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 January 2017

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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.

OCR will not enter into any discussion or correspondence in connection with this mark scheme.

Question			Solution	Marks	Guidance
1	(a)		<table><tr><td>μ (micro)</td><td>10^{-6}</td></tr><tr><td>M (mega)</td><td>10^{6}</td></tr><tr><td>k (kilo)</td><td>10^{3}</td></tr><tr><td>m (milli)</td><td>10^{-3}</td></tr></table>	1 1 1 1	One mark for each correct line of the table. Accept powers alone i.e. -6, 6,3, -3.
1	(b)		Relative error: Ratio of absolute error and true value (given in percentages), OR absolute error divided by true value.	1	Accept absolute error over true value.
1	(c)	(i)	(X =)0.00236; Relative error = $\Delta X/X$ = (0.002362 – 0.00236)/0.002362 Relative error = 0.00085 (= 0.085%)	1 1 1	 Evidence of correct calculation Ignore sign (subtraction can be done either way round)
		(ii)	(X =)0.002; Relative error = $\Delta X/X$ = (0.002362 – 0.002)/0.002362 = 0.153 (= ±15.3%)	1 1	 Ignore sign as above (2nd mark of (i) could be awarded here if not awarded in (i)
			QUESTION TOTAL	**10**	

Question			Solution	Marks	Guidance
2	(a)	(i)	$F_g = mg$ = 20 x 9.8 = 196 N	1	Unit is required. ACCEPT 200 N for 2 sf.
2	(a)	(ii)	(Using Pythagoras) $F_w = \sqrt{F^2 + F_g^2}$ $F_w = \sqrt{80^2 + 196^2} = 212$ **N** (= 210 N)	 1 1	Allow ecf of incorrect weight from part (i). Need to see unit but only one unit penalty in part (a).
2	(a)	(iii)	EITHER: Resolving horizontally: $F_W \sin \alpha = 80$ $\sin \alpha = 80/212 = 0.377$ $\alpha = 22(.2)°$ OR: Resolving vertically: $F_W \cos \alpha = 196$ $= 196/212 = 0.925$ $\alpha = 22(.3)°$ OR $\tan \alpha = 80/196$ $\tan \alpha = 0.408$ $\alpha = 22(.2)°$	 1 1 1 (1) (1) (1) (1) (1) (1)	Allow ecf of incorrect forces from part i) and ii). Use of F_W = 210 N gives $\alpha = 21°$ and use of F_g = 200 N as well gives $\alpha = 17°$. All acceptable if working shown.
2	(b)	(i)	$s = v\,t$ = 5 x 4 = 20 (m)	1	Ignore unit. Accept answer to answer to 1 sf.
2	(b)	(ii)	$a = dv/dt = (v - u)/t$ = (9 - 5)/2 = 4/2 = 2 m s^{-2}	1	Unit is required. Accept answer given to 1 sf.
2	(b)	(iii)	$a = dv/dt = (v - u)/t = \pm (9 - 0)/3$ $a = \pm 3$ m s^{-2}	1 1	Appropriate substitution into equation. Unit required but only one unit penalty in (b).
			QUESTION TOTAL	**10**	

Question			Solution	Marks	Guidance
3	(a)	(i)	Total Voltage drop is the sum of voltage drops across all resistors $V_0 = 5 + 2 + 10 = 17$ V	1	Ignore unit.
3	(a)	(ii)	Use of $R = V/I = 17/2$ $R_T = 8.5\ \underline{\Omega}$	1 1	Substitution of any voltage and 2A into equation. Allow ecf from (i). Unit required
3	(a)	(iii)	$R_1 = 5/2 = 2.5\ \underline{\Omega}$ $R_2 = 2/2 = 1\ \underline{\Omega}$ $R_3 = 10/2 = 5\ \underline{\Omega}$	1 1 1	Units required at least once in part (ii) and part (iii). If already penalised unit in part ii ignore unit. Max 2/3 if not clear which R is which. These marks can be awarded from working shown in part (ii). This is acceptable for both sections.
3	(a)	(iv)	Use of $P = IV$ or $P = I^2R$ or $P = V^2/R$ $P_1 = 2 \times 5 = 10\ \underline{\text{W}}$ $P_1 = (2)^2 \times 2.5 = 10\ \underline{\text{W}}$ $P_1 = 5^2/2.5 = 10\ \underline{\text{W}}$	1 1	Substituting appropriate values into one of the power equations. Unit required.
3	(b)	(i)	Henry (or H)	1	Not h.
3	(b)	(ii)	kg m^2 s^{-2} A^{-2}	1	Third answer should be ringed. Accept alternative clear indication of correct response.
			QUESTION TOTAL	**10**	

Question			Solution	Marks	Guidance
4	(a)		<table><tr><td>Ultimate Tensile Stress (UTS)</td><td>4</td></tr><tr><td>Yield Stress</td><td>2</td></tr><tr><td>Fracture Point</td><td>5</td></tr><tr><td>Elastic deformation</td><td>1</td></tr></table>	1 1 1 1	One mark for each correct line of the table.
4	(b)	(i)	Use of σ = F/A hence $A = F/\sigma = 85 \times 10^3/105 \times 10^6$ $A = 8.1 \times 10^{-4}$ m^2 (0.00081 m^2)	1 1	Allow values (ignoring POT) substituted into $\sigma = F/A$ for first mark. Lose second mark for POT errors. Unit necessary.
4	(b)	(ii)	$F_y = \sigma_y A = (210 \times 10^6) \times (8.1 \times 10^{-4})$ $F = 1.7 \times 10^5$ N (170 kN)	1 1	Correct substitution (ignoring POT). Allow ecf from part i) Lose one mark for POT errors Use of σ_y = 105 MPa scores zero.
4	(b)	(iii)	$E = \sigma/\varepsilon = 105 \times 10^6/500 \times 10^{-6}$ $E = 2.1 \times 10^{11}$ Pa (210 GPa or 210 000 MPa)	1 1	Correct substitution (ignoring POT). Lose one mark for POT errors. Unit required.
			QUESTION TOTAL	**10**	

Question			Solution	Marks	Guidance
5	(a)		Viscosity is a fluid's ability to resist <u>shear</u> forces.	1	Ignore 'flow'.
5	(b)		Laminar flow: <u>particles</u> move in layers/parallel (to direction of flow). Turbulent flow: <u>particle</u> movement is irregular/chaotic/unpredictable.	1 1	IGNORE 'smooth' ACCEPT 'random' Reference to particles needed at least once for both marks. Two opposite statements – max one mark awarded.
5	(c)	(i)	$P_w = \rho_w g h_w =$ 1000 x 9.8 x h P_w = 1000 x 9.8 x 1 = 9800 <u>Pa</u> or 9.8 <u>kPa</u>	1 1	Substitution of correct values of ρ_w and g and a value of height for first mark. Unit required. Lose one mark for POT errors.
5	(c)	(ii)	$P_m = \rho_m g h_m$ = 13500 x 9.8 x 0.5 P_m = 6.6 x 10^4 <u>Pa</u> (or 66 <u>kPa</u>)	1 1	Correct substitution required. Unit required but penalise only once in part (c). Lose one mark for POT errors, but allow same POT error ecf from part (i).
5	(c)	(iii)	P_g = 120 + 9.8 + 66 = 196 (kPa)	1	Accept 200 kPa (to 2 sf). Unit not required but consistent values must be added together. Allow ecf from part (i) and (ii).
5	(c)	(iv)	$P_g = P_{abs} - P_{atm}$ P_g = 196 – 100 = 96 (kPa)	1 1	First mark for quoting equation or correct substitution. Unit not required but consistent values must be subtracted. Allow ecf from part (iii).
			QUESTION TOTAL	**10**	

Question			Solution	Marks	Guidance
6		(i)	Volume of box = 3 x 3 x 10 = 90 m^3; Conversion of 12 °C to 285 K; Use of $PV = mRT$; $m = PV/RT$; m = (100 x 10^3) x 90)/(287 x 285) [= 110 kg]	1 1 1 1	Calculation of volume. Conversion of temperature to K. If T remains in °C max 2 marks can be awarded. Correct rearrangement of equation must be shown, but can be after values have been substituted. Correct substitution and calculation No mark for final value as this is a 'show that' question.
		(ii)	EITHER: Use of $P_1/T_1 = P_2/T_2$ rearranged to give $P_2 = P_1 T_2/T_1$; P_2 = (100 x 10^3) x 300/285 = 1.05 x 10^5 Pa (or 105 kPa) OR: Rearrange $PV = mRT$ to give $P = mRT/V$; P = (110 x 287 x 300)/90 = 1.05 x 10^5 Pa (or 105 kPa)	1 1 (1) (1)	ACCEPT 1.1 x 10^5 Pa (to 2 sf) Do not accept ecf of other values for m. Unit required. Lose one mark for POT errors. Use of temperatures in °C can score max 1 mark for correct rearrangement. [P = 2500 Pa]
		(iii)	ΔT = 300 - 285 = 15 K; Energy = $m\, c_v\, \Delta T$ = 110 x 718 x 15 = 1.2 x 10^6 J	1 1	Correct change in temperature Correct substitution and calculation. Ignore unit Only allow ecf of an incorrect temperature change. [if T_1 = 12, then ΔT = 288 and E = 2.3 x 10^7 J; award 1 mark]
		(iv)	Power = energy/time; time = 1.2 x 10^6/1500; Time = 800 s (= 13 minutes = 0.22 hours)	1 1	Substitution of values into equation. Allow ecf of energy from part iii). Unit required. Accept 8 x 10^2 s (1sf).
			QUESTION TOTAL	**10**	
			PAPER TOTAL	**60**	

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