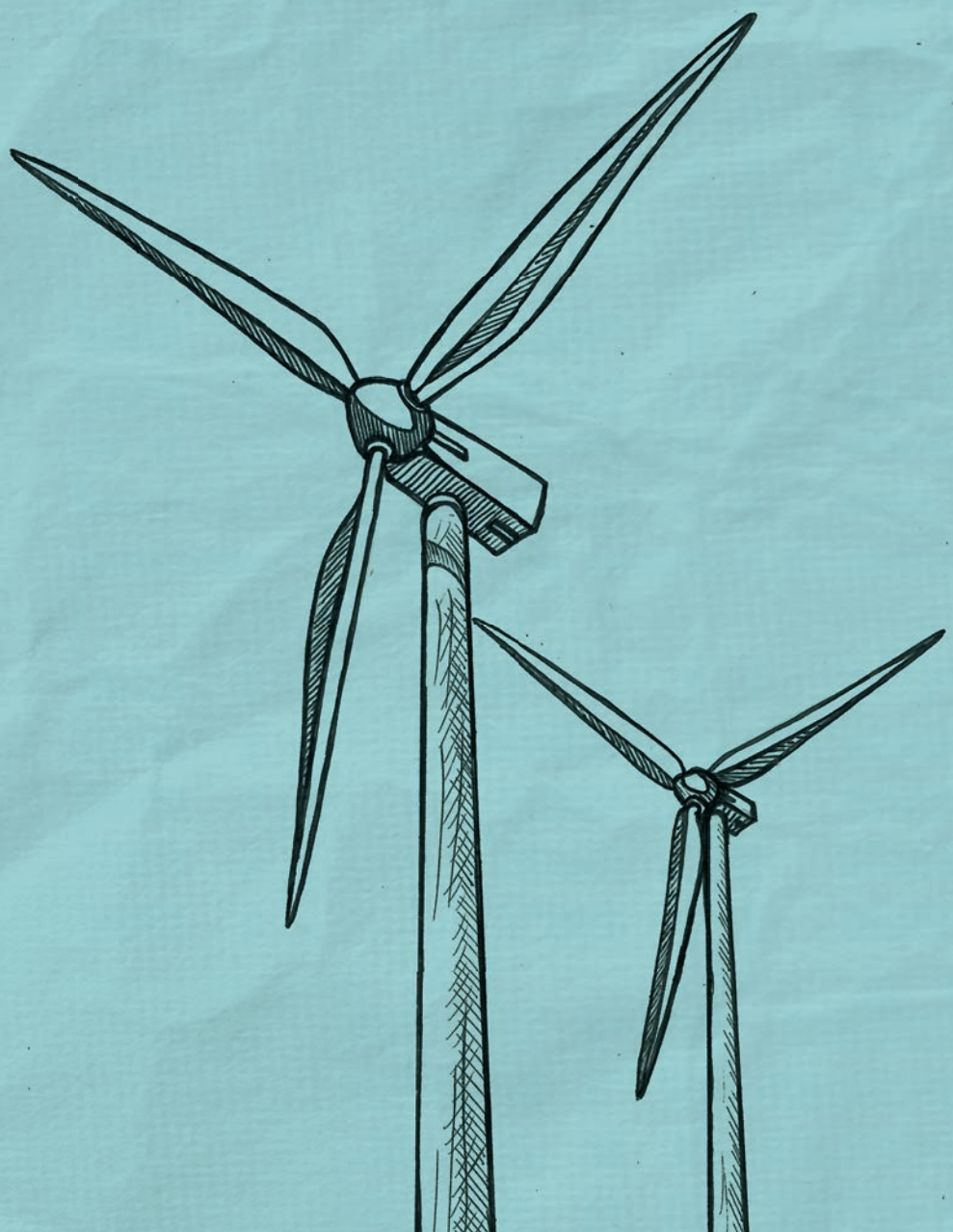
REVISE BTEC NATIONAL Engineering

REVISION WORKBOOK



Pearson

REVISE BTEC NATIONAL Engineering

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A note from the publisher

While the publishers have made every attempt to ensure that advice on the qualification and its assessment is accurate, the official specification and associated assessment guidance materials are the only authoritative source of information and should always be referred to for definitive guidance.

This qualification is reviewed on a regular basis and may be updated in the future. Any such updates that affect the content of this Revision Workbook will be outlined at www.pearsonfe.co.uk/BTECchanges.

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Introduction

Which units should you revise?

This Workbook has been designed to help you revise the skills you may need for the externally assessed units of your course. Remember that you won't necessarily be studying all the units included here – it will depend on the qualification you are taking.

BTEC Level 3 National Qualification	Externally assessed units
For each of: Extended Certificate Foundation Diploma Diploma	1 Engineering Principles 3 Engineering Product Design and Manufacture
Extended Diploma	1 Engineering Principles 3 Engineering Product Design and Manufacture 6 Microcontroller Systems for Engineers

Your Workbook

Each unit in this Workbook contains either one or two sets of revision questions or revision tasks, to help you **revise the skills** you may need in your assessment. The selected content, outcomes, questions and answers used in each unit are provided to help you to revise content and ways of applying your skills. Ask your tutor or check the Pearson website for the most up-to-date **Sample Assessment Material** and **Mark Schemes** to get an indication of the structure of your actual assessment and what this requires of you. The detail of the actual assessment may change so always make sure you are up to date.

This Workbook will often include one or more useful features that explain or break down longer questions or tasks. Remember that these features won't appear in your actual assessment!

Grey boxes like this contain **hints and tips** about ways that you might complete a task, interpret a brief, understand a concept or structure your responses.

Guided

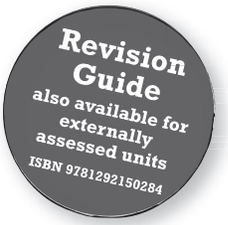
This icon will appear next to an example partial answer to a revision question or revision task. You should read the partial answer carefully, then complete it in your own words.

This is **a revision activity**. It will help you understand some of the skills needed to complete the revision task or question.

Links

These boxes will tell you where you can find more help in Pearson's BTEC National Revision Guide. Visit **www.pearsonschools.co.uk/revise** for more information.

There is often space on the pages of this Workbook for you to write in. However, if you are carrying out research and make ongoing notes, you may want to use separate paper. Similarly, some units will be assessed through submission of digital files, or on screen, rather than on paper. Ask your tutor or check the Pearson website for the most up-to-date details.



Contents

A small bit of small print

Pearson publishes Sample Assessment Material and the specification on its website. That is the official content, and this book should be used in conjunction with it. The revision questions and revision tasks in this book have been written to help you practise what you have learned in your revision. Remember: the real assessment may not look like this.

Unit 1: Engineering Principles

Your exam

Unit 1 will be assessed through an exam, which will be set by Pearson. You will need to use your ability to solve problems that require individual and combined application of mathematical techniques, and electrical, electronic and mechanical principles to solve engineering problems. You will explore and relate to the engineering contexts and data presented as you respond to short- and long-answer problem-solving questions.

Your Revision Workbook

This Workbook is designed to **revise skills** that might be needed in your exam. The selected content, outcomes, questions and answers are provided to help you revise content and ways of applying your skills. Ask your tutor or check the Pearson website for the most up-to-date Sample Assessment Material and Mark Scheme to get an indication of the structure of your actual exam and what this requires of you. The detail of the actual exam may change so always make sure you are up to date. Make sure you check the instructions in relation to:

- what you need to take into the exam, e.g. a ruler, protractor, pencil, scientific calculator that must not be programmable and that meets the requirements stated
- explaining each stage of your solution and showing all your working so your method is clear when answering any question involving mathematical calculations and stating your answer clearly in the appropriate units
- use of a formulae and constants booklet with reminders of mathematical laws, rules and standard formulae, and constants and engineering formulae – you can find this on pages 37–41 of this Workbook.

To support your revision, this Workbook contains revision questions to help you revise the skills that might be needed in your exam. Each revision paper is divided into three parts:

Section A: Applied mathematics

You will need to demonstrate your knowledge of the algebraic and trigonometric mathematical methods covered in the unit. Each question will have an engineering context but will focus on mathematical methods.

Section B: Mechanical principles

You will need to combine good working knowledge of mathematical methods and an understanding of the full range of mechanical engineering topics covered in the unit. You will need to be familiar with the application of a range of formulae to solve mechanical engineering problems.

Section C: Electrical/Electronic principles

You will need to combine good working knowledge of mathematical methods and an understanding of the full range of electrical/electronic engineering topics covered in the unit. You will need to be familiar with the application of a range of formulae to solve electrical/electronic engineering problems.

Types of questions

There is guidance in this Workbook for the skills involved in answering the following types of questions.

Describe Explain Find Calculate Solve Draw Label Identify State

Links To help you revise skills that might be needed in your Unit 1 exam, this Workbook contains two sets of revision questions starting on pages 2 and 19. The first is guided and models good techniques to help you develop your skills. The second gives you the opportunity to apply the skills you have developed. See the introduction on page iii for more information on features included to help you revise.

Revision test 1

To support your revision, this Workbook contains revision questions to help you revise the skills that might be needed in your exam. Ask your tutor or check the Pearson website for the latest **Sample Assessment Material** and **Mark Scheme** to get an idea of the structure of the actual exam and what this requires of you. Details of the actual exam may change so always make sure you are up to date.

SECTION A: Applied mathematics

Answer ALL questions. Write your answers in the spaces provided.

Complete the guided workings below to give an answer for each of the questions in Section A. Be sure to make use of the information booklet containing formulae and constants on pages 37–41.

1 A laser cutter is being used to make two straight cuts in a sheet of acrylic. The position of the cuts can be represented using a pair of linear simultaneous equations: $8y = 16x + 9$ and $-2y = 8x - 12$

Find the coordinates (x, y) where the cuts intersect.

When answering 'Find' questions you need to determine the solution to a problem given the information provided. This might involve applying the particular technique or mathematical method mentioned in the question.

Guided

Let $8y = 16x + 9$ be equation (1).

Let $-2y = 8x - 12$ be equation (2).

Links See page 5 of the Revision Guide to revise solving linear simultaneous equations.

Multiply equation (2) by 2 to give: .....

..... Let this be equation (3).

Subtract equation (3) from (1) to give: .....

.....

Rearrange to make y the subject: .....

.....

Solve for y: .....

.....

Substitute y into equation (2) and solve for x: .....

.....

Check the answer by substituting x and y into (1):

.....

.....

Answer: The cuts intersect when x = ... and y = ...

Total for Question 1 = 4 marks

2 A train is accelerating along a level track.
The distance, s, travelled by the train as a function of time, t, is given by the equation $s = 7t + 2t^2$.

Calculate the time taken for the train to travel a distance of 15 m.

When answering 'Calculate' questions, you need to find the number or amount of something using the information provided in the question. This might involve applying a particular technique, mathematical method or formula.

Guided

Substitute $s = 15$ into the equation to give:

$15 = 7t + 2t^2$

Rearrange into the general form of a quadratic, making one side equal to zero:

$2t^2 + 7t - 15 = 0$

Rewrite the equation in the form $2t^2 + 10t - 3t - 15 = 0$

Then: $2t(t + \ldots\ldots\ldots) - 3(t + \ldots\ldots\ldots) = 0$

Take $(t + \ldots\ldots\ldots)$ as a common factor to give:

$(t + \ldots\ldots\ldots)(2t - 3) = 0$

Equate each of the brackets to zero and find two possible values of t:

$(2t - \ldots\ldots\ldots) = 0$ so $t = \ldots\ldots\ldots$.

$(t + \ldots\ldots\ldots) = 0$ so $t = \ldots\ldots\ldots$.

Check values for t by substituting back into original equation:

$\ldots\ldots\ldots$.

$\ldots\ldots\ldots$.

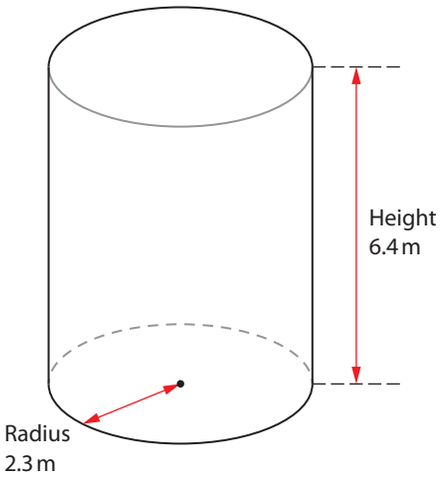
The negative value of t is not a feasible response in the given scenario.

Answer: The time taken for the train to travel 15 m is $\ldots\ldots\ldots$.

Links See pages 7–8 of the Revision Guide to revise solving quadratic equations.

Total for Question 2 = 5 marks

3 An engineering company manufactures storage tanks from sheet metal. A new design for an open-topped cylindrical tank needs to be analysed to determine the amount of material required in its construction.



Calculate the external surface area of the open-topped tank (the material thickness is negligible).

Guided

From the formula booklet, total surface area of a cylinder is: .....

.....

But this includes both top and bottom of a fully enclosed cylinder. In this case, only the bottom is required, so the surface area is: .....

.....

Substituting $h = 6.4$ and $r = 2.3$ gives: .....

.....

.....

Answer: The surface area of the open topped tank A = ...m^2

Links See page 14 of the Revision Guide to revise finding the surface area and volume of regular shapes.

Total for Question 3 = 3 marks

4 The voltage, v_c, across a charging capacitor at time, t, can be represented by the equation:
$\ln 12e^{-t} = 2$

Calculate the value of t. Show evidence of the use of the laws of logarithms in your answer.

Guided

Apply the rule $\ln AB = \ln A + \ln B$: .....

.....

Apply the rule $\ln A^x = x \ln A$: .....

$\ln 12 - t \ln e = 2$

Since $\ln e = 1$, then: .....

Rearrange to make t the subject: .....

.....

.....

Solve for t: .....

.....

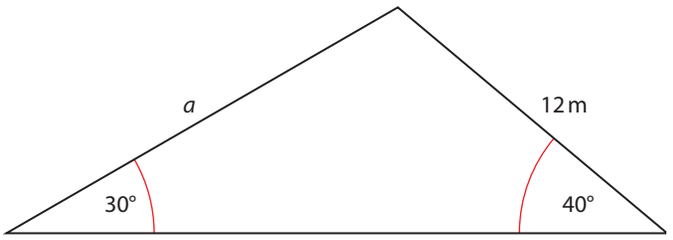
.....

Answer: $t =$ .....

Links See page 2 of the Revision Guide to revise applying the rules of logarithms.

Total for Question 4 = 5 marks

5 An engineer has been given a drawing of a triangular steel plate where all the dimensions have not been stated.



Calculate the length of side *a*.

Guided

From formula booklet, the sine rule is: .....

.....

.....

Rearrange to make *a* the subject: .....

.....

Diagram has been marked up with all sides and angles used in sine rule.

Substitute values into sine rule: .....

.....

.....

Solve for *a*: .....

.....

.....

Answer: Length of side *a* is .....

Links See page 12 of the Revision Guide to revise the application of the sine rule.

Total for Question 5 = 4 marks

END OF SECTION

TOTAL FOR SECTION A = 21 MARKS

SECTION B: Mechanical principles

Use appropriate units in your answers.

Complete the guided workings below to give an answer for each of the questions in Section B. Be sure to make use of the information booklet containing formulae and constants on pages 37–41.

6 Identify the units for direct stress.

A N

B kg/m^3

C N/m^2

D N m

Total for Question 6 = 1 mark

7 Identify the term that describes the relationship between direct stress and direct strain.

A Young's Modulus

B Extension

C Modulus of rigidity

D Uniformly distributed load

Total for Question 7 = 1 mark

8 A sports car with mass 1569 kg accelerates uniformly from rest to a velocity of 100 km/h in a time of 4.7 s.

(a) Calculate the acceleration of the vehicle. 3 marks

Guided

To find acceleration use $v = u + at$ (from the formula booklet).

Assign values to the variables from information in the question:

F = ?

u = 0

v = 100 km/h = ... = 27.77 m/s

a = ?

t = 4.7 s

m = 1569 kg

Rearrange to make a the subject: .....

.....

Substitute values of v, u and t into formula: .....

a = ...

a = ...m/s^2

Answer: The acceleration of the vehicle is .....m/s^2

(b) Calculate the force which is accelerating the vehicle. 2 marks

To find force use $F = ma$ (from the formula booklet).

Substitute values of m and a into the formula: .....

F = ...

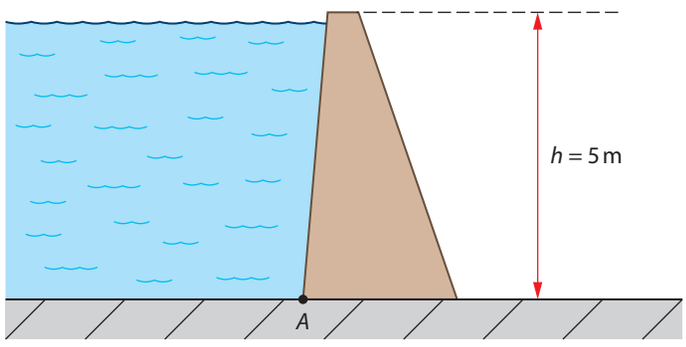
F = ... N

Answer: The force acting to accelerate the vehicle is ..... N

Links See page 22 of the Revision Guide to revise applying the SUVAT equations.

Total for Question 8 = 5 marks

9 A dam is used to hold water in a reservoir. The retaining wall of the dam is 5 m high and 9 m wide. Assume the density of water is 1000 kg/m^3.



(a) Calculate the hydrostatic thrust acting on the dam. **5 marks**

Guided

To find hydrostatic thrust, F, use $F = \rho gAx$ (from formula booklet).

Assign values to the variables from information in the question:

$\rho = 1000\,kg/m^3$

$g = 9.81\,m/s^2$ (from formula booklet)

$A = 5 \times 9 = 45\,m^2$

Recall that for a rectangular plane surface the height at which average pressure acts is:

$x = h/2 = 5/2 = 2.5\,m$

Substitute values into $F = \rho gAx$:

$F =$ ..... . × ..... . × ..... . × ..... .

$F =$ ..... . N

Answer: The hydrostatic thrust acting on the dam is ..... . N

(b) Calculate the turning moment around the base of the retaining wall. **3 marks**

Guided

Replace hydrostatic thrust with an equivalent single point force acting at the centre of pressure. For a rectangular plane surface the centre of pressure is distance $\frac{2}{3}h$ below the free surface

and so distance ..... . from its base.

To find the moment of a force use $M = Fd$.

Assign values of the variables from the information given in the question:

$F = 1103\,625\,N$

$d = 5/3 = 1.6\,m$

Substitute values into $M = Fd$:

$M =$ ..... . × ..... . = ... N m (clockwise)

Answer: The moment around the base of the retaining wall is ..... . N m

Links See page 29 of the Revision Guide to revise forces acting on a submerged plane surface.

Total for Question 9 = 8 marks

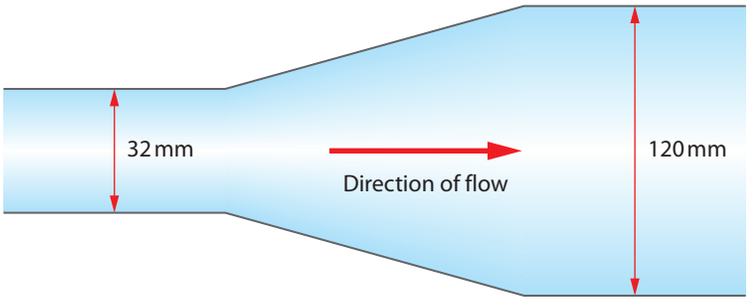
10 Explain one way in which the efficiency of a mechanical system might be increased.

.....

.....

Total for Question 10 = 2 marks

11 Waste water flows through a pipe, which increases in diameter from 32 mm to 120 mm.
The initial flow velocity of the water $v_1 = 3$ m/s.



Calculate the output flow velocity of the water.

Guided

To find the output flow velocity, v_2, use $A_1 \times v_1 = A_2 \times v_2$ (from the formula booklet).
Rearrange to make v_2 the subject:

$v_2 =$ ..... .

Assign values to the variables from information in the question:

$A_1 = \frac{\pi D_1^2}{4} =$ ..... . m^2

$A_2 = \frac{\pi D_2^2}{4} =$ ..... . m^2

$v_1 = 3$ m/s

Substitute values into formula: .....

$v_2 =$ .....

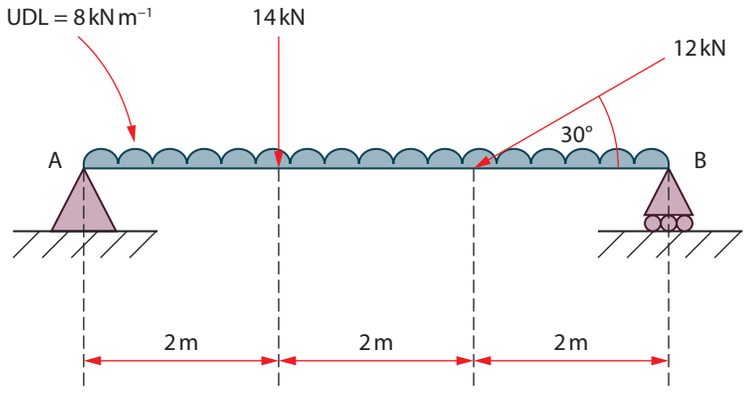
.....

Answer: The output flow velocity of the waste water is ..... . m/s

Links See page 31 of the Revision Guide to revise fluid flow in a gradually tapering pipe.

Total for Question 11 = 5 marks

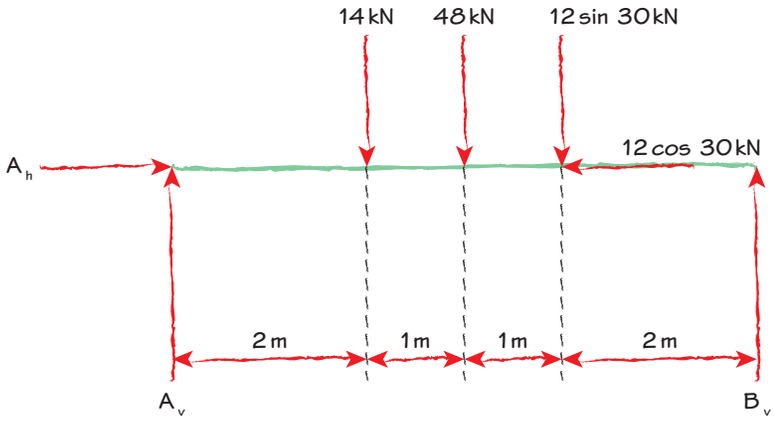
12 When designing supports for a bridge both vertical and horizontal loading needs to be considered to ensure that the bridge is supported safely.
The diagram shows a simply supported beam in static equilibrium.



(a) Calculate the vertical and horizontal reaction forces present at the pin support A. **6 marks**

Guided

UDL replaced with a single point force acting at the centre of the distribution.
Total force acting along the length of the UDL = 8 kN/m¹ x 6 m = 48 kN.
12 kN force acting at 30° from the horizontal resolved into vertical and horizontal components
Free body diagram of the beam:



Beam is in static equilibrium so $\sum F_h = 0$ (assume +ve acts left to right).
$\sum F_h = A_h - 12\cos 30 = 0$
A_h = ... kN
Beam is in static equilibrium so $\sum M = 0$.
Find A_v by taking moments about B (assume +ve acting clockwise).
$\sum M_B = (6 \times A_v) - (48 \times 3) - (14 \times 4) - (2 \times 12\sin 30) = 0$

.....

.....

A_v = ... kN

Answer:

Vertical reaction force at support A is ..... kN

Horizontal reaction force at support A is ..... kN

(b) Calculate the vertical reaction force present at the roller support B. 3 marks

Guided

Beam is in static equilibrium so $\sum M = 0$.

Find B_v by taking moments about A (assume +ve acting anticlockwise).

$\sum M_A = (6 \times B_v) - (48 \times 3) - (14 \times 2) - (4 \times 12 \sin 30) = 0$

.....

.....

B_v = ... kN

Answer: Vertical reaction force at support B is ..... kN

Check solution by confirming that $\sum F_v = 0$

$A_v + B_v = 48 + 14 + 12 \sin 30$

..... + ... = 68 kN

Links See page 18 of the Revision Guide to revise simply supported beams.

Total for Question 12 = 9 marks

END OF SECTION

TOTAL FOR SECTION B = 31 MARKS

SECTION C: Electrical/Electronic principles

Use appropriate units in your answers.

Complete the guided workings below to give an answer for each of the questions in Section C. Be sure to make use of the information booklet containing formulae and constants on pages 37–41.

13 Identify the statement which best describes the rectification of an electrical current.

A Stepping up

B Converting AC to DC

C Reducing impedance

D Converting DC to AC

Total for Question 13 = 1 mark

14 Identify the unit of measure for capacitance.

A Farad

B Ohm

C Tesla

D Ampere

Total for Question 14 = 1 mark

15 An engineer is analysing a single phase AC waveform on an oscilloscope.
The waveform has periodic time 0.025 s and peak voltage 155.5 V.

(a) Calculate the frequency of the waveform. **2 marks**

Guided

To find the frequency of the waveform use $T = \frac{1}{f}$ (from the formula booklet).

$f =$ ..... . Hz

Answer: The frequency of the waveform is ..... . Hz

(b) Calculate the root mean square (RMS) voltage. **2 marks**

Guided

To find the RMS voltage of the waveform use RMS voltage $= \frac{\text{peak voltage}}{\sqrt{2}}$.

RMS voltage $= \frac{\text{peak voltage}}{\sqrt{2}}$ (from the formula booklet)

RMS voltage = ... V

Answer: The RMS voltage of the waveform is V

(c) Explain why the RMS voltage (or current) is useful to engineers working with AC powered systems. **2 marks**

When answering 'Explain' questions, you need to give a clear written explanation relating to a particular component, feature or process. You may need to identify a relevant characteristic and then explain its effect.

Guided

The RMS voltage (or current) is equal to an equivalent DC voltage (or current) that when connected across a ..... . would produce the same ..... . effect. This is useful because RMS values can be used in ..... . law and power calculations when dealing with ..... . loads.

Links See page 63 of the Revision Guide to revise sinusoidal waveform parameters.

Total for Question 15 = 6 marks

16 An ideal transformer used in a USB phone charger has an input voltage of 230 V AC. The transformer output voltage is 5 V AC. The transformer provides a current of 2 A to the charger circuit. There are 200 turns on the secondary transformer coil.

(a) Calculate the number of turns in the primary coil. 3 marks

Guided

To find the number of turns in the primary use $\frac{V_1}{V_2} = \frac{N_1}{N_2}$ (from the formula booklet).

Assign values to the variables from information in the question:

$V_1 = 230\,V$ $V_2 = 5\,V$

$I_1 = ?$ $I_2 = 2\,A$

$N_1 = ?$ $N_2 = 200$

Make N_1 the subject of the formula:

$N_1 =$ ..... .

Substitute values into the equation:

$N_1 =$ ..... . = ...

Answer: The primary coil has ..... . turns.

(b) Calculate the current in the primary coil of the ideal transformer. 3 marks

Guided

In an ideal transformer the power in the primary coil is equal to the power in the secondary coil.

This means that $P = V_1 \times I_1 = V_2 \times I_2$.

Rearrange to make I_1 the subject:

$I_1 =$ ..... .

Substitute values into the equation:

$I_1 =$ ..... . = ... A

Answer: The current in the primary coil is ..... . A

(c) State the two most significant forms of transformer core losses that limit their efficiency. 2 marks

Guided

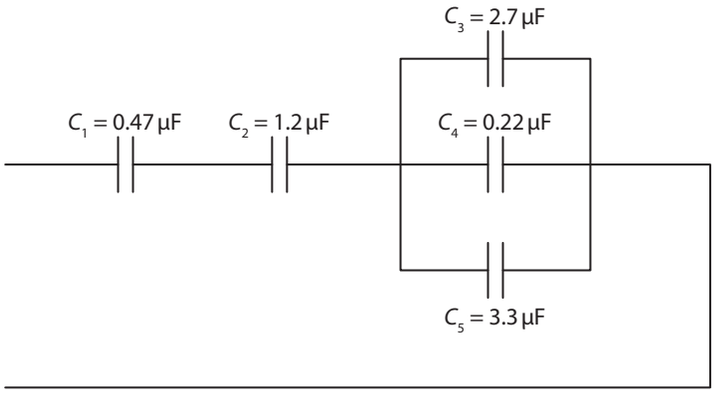
H ..... . losses.

E ..... . currents.

Links See page 62 of the Revision Guide to revise mutual inductance and transformers.

Total for Question 16 = 8 marks

17 An electrical engineer is analysing the network of capacitors shown.



Calculate the total capacitance of the circuit.

Guided

Find the equivalent capacitance of the parallel capacitor network A.

To find total capacitance for parallel network A use $C_A = C_3 + C_4 + C_5$ (from the formula booklet).

$C_A =$ ..... μF

Find the equivalent capacitance of the series capacitor network.

To find total capacitance for series network use $\frac{1}{C_{Total}} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_A}$ (from the formula booklet).

$\frac{1}{C_{Total}} =$ .....

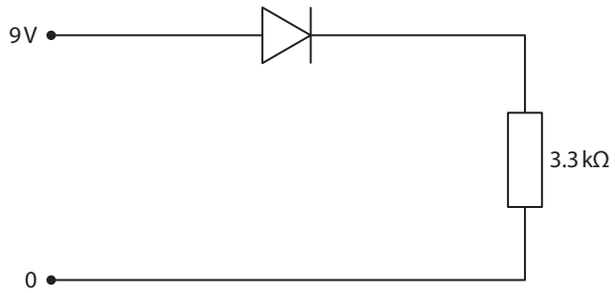
$C_{Total} =$ .....

Answer: The total equivalent capacitance of the circuit is ..... μF

Links See page 52 of the Revision Guide to revise capacitors in series and parallel combinations.

Total for Question 17 = 5 marks

18 A simple circuit contains a resistor and diode in series.
The voltage drop across the forward biased silicon diode is 0.7 V.



Calculate the current flowing in the circuit.

Guided

To find the voltage across the resistor use Kirchoff's voltage law: $V = V_1 + V_2$ (from the formula booklet).

Assign values to the variables from information in the question:

$V = 9\,V$

$V_1 = 0.7\,V$

$V_2 = ?$

$R = 3.3\,k\Omega = 3300\,\Omega$

V_2 = ... – ..... . = ... V

To find the current through the resistor use Ohm's law: $I = \frac{V}{R}$ (from the formula booklet).

I = ... = ... A

Answer: The current flowing through the resistor is ..... .

Links See page 51 of the Revision Guide to revise diodes and resistors in series.

Total for Question 18 = 4 marks

19 An engineer specifying an electrical installation must try and minimise resistive losses in long cable runs.
In one application a 38 m run of cable is required to have a maximum resistance of 0.5 Ω.
The resistivity of the copper alloy used in the cable is 1.76×10^{-8} Ω m.

Calculate the conductor cross-sectional area that will meet the maximum resistance requirements.

Guided

To find the cross-sectional area use $R = \frac{\rho l}{A}$ (from the formula booklet).

Assign values to the variables from information in the question:

$l = 38$ m

$R = 0.5\ \Omega$

$\rho = 1.76 \times 10^{-8}\ \Omega$ m

Rearrange the formula to make A the subject:

$A =$ .....

.....

Substitute the values into the equation:

$A =$ .....

.....

$A =$ ..... m^2

Answer: The cross-sectional area of the conductor is ..... m^2

Links See page 34 of the Revision Guide to revise resistance.

Total for Question 19 = 3 marks

END OF SECTION

TOTAL FOR SECTION C = 28 MARKS

END OF PAPER

TOTAL FOR PAPER = 80 MARKS

Revision test 2

To support your revision, this Workbook contains revision questions to help you revise the skills that might be needed in your exam. Ask your tutor or check the Pearson website for the latest **Sample Assessment Material** and **Mark Scheme** to get an idea of the structure of the actual exam and what this requires of you. Details of the actual exam may change so always make sure you are up to date.

SECTION A: Applied mathematics

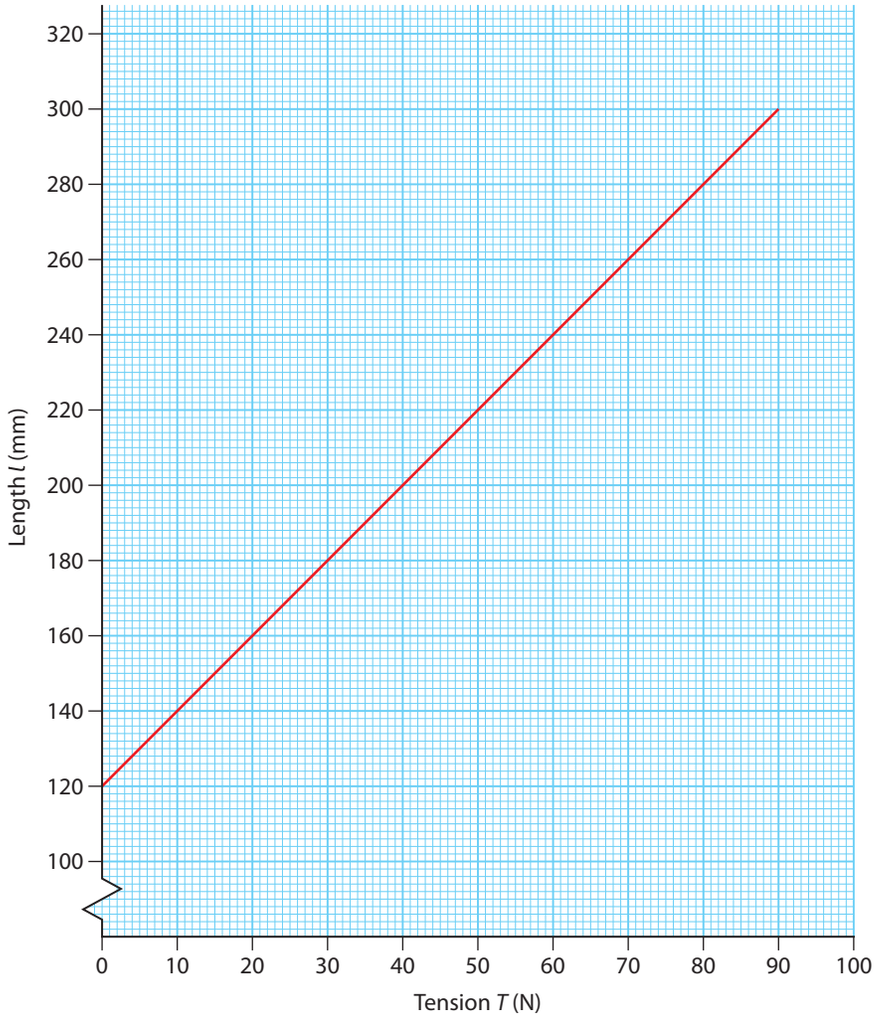
Answer ALL questions. Write your answers in the spaces provided.

Be sure to make use of the information booklet containing formulae and constants on pages 37–41.

1 As part of quality control checks a manufacturer of tension springs carries out experimental testing on samples from each batch manufactured.

The results for one such test have been plotted as a graph of spring tension, *T*, versus overall length, *l*, as shown.

Graph of spring tension versus overall spring length



Find the linear equation that represents the relationship between the spring tension, T, and overall length, l.

Answer .....

Links See page 4 of the Revision Guide to revise the equations of lines.

Total for Question 1 = 3 marks