OCR
Oxford Cambridge and RSA

Cambridge Technicals

Engineering

Unit **2**: Science for engineering

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

Mark Scheme for June 2018

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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.

Annotations

Annotation	**Meaning**
tick	correct response worthy of a mark. **number of ticks = no of marks awarded**
cross	incorrect
omission (carat)	missing something
ecf	error carried forward
bod	benefit of doubt
nbod	not benefit of doubt
pot	power of ten error
con	contradiction
re	rounding error
sf	significant figure error
up	unit penalty

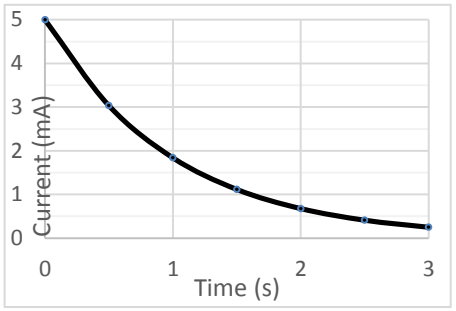
Subject specific marking instructions

In all numerical calculation questions a correct response to 2 sf will gain all marks unless specified otherwise. You do not need to see all the workings if the answer is correct.

Question			Answer	Marks	Guidance
1	(a)		$kg\ m\ s^{-1}$ $kg\ m\ s^{-2}$ $kg\ m^2\ s^{-2}$ $kg\ m^2\ s^{-1}$	1	Second one is ringed. Accept other clear methods to indicate choice.
	(b)		5 m= 5×10^6 µm [5,000,000] 100 cm^2 = 10^{-3} m^2 [0.001] 100 litre = 10^8 mm^3 [100,000,000]	1 1 1	
	(c)		(SE = $\sigma/(N)^{0.5}$ = $0.45/(15)^{0.5}$ =) 0.12	1	Answer is 0.116
	(d)		One mark for each of the following – up to a max of 3 marks • Checking/adjusting instrument • Comparing measurements (from one instrument with those from a more accurate instrument) • to a standard (method/procedure) • Use of predefined interval or marker • Ensures instrument measures correctly/accurately • Need to make all measurements repeatable/consistent • Errors can be accounted for / corrected / removed.	3	ALLOW set to zero.
	(e)		Relative error (151-150)/150 = 0.0067 (Absolute correction: 150 -151 =) -1(mm)	1 1	ALLOW $\frac{1}{150}$ (soi) and 0.00$\dot{6}$. ALLOW 0.67%. Ignore any units given. Correction must have negative sign.
			QUESTION TOTAL	10	

Question			Answer	Marks	Guidance
2	(a)	(i)	a = ΔV÷Δt / a = gradient of the graph / a = (30÷5) = 6 **m s^{-2}**	1 1	*CHECK ANSWER LINE; If answer = 6 m s^{-2} award 2 marks.* **Correct answer must include unit.** Ignore sign. Max 1 mark if 6 seen with no unit.
		(ii)	(F = m a = F = 75 x 6 =) 450 (N)	1	Ignore sign. Allow ecf of *a* from part (i).
	(b)	(i)	Conversion of speed into ms^{-1} (v = 100×10^3÷3600 =) 27.8 (ms^{-1}) (Kinetic energy = mv^2÷2= (1375×(27.8)^2)÷2 =) 5.3×10^5 (J)	1 1	*CHECK ANSWER LINE; If answer = 5.3×10^5 J award 2 marks.* Use of m = 1300 kg is incorrect – MAX 1 mark. If no conversion; energy = 6.9 x10^6 (or 10^8); award 1mark.
		(ii)	Either (using energy = force x distance): ΔE$_k$ / 5.3×10^5 = F s or F = 5.3×10^5 / 38 F = 14×10^3 (N) Or (using suvat): $a = \frac{v^2}{2s}$ and $F = ma$ (seen or implied) or $F = ma = \frac{mv^2}{2s} = \frac{13785 \times 27.8^2}{2 \times 38}$ F = 14×10^3 (N)	1 1 (1) (1)	*CHECK ANSWER LINE; If answer = 1.4×10^3 N award 2 marks.* Use of correct relationship. Allow ecf incorrect energy from (ii). Use of correct relationships. Allow ecf incorrect speed and/or mass from (i).

Question			Answer	Marks	Guidance
	(c)		Either using pythagorus: Resultant force = $\sqrt{((2000 - 400)^2 + 400^2)}$ ($= \sqrt{(2.72\times10^6)}$) $= 1650$ (N) (tan $\theta = 400 \div 1600 = 0.25$ so) $\theta = 14(°)$ or by using a scale diagram: force diagram or force triangle drawn to scale Resultant force in range $1600\ N \leq F \leq 1700\ N$ angle in range $12° \leq \theta \leq 16(°)$	1 1 1 (1) (1) (1)	 ACCEPT 1600 or 1700 with correct working. ACCEPT 0.24 (radian). BOD 76° if accompanied by a clearly labelled diagram showing/stating angle relative to F_2.
			QUESTION TOTAL	10	

Question			Answer	Marks	Guidance
3	(a)	(i)	Line passes through (0,5) and (2,0.68) (within half a small square), Smooth curve, with negative but becoming shallower gradient, across width of graph grid (ie 3 seconds).	1 1	
		(ii)	Either: Line tangent is drawn from the initial part of discharge curve to intersect the time X axis at the point denoting the time constant (approx 1 s in this case) Or: Time constant is the time taken for initial value to fall to 1/e or 37% of original value. Find the time taken for the current to fall to 1.84 mA (this gives value of 1 s) Or: Extrapolating curve until it (almost) reaches x axis. The time it takes to discharge is approximately 5 × time constant. Or: Find half life/time taken for current to halve. Time constant = half life÷ln2/ = half life×1.44 Or: Use data point value for *I* and value for *t*. Substitute into $I = I_o\, e^{\frac{-t}{RC}}$, (where $I_o = 5$) and time constant = *RC*.	 1 1 (1) (1) (1) (1) (1) (1) (1) (1)	These methods can be shown by annotating the graph.

Question			Answer	Marks	Guidance
	(b)	**(i)**	(Q = It = (2 × 10^{-3}) (5) =) 0.01 (C)	1	
		(ii)	(W =) ½VQ or (W =) ½VIt or (W =) ½ (40) (10×10-3) E = 0.20 **J**	1 1	*CHECK ANSWER LINE; If E = 0.20 J award 2 marks.* Use of correct equation. Correct value and **unit** with consistent POT. Max 1 mark for 0.2 without unit. Allow ecf of Q from part (i).
	(c)	**(i)**	(Input power (= I V = 2×300 =) 600 W (Output power = Input Power x efficiency = 600 x 0.8 =) 480 (W)	1 1	*CHECK ANSWER LINE; If Output power = 480 W award 2 marks.* Calculation of power. Correct calculation of output power.
		(ii)	(Energy supplied = Input Power x time = 600 x 60 =) 36000 (J)	1	Use of output power is incorrect but allow ecf of input power from part (i) if clearly stated.
			QUESTION TOTAL	10	

Question			Answer	Marks	Guidance
4		(i)	Material 1. because there is a higher gradient (of the stress-strain curve in the elastic region)/higher value of Young's Modulus/less strain at the same stress.	1 1	Not just lower strain.
		(ii)	Material 1. because there is a higher stress value before failure/higher maximum stress/higher UTS value.	1 1	Not just higher stress. Do not allow higher force before failure, unless reference to area of samples.
		(iii)	Material 2. because there is a larger area under the curve/more energy stored within the material before failure/work done before failure.	1 1	

Question			Answer	Marks	Guidance
	(b)		Steel is more suitable **because** eg, its yield strength is greater than the maximum stress level and/its extension is less than required or it has a high enough Youngs modulus.	1	Must include reason. ACCEPT steel is more suitable because it is stronger/stiffer/ (than Aluminium).
			Either: Max stress = F/A = 10 /40 = 250(MPa) Max strain = e/l = 2×10^{-3} or 1/500 Calculating strain of each material. Strain for steel at 250 MPa (= $250\times10^{6}\div201\times10^{9}$ =)1.2×10^{-3} and Strain for aluminium at 250 MPa (= $250\times10^{6}\div69\times10^{9}$ =) 3.6×10^{-3}.	 1 1 1	 Any POT errors, max 2 marks for correct methods.
			Or: Max Stress = 250 (MPa) Attempt to calculate extension = length x σ /E (soi) steel extension (= 1 x (250 x 10^{6})/(201 x 10^{9}) =) 1.2 x 10^{-3} m and aluminium extension (= 1 x (250 x 10^{6})/(69 x 10^{9}) =) 3.6 x 10^{-3} m.	 (1) (1) (1)	 Any POT errors, max 2 marks for correct methods.
			Or: Max stress = F/A = 10 /40 = 250(MPa) Max strain = e/l = 2×10^{-3} or 1/500 Minimum Youngs Modulus (= $250\times10^{6}\div2\times10^{-3}$ =) 1.25×10^{11} Pa.	 (1) (1) (1)	 Any POT errors, max 2 marks for correct methods.
			Or: Max stress = F/A = 10 /40 = 250(MPa) Max strain = e/l = 2×10^{-3} or 1/500 Calculating stress of each material at that strain. Stress for steel (= $2\times10^{-3}\times201\times10^{9}$ =) 4.0×10^{8} Pa / 400 MPa and Stress for aluminium (= $2\times10^{-3}\times69\times10^{9}$ =) 1.4×10^{8} / 140 MPa.	 1 1 1	 Any POT errors, max 2 marks for correct methods.
			QUESTION TOTAL	10	

Question			Answer	Marks	Guidance
5	(a)	(i)	P = F/A = 700÷A (P = 700 /350 x 10^4 =) 2.0 x 10^4 (Pa)	1 1	*CHECK ANSWER LINE; If E = 2.0×10^4 Pa award 2 marks.* Dividing 700N by either area. Correct calculation.
		(ii)	($P_1 = P_2$, so $P_2 = F_1/A_1$ so F_1 = (2.0 x 10^4) (50 x 10^{-4}) =) 100 (N)	1	Allow ecf of incorrect area from (i).
		(iii)	Displaced volume of fluid is the same on both sides/ $V_1=V_2$ (because liquids are incompressible) / displacement is inversely proportional to area / $\frac{d_1}{d_2} = \frac{A_2}{A_1}$. ($d_1$ = (350 ÷ 50) ×15, so h =) 105 (cm).	1 1	*CHECK ANSWER LINE; If h = 105 cm award 2 marks.*

Question			Answer	Marks	Guidance
5	(b)	(i)	(Pressure $= \rho g h = (1000)(9.8)(1) =) 9.8 \times 10^3$ (Pa)	1	
		(ii)	Either:		*CHECK ANSWER LINE; If h_L = 93 cm award 5 marks.*
			Pressure on both sides will be equal once baffle is removed /$P_L = P_R$.	1	Stated either in words or symbols
			$\rho_w h_L g = (\rho_w h_R + \rho_o h_3) g$ so $\rho_w (h_L - h_R) = \rho_o h_3$ so $h_L - h_R = (\rho_o h_3) / \rho_w$	1	correct rearrangement of formula
			$h_L - h_R = (800 \times 0.7)/ 1000 = 0.56$ m	1	
			(Total volume of water columns will not change, so providing area of columns equal.) $h_1 + h_2 + h_3 = h_L + h_R + h_3 = 2$m OR $h_1 + h_2 = h_L + h_R = 1.3$ m	1	
			Using simultaneous equations:		
			h_L=0.93 **m** (and h_R=0.37 m)	1	Final value with **unit.**
			Or:		
			original pressure on right hand column = sum of oil pressure + water pressure	(1)	
			$P_R = (\rho_w h_2 + \rho_o h_3) g = ((1000 \times 0.3) + (800 \times 0.7)) \times 9.8 = 8428$ Pa	(1)	
			Difference in pressure between the two columns $\Delta P = 9800 - 8428 = 1372$ Pa	(1)	
			Giving rise to a height difference = $\Delta P \div (\rho_w \times g) = 1372 \div (1000 \times 9.8) = 0.14$m	(1)	
			Providing area of columns equal.		
			Water on left moves down by $0.14 \div 2 = 0.07$ m so height = 0.93 **m**.	(1)	Final value with **unit**.
			QUESTION TOTAL	11	

Question			Answer	Marks	Guidance
6		(i)	(Mass of water per second =)volume <u>per second</u> x density or velocity x pipe cross section x density or ρ v A or 1000 x 2.5 x $(\pi(1)^2$ =	1	*CHECK ANSWER LINE; If mass = 7850 (kg s^{-1}) award 2 marks.*
			= 7.85 x 10^3 (kg s^{-1})	1	Accept 7800 and 7900 here.
		(ii)	Use of $\Delta E_p = m\ g\ (\Delta h)$	1	*CHECK ANSWER LINE; If energy = 490 (J kg^{-1}) award 2 marks.* Use of E=mgh with any mass, not just quoting equation.
			(For unit mass, m = 1, so $\Delta E_m/m = 9.8 \times 50 =$) 490 (J kg^{-1})	1	
		(iii)	Power input = energy per second = $\Delta E_m/m$ x mass flow rate (soi)	1	*CHECK ANSWER LINE; If power = 3850 kW award 2 marks.*
			($P_s = (\dot{m}/t)\ (\Delta E_m/m) = (7.9 \times 10^3) \times 490 =$) 3.85×10^6 (W)	1	Accept 3.8×10^6 and 3.9×10^6 here. Allow ecf of calculated values in (i) and (ii) multiplied together.

Question			Answer	Marks	Guidance
		(iv)	For generator: Power input = power output ÷ efficiency = 3300 ÷ 0.95 = 3470 Power input for generator is power output of turbine. turbine efficiency = power output ÷ power input = 3470 ÷ 3850 = 0.90 / 90% OR: Combined efficiency = power output ÷ power input = 3300 ÷ 3850 = 0.86 / 86% Combined efficiency is the product of efficiencies / = $\eta_g \times \eta_t$ Turbine efficiency = 0.86 ÷ 0.95 = 0.90 / 90%	1 1 1 (1) (1) (1)	*CHECK ANSWER LINE; If efficiency = 90% award 3 marks.* Allow ecf of incorrect value of power input from part (iii)
			QUESTION TOTAL	9	

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