OCR
Oxford Cambridge and RSA

Level 3 Cambridge Technical in Engineering

05822/05823/05824/05825

Unit 3: Principles of mechanical engineering

Sample Assessment Material

Date - Morning/Afternoon

Time allowed: 1 hour 30 minutes

You must have:

- the formula booklet for Level 3 Cambridge Technical in Engineering (inserted)
- a ruler (cm/mm)
- a scientific calculator

First Name							Last Name				
Centre Number							Candidate Number				
Date of Birth											

INSTRUCTIONS

- Use black ink. You may use an HB pencil for graphs and diagrams.
- Complete the boxes above with your name, centre number, candidate number and date of birth.
- Answer **all** the questions.
- Write your answer to each question in the space provided. Additional paper may be used if required but you must clearly show your candidate number, centre number and question number(s).
- The acceleration due to gravity is denoted by g ms^{-2}. Unless otherwise instructed, when a numerical value is needed, use g = 9.8

INFORMATION

- The total mark for this paper is **60**.
- The marks for each question are shown in brackets **[ ]**.
- Where appropriate, your answers should be supported with working.

  Marks may be given for a correct method even if the answer is incorrect.
- An answer may receive no marks unless you show sufficient detail of the working to indicate that a correct method is being used.
- Final answers should be given to a degree of accuracy appropriate to the context.
- This document consists of **16** pages. Any blank pages are indicated.

Answer **all** questions.

1 (a) Fig. 1 shows a stress versus strain graph for a material often used to manufacture engineered components.

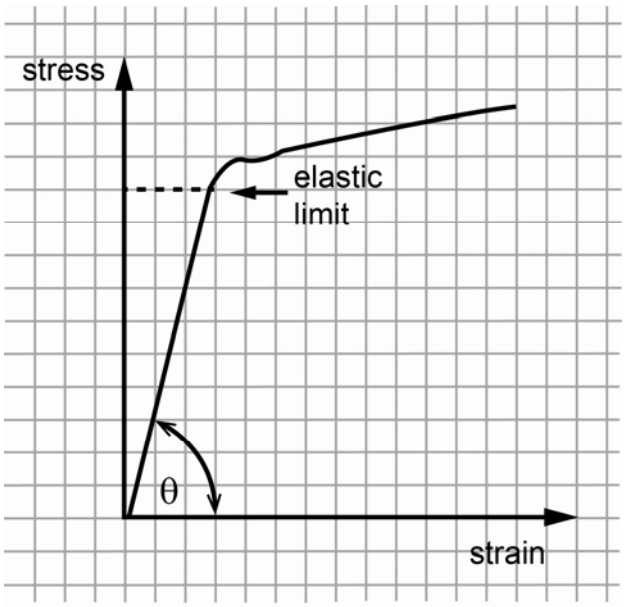

Fig. 1

(i) Identify the property of the material represented by the angle marked θ.

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

(ii) State why most components are designed to have a working stress that is lower than the elastic limit of the material.

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

(b) A cylinder manufactured from an unknown material is 10mm in diameter and 40mm long.

The cylinder is put into direct compression by a load of 25kN. When the load is applied it becomes 39.92mm long.

Calculate the stress in the material showing your working.

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

(c)

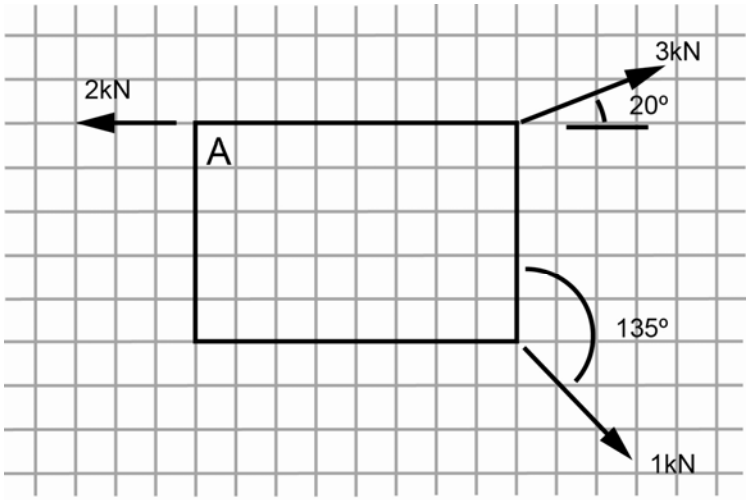

Fig. 2

Fig.2 shows a rectangular lamina 2m x 1.25m, acted on by three forces. Calculate:

(i) the magnitude of the resultant force

.....

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

(ii) the angle of the resultant force

.....

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

(iii) the perpendicular distance of the resultant force from point A.

.....

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

2 (a) Gear systems and belt and pulley systems are alternative methods of transmitting rotary motion. Give **one** advantage of each method:

(i) One advantage of a belt and pulley system is:

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

(ii) One advantage of a gear system is:

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

Fig. 3 shows a simple pulley system.

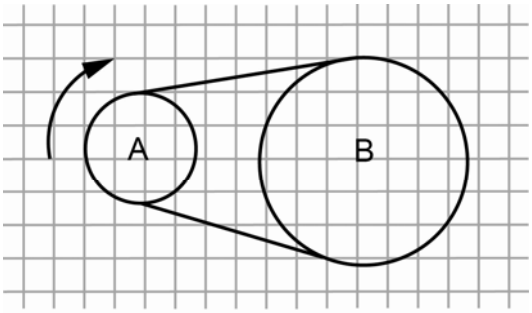

Fig. 3

The driving pulley (A) has a diameter of 75mm and the driven pulley (B) has a diameter of 200mm.

(b) Calculate the mechanical advantage of the system

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

(c) Give **one** reason why idler gears are often included as part of a gear system.

.....

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

(d) Fig. 4 shows a common type of gear system.

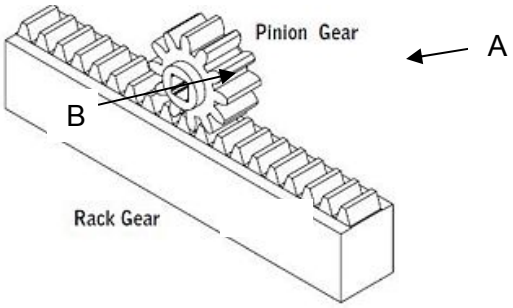

Fig. 4

(i) Name component A ..... **[1]**

(ii) Name component B ..... **[1]**

(iii) Give **one** application for this type of gear system.

.....

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

(e)

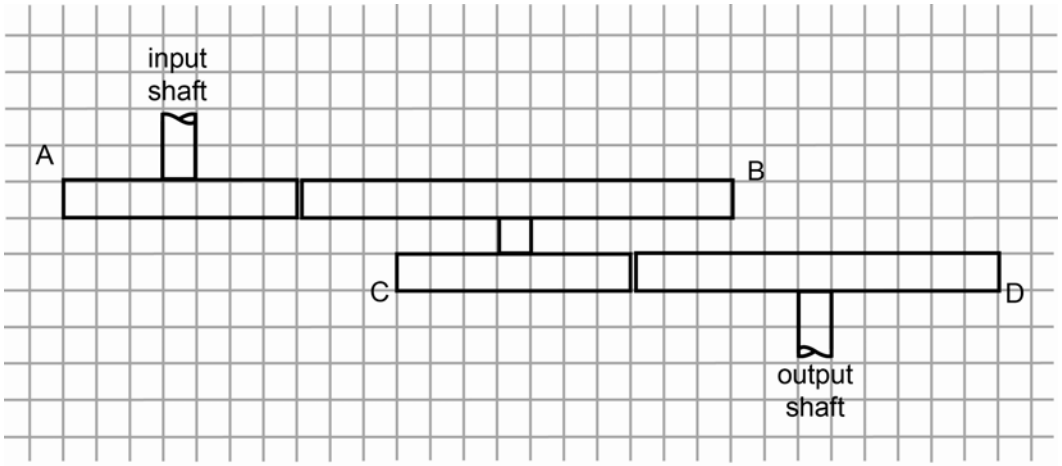

Fig. 5

Fig. 5 shows the plan view of a compound gear train of 4 gears A, B, C and D. Gears B and C are fixed onto a common shaft.

Gear A has 10 teeth, gear B has 36 teeth and gear D has 40 teeth. Calculate the number of teeth required on gear C for the overall velocity ratio of the gear train to be 1:12.

.....

.....

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

3

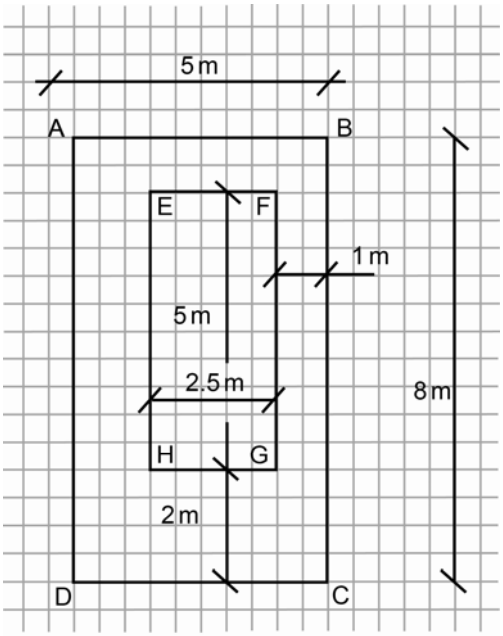

Fig. 6

Fig. 6 shows a rectangular plate ABCD. The plate has a rectangular hole EFGH as shown.

(a) (i) Find the coordinates of the centroid of the plate measured from point A.

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..... **[6]**

(ii) The plate is 12mm thick and is made from steel with a density of 8000kg/m^2
Determine the mass of the plate.

.....

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

(b) The plate is suspended from point A. Calculate the angle which side AB would make with the horizontal.

.....

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

4 Fig. 7 shows a tower crane.

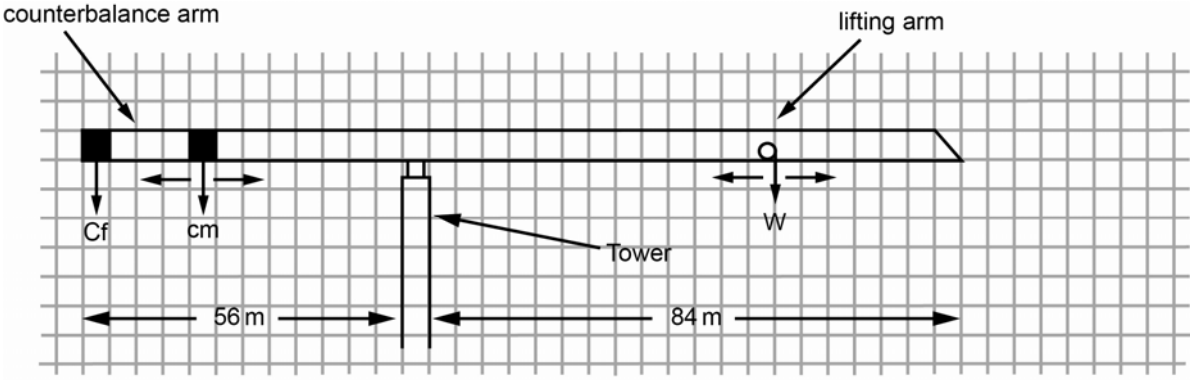

Fig. 7

The counterbalance arm is carrying a fixed counterbalance weight (Cf) and a mobile counterbalance weight (cm). Each weight has a mass of 2 tonnes.

The counterbalance arm has a length of 56m, and the length of the lifting arm is 84m. The total mass of the arms is 10 tonnes. The construction of the arms is uniform.

The weight (W) lifted by the crane can move along the arm to any position from the tower supporting the arms. The movable counterbalance is used to eliminate any turning moment at the connection with the tower.

(a) (i) Calculate the distance from the tower that the movable counterbalance should be placed when the crane is unloaded.

.....

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

(ii) Determine the maximum load that can be lifted by the crane at the furthest point from the tower.

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

(b) The crane is used to lift a mass of 0.5 tonnes to a height of 3m. The mass is released and falls onto a steel pile of mass 0.3 tonnes.

(i) Calculate the velocity of the mass just before impact with the steel pile.

.....

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

(ii) Applying the principle of conservation of momentum and assuming that the mass does not rebound, calculate the combined velocity of the mass and the steel pile.

.....

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

(iii) Calculate the kinetic energy of the combined mass and the steel pile.

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

(iv) The steel pile is driven 120mm into the ground. Determine the total work done by the resistance of the ground.

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

5 (a)

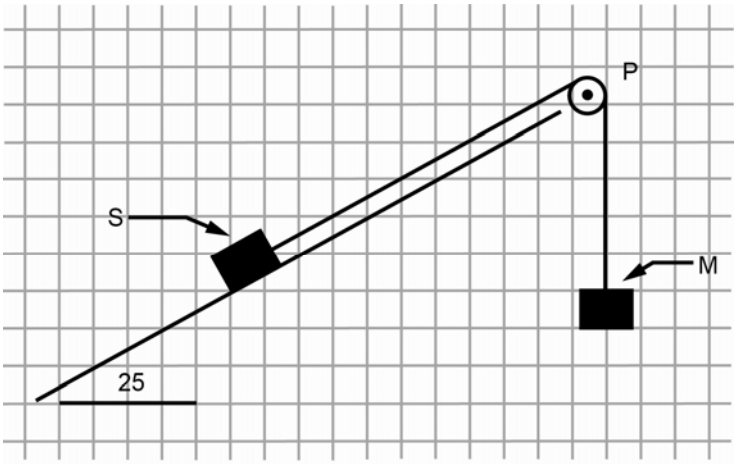

Fig. 8

Fig. 8 shows a sledge (S) of mass 500kg resting on a rough slope at 25° to the horizontal. The sledge is pulled up the slope by a cable, passing over a pulley (P), connected to a mass (M) of 800kg.

(i) Draw a diagram showing the forces and acceleration acting on the sledge **S.**

[1]

(ii) The coefficient of friction between the sledge and the surface of the slope is 0.3. Calculate the resistance to motion due to friction.

.....

.....

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

(iii) Draw a diagram showing the forces and acceleration acting on the mass **M.**

[1]

(iv) The cable connecting **M** and **S** does not stretch and the pulley **P** is smooth. Calculate the acceleration of the sledge and the tension in the cable.

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..... **[5]**

6 (a) Fig. 9 shows a beam built into a wall.

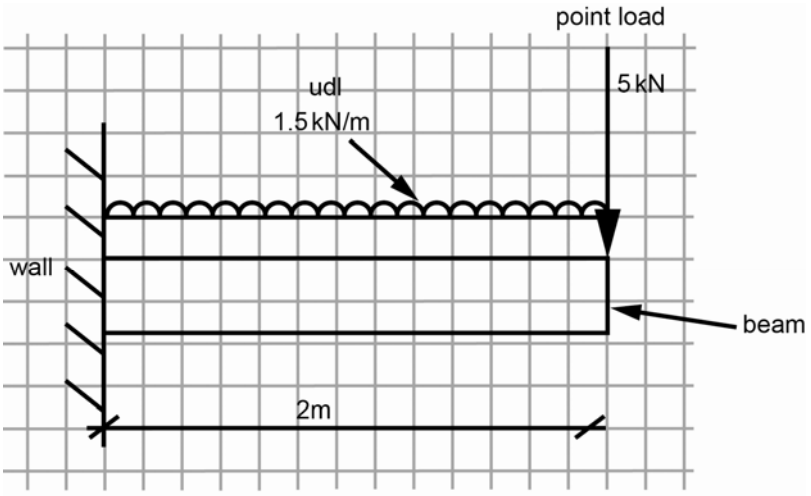

Fig. 9

(i) Name the type of beam shown in Fig. 9.

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

(ii) Calculate the reactions at the wall caused by the point load and uniformly distributed load (udl) to the beam shown in Fig.9

.....

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

(b) Fig.10 shows a simply supported beam carrying point loads

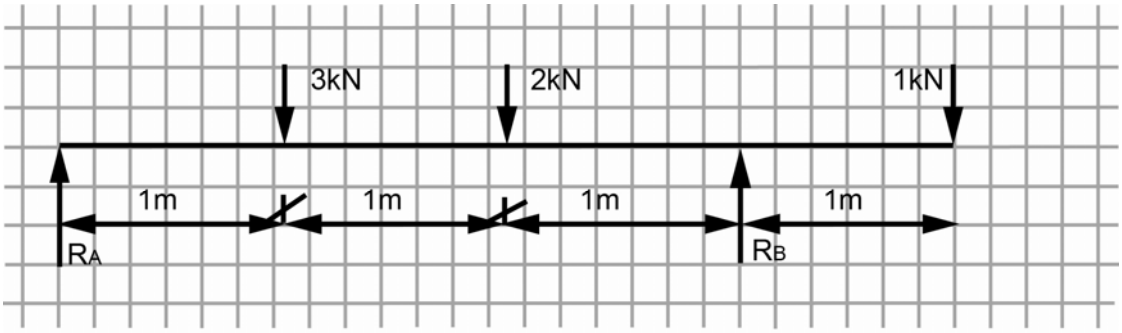

Fig. 10

(i) Calculate the reactions R_A and R_B

.....

.....

.....

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

(ii) Draw the bending moment diagram for the beam

[5]

END OF QUESTION PAPER

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SPECIMEN

Sample Assessment Material

Level 3 Cambridge Technicals in Engineering

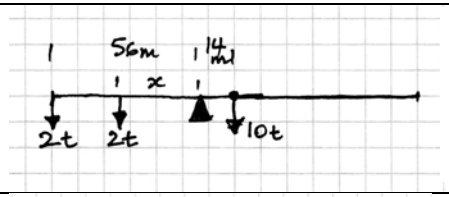
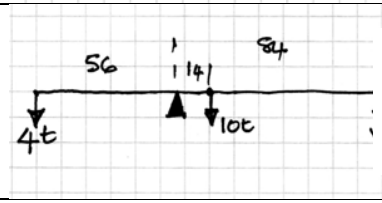
Unit 3: Principles of mechanical engineering

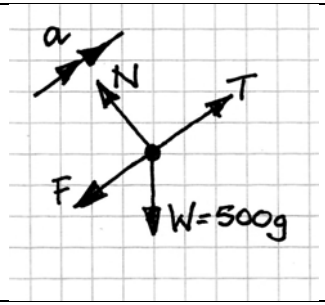
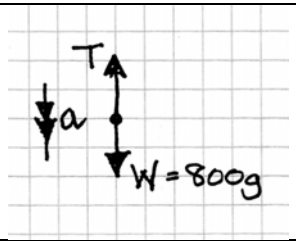
MARK SCHEME

Duration: 1 hour 30 minutes

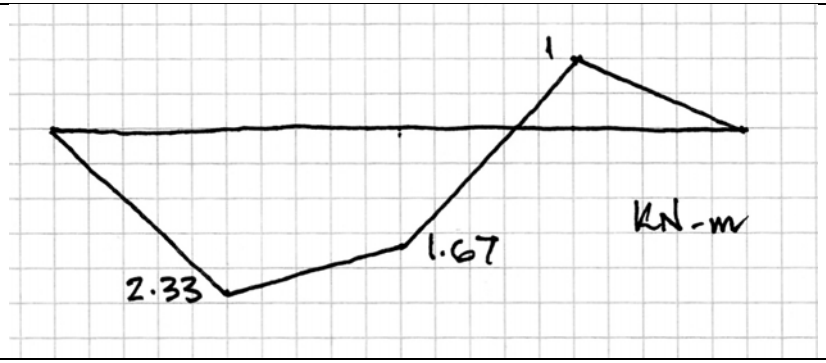
MAXIMUM MARK 60

Question			Answer	Marks	Guidance
1	a	i	Stiffness or Youngs modulus	1	Accept either (This mark is for applying knowledge from Unit 2 LO4 Understand properties of materials)
		ii	Stresses beyond the elastic limit cause permanent damage	1	Accept alternative valid explanation.
	b		Stress=force/cross-sectional area = $25x10^3/\pi x5^2$= 318.3 N/mm^2	2	1 mark for correct formula used plus 1 mark for correct answer including unit. Accept N/mm2 or N/mm-2
	c	i	Resolve horizontally Rx= 3cos20 – 2 +1cos45 = 1.53 kN Resolve vertically Ry= 3sin20 – 1cos45 = 0.319 kN R =$\sqrt{1.53^2+0.319^2}$) = 1.56 kN	1 1 1	1 mark for resolve a vector into two perpendicular vectors (LO2 of Unit 2) Accept ECF for R
		ii	tanθ = 0.319/1.53 => θ = 11.8° below horizontal	1	1 mark for the correct answer. Correct answer only.
		iii	Taking moments about point A 3x(sin20)x2 – 1x(cos45)x2 + 1x(cos45)x1.25 = 1.56xd d = 0.976m	2	 1 mark for method/approach 1 mark for correct answer
2	a	i	advantages of belt and pulley drive e.g. Quieter, Lighter	1	Accept any other reasonable advantage
		ii	advantage of gear system e.g. No slipping Greater torque transmission	1	Accept any other reasonable advantage
	b		MA = 200/75 = 2.67	1	
	c		Purpose of idler gear: To reverse rotation of the driven gear To allow smaller gears to be used to span between input and output shafts.	1	Only one valid reason needed. Accept any reasonable explanation
	d	i	pinion	1	
		ii	rack	1	
		iii	Examples: car steering gear, canal lock gates etc	1	Accept any suitable application

Question			Answer	Marks	Guidance
	e		(Product of driving teeth)/(Product of driven teeth) = V.R. (10xN)/(36x40) = 1/12 N=(36x40)/(12x10) N= 12 teeth	 1 1 1	1 mark for method 1 mark for transposition of equation 1 mark for correct solution
3	a	i	Total area = 8x5 – 5x2.5 = 27.5 m2 method of first moment of area gives; $\bar{x}$ = [40x2.5 – 12.5x(1.5+1.25)]/27.5 $\bar{x}$ = 2.39m $\bar{y}$ = [40x4 – 12.5x3.5]/27.5 $\bar{y}$ = 4.23m	1 1 1 1 1 1	 award mark for selection of correct method 1 mark for correct values into equation 1 mark for correct solution 1 mark for correct values into equation 1 mark for correct solution
		ii	mass = Vxρ = 27.5x(12/1000)x8000 mass =2640 kg	1 1	1 mark for correct substitution of values into equation. This mark is for applying knowledge of Mass from Unit 2 LO2 1 mark for correct solution with unit
	b		angle = $\tan^{-1}$(2.39/4.23) =29.5°	1 1	1 mark (This mark is for applying knowledge from Unit 1 LO4 Problems solving involving right-angled triangles) 1 mark for correct solution
4	a	i	 Take moments about tower: 10x14-2x56-2x=0 => x= 14 metres	 1 1	1 mark method 1 mark for solution.
		ii	 Method as above: Wx84+10x14-4x56=0 W = 1 tonne	 1	1 mark for solution Error Carried Forward.

Question			Answer	Marks	Guidance
	b	i	using conservation of energy: ½ mv^2=mgh => v=√2gh) = √(2x9.81x3) = 7.67 m/s	 1 1	Could use constant acceleration method. 1 mark method 1 mark for solution
		ii	$m_1u_1+m_2u_2=(m_1+m_2)v$ 500x7.67 = 800v v=4.79 m/s	1 1	1 mark for application of method 1 mark for solution Error Carried Forward
		iii	KE= ½ mv^2 = ½ 800x4.79^2 =9177.6J	1	accept answer without units if otherwise correct. Error Carried Forward. (This mark is for applying knowledge from Unit 2 LO2 Kinematics)
		iv	total work done = KE + PE => 9177.6 + (800x9.81x120/1000) = 10119.4J	2	1 mark for method 1 mark for solution. Error Carried Forward
5	a	i		1	accept alternative labelling
		ii	At S, perpendicular to slope: N-W(cos25)=0 N=500g(cos25)=4.45kN Limiting F = μN = 0.3x4.45 = 1.335kN	1 1 1	1 mark for method/approach 1 mark for calculation of N 1 mark for correct answer.
		iii		1	Accept alternative labelling
		iv	At S parallel to slope: T-F-Wsin25 = ma T-1335-2073=500a	1	1 mark for method

Question			Answer	Marks	Guidance
			At M vertically: 800g – T = 800a 7848 – T = 800a solve simultaneous equation a = 3.41 m/s^2 T=5.11kN	1 1 1+1	1 mark F=ma parallel to slope 1 mark F=ma vertically at M 2 (These two marks are for applying knowledge from Unit 1 LO1 Solve linear simultaneous equations)

Question			Answer	Marks	Guidance
6	a	i	Cantilever	1	
		ii	Vertical reaction = 1.5x2+5 = 8kN Moment = 3x1.5 + 5x2 = 14.5 kN▪m	1 1	
	b	i	Rotational equilibrium about A: 3x1 + 2x2 – Rbx3 + 1x4 = 0 Rb = 11/3 = 3.67kN Vertical equ Ra + Rb = 3 + 2 + 1 Ra = 6-3.67=2.33kN	 1 1	 1 Mark for R_B 1 mark for R_A
		ii		3 2	1 mark for each of the point BM values (any appropriate method of calculation) 2 marks for completed diagram (point values/straight lines).