

## Level 3 Alternative Academic Qualification Cambridge Advanced Nationals in Engineering

H027/H127 Unit F130: Principles of engineering

#### Sample Assessment Material (SAM)

#### Time allowed: 1 hour 30 minutes

- The Formulae Booklet for Unit F130 (inserted)
- a ruler (cm/mm)

Please write clearly in black ink. Do not write in the barcodes.			
Centre number	Candidate number		
First name(s)			
Last name			
Date of birth	D D M M Y Y Y		
-			

#### INSTRUCTIONS

- Use black ink. You can use an HB pencil, but only for graphs and diagrams.
- Write your answer to each question in the space provided. You can use extra paper if you need to, but you must clearly show your candidate number, the centre number and the question numbers.
- In the live exam there might be lined pages at the end of the question paper for you to use if you need extra space. Remember, you must clearly show the question numbers.
- · Answer **all** the questions.
- Where appropriate, your answer should be supported with working. Marks might be given for using a correct method, even if your answer is wrong.
- Give non-exact numerical answers correct to 3 significant figures unless a different degree of accuracy is specified in the question.

#### INFORMATION

- The total mark for this paper is **70**.
- The marks for each question are shown in brackets []
- This document consists of **22** pages.

#### ADVICE

· Read each question carefully before you start your answer.

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#### Section A

**1** Which quantity is defined as an external agent capable of changing a body's state of rest or motion?

Tick ( $\checkmark$ ) <b>one</b> box.	
Displacement	
Energy	
Force	
Velocity	
	[1]

2 Which quantity is defined as the straight-line distance between two points in a given direction?

Tick (✓) <b>one</b> box.		
Displacement		8
Height		2
Length		
Work done		8 8 

**3** Using an SI prefix the ultimate tensile strength of a material is given as 415 MNm<sup>-2</sup>.

Which is the equivalent quantity expressed using engineering notation?

Tick (✓) **one** box. 415 x 10<sup>-9</sup> Nm<sup>-2</sup>

415 x 10<sup>-6</sup> Nm<sup>-2</sup>

 $415 \ x \ 10^6 \ Nm^{-2}$ 

 $415 \ x \ 10^9 \ Nm^{-2}$ 



[1]

**4** A cylindrical storage tank is 2.2 m high with a radius of 0.8 m.

Calculate the external curved surface area of the tank.

external curved surface area = ......m<sup>2</sup>
[2]

**5** A steel cable with a diameter of 0.05 m supports a load of  $22 \times 10^3 \text{ N}$ .

Calculate the direct tensile stress ( $\sigma$ ) in the cable.

Ignore the weight of the cable.

direct tensile stress ( $\sigma$ ) = .....Nm<sup>-2</sup>

[3]

6 This free body diagram represents a system of coplanar concurrent forces.

Diagram is not to scale.



#### (a)

(i) Calculate the sum of the vertical components of the forces  $(F_{\nu})$ .

sum of forces $(F_v)$ =k	٢N
1	31

(ii) The sum of the horizontal components of the forces is 2.47 kN.

Calculate the magnitude of the resultant force  $(F_R)$  that is equivalent to this system of forces.

resultant force  $(F_R) = \dots kN$ 

[2]

**7** This is a stress versus strain graph for a material used to manufacture engineering components.



Calculate the modulus of elasticity (E) of the material.

modulus of elasticity  $(E) = \dots$  Pa [2]

8 This diagram shows a simply supported beam under load. The beam is in static equilibrium.

Ignore the weight of the beam.

Diagram not to scale.



(a) Calculate the magnitude and position of the single point load that is equivalent to the uniformly distributed load (UDL).

Magnitude = .....kN

Distance from $R_A =$	m
	[2]

(b) The reaction force acting at  $R_B$  is 22.3 kN.

Determine the magnitude of the applied point load C.

You must show your working.

Magnitude of point load (C) = .....kN



A constant dynamic friction force of 240 N resists the motion of vehicle A as it is being towed.

The tow rope joining the two vehicles has a maximum safe working load of 3 kN.

Determine the maximum acceleration (*a*) vehicle A can achieve without exceeding the safe working load of the tow rope.

Give your answer in an appropriate unit.

You must show your working.

maximum acceleration (a) = ..... unit .....

[6]



**10** A drop hammer with a mass of 120 kg strikes a steel post being driven into the ground.

The drop hammer reaches a velocity of  $10.85 \,\mathrm{ms}^{-1}$  immediately before hitting the post. After impact the drop hammer and post move together in a straight-line without any rebound. The post has a mass of  $240 \,\mathrm{kg}$  and moves into the ground by  $0.10 \,\mathrm{m}$  after being struck.

(a) Show that the velocity ( $\nu$ ) of the combined drop hammer and post immediately after impact is  $3.62 \text{ ms}^{-1}$ .

Use the principle of conservation of momentum for perfectly inelastic collisions between two bodies.

You must show your working.

(b) Hence, determine the average force (F) that decelerates the post as it moves into the ground.

You must show your working.

force (*F*) = .....N

#### Section B





What is the name of the current carrying particle shown in the diagram?



Cell

Electron

Nucleus

Voltage

[1]

**12** An engineer is converting an angle in degrees into radians.

What is the 330° angle when measured in radians?

Tick ( $\checkmark$ ) one box.

3.67 radians

5.50 radians

- 5.76 radians
- 11.5 radians



**13** Which circuit symbol represents a capacitor with a capacitance of  $22 \times 10^{-9}$  Farads?

Tick ( $\checkmark$ ) **one** box.



**14** Calculate the total resistance (*RT*) between points A and B of the network of resistors shown below.



Inductance  $(L) = \dots$  H

[2]

**15** A coil has 200 turns of copper wire which produces a magnetic flux of 0.01Wb. A steady 50 A current is being passed through the coil.

Calculate the inductance (L) of the coil.

- **16** A circuit has a single  $50\Omega$  lamp which draws a current of 10mA.
- (a) Calculate the power dissipated (*P*) in the lamp.

(c) Calculate the length of time that a 2500 mAh battery would be able to power this circuit until it was fully discharged.

time = ..... hours [2]

- 14
- **17** This diagram shows the voltage in an AC circuit over time.



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**18** The following circuit is a non-inverting amplifier.



(a) Calculate the voltage gain  $(A_{\nu})$  for the above circuit.

voltage gain  $(A_{\nu}) =$  .....[2]

(b) This amplifier is cascaded with another amplifier with a gain  $(A_{\nu})$  of 0.5.

Calculate the overall voltage gain of the system in dB.

overall voltage gain of the system = .....dB [3]

- **19** An engineer is given the partially complete truth table for an **AND** gate.
- (a) Complete the truth table by filling in column **Q**.

Α	В	Q	
0	0		
0	1		
1	0		
1	1		
	•	[1]	

(b) The diagram shows a logic gate circuit.



Complete the truth table for this circuit.

D	E	F	G	Н	J	K
0	0	0				
0	0	1				
0	1	0				
0	1	1				
-	0	0				
1	0	1				
1	1	0				
1	1	1				
						[4]

20 The diagram shows a network of resistors that is connected to two DC power sources.



Determine the current  $(I_1)$  flowing through  $R_1$ .

You must show your working.

Current  $(I_1)$  flowing through  $R_1 = \dots$  [8]

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#### END OF QUESTION PAPER

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# Level 3 Cambridge Advanced National (AAQ) in Engineering (Certificate)

Level 3 Cambridge Advanced National (AAQ) in Engineering (Extended Certificate)

Unit F130: Principles of engineering SAMPLE ASSESSMENT MATERIAL MARK SCHEME

Last updated: 24/03/2025

This document has 11 pages.

# MARKING INSTRUCTIONS

### **Crossed-out answers**

If a student has crossed out an answer and written a clear alternative, do **not** mark the crossed-out answer.

If a student has crossed out an answer and **not** written a clear alternative, give the student the benefit of the doubt and mark the crossed-out answer if it's readable.

#### Multiple choice question answers

When a multiple choice question has only one correct answer and a student has written two or more answers (even if one of these answers is correct), you should **not** award a mark.

#### When a student writes more than one answer

#### 1. Questions that ask for a set number (including 1) of short answers or points

If a question asks for a set number of short answers or points (e.g. **two** reasons for something), mark only the **first set number** of answers/points.

**First** mark the answers/points against any printed numbers on the answer lines, marking the **first** answer/point written against each printed number. **Then**, if students have not followed the printed numbers, mark the answers/points from left to right on each line and **then** line by line until the set number of answers/points have been marked. Do **not** mark the remaining answers/points.

#### 2. Questions that ask for a single developed answer

If a student has written two or more answers to a question that only requires a single (developed) answer, and has **not** crossed out unintended answers, mark only the first answer.

#### 3. Contradictory answers in points-based questions

When a student has written contradictory answers, do **not** award any marks, even if one of the answers is correct.

Levels of Response marking

**1. To determine the level** start at the highest level and work down until you reach the level that best describes the answer

Quality of the answer	Award mark	
Consistently meets the criteria for this level	At the top of the level (6 and 9 mark questions)	
Meets the criteria but with some inconsistency	At the middle of the level (9 mark questions)	
On the borderline of this level and the one below	At the bottom of the level (6 and 9 mark	
	questions)	

#### 2. To determine the mark within the level, consider the following:

#### Mark scheme abbreviations

Annotation	Meaning
soi	Seen or implied in subsequent workings
ecf	Allow error carried forward from another question/item
ft	Allow follow through of an incorrect calculation within a question/item
pot	Allow power of ten error

#### Categorisation of marks (for questions other than MCQs)

#### B marks

These are awarded as <u>independent</u> marks, which do not depend on other marks. For a **B**-mark to be scored, the point to which it refers must be seen specifically in the candidate's answers.

#### M marks

These are <u>method</u> marks upon which **A**-marks (accuracy/answer marks) later depend. For an **M**-mark to be scored, the point to which it refers must be seen in the candidate's answers. If a candidate fails to score a particular **M**-mark, then none of the dependent **A**-marks can be scored.

#### C marks

These are <u>compensatory</u> method marks which can be scored even if the points to which they refer are not written down by the candidate, providing subsequent working gives evidence that they must have known it. For example, if an equation carries a **C**-mark and the candidate does not write down the actual equation but does correct working which shows the candidate knew the equation, then the **C**-mark is given.

#### A marks

These are <u>accuracy or answer</u> marks, which either depend on an M-mark, or are independent of/allow a **C**-mark to be scored.

# **MARK SCHEME**

(See the EA Item Types document for examples)

## **SECTION A**

1		
Max mark	1 (PO1)	
Answer	Force	
Guidance	Correct answer only (MCQ)	

2		
Max mark	1 (PO1)	
Answer	Displacement	
Guidance	Correct answer only (MCQ)	

3	
Max mark	1 (PO1)
Answer	415 x 10 <sup>6</sup> Nm <sup>-2</sup>
Guidance	Correct answer only (MCQ)

4		
Max mark	2 (PO1)	
Answer	$= 2 \times \pi \times 0.8 \times 2.2$ (C1) Substitution = 11.1 (3 SF) (A1) Answer	
Guidance	Accept answers that round to 11.1. Accept correct answers stated in other appropriate units of measure. Award full marks for the correct answer.	

5		
Max mark	3 (PO1)	
	$A = 0.00196 m^2$ (C1) Correct calculation of the cross-sectional area	
Answer	$\sigma = \frac{22 \times 10^3}{0.00196}$ (C1) Substitution (ft)	
	$\sigma = 11200000$ (3 SF) (A1) Answer (ft)	
Guidance	Accept answers that round to 11200000. Accept correct answers stated in other appropriate units of measure. Award full marks for the correct answer.	

6 (a) (i)		
Max mark	3 (PO2)	
Answer	$\Sigma Fv = 11 sin 30 + 15 sin 45 \pm 8 sin 80$ (C1) Substitution of correct trig function Candidate establishes +ve as vertically upwards	
	$\sum F_{v} = 11 \sin 30 + 15 \sin 45 - 8 \sin 80$ $\sum F_{v} = 8.23  (3 \text{ SF})$	(C1) Recognition (soi) (ft) (A1) Answer (ft)
	Alternative answer $\Sigma Fv = -11 \sin 30 - 15 \sin 45 \pm 8 \sin 80$ (C1) Substitution of correct trig	
	$\Sigma F_v = -11 \sin 30 - 15 \sin 45 + 8 \sin 80$ $\Sigma F_v = -8.23$ (3 SF)	(C1) Recognition (soi) (ft) (A1) Answer (ft)
Guidance	Accept answers that round to 8.23. Accept correct answers stated in other appro Award full marks for the correct answer.	opriate units of measure.

6 (a) (ii)		
Max mark	2 (PO2)	
Answer	$F_R = \sqrt{8.23^2 + 2.47^2}$ (C1) Substitution (ecf from 6 (a)(i)) $F_R = 8.59 (3 \text{ SF})$ (A1) Answer	
Guidance	Accept answers that round to 8.59. Accept correct answers stated in other appropriate units of measure. Award full marks for a correct answer.	

7		
Max mark	2 (PO2)	
Answer	$E = \frac{170 \times 10^{6}}{2 \cdot 5 \times 10^{-3}}$ (C1) Substitution (any appropriate values from the graph) (pot) $E = 68.0 \times 10^{9}$ (A1) Answer	
Guidance	Accept answers in the range 66.0 to 70.0 x 10 <sup>9</sup> Pa. Award full marks for the correct answer within range.	

8 (a)		
Max mark	2 (PO2)	
Answer	Magnitude= 15(EDistance from $R_A$ = 1.5(B	1) Answer 1) Answer
Guidance	Accept correct answers stated in other appropriate units of measure.	

8 (b)		
Max mark	4 (PO2)	
Answer	Take moments about $R_A$ (1.5 x 15) + (4 x 12) + (7 <i>C</i> ) = 9 x 22.3 of the equation 22.5 + 48 + 7 <i>C</i> = 200.7 7 <i>C</i> = (200.7 - 22.5 - 48) or <i>C</i> = (200.7 - 22.5 - 48)/7 <i>C</i> = 18.6	(M1) (M1) Substitution for each side (M1) Rearrangement (A1) Answer
Guidance	Accept correct answers stated in other appropriate units of measure.	
	·	

9		
Max mark	6 (PO2)	
Answer	Max safe towing force – friction = ma 3  kN = 3000 N 3000 = 240 + (1450  x a) a = (3000 - 240)/1450 a = 1.90 Unit: ms <sup>-2</sup>	<ul> <li>(M1) Recognition (soi)</li> <li>(M1) Conversion (soi)</li> <li>(M1) Substitution</li> <li>(M1) Rearrangement</li> <li>(A1) Answer</li> <li>(B1) Unit</li> </ul>
Guidance	Accept answers that round to 1.90.	

10 (a)		
Max mark	2 (PO2)	
Answer	$v = \frac{m_1 u}{(m_1 + m_2)}$ (M1) Rearrange conservation of momentum equation (soi) $v = \frac{(120 \times 10.85)}{(120 + 240)}$ or simplified to $v = \frac{(1302)}{(360)}$ (M1) Substitute Alternative answer $m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$ $m_1 u_1 = 120 \times 10.85 = 1302$ $m_2 u_2 = 0$ $(m_1 + m_2) v = 360 \times 3.62 = 1303.2$ (M1) Substitution Momentum before = Momentum after $1302 \approx 1303.2$ (M1) Recognition So $m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$	
Guidance	This is a 'Show that' question and the answer is given in the question 3.62 ms <sup>-1</sup>	

 $\mathbf{\mathcal{O}}$ 

10 (b)		
Max mark	6 (PO3)	
Answer	Deceleration: $v^2 = u^2 + 2as$	(M1) Recognition (soi)
	$a = \frac{v^2 - u^2}{2s}$	(M1) Rearrangement (soi)
	$a = \frac{0^2 - 3.62^2}{2 \times 0.10}$ or $a = \frac{-13.1}{0.2}$	(M1) Substitution
	a = -65.5	(A1) Answer
	Average force: $F = (120 + 240) \times (-65.5)$ or $F = 360 \times (-65.5)$	(M1) Substitution into $F = ma$ (ft)
	F = -23600 (3SF)	(A1) Answer (ft)
Alt Method	KE of the combined mass:	
	$KE = \frac{1}{2}mv^2$	(M1) Recognition (soi)
	$KE = \frac{1}{2} \times 360 \times 3.62^2$	(M1) Substitution
	KE = 2358.79	(A1) Answer
	Conservation of energy: $f = \frac{KE}{d}$	(M1) Rearrange $KE = fd$
	$f = \frac{2358.79}{0.1}$	(M1) Substitution (ft)
	f = 23600 (3SF)	(A1) Answer (ft)
Guidance	Accept answers that round to 23600 Accept correct answers stated in oth	er appropriate units of measure.

## **SECTION B**

11	
Max mark	1 (PO1)
Answer	Electron
Guidance	Correct answer only (MCQ)

12			
Max mark	1 (PO1)		
Answer	5.76		
Guidance	Correct answer only (MCQ)		

13	
Max mark	1 (PO1)
Answer	22nF
Guidance	Correct answer only (MCQ)

14		
Max mark	2 (PO1)	
Answer	$R_T = 4.7 + 2.2 + 33$ (C1) Substitution $R_T = 39.9$ (A1) Answer	
Guidance	Accept correct answers stated in other appropriate units of measure. Award full marks for the correct answer.	

15			
Max mark	2 (PO1)		
Answer	$L = (0.01 \times 200)/50$ (C1) Substitution		
	L = 0.04 (A1) Answer		
Guidance	Accept correct answers stated in other appropriate units of measure.		
	Award full marks for the correct answer.		

16 (a)		
Max mark	3 (PO1)	
Answer	10mA = 0.01A P = 0.012 × 50 P = 0.005	(C1) Conversion (C1) Substitution (ft) (A1) Answer (ft)
Guidance	Accept correct answers stated in other appropriate units of measure. Award full marks for the correct answer.	

16 (b)	
Max mark	1 (PO2)
Answer	Heat/Infrared radiation (B1)
Guidance	Do <b>not</b> accept 'resistance of the wires' or similar. Do <b>not</b> accept 'visible light' or 'light' as it is not waste Accept other alternative correct answers

16 (c)		
Max mark	2 (PO2)	
Answer	Time = Battery capacity/current or 2500 / 10 Time = 250	(C1) Recognition (A1) Answer
Guidance	Award full marks for the correct answer.	

17 (a)	
Max mark	1 (PO2)
Answer	1 (B1) Interpreting the graph
Guidance	Correct answer only

17 (b)		
Max mark	3 (PO2)	
Answer	$f = 1 / 1x10^{-3}$ (C1) Substitution/Conversion (ecf 17(a)) $f = 1000$ (A1) Answer (ft)Unit: Hz(B1) Unit	
Guidance	Accept correct answers stated in other appropriate units of measure. Award full marks for a correct answer.	

18 (a)		
Max mark	2 (PO1)	
	Voltage $A_v = 1 + (20/10)$	(C1) Substitution
Answer	Voltage $A_v = 3$ (A	A1) Answer
Guidance	Award full marks for the correct answ	er.

18 (b)		
Max mark	3 (PO2)	
	Voltage gain = $20 \log(3) + 20 \log(0.5)$ (0	C1) Substitution (ecf from 18(a))
Answer	Voltage gain = 9.54 + -6 (C1) negative	Recognition that gains can be
	Voltage gain = 3.52 (A1)	Answer (ft)
Guidance	Award full marks for the correct answer.	

19 (a)	
Max mark	1 (PO1)
Answer	B1 for: Q 0 0 1
Guidance	Correct answer for column Q

19 (b)							
Max mark	4 (PO2)						
Answer				1			
	D	E	F	G	Н	J	K
	0	0	• 0	1	0	1	0
	0	0	1	1	0	0	0
	0	1	0	0	1	1	1
	0	1	1	0	1	1	1
	1	0	0	1	0	1	0
	1	0	1	1	0	0	0
	1	1	0	0	0	1	0
	1	1	1	0	0	1	0
	B1 mark per correct column completed G to K (max 4). Allow ft from G to H Allow ft from G to J Allow ft from H and J to K						
Guidance							

20	
Max mark	8 (PO3)
Answer	For a junction $I_3 = I_1 + I_2$ or $\sum I_{In} = \sum I_{out}$ or For a loop $\sum V = 0$ (M1) Recognition KCL or KVL (soi) Loop 1: $5 = 10I_1 + 47I_3$ (M1) Setting up Loop 1 equation (soi) $5 = 10I_1 + 47(I_1 + I_2)$ $5 = 57I_1 + 47I_2$ (M1) Substitution (soi) & simplification using $I_1$ and $I_2$ Loop 2: $8 = 33I_2 + 47I_3$ (M1) Setting up Loop 2 equation (soi) $8 = 33I_2 + 47(I_1 + I_2)$ $8 = 47I_1 + 80I_2$ (M1) Substitution (soi) & simplification using $I_1$ and $I_2$ $8.51 = 97.02I_1 + 80I_2$ (M1) For multiplying Loop 1 by 80/47 (ft) $0.51 = 50.02I_1$ (M1) Elimination step in simultanious equations (ft) $I_1 = 0.51/50.02$ = 0.0102 (3 SF) (A1) Answer (ft)
Guidance	Accept any alternative methods of working.