC process that can be used to manufacture this item.

..... [1]

Like Question 5 (a) (i) and 5 (b) (i), a common mistake with this question was to ignore the form of the raw material and suggest an additive manufacturing machine. Similarly many candidates correctly named a machine for this manufacture (a lathe) when the question was actually asking for the process (turning).

Question 5 (d)

- (d) **Fig. 8** shows a gear assembly which was made from several pieces of metal joined together by laser welding.

Fig. 8



Explain why parts of small items such as this can be joined by CNC laser welding but not by conventional welding.

.....


.....

.....

..... [3]

Most candidates gained at least 1 mark and the majority gained 2 marks. These were for referencing the accuracy of CNC laser welding and the quickness of CNC laser welding. It was clear that some candidates had much more detailed knowledge of CNC laser welding and were able to give detailed responses drawing on this knowledge. Other candidates were able to draw on experience of conventional welding and apply this to the question. In either case common additional correct responses referred to the fact that conventional welding adds filler, increases the weld volume which could impact functionality or cause heating which may distort the component.

Assessment for learning

 Word processing, for candidates that are entitled to it, was very effective for this kind of question. There is the advantage that the number of marks available is clearly shown at the bottom right of the question and this can be used to help candidates formulate a suitable length response by having at least the same number of sentences as there are marks available.

Assessment for learning



Unlike, for example, Question 5 (d), the number of marks in the bottom right hand corner of a level of response question does not necessarily correlate to the number of lines or points that should be written. With the response not being constructed in the question paper, EAA candidates will also lose some of the clues as to how long the response needs to be. Centres could help candidates prepare for this by having them type a handwritten response that fills the response lines. That way candidates will have a gauge for how long their response should be. They can of course make their responses longer if need be.

Question 6 (a)

6 (a) State **two** ways that modern technology can improve engineering production.

1

.....

2

.....

[2]

This question required candidates to show knowledge, and was generally answered well.

Question 6 (c)*

(c)* Discuss the statement; 'Automation using modern technologies changes the workforce and the types of job that are carried out in an engineering company'.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

[6]

It was clear that many candidates had learned a stock response from practising Question 6 level of response questions from previous exam series. Unfortunately many candidates simply wrote a stock response that gave a very good account of the advantages and disadvantages of automation to manufacturing, for example improved accuracy and reduced manufacturing times, neglecting the fact that this question asked for the changes to the workforce and the types of jobs in an engineering company. Because this is a level of response question, candidates were limited to Level 1 if the spelling and punctuation in their response was poor enough to be intrusive. Likewise, the question asked about changes to the workforce and the types of jobs. Candidates who wrote just about changes to the workforce or the types of jobs were also limited to Level 1.

Assessment for learning



Many candidates with exam access arrangements used word processing just for this level of response question. While this is a good idea it must be remembered that poor spelling and punctuation can limit a response to Level 1 so it is vital that candidates check their responses carefully in order that the marks of a good response are not limited by spelling and punctuation.

Exemplar 1

This statement shows that by using machines and modern technology it is changing the work face because it is getting rid of actual workers and replacing them with machines. And this is making people lose jobs.

This first exemplar demonstrates a typical low scoring response, gaining 1 out of 6 marks. The candidate has written about a couple of points in the indicative content but the marks that can be gained are seriously limited by the short response given by the candidate, who has used just a fraction of the response lines available. It should be noted as well that additional answer space is available at the back of the exam paper.

Exemplar 2

Automation has changed the types of jobs certain people do as it creates new jobs. Although, automation reduces the size of the work force which in turn reduces the amount of jobs in engineering. On the other hand the machines must still be maintained and repaired which allows for a different type of job, furthermore automation must still be monitored and operated by other employees. In contrast, maintenance jobs are common with non-automated tools (hand tools) so it may not be considered a change to continue, automation changes the types and amount of jobs available as they replace a workforce but also create new jobs, another change, as the machines must be maintained. On the contrary, automation may

This exemplar continues on the next page

not create drastic changes within a workforce as it may only sort engineering products out or separate materials, as machines have a large start-up cost, they may not be used on a large scale. Therefore, [6]

6c automation may not always create large changes within a workforce.

in conclusion, I personally believe automation does create new jobs and changes within a workforce in an engineering company. These changes allow for better efficiency and a lessened chance of human error.

This exemplar shows a 3-mark response. The candidate has used all of the response lines in the question and then continued on the additional response lines at the end of the paper. The candidate has given two references to the changes to the work force and two to the kinds of jobs required to operate modern technologies for manufacturing. Although a lot has been written by the candidate there is an element of repetition, especially with regards to maintenance. Also, the last four lines of the response lines and all of the response on the additional pages are related to manufacturing not the workforce and so have not gained any further marks.

Exemplar 3

Automation has changed the workforce as some people have lost jobs due to machines replacing their role. Other workers have been re-trained to know how to safely operate the new machines. The remaining workforce have also had their roles changed as they no longer work directly with material and products, using traditional manufacturing processes, instead they program and overlook machines which ~~also~~ manufacture the products. They also have to help keep machines clean and maintain them regularly to ~~ensure~~ ensure no defective products. There also has to be workers present 24/7 and during the night in case a machine breaks.

This exemplar shows a good example of a 6-mark response. The candidate has made several references to the changes in the workforce such as retraining, safer working conditions and job losses. Likewise they have also made several references to the kinds of jobs such as programming, operating CNC machines and requirement of shift working because the machines are working 24/7. The candidate has not used all of the response lines but the quality and development of what they have written has easily produced a 6-mark response.

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