Examiners' Report

Lead Examiner Feedback

January 2021

Pearson BTEC Nationals

In Engineering (31706H)

Unit 1: Engineering Principles

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Introduction

This was the sixth series for the new style of examination for Unit 1 Engineering Principles, with this mandatory unit being assessed in the same format as in the previous series, which is a traditional paper-based examination that has a number of different styles of question including multiple choice, short written responses and calculations.

The focus of the paper being on a range of questions that assess applied mathematics, along with mechanical, and electrical and electronic principles. The range of questions continues to change for each examination series, with new topics being assessed along with others which have been assessed previously.

Centres are reminded that although the paper is always of the same structure, the nature of questions in each section will differ from one series to the next. It is important therefore for centres to remember that, due to nature of the specification, they should continue to ensure that learners are given the opportunity to become familiar with the processes of solving problems, and the mathematical skills required to arrive at solutions. It was noticeable that a significant number of learners were unable to apply basic arithmetic and algebraic techniques accurately.

As has been the case in recent examinations there were questions where multiple topics from the specification were drawn together in the form of synoptic questions towards the end of both Section B and Section C. It is important that learners are able to extract relevant information from such questions to be able to identify an appropriate starting point and develop this to a solution.

Furthermore, learners should be able to identify and use the appropriate units that relate to the electrical/electronic and mechanical principles being assessed; credit is awarded for the correct unit in some question in a similar way that identifying appropriate approaches is rewarded in other questions.

The paper had 21 questions. Each question was based on an engineering concept, with some questions having multiple parts. Learners were required to demonstrate knowledge and understanding related to a range of specification topics and apply this to arrive at solutions to the different questions in the examination. The paper is written in such a way as to provide as broad a coverage as possible for each area of the unit content. Questions had varying weightings attached to them, with 1 to 5 marks for the lower demand questions and up to 10 marks for questions where an extended response was required, such as the synoptic calculations towards the end of Section B and Section C for either mechanical or electrical and electronic principles.

Each of the questions that involved calculations was marked using both method (M) marks and accuracy (A) marks, as shown in the mark scheme. In a small number of instances, the 'correct answer only' was required; in these situations the follow through rule for 'error carried forward' was not applicable. The short written response questions were point marked against mark schemes that expected a linked response for the explain questions. A small number of questions were multiple choice for which learners had to select the correct answer from a range of four alternative options.

Introduction to the Overall Performance of the Unit

Learner performance was generally consistent across the paper, with some questions proving much more challenging than others due to their synoptic nature. Overall, there was evidence of learners having been taught well across much of unit content, although some topic areas performed less well than expected although this could well be as a result of reduced contact time during the summer term of 2020 and the challenges associated with remote learning. Aspects of the examination where performance was less consistent included expansion of brackets and calculating a velocity ratio. The extended calculations allowed for differentiation across learner abilities. It was again positive to see that across the cohort of learners there were examples of full marks being awarded for every question on the paper, with some learners achieving very high marks overall on the examination.

It continues to be important that learners are given the opportunity to practice responding to shorter and/or lower demand questions as well as extended calculation questions. As with previous series there were again a small number of occasions where learners did not present any working to support a numerical value that was stated in isolation as their answer to a question - an incorrect answer in this situation would achieve zero marks. It is important that learners follow the guidance on the front cover of the examination and show working as this allows access to ‘method marks’ should the solution be incorrect or only partial working presented.

Learners responded well to the questions in the examination and in many cases provided clear responses to the majority of the questions. A significant proportion of learners were able to achieve some marks that were available for the various extended calculations even when the correct solution was not found or only partial working that followed a suitable method was presented. A number of learners annotated their working to explain what each stage was; this is good practice as it allows the examiner to identify the process being taken to find a solution to problems.

Learners responded better to the written questions in comparison to previous examinations, with many learners providing answers and demonstrating an understanding of the concepts involved. As noted previously it is important that learners are prepared fully for the examination and have the opportunity to practice short-open response questions of the form that were included in both this paper, previous examinations and also in both examples of the sample assessment materials.

Individual Questions

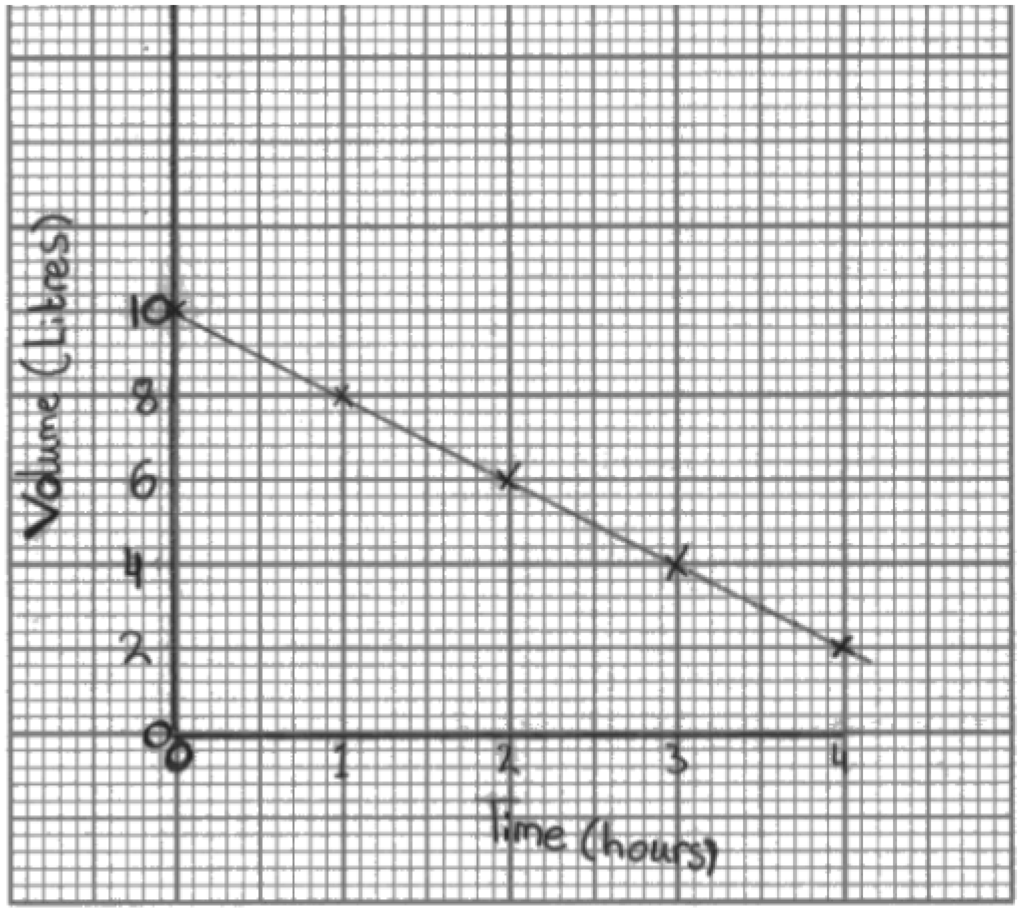
The following section considers each question on the paper, providing examples of learner responses and a brief commentary of why the responses gained the marks they did. This section should be considered with the examination paper and the corresponding mark scheme.

Question 1

This question was a single part question and was generally well answered by learners. A large proportion of learners were able to achieve full marks with the space provided being used to good effect. Even where learners did not achieve full marks the majority were able to provide appropriate labels and values for the two axes.

Where learners did not achieve full marks the reasons were generally incorrectly plotted, often with a positive gradient or not including an intercept with the volume axis. A number of learners plotted a graph of time against volume which were awarded marks for correct features that had been included.

This response gained 4 marks



In this response the learner has included both axes with appropriate titles and values (although not to the same scale). The intercept of the ‘volume’ axis is correctly shown at 10, and the straight line has been plotted with the correct gradient of -2.

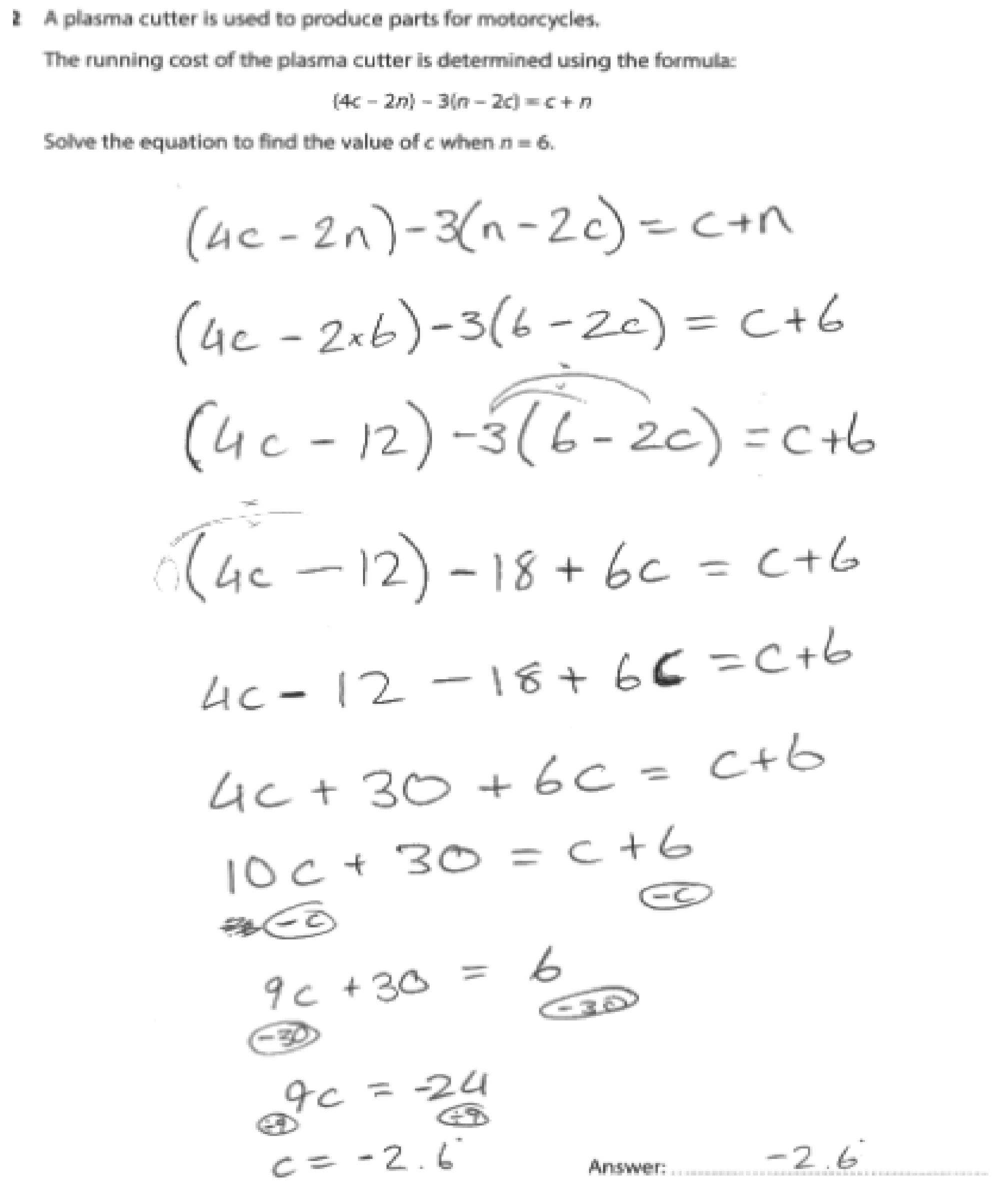
Question 2

This question was a single part question where learners needed to apply basic algebraic processes to expand the brackets in the given formula and then calculate the value of ‘c’ for a given value of ‘n’. A small number of learners followed good practice and substituted the value of ‘c’ that they calculated back in to the formula to confirm their answer was correct

It was somewhat disappointing that a large proportion of learners were not able to complete the expansion and simplification of the formula with accuracy, with common errors including not multiplying both terms by a factor of 3 for the second set of bracketed values, or when multiplying -3 by -2 the value was given as -6 rather than 6.

Some learners attempted to treat the formula as a quadratic and use the quadratic formula, although positively the vast majority of learners showed their working in full which allowed some follow through marks to be awarded.

This response gained 3 marks



2 A plasma cutter is used to produce parts for motorcycles.

The running cost of the plasma cutter is determined using the formula:

$$(4c - 2n) - 3(n - 2c) = c + n$$

Solve the equation to find the value of c when $n = 6$.

$(4c - 2n) - 3(n - 2c) = c + n$

$(4c - 2 \times 6) - 3(6 - 2c) = c + 6$

$(4c - 12) - 3(6 - 2c) = c + 6$

$(4c - 12) - 18 + 6c = c + 6$

$4c - 12 - 18 + 6c = c + 6$

$4c + 30 + 6c = c + 6$

$10c + 30 = c + 6$ $(-c)$

$9c + 30 = 6$ (-30)

$9c = -24$ $(\div 9)$

$c = -2.\dot{6}$

Answer: $-2.\dot{6}$

This response achieves three marks. The learner has correctly substituted the value of ‘n’ as 6 into the formula. They have then expanded the brackets correctly. Unfortunately the simplification has an error in the 4th line of working (should be -30 not +30). Subsequent working is correct and the value of ‘c’ is arithmetically correct. This allows the final mark to be awarded allowing follow through from the incorrect simplification.

Question 3

This question was answered well by a large proportion of learners, however there was a significant number of learners who made errors such as incorrect conversion of units, or failing to convert units. A number of learners also failed to calculate the radius of the roller from the given diameter. Other common errors included not squaring the radius when calculating the area of the circles.

A range of approaches were seen, with some learners calculating each surface individually and then adding them together, whilst others used a combined formula to arrive at an answer. The latter approach was more common.

This response has gained 4 marks.

3 The diagram shows a solid cylindrical roller that is manufactured from steel.

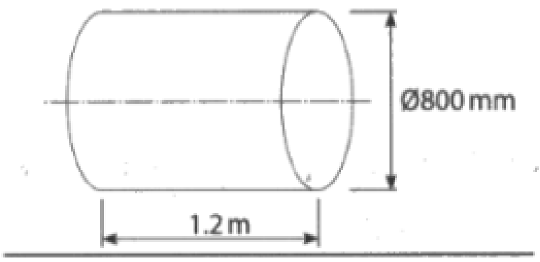


Diagram not to scale

Calculate the total surface area (TSA) of the solid cylindrical roller.

$TSA = 2\pi rh + 2\pi r^2$

$h = 1.2m \rightarrow 1200mm$

$d = 800mm \rightarrow R = 400mm$

$2 \times \pi \times 400 \times 1200 + 2 \times \pi \times 400^2$

$4,021,238.597\ mm^2$

The learner has recognising interpreted the diagram to calculate the radius and has converted the length of the roller into millimetres. A range of conversions were seen in learner responses, all of which were acceptable provided there was consistency between the dimensions.

Values have been substituted correctly, and working shown in full. The answer is correct, allowing full marks to be awarded.

Question 4

Q4 Majority completed with full marks. Some failed to get 4a) but then calculated 4b). Some dropped a mark in 4a) by not stating that 9-2=7.

Learners generally performed well on this question with a large proportion of learners being able achieve full marks across the two parts of the question. There was a small proportion of learners who selected an incorrect law of indices when answering part (a), or they did not fully simplify the formula.

This response gained 1 mark for part a and 1 mark for part b.

4 A milling machine depreciates due to wear and tear and this is represented by the formula:

$$d = \frac{a^9}{a^2}$$

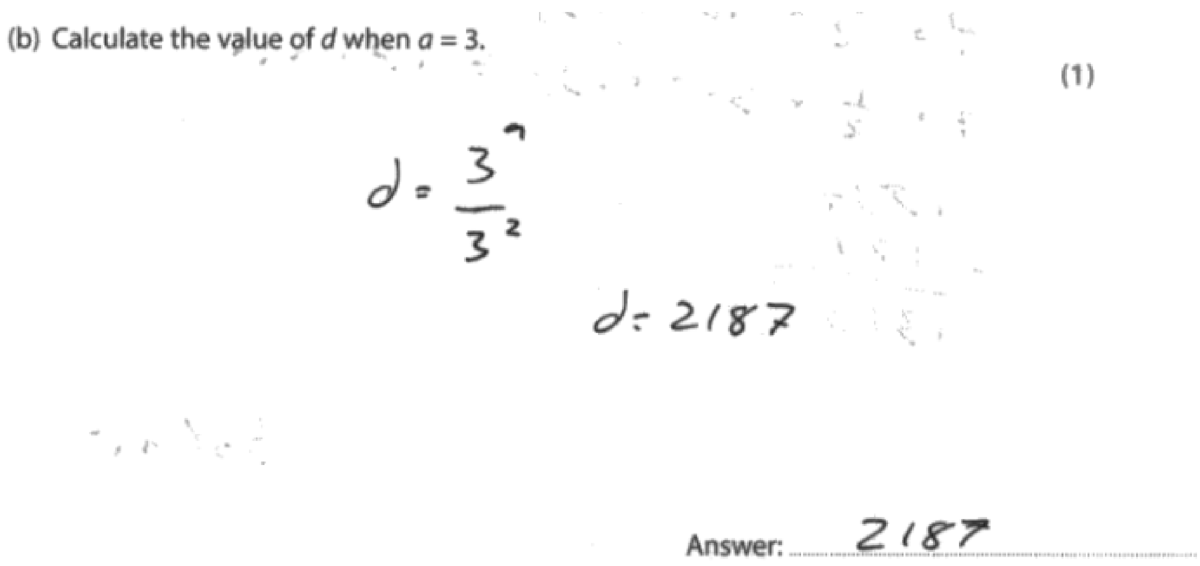
where d is the depreciation and a is the age of the milling machine.

(a) Simplify the formula using one of the laws of indices.

(2)

$d = \frac{a^9}{a^2} = a^{(9-2)}$

Answer: $a^{(9-2)}$


(b) Calculate the value of d when $a = 3$. (1)

$d = \frac{3^7}{3^2}$

$d = 2187$

Answer: 2187

The learner has selected the correct law of indices and has substituted the correct values in to the law. They have not however simplified, therefore can only be awarded 1 mark. They have then used the correct values to complete the calculation for part (b). They have not used the formula from part (a) however 1 mark can be awarded for the correct answer.

Question 5

Learners performed with limited success on this question with marks being awarded mostly around the middle of the range, although a significant number of learners achieved full marks. Learners often did not complete the conversion of degrees to radian measure and therefore were not able to correctly calculate the areas of the sectors of the circles. Where the correct process was followed, learners gained credit for their subsequent work.

A range of different approaches were taken by learners with full marks being awarded for the correct answer irrespective of the approach that was used.

This response gained 5 marks

5 The diagram shows a component that is part of a circular guard for a portable power tool.

The component is shaded grey.

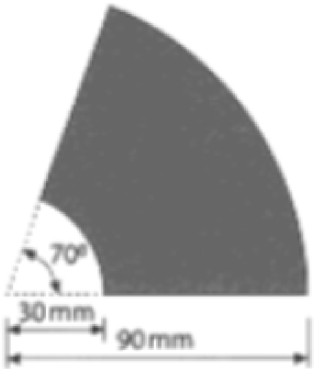


Diagram not to scale

Calculate the area of the component.

grey

πr^2

90mm

$\pi \times 90^2 = 8100\pi$

$8100\pi \div 5.14287$

$= 1575\pi \text{ mm}^2$

~~360÷70~~ = 5.14

$360 \div 70 = 5.14287$

white

$\pi \times 30^2 = 900\pi$

$900\pi \div 5.14287$

$= 175\pi \text{ mm}^2$

$1575\pi - 175\pi = 1400\pi = 4398.2297$

Answer: 4398.23 mm^2

This learner has not followed the examples of working shown in the mark scheme precisely, however they have arrived at the correct final answer. They have calculated the areas of full circles with radii of 30mm and 90mm. These have been expressed in terms of Pi. They have then calculated the proportion of the whole circles that form the shaded sector and applied this value to calculate the areas of the sectors. The working is accurate throughout. Note that answers in terms of Pi are acceptable.

Question 6

Question 6 was the first of the questions that assessed learners' understanding of mechanical principles. As is the format of the paper, this was also the first multiple choice question on the paper that requires learners to select the correct answer from a range of options.

This question asked learners to identify the substance that the relative density of a solid material is usually compared to. A significant proportion of learners correctly identified the correct answer of water.

Question 7

Learners performed less well on this multiple choice question when compared to that seen for question 6. A significant proportion of learners correctly identified the uniformly distributed load as having a value of 12 kN/m. The diagram is of the same format to that used for simply supported beam calculations in previous examinations, therefore it was somewhat surprising that learners were not able to interpret either the quantity or the convention used on the diagram.

Question 8

Learners performance was similar to question 7 with a large number of learners not identifying the correct unit for rotational inertia. This is an area of the specification that has been assessed in a longer question previously, therefore it is possible that learners lack the familiarity with this area of the specification that they may have with others.

Question 9

Question 9 was the first calculation in Section B and was related to fluid flow in a gradually tapering pipe. This is an area of the specification that has been addressed in a number of the previous examinations, therefore it would be expected learners would have some familiarity with the concepts involved.

A significant minority of learners did not interpret the wording of the question (a gradually tapering circular pipe) or the diagram that included a centreline and assumed that the pipe had a rectangular cross section. This prevented any marks from being awarded for part (a). Despite this, learners did then carry their value for the cross-sectional area forward and were able to achieve up to 3 marks for part (b).

As with many questions on this examination, and indeed on previous versions of the exam, learners again made rudimentary errors when substituting values into a formula and also in the rearranging of the formula. It is generally good practice to substitute values towards the end a calculation to reduce the opportunity for errors when rearranging.

Where learners were familiar with the concepts and their application, performance was much improved and many learners were able to achieve full marks.

This response gained 2 marks for part (a) and 3 mark for part (b)

9 The diagram shows a section of a gradually tapering circular pipe.

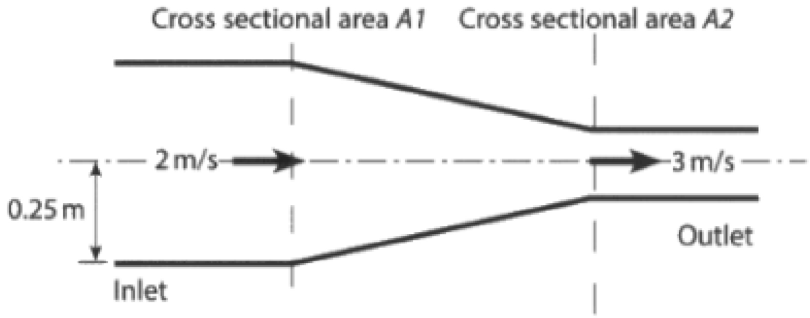


Diagram not to scale

(a) Calculate the cross sectional area ($A1$) of the pipe inlet.

(2)

$A_1 = \pi r^2 = \pi \cdot 0.25^2 = 0.196\ m^2$

Answer: 0.196 m^2

(b) Calculate the cross sectional area ($A2$) of the pipe outlet.

Assume that the pipe is rigid and the fluid is incompressible.

(3)

$A_1 \times V_1 = A_2 \times V_2$ $\qquad A_2 = \frac{A_1 \times V_1}{V_2}$

$0.196 \times 2 = A_2 \times 3$

$A_2 = \frac{0.196 \times 2}{3} = 0.131\ m^2$ Answer: 0.131 m^2

In this example the learner has identified the required information from the diagram, namely the radius of the pipe to calculate the cross-sectional area. This has been given to an appropriate level of precision. The learner has identified the correct formula to use for part (b) and has rearranged this with accuracy. Values have been substituted correctly and the answer has been accurately calculated.

For both parts of the question the learner has shown the formula they intend to use before populating them with values. This is good practice and allows the examiner to check that an appropriate approach has been taken to complete the calculations.

Question 10

Question 10 is a short open written response question with learner being asked to describe one use of a free-body diagram. The majority of learners who attempted this question were able to recognise that free-body diagrams are used to represent forces on an object, although this was not always developed to allow the second mark to be awarded. Some learners had misconceptions about the use of free-body diagrams with reference to using them to share design ideas being a common incorrect answer.

This response gained 2 marks.

10 Free-body diagrams are used by engineers.

Describe **one** use of a free-body diagram.

A free-body diagram is used to show which forces are acting on a body. The length of the arrow is proportional to the size of the force being show. E.g an arrow of 2cm = 4N and 1cm = 2N

In this response the learner has identified that a free-body diagram shows the forces acting on a body which is expanded with reference to the length of the arrow being proportional to the magnitude of the force. This is an interpretation of the first bullet point in the marking scheme.

Question 11

This question was another multi-part calculation in the mechanical principles section of the paper. The question assesses an aspect of the specification that has not been covered previously, namely velocity ratios. The first part focussed on calculating the velocity ratio of the compound gear train, with part (b) then required learners to calculate the velocity of the driven gear wheel.

As reported on previously, it is important that learners have familiarity with the principles associated with concepts such as velocity ratio, as a common error amongst learners was to include the idler gear in their calculations, when this should not be the case. There was generally some recognition of the velocity ratio being related to the number of teeth on the individual gears, although in many cases learners did not recognise that the correct approach and gave answers such as 10:6:18 for part (a).

For part (b) some learners used the correct approach but with incorrect values from part (a). This resulted in follow through marks being available.

This response gained 3 marks for part (a) and 3 mark for part (b)

11 The diagram shows a compound gear train. The driver gear is rotated at 300 revs/min.

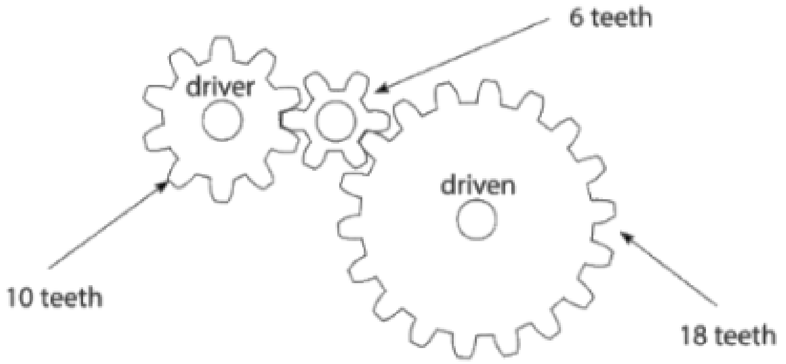


Diagram not to scale

(a) Calculate the velocity ratio of the compound gear train.

(3)

10 teeth = 300rpm

$\frac{10}{6} = 1.\dot{6}$

300 × 1.$\dot{6}$

= 500 ~~amp~~ rpm

$\frac{6}{18} = 0.\dot{3}$

500 × 0.$\dot{3}$

= 166.$\dot{6}$

$\frac{166.\dot{6}}{300} = 0.\dot{5}$

Answer: 0.$\dot{5}\dot{5}$

(b) Calculate the velocity of the driven gear in revs/min.

(3)

300 × 0.$\dot{5}$

= 166.$\dot{6}$ Rpm

300Rpm × 1.$\dot{6}$

= 500Rpm

500Rpm × 0.$\dot{3}$

= 166.6Rpm

Answer: 166.$\dot{6}$ Rpm

In part (a) the learner has interpreted the diagram correctly and used it to calculate the velocity of the driven wheel. This is a stage that is not required, however they have then used their calculated value to correctly determine the velocity ratio of the system. Answers in decimal or fraction form were acceptable.

In part (b) they have used the velocity ratio they calculated correctly and used this to calculate the velocity of the driven gear. The answer is shown correctly and 2 marks can be awarded.

Question 12

This was the first example in Section B of question that had more than one stage for learners to complete in order to reach the correct answer. Although a large proportion of learners were able to gain full marks, a significant proportion made errors at early stages, often attempting to convert the stress in the connecting rod in to a different unit. Some learners did not make sure that the dimensions were consistent, whilst a small minority did not calculate the direct strain correctly. Where this was the case, learners often gained some credit if they then followed the correct process to calculate Young's Modulus. This was a question where a mark was awarded for an appropriate unit.

This response gained 5 marks

12 The diagram shows a connecting rod.

The direct stress in the connecting rod is 857 N/mm².

The connecting rod extends by 0.03 m when it is subjected to a tensile load of 60 kN.

Diagram not to scale

Calculate the Young's Modulus of the material used for the connecting rod.

Give your answer in an appropriate unit.

Data

Direct stress = 857 N/mm²

Extension = 0.03m

Lenght = 2.5 m

Load = 60kN

Strain = Extension / 0. Lenght

= 0.03 m / 2.5 m

= 0.012

Young modulus = Direct stress / Direct strain

$E = \frac{\sigma}{\varepsilon}$

$E = \frac{857\ N/mm^2}{0.012}$

$E = 71416.6\ N/mm^2$

The learner has shown their working clearly and concisely. They have firstly converted dimensions into metres for consistency and calculated the direct strain. This has been substituted correctly into the formula for Young's

Modulus. The answer is correct and the unit given is consistent with the values used in the calculation, hence full marks can be awarded.

Question 13

As the final question in Section B, Question 13 draws together a number of concepts. In this example this included linear motion and conservation of momentum. A significant number of learners were able to access some marks, however the question was challenging for many.

A range of approaches were taken to calculate the combined velocity of the hammer and the spike after impact. Errors were quite common during this stage of the calculation as the acceleration was often calculated incorrectly, with some learners making incorrect assumptions. This was often then taken forward with some accuracy through the use of SUVAT equations to calculate the velocity of the combined hammer and spike, and then conservation of momentum applied with accuracy to find the impact velocity of the hammer. The latter stages were often completed with some accuracy despite incorrect prior working.

This response gained 7 marks

13 The diagram shows a drop hammer and spike.

The 12 kg hammer is dropped onto the stationary 8 kg spike.

The hammer remains in contact with the spike.

The ground has a resistive force of 800 N.

The spike is driven 0.15 m into the ground.

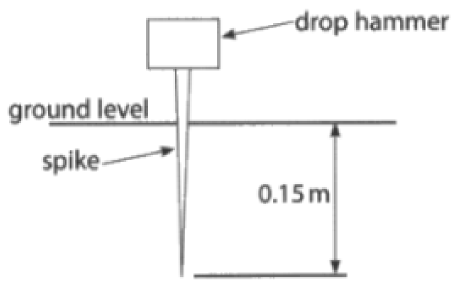


Diagram not to scale

Calculate the velocity of the hammer just before it makes contact with the spike.

Assume there are no energy losses from the collision between the hammer and the spike and from air friction.

$12v_1 + (8 \times 0) = 20v_2$

$u = ?$
$v = 0$
$a = -40\,m\,s^{-2}$
$s = 0.15\,m$
$t = x$

$F = ma$

$800 = 20 \times a$

$a = \frac{80}{2} = -40\,m\,s^{-2}$

$v^2 = u^2 + 2as$

$u^2 = v^2 - 2as$

$u = \sqrt{(v^2 - 2as)}$

$u = \sqrt{(0^2 - 2(-40 \times 0.15))}$

$u = 2\sqrt{3} = 3.464101615\,m\,s^{-1}$

$u = V_2$

$12v_1 = 20v_2$

$v_1 = \frac{20}{12} v_2$

$= \frac{20}{12} \times 2\sqrt{3}$

$v_1 = 5.77350...\,m\,s^{-1}$

Answer: $5.77\,m\,s^{-1}$ (3s.f)

No marks are awarded for calculating acceleration as an incorrect assumption has been made. The learner then uses this incorrect value for acceleration with accuracy, using an appropriate SUVAT equation and substituting values in appropriately. This is rearranged as required to calculate the velocity.

The learner then applies conservation of momentum using their value for the velocity. They follow the process through correctly, and have arrived at a final answer that is arithmetically correct based on the value for acceleration that they calculated earlier. 7 marks can be awarded in total for this response.

This response achieves 9 marks

$m_1v_1 = m_2v_2$ $v^2 = u^2 + 2as$

800N ↑ 20kg × 9.81 = 196.2 N ↓ ~~117.72N~~ ↓

~~313.92N~~

603.8N ↑

$s = 0.15$

$v = 0$

$u = ?$

$a = 30.19$

603.8 = 20 × a

a = 30.19

12 × 9.81 = 117.72N

$u^2 = -2as$

$-2(30.19 \times 0.15)$

$u^2 = -9.057$

$u = 3.009485\ ms^{-1}$

→ 20 × v_2 = 60.1897 $kgms^{-1}$

= 12 × v_1 → $v_1 = 5.016ms^{-1}$

Answer: $5.016ms^{-1}$

(Total for Question 13 = 9 marks)

In this example the learner has shown their working for each step they took, including some indication of how stages follow from each other. They have correctly calculated the acceleration of the combined hammer and spike following impact and have then followed the same process as the previous example by applying the principles of linear motion and conservation of momentum to calculate the velocity of the hammer immediately prior to impact. Some stages have been combined, and in places the working is not shown in full, however the correct answer has been stated therefore full marks are awardable.

Question 14

This was the first question in section C where knowledge of electrical/electronic principles were assessed. As with section B there are a small number of multiple choice questions at the start of the section.

In this question a large proportion of learners were able to identify that a dielectric material is an electrical insulator that can be polarised by an applied electric field.

Question 15

This was a further multiple choice question, with learners performing well compared to question 14. The majority of learners correctly identified that the circuit symbol was for a Zener diode.

Question16

Learners responded well to this short calculation question. The majority of learners identified the correct formula to use from the information booklet and correctly substituted values. A minority of learners selected the wrong formula and therefore were unable to gain credit.

This response achieves 2 marks.

16 A 3 v DC battery is connected to a 32 Ω resistor in series.

Calculate the power dissipated by the resistor.

$$P = \frac{V^2}{R}$$

$$P = \frac{3^2}{32} = \frac{9}{32} \text{ W}$$

Answer: $\frac{9}{32}$ W

The learner has selected the correct formula from the information booklet. They have then substituted values in correctly. The answer has been left in the form of a fraction, which as noted earlier, is an acceptable approach for providing answers.

Question17

The majority of learners found question 17 to be accessible with a large proportion being able to achieve two marks. Learners selected the correct formula from the information booklet and then populated it correctly. Although units did not need to be converted, a large proportion did convert the 5mm gap into metres. Provided this was then applied correctly, the full marks could be accessed. Some learners omitted the unit, or gave one that was not appropriate, which was somewhat surprising as the unit in this particular question is a derived unit.

This response has gained 3 marks.

17 The diagram shows two charged conducting plates with a potential difference applied across them.

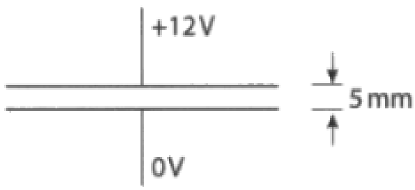


Diagram not to scale

Calculate the uniform electric field strength between the two plates.

Give your answer in an appropriate unit.

$$E = \frac{V}{d} = \frac{12}{5} = 2.4$$

Answer: 2.4 V/mm

The learner identified the correct formula to use and has populated this correctly. They have also stated the correct answer of 2.4 with a unit that is appropriate for the values used in their calculation.

Question 18

Question 18 was a short open response question which required learners to explain one advantage of using a stabilised power supply when prototyping circuits. Many learners recognised a link between the provision of a constant or controllable supply and the ability to obtain reliable results or to prevent damage to circuits. Some learners made reference to safety as a generic term, which gained no marks.

This response gains 2 marks.

18 Explain **one** advantage of using a stabilised power supply when prototyping electronic circuits.

An advantage of using a stab:lised power supply is that there will be a constant and steady flow of power going to the circuit making it easier to get a reliable test result instead of using a flow ~~of~~ electricity that isnt constant ~~could~~ and steady with spikes of power that could damage the circuit.

In this example the learner has recognised that the supply is constant and steady as an initial point in their explanation. They then expand on this by stating this leads to more reliable test results and can therefore be awarded the second mark.

Answers to explain questions should always have an initial point which is expanded on to gain both of the available marks.

Question 19

Question 19 was a two part calculation which assessed learners understanding of alternating current theory. The first part of the question was an area of the specification that has been assessed previously, this being the relationship between peak voltage and RMS voltage. A large proportion of learners were able to access the marks available for this part of the question.

There was some confusion when learners were calculating the average value of the voltage, with a small yet significant proportion adding the RMS voltage to the peak voltage and dividing by two. Other errors were generally as a result of incorrect rearranging in part (a).

This response gained 3 marks for part (a) and 2 marks for part (b)

19 A single phase A.C. power supply has an RMS voltage of 230 v.

(a) Calculate the peak value of the power supply.

(3)

RMS v = $\frac{\text{peak voltage}}{\sqrt{2}}$

~~peak voltage~~

peak voltage = RMS voltage × $\sqrt{2}$

peak voltage = 230v × $\sqrt{2}$

peak v = 325.27v

Answer: 325.27v

(b) Calculate the average value of voltage for the power supply.

(2)

Average value = $\frac{2}{\pi}$ × Maximum value

Maximum value = peak voltage

Average value = $\frac{2}{\pi}$ × 325.27

Average value = 207.073

This example follows the correct process in both part (a) and part (b). As a result all marks can be awarded. The learner has shown all of the stages, including rearranging in part (a) before they substituted values. The value of the peak voltage has been carried forward correctly in to part (b) and the correct value calculated.

Learners are encouraged to show all rearranging algebraically before substituting values as this allows examiners to note if an incorrect rearrangement has been completed or if incorrect values have been substituted.

This response gained 2 marks for part (a) and 2 mark for part (b)

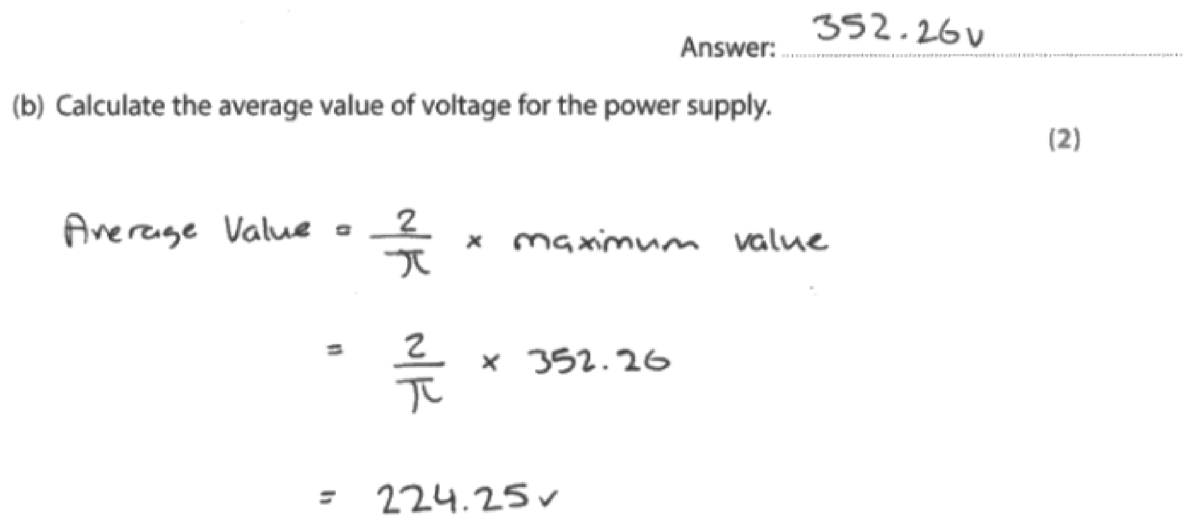
(a) Calculate the peak value of the power supply.

(3)

Peak Voltage = R.MS × $\sqrt{2}$

= 230 × $\sqrt{2}$

= 352.26 V


Answer: 352.26v

(b) Calculate the average value of voltage for the power supply.

(2)

Average Value $= \frac{2}{\pi} \times$ maximum value

$= \frac{2}{\pi} \times 352.26$

$= 224.25$v

For part (a) the learner has used the correct formula which has been rearranged and values substituted with accuracy. The answer has digits transposed, therefore only 2 marks can be awarded. Had the learner not shown their working, then part (a) would have been awarded zero marks. In part (b) the learner has used their peak voltage (352.26) in the correct formula, allowing follow through from part (a). The answer is arithmetically correct, therefore 2 marks can be awarded for part (b).

Question 20

This was a further calculation that assessed a topic area that has been covered to an extent in previous series. Although a significant proportion of learners achieved full marks, it was clear that this was a topic area that they were less familiar with and often made errors in the second part of the calculation. Where learners achieved only partial marks this tended to be for making mistakes when calculating the value of H. It was common for learners to omit the current and calculate a value of 1200. This was often then applied with some accuracy in the second stage of the calculation.

A further common mistake was to not include the correct value for μ_0 from the information booklet of formulae and constants, with many learners simply substituting the value of 1 instead. This resulted in a proportion of learners failing to achieve full marks despite other aspects of the calculation being correct.

This response gained 6 marks.

20 The diagram shows a coil with 120 turns wrapped around a former. The coil has a relative permeability (μ_r) of 200.

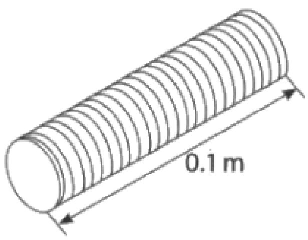


Diagram not to scale

A current of 1.5 A flows through the coil.

Calculate the flux density of the magnetic field around the coil.

$B = \frac{\phi}{A}$ $H = \frac{NI}{L}$

$F = BIL$ $H = \frac{120 \times 1.5}{0.1}$

$H = 1800$

$$\frac{B}{H} = \mu_0 \mu_r$$

$$B = \mu_0 \mu_r H$$

$$B = 1800 \times (4\pi \times 10^{-7}) \times 200$$

$$B = 0.4523893421$$

Answer: 0.45 (2sf) $NA^{-1}m^{-1}$

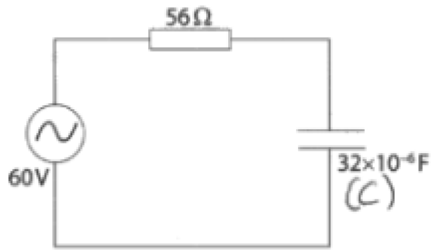
All of the working is correct in this response. They have shown the formulae they intend to use before substituting values. This, as noted previously, is good practice. As with other example responses, the learner has rearranged prior to substituting values, and has then substituted all of the correct values. The answer has been shown to an appropriate degree of accuracy, as instructed on the front cover of the examination paper.

Question 21

Learners often achieved some marks for partial working in this question, although there were a significant number of learners who achieved full marks. Partial working often involved either calculating the value of Z for the first stage and an attempt at calculating the capacitive reactance X_C. It was encouraging that even where learners did not complete the calculations in full, they were able to recognise that they needed to calculate the value of Z as an initial stage to the solution. A proportion of learners made errors during the rearranging stage to calculate the value of X_C although follow through marks were awarded if an incorrect value was used when applying the correct method at subsequent stages.

This response gained 10 marks.

21 A 32×10^{-6} F capacitor is connected to a 60V A.C. supply in series with a 56Ω resistor.



The current flowing in the circuit is 0.16 A.

Calculate the frequency of the A.C. supply.

$X_C = \frac{1}{2\pi f C}$

$Z = \sqrt{X_C^2 + R^2}$

$Z^2 = X_C^2 + R^2$

$-Z^2$

$X_C^2 + R^2 - Z^2 = 0$

$-X_C^2$

$R^2 - Z^2 = -X_C^2$

$56^2 - 375^2 = -X_C^2$

square root ← $\sqrt{137489} = X_C^2$

$X_C = 370.79$

$I = \frac{V}{Z}$

$Z = \frac{V}{I}$

$Z = \frac{60}{0.16}$

$Z = 375$

$X_C = \frac{1}{2\pi \times F \times C}$

$370.7 = \frac{1}{2\pi \times F \times 32\times10^{-6}}$

$370.1 \times 2\pi \times 32\times10^{-6} = \frac{1}{F}$

$0.074 = \frac{1}{F}$

$f = 1 \div 0.074$

$f = 13.41$

The learner has completed all of the stages of the calculation with accuracy, and has followed the correct process throughout. Some brief annotation is shown, and values have been used correctly throughout.

This response gained 8 marks.

$$R_T = \frac{V}{I} = 375\ \Omega = Z$$

$$X_C = \sqrt{Z^2 - R^2} = \sqrt{375^2 - 56^2} = 269.24\ \Omega.$$

$$X_C = \frac{1}{2\pi f C} \qquad \frac{X_C}{1} = \frac{1}{2\pi f C}$$

$$X_C \times 2\pi f C = 1$$

$$f = \frac{1}{X_C \times 2\pi C} = \frac{1}{269.24 \times 2 \times \pi \times 30 \times 10^{-6}} = 19.70\ \text{HZ}$$

Answer: 19.70 HZ

The first stage of the calculation for Z has been completed with full accuracy, allowing the first 3 marks to be awarded. The learner has also recognised the relationship between Z, R and X_C, rearranging and substituting values correctly, however the calculated value for X_C is incorrect. The learner then rearranges correctly in terms of f, but does not substitute the correct values (30×10^{-6} has been used instead of 32×10^{-6}). The final answer is arithmetically correct therefore 1 mark can be awarded allowing follow through for the incorrect substitution.

Summary

Based on their performance on this paper, learners should:

- Attempt all questions on the paper as method marks are often awarded for partial solutions or partial working.
- Show working in full as again this allows access to method marks. If arithmetic errors are made then marks could still be awarded if an incorrect value has been taken forward.
- Show the formulae that are being used, this can allow examiners to check the correct substitutions have been made.
- Rearrange formulae before substituting values.
- Practice algebraic operations such as expanding brackets, simplifying expressions and rearranging and manipulating algebraic formulae to change the subject of the formula.
- Practice conversions between different units and the application of standard form.
- Use appropriate units where the question asks for them as marks are awarded for the correct unit.
- Avoid excessive rounding at intermediate stages of calculations, or truncating values.
- Provide linked responses for ‘explain’ questions. An initial lead point should always be expanded upon with either an expansion or a justification.

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