

Pearson BTEC Level 3 National in Engineering

Unit 1: Engineering Principles



Sample Assessment Materials (SAMs)

For use with:

- *Extended Certificate, Foundation Diploma, Diploma and Extended Diploma in Engineering*
- *Diploma and Extended Diploma in Electrical and Electronic Engineering*
- *Diploma and Extended Diploma in Mechanical Engineering*
- *Diploma and Extended Diploma in Computer Engineering*
- *Diploma and Extended Diploma in Manufacturing Engineering*
- *Diploma and Extended Diploma in Aeronautical Engineering*

First teaching from September 2016

Issue 2

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Pearson BTEC Level 3

Engineering

Sample assessment material for first teaching
September 2016

**Information Booklet of Formulae and
Constants Insert**

Paper Reference

XXXXXX/XX

You do not need any other materials.

Instructions

- You will need the information in this booklet to answer most questions.
- Read the information carefully.
- You must **not** write your answers in this booklet.
- Only your answers given in the question paper will be marked.

Turn over ►

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Formulae and Constants

Maths

Rules of Indices

$$a^m \times a^n = a^{(m+n)}$$

$$a^m \div a^n = a^{(m-n)}$$

$$(a^m)^n = a^{mn}$$

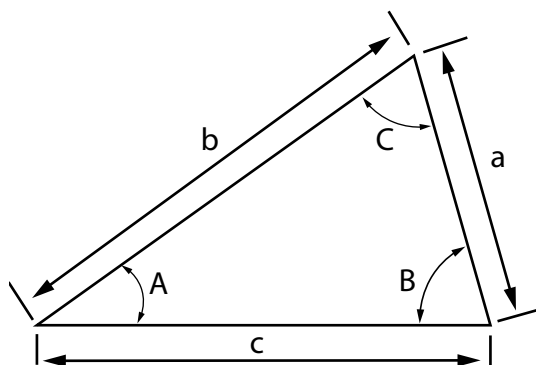
Rules of Logarithms

$$\log AB = \log A + \log B$$

$$\log \frac{A}{B} = \log A - \log B$$

$$\log A^x = x \log A$$

Trigonometric rules



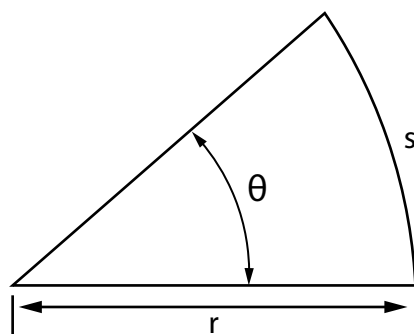
Sine rule

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \quad \text{or} \quad \frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

Cosine rule

$$a^2 = b^2 + c^2 - 2bc \cos A$$

Volume and area of regular shapes

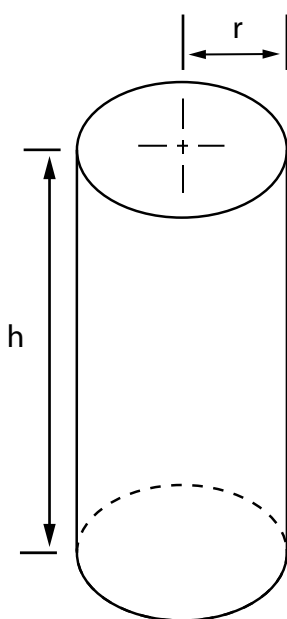


length of an arc of a circle

$$s = r\theta \quad (\text{where } \theta \text{ is expressed in radians})$$

area of a sector of a circle

$$A = \frac{1}{2} r^2 \theta \quad (\text{where } \theta \text{ is expressed in radians})$$

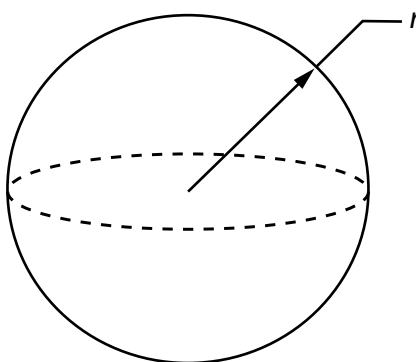


volume of a cylinder

$$v = \pi r^2 h$$

total surface area of a cylinder

$$\text{TSA} = 2 \pi r h + 2 \pi r^2$$

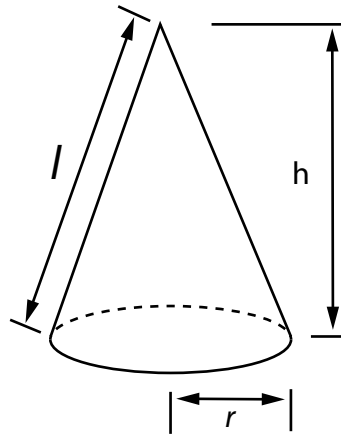


volume of sphere

$$v = \frac{4}{3} \pi r^3$$

surface area of a sphere

$$\text{SA} = 4 \pi r^2$$



volume of a cone

$$v = \frac{1}{3} \pi r^2 h$$

curved surface area of cone

$$CSA = \pi r l$$

Quadratic Formula

To solve $ax^2 + bx + c = 0$, $a \neq 0$

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Physical constants

Acceleration due to gravity

$$g = 9.81 \text{ m/s}^2$$

Permittivity of free space

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ F/m}$$

Permeability of free space

$$\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$$

Equations of linear motion with uniform acceleration

v = final velocity, u = initial velocity, a = acceleration, t = time and s = distance

$$v = u + at$$

$$s = ut + \frac{1}{2} at^2$$

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

$$s = \frac{1}{2}(u + v)t$$

Stress and strain

Direct stress	$\sigma = F/A$
---------------	----------------

Direct strain	$\epsilon = \Delta L/L$
---------------	-------------------------

Shear stress	$\tau = F/A$
--------------	--------------

Shear strain	$\gamma = a/b$
--------------	----------------

Young's Modulus (modulus of elasticity)	$E = \sigma/\epsilon$
---	-----------------------

Modulus of rigidity	$G = \tau/\gamma$
---------------------	-------------------

Work, Power, Energy and Forces

Force	$F = ma$
-------	----------

Components of forces	$F_x = F\cos\theta, F_y = F\sin\theta$ where θ is measured from the horizontal
----------------------	--

Mechanical work	$W = Fs$
-----------------	----------

Mechanical power	$P = Fv, P = W/t$
------------------	-------------------

Mechanical Efficiency	$\text{Efficiency } (\eta) = \frac{P_{out}}{P_{in}}$
-----------------------	--

Force to overcome limiting friction	$F = \mu N$ (where N is the normal force)
-------------------------------------	--

Gravitational potential energy	$PE = mgh$
--------------------------------	------------

Kinetic energy	$KE = \frac{1}{2} mv^2$
----------------	-------------------------

Angular parameters

Centripetal acceleration	$a = \omega^2 r$ or $a = v^2 / r$
Power	$P = T\omega$
Rotational Inertia	$I = k m r^2$ The inertial constant for a solid cylinder (flywheel) $k = \frac{1}{2}$ and for a thin walled hollow cylinder $k \approx 1$ (along the axis of rotation).
Rotational Kinetic energy	$KE = \frac{1}{2} I \omega^2$
Angular frequency	$\omega = 2\pi f$
Frequency	$f = \frac{1}{\text{time period}}$
Radians to degrees conversion	$\theta(\text{degrees}) = \frac{360 \theta(\text{radians})}{2\pi}$ where $2\pi \text{ radians} = 360^\circ$
Degrees to radians conversion	$\theta(\text{radians}) = \frac{2\pi \theta(\text{degrees})}{360}$

Fluid Principles

Continuity of volumetric flow	$A_1 v_1 = A_2 v_2$
Continuity of mass flow	$\rho A_1 v_1 = \rho A_2 v_2$
Hydrostatic thrust on an immersed plane surface	$F = \rho g A x$
Density	$\rho = m/V$

Static and DC Electricity theory

Current/electron flow

$$I = \frac{q}{t}$$

Coulomb's law

$$F = \frac{(q_1 q_2)}{(4\pi\epsilon_0 r^2)}$$

Resistance

$$R = \frac{\rho l}{A}$$

Resistance: temperature coefficient

$$\frac{\Delta R}{R_0} = \alpha \Delta T$$

Ohm's Law DC circuits

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

Total for resistors in series

$$R_T = R_1 + R_2 + R_3 \dots$$

Total for resistors in parallel

$$\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \dots$$

Power

$$P = IV, P = I^2 R, P = \frac{V^2}{R}$$

Electrical Efficiency

$$\text{Efficiency } (\eta) = \frac{P_{out}}{P_{in}}$$

Kirchoff's Current Law

$$I = I_1 + I_2 + I_3 \dots$$

Kirchoff's Voltage Law

$$V = V_1 + V_2 + V_3 \dots \text{ or } \sum PD = \sum IR$$

Capacitance

Electric Field Strength

$$E = \frac{F}{q} \text{ or } E = \frac{V}{d} \text{ for uniform electric fields}$$

Capacitance

$$C = \frac{\epsilon A}{d}$$

Time constant

$$\tau = RC$$

Charge stored

$$Q = CV$$

Energy stored in a Capacitor

$$W = \frac{1}{2} CV^2$$

Capacitors in series

$$\frac{1}{C_T} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} \dots$$

Capacitors in parallel

$$C_T = C_1 + C_2 + C_3 \dots$$

Voltage decay on Capacitor discharge

$$v_c = Ve^{(-t/\tau)}$$

Magnetism and Electromagnetism

Magnetic Flux Density

$$B = \frac{\phi}{A}$$

Magnetomotive Force

$$F_m = NI$$

Magnetic Field Strength or Magnetising force

$$H = \frac{NI}{l}$$

Permeability

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

Reluctance

$$S = \frac{F_m}{\phi}$$

Induced EMF

$$E = Blv, E = -N \frac{d\phi}{dt} = -L \frac{di}{dt}$$

Energy stored in an inductor

$$W = \frac{1}{2} LI^2$$

Inductance of a coil

$$L = N \frac{\phi}{I}$$

Transformer equation

$$\frac{V_1}{V_2} = \frac{N_1}{N_2}$$

Single Phase Alternating Current Theory

Time Period

$$T = \frac{1}{f}$$

Capacitive reactance

$$X_c = \frac{1}{2\pi fC}$$

Inductive reactance

$$X_L = 2\pi fL$$

Ohm's Law AC circuits

$$I = \frac{V}{Z} \text{ (when voltage and current are in phase)}$$

Root mean square voltage

$$r.m.s. \text{ voltage} = \frac{\text{peak voltage}}{\sqrt{2}}$$

Total impedance of an inductor in series with a resistance

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

Total impedance of a capacitor in series with a resistance

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

Waveform average value

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

Form factor of a waveform

$$\text{Form factor} = \frac{\text{r.m.s. value}}{\text{average value}}$$

Write your name here

Surname

Other names

Pearson BTEC Level 3
Nationals Extended
Certificate, Foundation
Diploma, Diploma,
Extended Diploma in
Engineering and all
titles – Manufacturing /
Aeronautical / Computer /
Electrical and Electronic /
Mechanical Engineering

Centre Number

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Learner Registration Number

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Engineering

Unit 1: Engineering Principles

Sample Assessment Materials for first teaching
September 2016 onwards

Time: 2 hours

Paper Reference

31706H

You must have:

Information booklet of formulae and constants,
ruler, protractor, pencil

Total Marks

Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and learner registration number.
- This paper is divided into three sections (A, B and C).
- Answer **all** questions.
- Answer the questions in the spaces provided
– *there may be more space than you need.*

Information

- The total mark for this paper is 80.
- The marks for **each** question are shown in brackets
– *use this as a guide as to how much time to spend on each question.*
- You may use a non-programmable calculator that does not have the facility for symbolic algebra manipulation or allow the storage and retrieval of mathematical formulae.

Advice

- Read each question carefully before you start to answer it.
- Try to answer every question and show all your working.
- Check your answers if you have time at the end.

Turn over ►

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SECTION A

Applied Mathematics

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

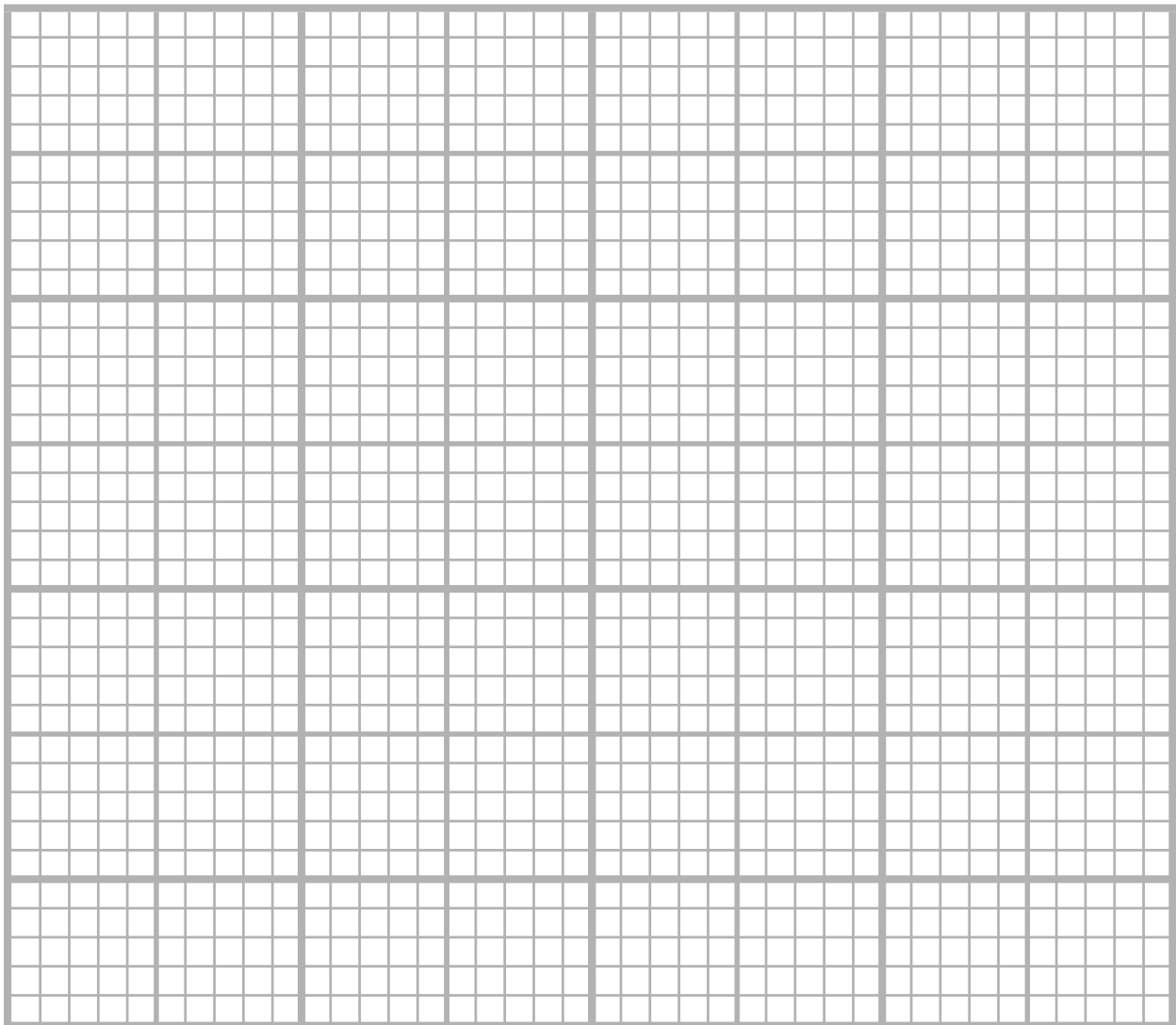
The total time taken to install a lighting system is represented by the equation of a straight line:

$$\text{Total time (in hours)} = 3n + 7$$

where n is the number of lights to be installed

- 1 Draw a straight line graph to show the time taken to install up to 5 lights.

You should include labels and axis values on your graph.



(Total for Question 1 = 4 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Two grooves are being milled into a piece of steel.

The motion of the cutter is represented by the following simultaneous equations:

$$20y = 30x + 9$$

$$-3y = 1.5x - 6$$

- 2 Find the co-ordinate (x, y) where the grooves cross.

(4)

Answer

(Total for Question 2 = 4 marks)

The diagram shows a template for a component.

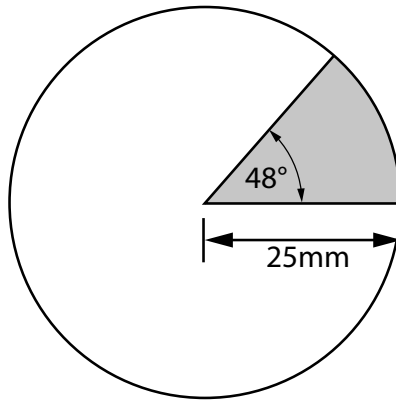


Diagram not to scale

- 3** (i) Convert 48° into radians.

(2)

Answer

- (ii) Calculate the area of the shaded sector of the circle, using radians.

(2)

Answer

(Total for Question 3 = 4 marks)

The total noise level of three compressors can be represented by the equation:

$$\log 24 = \log z + 2\log 2$$

where z is the unknown noise level of the third compressor.

- 4** Solve the equation to find the value of z .

Show evidence of the use of the laws of logarithms in your answer.

(4)

Answer

(Total for Question 4 = 4 marks)

The diagram represents a joining plate.

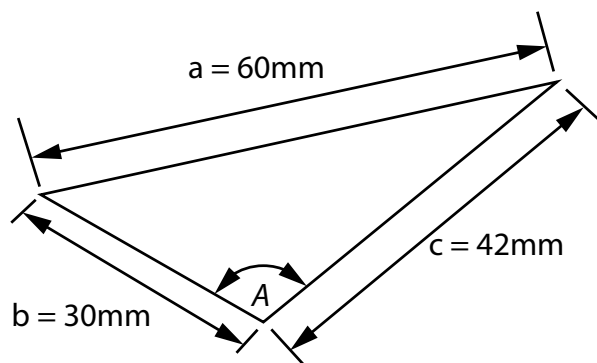


Diagram not to scale

- 5** Calculate the size of angle A.

Answer

(Total for Question 5 = 5 marks)

TOTAL FOR SECTION A = 21 MARKS

SECTION B**Mechanical Principles**

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

6 Identify the unit of measure for pressure.

(1)

- ☐ A celcius
- ☐ B coulomb
- ☐ C litre
- ☐ D pascal

(Total for Question 6 = 1 mark)

7 Identify the term that describes the relationship between the change in length of a material and its original length.

(1)

- ☐ A stress
- ☐ B strength
- ☐ C strain
- ☐ D strip

(Total for Question 7 = 1 mark)

Materials can be exposed to a range of environments and in-service conditions.

8 State **one** factor that affects the Young's modulus of a material.

(1)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Answer

(Total for Question 8 = 1 mark)

A dam retains water that is 10 m deep and 5 m wide.

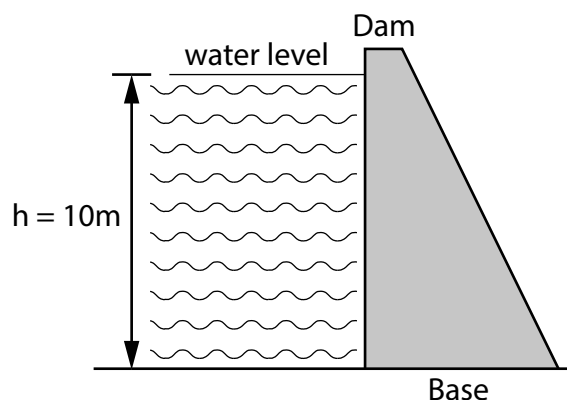


Diagram not to scale

- 9 (i) Calculate the area of the water against the dam wall.

(2)

Answer

- (ii) Calculate the hydrostatic thrust on the dam wall.

Assume the density of water is 1000 kg/m^3 .

Give your answers in an appropriate unit.

(4)

Answer

(Total for Question 9 = 6 marks)

10 Explain **one** way in which energy losses in mechanical equipment affect the efficiency of an engineering system.

(2)

.....

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(Total for Question 10 = 2 marks)

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

DO NOT WRITE IN THIS AREA

Coolant is being passed through a tapering pipe.

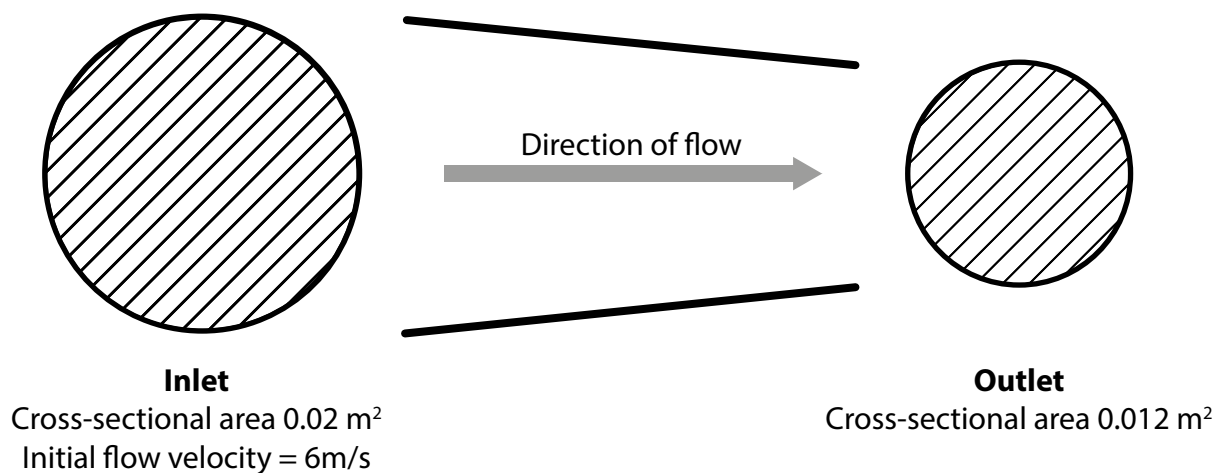


Diagram not to scale

11 Calculate the output flow velocity of the coolant.

(3)

Answer

(Total for Question 12 = 3 marks)

The diagram shows a simply supported beam in static equilibrium.

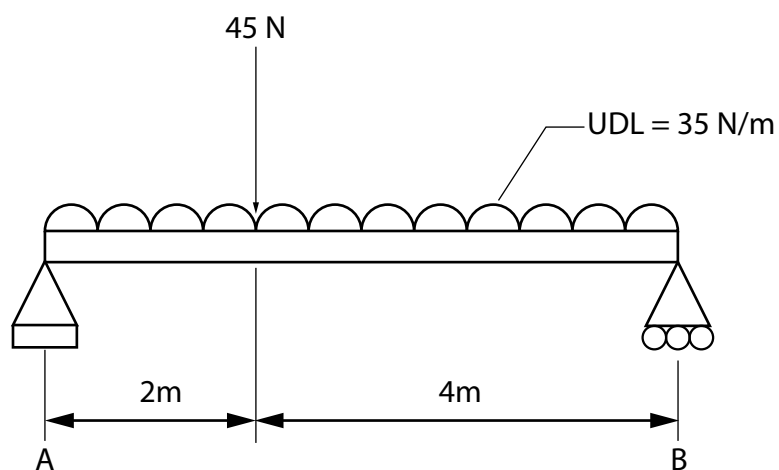


Diagram not to scale

12 Calculate the vertical reaction forces at point B.

(7)

Answer

(Total for Question 11 = 7 marks)

A person is moving an 8 kg load up an inclined plane.

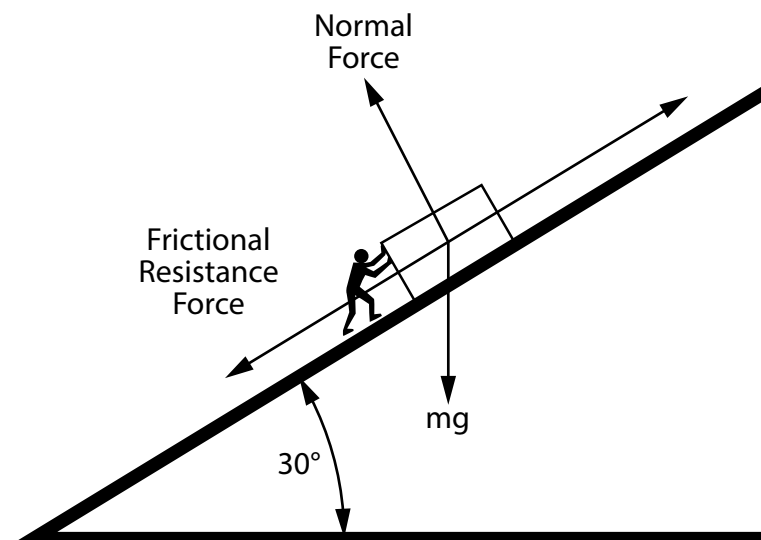


Diagram not to scale

- 13 (a) Calculate the frictional resistance force acting on the load.

The coefficient of friction between the load and the inclined plane is 0.4.

(7)

Answer

- (b) State one method of reducing friction within an engineering system

(1)

(Total for Question 13 = 8 marks)

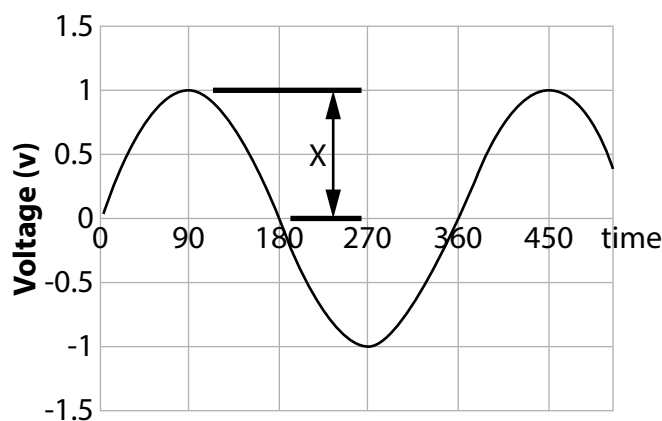
TOTAL FOR SECTION B = 29 MARKS

SECTION C

Electrical/Electronic Principles

Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

An engineer has taken a screen shot of the waveform of an AC voltage



14 Identify the feature of the waveform labelled X.

(1)

- ☐ A amplitude
- ☐ B form factor
- ☐ C frequency
- ☐ D time period

(Total for Question 14 = 1 mark)

15 Identify the unit of measure for electrical energy.

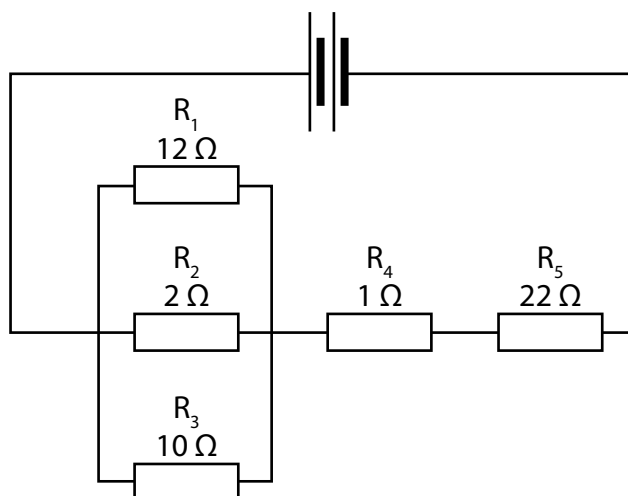
(1)

- ☐ A hertz
- ☐ B joule
- ☐ C watt
- ☐ D weber

(Total for Question 15 = 1 mark)

The circuit diagram shows resistors connected in a series and parallel combination.

DC circuit



- 16** (i) Calculate the resistance of the resistors in the parallel branch of the network.

(3)

Answer

- (ii) Calculate the total resistance of the resistors in the network.

(2)

Answer

(Total for Question 16 = 5 marks)

An electric motor is supplied with 20 V and has a power rating of 0.75 kW

The DC motor is operating at full power.

17 (a) Calculate the current drawn by the motor.

Give your answer in an appropriate unit.

(5)

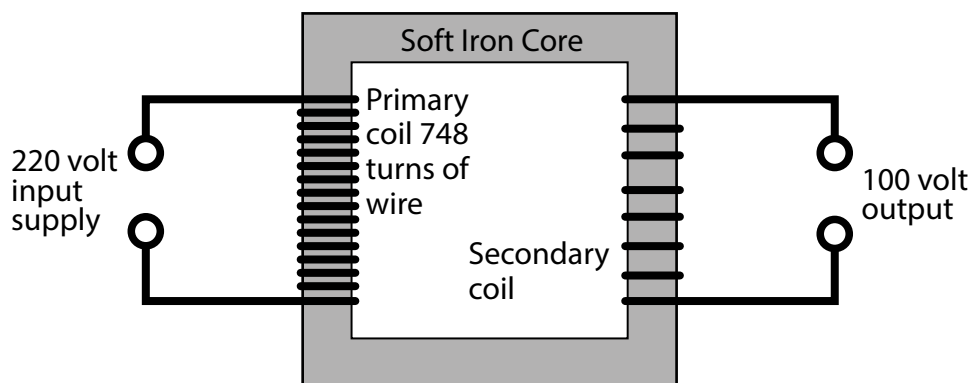
Answer

(b) State **one** cause of energy losses in an electrical motor, other than friction.

(1)

(Total for Question 17 = 6 marks)

A transformer is used by engineers as a power source for portable tools.



18 (a) Calculate the number of turns in the secondary coil.

(3)

Answer

(b) Explain **one** effect of eddy currents on transformers.

(2)

(Total for Question 18 = 5 marks)

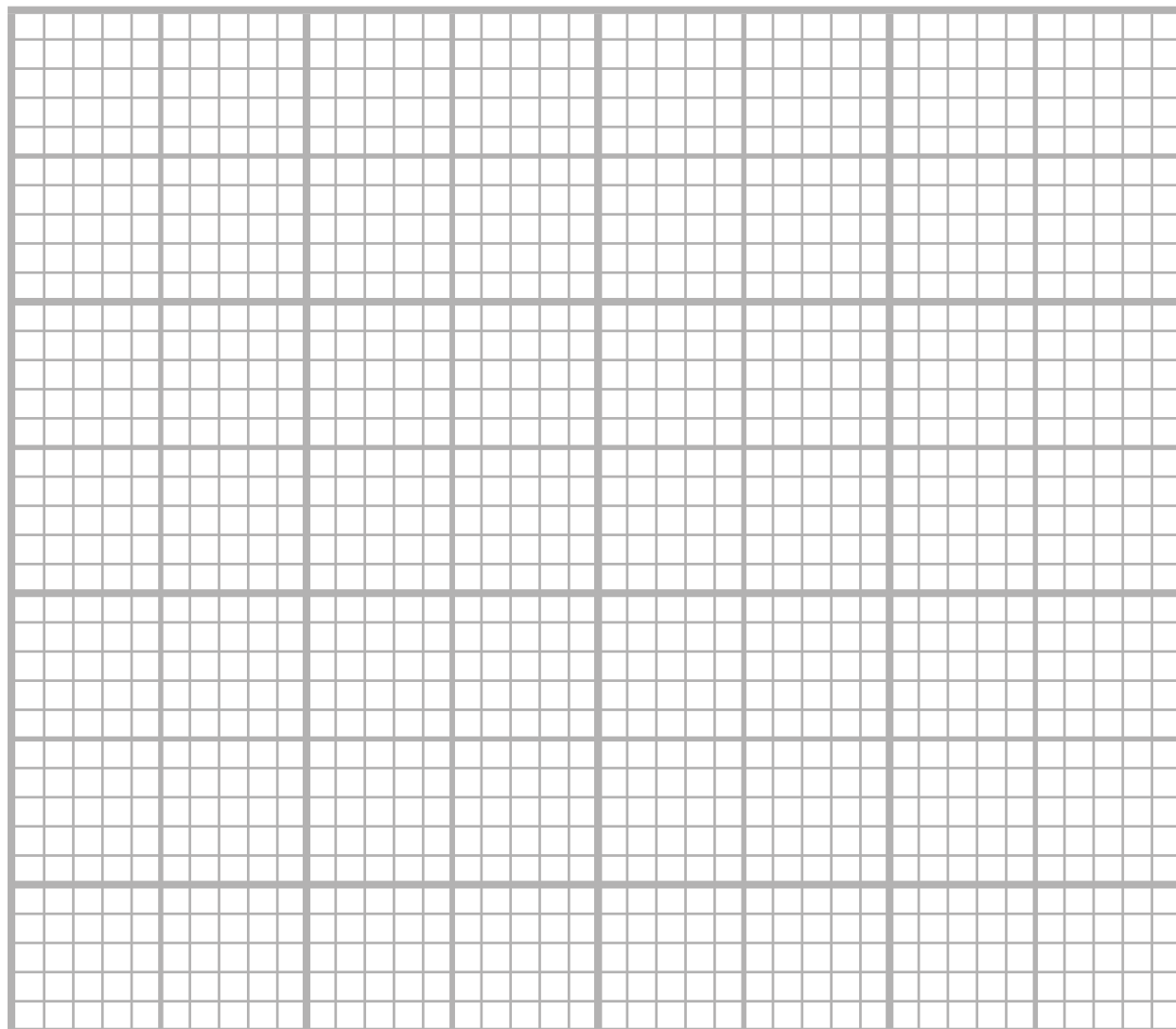
Two AC voltage waveforms are represented by:

$$V_1 = 100\sin(100\omega t) \text{ volts}$$

$$V_2 = 200\sin(100\omega t - \pi/6) \text{ volts}$$

19 Draw a phasor diagram to represent $V_1 + V_2$ and find the resultant phasor.

(5)

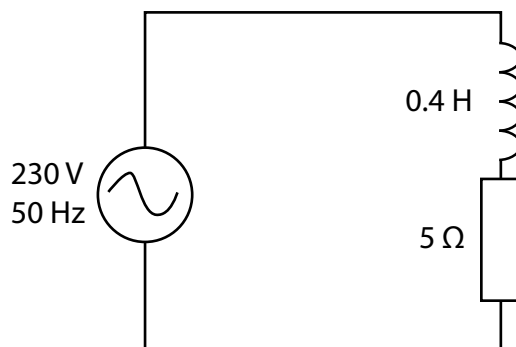


Answer

(Total for Question 19 = 5 marks)

A solenoid has an inductance of 0.4 H and an internal resistance of 5Ω .

The solenoid is connected to a 230 V , 50 Hz AC supply.



20 Calculate the current drawn from the supply.

(7)

Answer

(Total for Question 20 = 7 marks)

TOTAL FOR SECTION C = 30 MARKS
TOTAL FOR PAPER = 80 MARKS

Unit 1: Engineering Principles – sample mark scheme

General marking guidance

- All learners must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do, rather than be penalised for omissions.
- Examiners should mark according to the mark scheme, not according to their perception of where the grade boundaries may lie.
- All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.

Types of Mark and Abbreviations

This mark scheme uses the following types of marks:

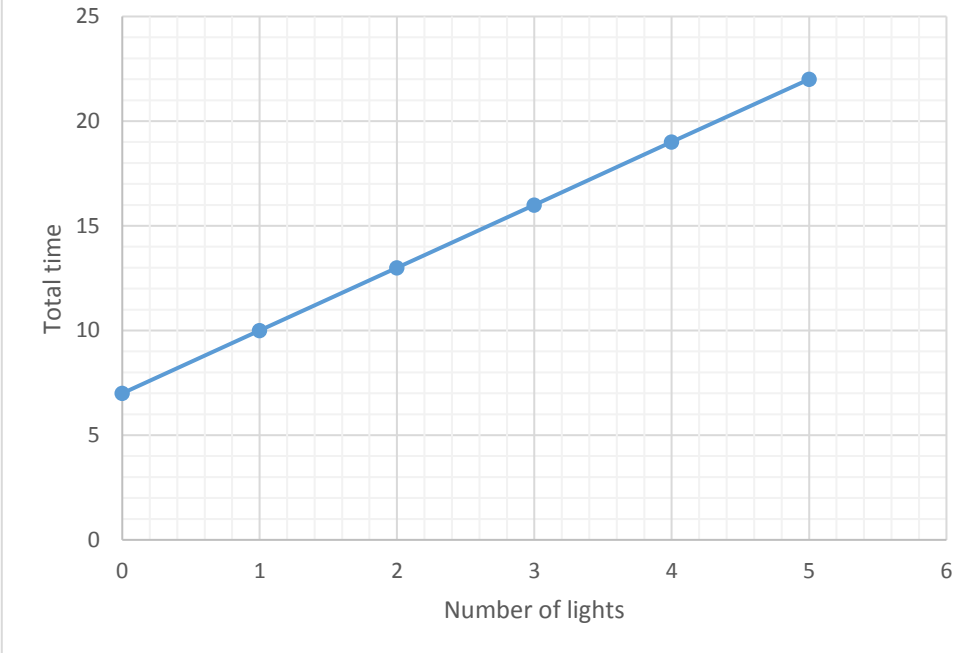
- M marks – method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated
- A marks – accuracy marks can be awarded only if the relevant method (M) marks have been earned
- B marks – unconditional accuracy marks (independent of M marks)
- marks should not be subdivided.

Abbreviations:

- ft – follow through
- cao – correct answer only
- cso – correct solution only, there must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC – special case
- oe – or equivalent (and appropriate)
- dp – decimal places
- sf – significant figures

BTEC Next Generation Mark Scheme

Engineering Unit 1 Sample Assessment Materials

Question number	Answer	Mark
1	 <p>1 mark for axes with appropriate labels 1 mark for axes with appropriate values 1 mark for correct 'y intercept' at 7 1 mark for accurate plotting of graph with a gradient of 3</p>	(4)

Question number	Working	Answer	Notes	Mark
2	$(1) 20y = 30x + 9$ $(2) -3y = 1.5x - 6$ multiply (2) by 20 $20y = 30x + 9$ $-60y = 30x - 120$ $80y = 129$ $y = 1.6125$ Substitute into (1) $32.5 = 30x + 9$ $x = 0.775$ Or any similar/appropriate method giving correct answers.	<u>$x = 0.775$</u> <u>$y = 1.6125$</u> Allow ft if second variable is correct in relation to the first incorrect answer.	M1 for multiplying the equation 2 by 20 (oe) M1 for subtraction eqn 2 from eqn 1 A1 for correct value of y A1 for correct value of x (ft)	(4)

Question number	Working	Answer	Notes	Mark
3 (i)	$\theta = (48 \times \pi)/180$ $\theta = 0.838 \text{ rad}$	$\theta = 0.838 \text{ rad}$ <u>$A = 261.9 \text{ mm}^2$</u>	M1 for correct substitution of values A1 for correct value of radians	(4)
(ii)	Area $A = r^2\theta/2$ $A = (25^2 \times 0.838)/2$ $A = 261.9 \text{ mm}^2$		M1 for calculating area (ft) A1 for area	

Question number	Working	Answer	Notes	Mark
4	$\text{Log}24 = \text{log}z + 2\text{log}2$ $\text{Log}24 = \text{log}z + \text{log}2^2$ $\text{Log}24 = \text{log}z + \text{log}4$ $\text{Log}z = \text{log}24 - \text{log}4$ $\text{Log}z = \text{log}(24/4)$ $\text{Log}z = \text{log}6$ $z = 6$	<u>$z = 6$</u>	M1 for application of $x\text{log}y = \text{log}y^x$ M1 for correctly re-arranging the equation in terms of $\text{log}z$ M1 for application of $\text{log}x - \text{log}y = \text{log}(x/y)$ A1 for correct answer for z (cao)	(4)

Question number	Working	Answer	Notes	Mark
5	$\cos(A) = \frac{(b^2 + c^2 - a^2)}{2bc}$ $\cos(A) = \frac{(30^2 + 42^2 - 60^2)}{2 \times 30 \times 42}$ $\cos(A) = -0.37$ $A = \cos^{-1}(-0.37)$ $A = 111.80^\circ$	<u>$A = 111.80^\circ$</u> Accept answers wrt 112°	M1 for recognition of cosine rule M1 for rearranging equation in terms of $\cos A$ M1 for correct substitution of values M1 for inverse cosine (ft) A1 for correct value of A	(5)

Question Number	Answer	Mark
6	D - pascal	(1)

Question Number	Answer	Mark
7	C - strain	(1)

Question Number	Answer	Mark
8	Award one mark for a valid statement. <ul style="list-style-type: none"> ● Impurities in the material (1) ● Temperature of the material (1) 	(1)

Question number	Working	Answer	Notes	Mark
9 (i)	$A = 10 \times 5$ $A = 50 \text{ m}^2$	<u>$A = 50 \text{ m}^2$</u>	M1 for correct substitution of values A1 for the correct answer area	(6)
(ii)	$F = \rho g A x$ $x = h/2$ $x = 10/2$ $x = 5$ $F = 1000 \times 9.81 \times 50 \times 5$ $F = 2\,452\,500 \text{ N}$ $F = 2.4525 \text{ MN}$	<u>$F = 2.4525 \text{ MN}$</u> Do not penalise if centre of pressure is calculated as $1/3$ <u>$F = 1.64 \text{ MN}$</u>	M1 for finding centre of pressure x (may be implied) M1 correct substitution of values (ft) A1 for correct value of F (ft) A1 unit (dep)	

Question Number	Answer	Mark
10	Award one mark for each valid statement up to a maximum of two marks. <ul style="list-style-type: none"> ● Energy is converted in to unwanted forms of energy in the equipment (1) reducing the efficiency of the system (1) ● Moving parts create friction (1) leading to unwanted heat generation (1) 	(2)

Question number	Working	Answer	Notes	Mark
11	Volumetric flow $A_1v_1=A_2v_2$ $v_2= A_1v_1/A_2$ $v_2 = 0.02 \times 6 / 0.012$ $v_2 = 10 \text{ m/s}$	<u>$v_2 = 10 \text{ m/s}$</u>	M1 for rearranging the equation in terms of v_2 M1 for substituting the correct values A1 for correct answer of output flow velocity (ft)	(3)

Question number	Working:	Answer	Notes	Mark
12	$M = Fd$ Clockwise moments = anticlockwise moments Taking moments about A: $(2 \times 45) + (35 \times 6 \times 3) = 6R_c$ $6R_c = 720$ $R_c = 120 \text{ N}$	<u>$R_c = 120 \text{ N}$</u>	M1 for recognising $M = Fd$ M1 M1 for correct balancing of moments. M1 for correct substitution of values (ft) M1 for reducing UDL to a point load (may be implied) (ft) M1 for rearranging for R_c (ft) A1 for correct answer	(7)

Question number	Working	Answer	Notes	Mark
13 (a)	<p>Split force into parallel and perpendicular components due to gravity</p> <p>Force due to gravity perpendicular</p> $F_{pl} = mg \cos 30$ $F_{pl} = 8 \times 9.81 \times \cos 30$ $F_{pl} = 67.97 \text{ N}$ <p>Frictional resistance force</p> $Fr = \mu N$ $Fr = 0.4 \times 67.97$ $Fr = 27.19 \text{ N}$	<u>$Fr = 27.19 \text{ N}$</u>	<p>M1 recognition of need to split force due to gravity into two</p> <p>M1 for correct substitution of values</p> <p>M1 recognition that θ equals 30 degrees</p> <p>A1 mark for correct answer of (Fpl)</p> <p>M1 recognition that perpendicular force equals normal force</p> <p>M1 for correct substitution of values</p> <p>A1 correct answer for frictional resistance.</p>	(7)

Question Number	Answer	Mark
13 (b)	<p>Award one mark for a valid statement.</p> <ul style="list-style-type: none"> • Lubrication eg oil, grease (1) • Use wheels (1) • Smooth the surfaces (1) • Change materials (1) 	(1)

Question Number	Answer	Mark
14	A - amplitude	(1)

Question Number	Answer	Mark
15	B - joule	(1)

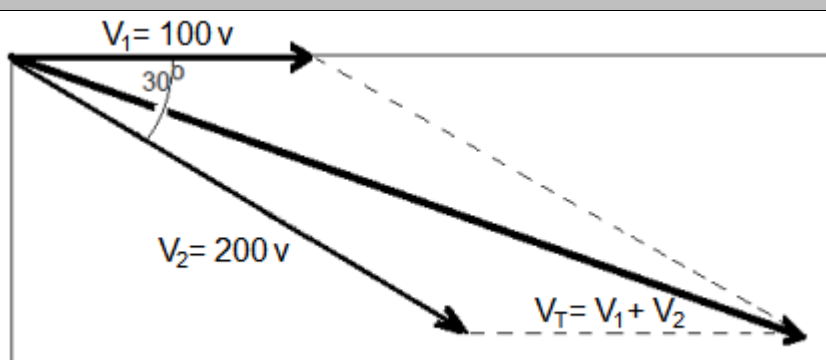
Question number	Working	Answer	Notes	Mark
16 (i)	Resistance of the parallel branches $1/R_p = (1/R_1) + (1/R_2) + (1/R_3)$ $1/R_p = (1/12) + (1/2) + (1/10)$ $1/R_p = 0.683$ $R_p = 1/0.683$ $R_p = 1.46 \Omega$	<u>$R = 1.46 \Omega$</u> <u>$R = 24.46 \Omega$</u>	M1 for correct substitution of values M1 for a correctly rearranging the equation in terms of R_p A1 for correct answer for R_p (ft)	(5)
(ii)	Total resistance $R_t = 1.46 + 1 + 22$ $R_t = 24.46 \Omega$		M1 for substituting correct values (ft) A1 for correct answer for R_t	

Question number	Working	Answer	Notes	Mark
17(a)	$P = IV$ $I = P/V$ $0.75 \text{ kW} = 750 \text{ watts}$ $I = 750/20$ $I = 37.5 \text{ A}$	<u>$I = 37.5 \text{ A}$</u>	M1 for converting from Kw to watts M1 for rearranging the equation in terms of I M1 for correct substitution of values A1 for correct answer for I (ft) A1 (dep) correct unit.	(5)

Question Number	Answer	Mark
17(b)	Award one mark for a correct cause of energy loss <ul style="list-style-type: none"> ● electrical resistance (1) ● eddy current (1) ● Hysteresis (1) 	(1)

Question number	Working	Answer	Notes	Mark
18(a)	$V_1/V_2 = N_1/N_2$ $220/100 = 748/N_2$ $N_2 = 748 \times 100 / 220$ $N_2 = 340 \text{ turns}$	<u>$N_2 = 340 \text{ turns}$</u>	M1 for substitution of values M1 for rearranging the equation in terms of N_2 (ft) A1 for the value of N_2	(3)

Question Number	Answer	Mark
18(b)	Award one mark for a correct identification and one further mark for expansion. <ul style="list-style-type: none"> • Efficiency of the transformer is reduced (1) because resistive losses/eddy current losses are generated (1). • Eddy currents increase the temperature of the magnetic core materials (1) causing energy losses through heat (1). Accept any other relevant phrasing/wording	(2)

Question number	Answer	Mark
19	 <p>1 mark for plotting V_1 with a magnitude of 100 1 mark for plotting V_2 with a magnitude of 200 1 mark for plotting V_2 with an angle of 30° between V_1 and V_2. 1 mark for plotting V_T with a magnitude wrt 290 1 mark for plotting V_T with phase angle of 20°</p>	(5)

Question number	Working	Answer	Notes	Mark
20	$X_L = 2\pi fL$ $X_L = 2 \times \pi \times 50 \times 0.4$ $X_L = 125.66 \Omega$ Total impedance: $Z = \sqrt{(125.66^2 + 5^2)}$ $Z = 125.8 \Omega$ $I = V/Z$ $I = 230/125.8$ <u>$I = 1.82 A$</u>	<u>$I = 1.82 A$</u>	M2 for fully correct substitution of values (M1 for correct substitution for either f or L) A1 for correct answer X_L (ft) M1 for fully correct substitution values A1 for total impedance M1 for correct substitution (ft) A1 for correct answer for I	(7)

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