Cambridge Technicals

Engineering

Unit 3: Principles of mechanical engineering

Level 3 Cambridge Technical Certificate/Diploma in Engineering
05822 - 05825 & 05873

Mark Scheme for June 2024

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

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MARKING INSTRUCTIONS

PREPARATION FOR MARKING

RM ASSESSOR

1.   Make sure that you have accessed and completed the relevant training packages for on-screen marking: *RM Assessor Assessor Online Training*; *OCR Essential Guide to Marking*.

2.   Make sure that you have read and understood the mark scheme and the question paper for this unit. These are posted on the RM Cambridge Assessment Support Portal http://www.rm.com/support/ca

3.   Log-in to RM Assessor and mark the **required number** of practice responses ("scripts") and the **number of required** standardisation responses.

YOU MUST MARK 5 PRACTICE AND 10 STANDARDISATION RESPONSES BEFORE YOU CAN BE APPROVED TO MARK LIVE SCRIPTS.

MARKING

1.   Mark strictly to the mark scheme.

2.   Marks awarded must relate directly to the marking criteria.

3.   The schedule of dates is very important. It is essential that you meet the 50% Batch 1 and 100% Batch 2 deadlines. If you experience problems, you must contact your Team Leader (Supervisor) without delay.

4.   If you are in any doubt about applying the mark scheme, consult your Team Leader by telephone, *RM Assessor* messaging or by email.

5.   **Crossed Out Responses**
     Where a candidate has crossed out a response and provided a clear alternative then the crossed out response is not marked. Where no alternative response has been provided, examiners may give candidates the benefit of the doubt and mark the crossed out response where legible.

Multiple Choice Question Responses
When a multiple choice question has only a single, correct response and a candidate provides two responses (even if one of these responses is correct), then no mark should be awarded (as it is not possible to determine which was the first response selected by the candidate). When a question requires candidates to select more than one option/multiple options, then local marking arrangements need to ensure consistency of approach.

Contradictory Responses
When a candidate provides contradictory responses, then no mark should be awarded, even if one of the answers is correct.

Short Answer Questions (requiring only a list by way of a response, usually worth only **one mark per response**)
Where candidates are required to provide a set number of short answer responses then only the set number of responses should be marked. The response space should be marked from left to right on each line and then line by line until the required number of responses have been considered. The remaining responses should not then be marked. Examiners will have to apply judgement as to whether a 'second response' on a line is a development of the 'first response', rather than a separate, discrete response. (The underlying assumption is that the candidate is attempting to hedge their bets and therefore getting undue benefit rather than engaging with the question and giving the most relevant/correct responses.)

Short Answer Questions (requiring a more developed response, worth **two or more marks**)
If the candidates are required to provide a description of, say, three items or factors and four items or factors are provided, then mark on a similar basis – that is downwards (as it is unlikely in this situation that a candidate will provide more than one response in each section of the response space.)

Longer Answer Questions (requiring a developed response)
Where candidates have provided two (or more) responses to a medium or high tariff question which only required a single (developed) response and not crossed out the first response, then only the first response should be marked. Examiners will need to apply professional judgement as to whether the second (or a subsequent) response is a 'new start' or simply a poorly expressed continuation of the first response.

6. Always check the pages (and additional lined pages if present) at the end of the response in case any answers have been continued there. If the candidate has continued an answer there then add an annotation to confirm that the work has been seen.

7. Award No Response (NR) if:
   • there is nothing written in the answer space

   Award Zero '0' if:
   anything is written in the answer space and is not worthy of credit (this includes text and symbols).

8. The RM Assessor **comments box** is used by your team leader to explain the marking of the practice responses.
    Please refer to these comments when checking your practice responses. **Do not use the comments box for any other reason.**
    If you have any questions or comments for your team leader, use the phone, the RM Assessor messaging system, or e-mail.

9. Assistant Examiners will email a brief report on the performance of candidates to your Team Leader (Supervisor) by the end of the marking
    period. Your report should contain notes on particular strength displayed as well as common errors or weaknesses. Constructive criticism of
    the question paper/mark scheme is also appreciated.

10. **Subject specific marking instructions**

    In all numerical calculation questions a correct response to 2 sf will gain all marks unless specified otherwise. When an answer is given to
    more than 2 sf, if it rounds to the answer given in the mark scheme to 2 sf, the mark can be awarded.
    If this is not the case for specific questions, this will be detailed in the mark scheme.
    You do not need to see all the workings if the answer is correct. Any answers or units in brackets do not need to be seen.

11. **Annotations**

Annotation	Meaning
✔	Correct response worthy of a mark. **Number of ticks = number of marks awarded.**
✖	Incorrect response
∧	Incomplete response
ECF	Error carried forward
BOD	Benefit of doubt
NBOD	No benefit of doubt
POT	Power of ten error
RE	Rounding error
SF	Significant figure error
SEEN	Seen
BP	Blank page

Mark scheme abbreviations

Other abbreviations used in mark scheme	Meaning
oe	or equivalent
ecf	error carried forward
wtte	words to that effect
soi	seen or implied
SC	special case
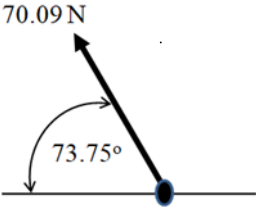
Question			Answer/Indicative content	Marks	Guidance
1	**(a)**	**(i)**	[70 x 120] / 2 (= 4200)	1	
			$20^2 \pi$ / 2 (= 628.32)	1	**ALLOW** 200π
			4200 - 628.32 = **3571.68** (mm²)	1	**ALLOW 35.7 cm²** or **3.57 x 10⁻³ m²** only if the units are shown
				[3]	

Question			Answer/Indicative content	Marks	Guidance
		(ii)			

	Area,A	$\bar{x}$	$\bar{y}$	A$\bar{x}$	A$\bar{y}$
Triangle	4200	**46.67/46.7**	40	196014	168000
S-circle	-628.32	**61.51/61.5**	40	-38648	-25132.8
TOTAL	3571.68			157366	142867

$\bar{x} = \dfrac{(4200 \text{x} 46.67) - (628.32 \text{x} 61.51)}{3571.68}$

$\bar{y} = \dfrac{(4200 \text{x} 40) - (628.32 \text{ x } 40)}{3571.68}$

$\bar{x} = $ **44.06**

$\bar{y} = $ **40.00**

Marks and Guidance for (ii):

- 2 — Correct value of $\bar{x}$ for each segment **ALLOW 140/3**
- 2 — Correct value of $\bar{y}$ for each segment soi with correct final answer
- 1 — Calculating centroid value using an appropriate method, using *their* values seen for either $\bar{x}$ or $\bar{y}$ or soi with a correct answer. **ALLOW** ecf in any area from 1(a)(i)
- 1 — ($\bar{x} = $ 44.06)
- 1 — ($\bar{y} = $ 40.00)

[7]

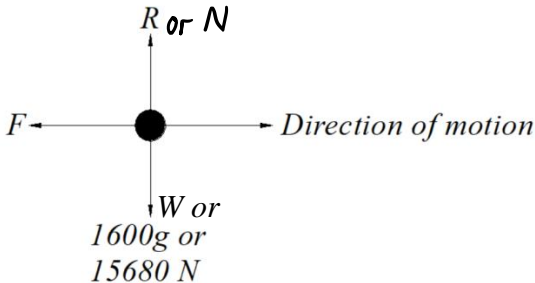| Question			Answer/Indicative content	Marks	Guidance
2	**(a)**		A rack and pinion gear system consists of a **spur** gear known as the pinion and a **flat-toothed** component known as the rack. It is used to convert **rotational/linear** motion to **linear/rotational** motion.	1 1 1 1	1 mark for each correct response The third and fourth responses cannot be the same. It must either be rotational then linear or linear then rotational to gain both marks for that part.
				[4]	
	(b)		Motorbike / bicycle / conveyor belts / tracked vehicles / car engines / chain saw / rolling machine	1	Accept any correct response
				[1]	
	(c)		(VR = V output/V input = Input diameter/Output diameter) VR = 225/75 = 255/Output diameter Output diameter = 75 * 255/225 = **85** (mm)	 1 1 1	No marks for this as both equations are in formula booklet Rearranging and substitution can be done in either order. Substitution Re-arrangement of formula soi by correct answer **ALLOW 8.5 cm** or **0.85 m** if units are shown **SC ALLOW VR = 3 for 1 mark if clearly specified**
			Alternative solution (MA= V input/V output) = Output diameter/Input diameter) MA = 75/225 = Output diameter/255 Output diameter = 75/225 * 255 = **85** (mm)	 1 1 1	No marks for this as both equations are in formula booklet Rearranging and substitution can be done in either order. Substitution Re-arrangement of formula soi by correct answer **ALLOW 8.5 cm** or **0.85 m** if units are shown **SC ALLOW MA = 1/3 for 1 mark if clearly specified**
				[3]	

Question			Answer/Indicative content	Marks	Guidance
2	**(d)**		Advantages: • Simple to manufacture • Simpler to maintain/repair/replace • Pulley wheels can be at a distance to each other • Quieter (at high speeds) • Less energy is needed to cause motion • Easier/fewer parts to lubricate • Less susceptible to vibration • More torque at low speed Disadvantages: • They are prone to slip • VR is much less • More likely to break/tear/wear • Less torque at high speed	2 1	1 mark for each correct response (max 2) IGNORE cheaper **NOT** simpler to use Accept does not require lubrication of parts Award marks for other suitable responses 1 mark for a correct response Award mark for other suitable responses
				[3]	

	Question		Answer/Indicative content	Marks	Guidance
3	**(a)**		Cross-sectional area = 100 x 2 = 200 mm^2	1	Calculate cross sectional area **NOT** volume **DO NOT ALLOW** POT error
			200 x 250 =	1	Substitution Assume 20000 without working is an area, but any substitution using any volume scores a total of zero marks **ALLOW** ecf from *their* area for this mark only
			50000 (N)	1	**ALLOW 50 kN** if units are shown
				[3]	
	(b)		Class: **2/ Second**	1	
				[1]	
	(c)	**(i)**	1150/350 = **3.29**	1	**ALLOW 23/7 or anything which rounds to 3.3**
				[1]	
		(ii)	42 x 9.8 = 411.6 (N) or 42/3.29 = 12.77 (kg)	1	
			411.6/3.29 or 12.77 x 9.8 = **125.1** (N)	1	**ALLOW** ecf from c (i)
		(ii)	Alternative solution 0,35 x 42 x 9.8 = 144.06	1	
			144.06/1.15 = **125.3** (N)	1	
				[2]	

Question			Answer/Indicative content	Marks	Guidance
4	**(a)**		Fixed / Encastre	1	Accept any unambiguous responses
			Simply/Simple (supported)	1	
			Continuously/Continuous (supported)	1	
				[3]	
	(b)	**(i)**	Vertical component:		
			= 85 (sin 40) = **54.64** (kN)	1	**ALLOW** 85000 (sin 40) = **54640** (N) Synoptic assessment from Unit 1 (4.3) 1 mark
				[1]	
		(ii)	75 + 54.64 - 35 = **94.64** (kN) / **94640** (N)	1	**ALLOW** ecf from 4(b)(i) (*Their* answer + 40 kN)
				[1]	
		(iii)			**ALLOW** ecf from 4(b)(i) for both marks
			(6x75)+(4x54.64)-(1.6x35)	1	
			=**612.56** (kNm) / **612560** (Nm)	1	(4 x *their* b(i) + 394) kNm
				[2]	

Question			Answer/Indicative content	Marks	Guidance
5	(a)		$45\cos(70)=$ **15.39** (horizontal component of 45 N $45\sin(70)=$ **42.29** (vertical component of 45 N) Total horizontal $=15.39 - 35 =$ **(-) 19.61** (N) Total vertical $42.29+25 =$ **(-) 67.29** (N)	1 1	Resolve 45 N for both horizontal and vertical forces soi Both correct IGNORE the direction until marking the diagram **SC ALLOW 1 mark for one of 19.61 or 67.29**
			$\sqrt{(67.29^2+19.61^2)} =$ **70.09** (N) $\mathrm{Tan}^{-1}(67.20/19.61) =$ **73.75º or 106.23º or 253.75º**	1 1	Correct magnitude Correct angle/direction.
			70.09 N 73.75º	1	Diagram showing the resultant force and angle from horizontal. ALLOW ecf using *their* values Synoptic assessment from Unit 1 (4.3) 3 marks
				[5]	
	(b)		$(65*35)+(110*25)+(75*42.29)-(65*15.39)$	1	**ALLOW** 1 mark for 3 out of 4 correct moments with correct sign.
			$=$**7196.05** or **7.196** (anti-clockwise)	1	
			N mm or **N m**	1	Consistent units.
				[3]	
	(c)		$7196.05 = 85\,x$	1	**ALLOW** ecf from 5b for both marks
			$x = 7196.05 / 85 =$ **84.66** (mm) / **0.08466** (m)	1	

Question			Answer/Indicative content	Marks	Guidance
6	**(a)**	**(i)**	90 km/h = 25ms^{-1}	1	Conversion of km/h to m/s
					Synoptic assessment from Unit 2 (1.1) 1 mark
			KE = ½ mv^2 = 1600x(25)^2/2 =	1	Substitution.
					ALLOW v = 90 (ke = 6480000J)
					or *their* incorrect value for v as ecf for this mark only
			5x10^5/500 000 J	1	**ALLOW 500 kJ oe if units are shown**
				[3]	
		(ii)	W = Fd		Synoptic assessment from Unit 2 (2.4) 1 mark
					ALLOW ecf from 6(a)(i) for both marks
			5x10^5 = F x 50	1	Rearranging and substitution can be done in either order.
			F = 5x10^5/50 = **10000** (N) or **10** (kN)	1	
			Alternative solution:		**ALLOW** ecf for velocity from 6(a)(i) for both marks
			s = (u +v) t / 2, 50 = (25 + 0) t / 2, t = 4 s		
			v = u + a t, 0 = 25 +4 a, a = -6.25 m s^{-2}	1	
			F = m a = 1600 x 6.25 = **10000** N	1	(*Their* v squared x16)
				[2]	

Question			Answer/Indicative content	Marks	Guidance
6	**(a)**	**(iii)**			Forces must be labelled to gain any marks
				1	Friction force shown at 180 degrees to the direction of motion.
					ALLOW momentum for direction of motion.
					ALLOW the numerical answer from 6 (a) (ii) instead of F with ecf for this mark only if no other numerical horizontal force is shown.
					IGNORE driving force/acceleration/air resistance/drag
				1	Weight of car **and** reaction force/normal in correct directions.
					IGNORE incorrect calculation of W for this mark
					ALLOW arrows close to the object (they don't have to be touching)
				[2]	
		(iv)	$F = \mu R$		**ALLOW** ecf from 6 (a)(ii) for all three marks
					Rearranging and substitution can be done in either order.
			$F / R = \mu$	1	Re-arrangement
			$= 10000 / (1600 \times 9.8)$	1	Substitution
			$= \mathbf{0.638}$	1	Accept 0.637 if 9.81 is used for g
				[3]	

Question			Answer/Indicative content	Marks	Guidance
6	**(a)**	**(v)**	($a = F/m$)		**ALLOW** ecf for F from 6 (a)(ii) for both marks
			$a = 10000/1600$	1	Substitution and re-arrangement
			$a = \pm\mathbf{6.25}$ (m s^{-2})	1	Award both marks if answer is given in part (a)(ii) and no further answer is shown for this question.
					Award 1 mark if the answer from part (a) (ii) is seen but not as the final answer.
			Alternative solution		**ALLOW** ecf for v from 6(a)(i) for both marks
			$v^2 = u^2 + 2as,\ \ 0^2 = 25^2 + 2\ x\ a\ \ x\ 50,\ \ \ a = (0^2 - 25^2) / 100$	1	Substitution and re-arrangement
			$a = \pm\mathbf{6.25}$ (m s^{-2})	1	Award both marks if answer is given in part (a)(ii)
			Alternative solution		**ALLOW** ecf for v from 6(a)(i) for both marks
			$s = (u +v)\ t / 2,\ \ \ \ 50 = (25 + 0)\ t / 2,\ \ \ \ t = 4\ s$	1	Substitution and re-arrangement
			$v = u + a\ t,\ \ \ \ \ \ \ \ \ \ 0 = 25 + 4\ a,$		
			$a = = \pm\mathbf{6.25}$ (m s^{-2})	1	Award both marks if answer is given in part (a)(ii)
				[2]	
	(b)		Momentum before = (3500 x 15) – (1500 x 20) = 22500	1	Do not need to see 22500 for this mark
			Momentum after (3500×3) + (1500v) = ***Their*** expression/value for Momentum before soi	1	NB If the two momenta before are added together then a final answer of 48ms^{-1} is achieved which then gains this mark only.
			Momentum after 10500+1500v = 22500 $v = 12000/1500 = \mathbf{8}$ m s^{-1}	1	
				[3]	

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