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BTEC

Mark Scheme (Results)

Summer 2017

BTEC Level 3 National in Engineering
Unit 1: Engineering Principles
(31706H)

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Engineering	Level 3 National	31706H	Unit 1: Engineering Principles

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Unit 1: Engineering Principles

General marking guidance

- All learners must receive the same treatment. Examiners must mark the first candidate in exactly the same way as they mark the last.
- Mark schemes should be applied positively. Candidates must be rewarded for what they have shown they can do, rather than be penalised for omissions.
- Examiners should mark according to the mark scheme, not according to their perception of where the grade boundaries may lie.
- All marks on the mark scheme should be used appropriately.
- All the marks on the mark scheme are designed to be awarded. Examiners should always award full marks if deserved, i.e. if the answer matches the mark scheme. Examiners should also be prepared to award zero marks if the candidate's response is not worthy of credit according to the mark scheme.
- Where some judgement is required, mark schemes will provide the principles by which marks will be awarded and exemplification may be limited.
- When examiners are in doubt regarding the application of the mark scheme to a candidate's response, the team leader must be consulted.
- Crossed-out work should be marked UNLESS the candidate has replaced it with an alternative response.

Specific marking guidance

This mark scheme uses the following types of marks:

- M marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- A marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- B marks are unconditional accuracy marks (independent of M marks)
- Marks should not be subdivided.

Abbreviations:

- ft – follow through
- cao – correct answer only
- cso - correct solution only. There must be no errors in this part of the question to obtain this mark
- isw – ignore subsequent working
- awrt – answers which round to
- SC - special case
- oe – or equivalent (and appropriate)
- dp - decimal places
- sf - significant figures

Engineering Unit 1 - 1706

Question number	Working	Answer	Notes	Mark
1	$s = r\theta$ $\theta = (66 \times \pi) / 180 = 1.15$ $s = 1.15 \times 52$ $s = 59.90$ mm also be solved by angle ratios: $s = 66/360 \times \pi d$ $s = (66/360) \times \pi \times 104$ $s = 59.90$ mm	$s = 59.90$ mm Accept final values that round to whole numbers.	M1 for θ or M1 for angle ratios A1 for correct value of s	**(2)**

Question number	Working	Answer	Notes	Mark
2	$6t^2 - 16t + 10 = 0$ $2(3t^2 - 8t + 5)$ $2(3t - 5)(t - 1)$ $t = 1$ or $t = 5/3$ $t = 1, t = 1.67$	$t = 1, t = 1.67$ Accept final values that round to one decimal place.	M1 for appropriate factorisation A1 for correct values of t	**(2)**

Question number	Working	Answer	Notes	Mark
3	Surface area of hemisphere: $= (4\pi r^2)/2$ $= (2\pi \times 2.3^2)$ $= 33.238\ m^2$ Surface area of cylinder: $= \pi dh$ $= \pi \times 4.6 \times 4.7$ $= 67.921\ m^2$ Area of base circle: $= \pi r^2$ $= \pi \times 2.3^2$ $= 16.619\ m^2$ Surface area of silo: $= 33.238 + 67.921 + 16.619$ $= 117.78\ m^2$	Area $= 117.78\ m^2$ Accept final values that round to one decimal place. Allow follow through for rounding variations.	M1 for surface area of hemisphere M1 for surface area of cylinder M1 for area of base circle A1 for total area	**(4)**

Question number	Working	Answer	Notes	Mark
4	$2\log 3 + \log 4 = \log A + 4\log 2$ $\log 3^2 + \log 4 = \log A + \log 2^4$ $\log 9 + \log 4 = \log A + \log 16$ $\log 36 = \log A + \log 16$ $\log A = \log (36/16)$ $\log A = \log (2.25)$ $A = 2.25$ Alternative approach: $\log 36 = \log 16A$ $36 = 16A$ $A = 36/16$ $A = 2.25$	$A = 2.25$ Accept final values that round to two decimal places. Allow follow through for rounding variations.	M1 for application of $x\log y = \log y^x$ M1 for application of $\log x - \log y = \log (x/y)$ or M1 for application of $\log x + \log y = \log xy$ A1 for correct value of A	**(3)**

Question number	Working	Answer	Notes	Mark
5 (a)	Finding the value of h: Sin 15 = h/170 h = 170 sin 15 = 44.00 m potential energy = mgh PE = 450 x 9.81 x 44 PE = 194 240 J PE = 194.24 kJ	PE = 194.24 kJ Accept final values that round to whole numbers. Allow follow through for rounding variations. Allow follow through for incorrect working at earlier stages	M1 for application of trig to find h A1 for finding value of h M1 for finding potential energy A1 for correct value of potential energy	**(4)**

Question Number	Answer	Mark
5 (b)	Award **one** mark for advantage and **one** additional mark for an appropriate linked expansion. • The ramp reduces the force necessary to overcome the force of gravity when lifting the transformer (1) by extending the distance travelled horizontally. (1) • Only the component of the gravitational force parallel to the ramp needs to be overcome (1) therefore the more shallow the slope, the easier it will be to raise the transformer to the desired height. (1) Accept any other appropriate explanation.	**(2)**

Question number	Working	Answer	Notes	Mark
6	**Resolving forces vertically** $200 = 200\sin 66 + F\sin\theta$ $200 = 182.71 + F\sin\theta$ $F\sin\theta = 17.29$ **Resolving forces horizontally** $200\cos 66 = F\cos\theta$ $F\cos\theta = -81.35$ **To find F** $200\cos 66 = F\cos 12.52$ $F = 200\cos 66/\cos -12.02$ $\underline{F = 83.17\ N}$ Alternative approach: $F = \sqrt{(17.29^2 + 81.35^2)}$ $\underline{F = 83.17\ N}$ **To find θ** $\tan\theta$ = opp/hyp $\tan\theta = 17.29/81.35 = 0.213$ $\underline{\theta = 12.02°}$	$\underline{\theta = 12.02°}$ $\underline{F = 83.17\ N}$ Accept final values that round to whole numbers. Allow follow through for rounding variations or incorrect working at earlier stages. Accept responses that state 'below the horizontal'	M1 for resolving vertically M1 for resolving horizontally A1 for correct value of F M1 for finding θ A1 for correct value of θ	**(5)**

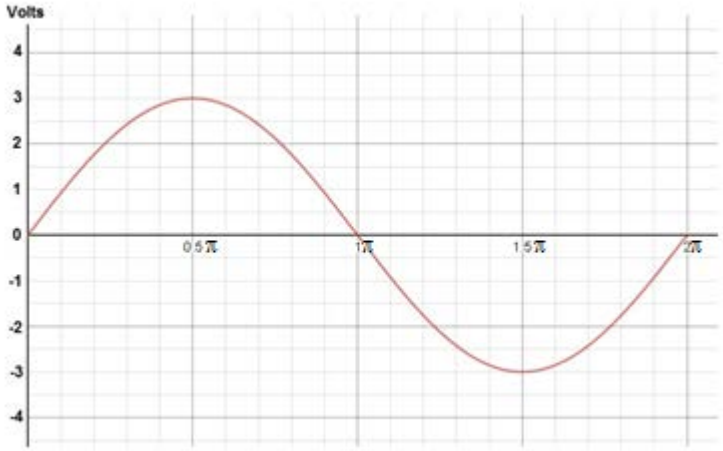
Question number	Working	Answer	Notes	Mark
7	Fresh water: Force = ρgAx = (1000 x 9.81 x 4 x 10 x 4/2) = 784800 N M_F = 784800 x 4 x 1/3 M_F = 1046400 Nm clockwise Sea water: Force = ρgAx = (1030 x 9.81 x 1.5 x 10 x 1.5/2) = 113673.38 N M_S = 113673.38 x (1.5/3) M_S = 56836.69 Nm anticlockwise Resultant turning moment: M = M_F - M_S M = 1046400 – 56836.69 M = 989563.31 Nm <u>M = 990 kNm clockwise</u> Do not penalise if centre of pressure is calculated as 1/2 height or similar.	<u>M = 990 kNm clockwise</u> Accept final values that round to two decimal places. Allow follow through for rounding variations.	M1 for force due to fresh water M1 for process of calculating M_F M1 for force due to sea water M1 for process of calculating M_S A1 for correct magnitude of resultant turning moment B1 for direction of resultant turning moment (dep)	**(6)**

Question number	Working	Answer	Notes	Mark
8	Impact velocity of hammer $v^2 = u^2 + 2as$ $v^2 = 0 + 2 \times 9.81 \times 3.2$ $v = \sqrt{62.78} = 7.92$ m/s Note – can also be found using conservation of energy conservation of momentum $m_h v_h + m_p v_p = m_t v_t$ $700 \times 7.92 + 200 \times 0 = 900 v_t$ $5544 = 900 v_t$ $\underline{v_t = 6.16 \text{ m/s}}$ final velocity = 0 m/s $v^2 = u^2 + 2as$ $0 = 6.16^2 + 2a \times 0.18$ $37.95 = -0.35a$ $a = -108.42 \text{ m/s}^2$ Resistance force = mg + ma = 900 x 9.81 + 900 x 108.42 Force = 106 403N = 106.40 kN	F = 106.40 kN Accept final values that round to whole numbers. Allow follow through for rounding variations.	M1 for the process of finding impact velocity of hammer M1 for the process of finding combined velocity of hammer and pile A1 for finding the value of v_t M1 for the process of finding deceleration of pile/hammer M1 for process of finding resistance force A1 for correct value of resistance force	**(6)**

Question number	Working	Answer	Notes	Mark
9	Taking moments about A: 26 x 1 = (40 x 0.5) + 1.25L 26 = 20 + 1.25L 6 = 1.25L L = 4.8N Taking moments about B: 40 x 0.5 = 1 x R_A + (0.25 x 4.8) 20 = R_A + 1.2 R_A = 18.8N Alternative approach: Taking moments about B: 0.25L + 1 x R_A = (40 x 1 x 0.5) 0.25L + R_A = 20 R_A = 20 – 0.25L Resolving vertically 40 x 1 + L = R_A + R_B 40 + L = R_A +26 R_A = 14 + L Calculating L 20 – 0.25L = 14 + L 6 = 1.25L L = 4.8N Substituting R_A = 14 + L R_A = 14 + 4.8 R_A = 18.8 N	L = 4.8 N R_A = 18.8 N Accept final values that round to whole numbers. Allow follow through for rounding variations. Allow follow through for incorrect working at earlier stages	M1 for taking moments to find L A1 for value of L M1 for taking moments to find R_A or M1 for total reaction forces = total load A1 for R_A	**(4)**

Question number	Working	Answer	Notes	Mark
10	$C = \varepsilon A/d$ $C = (5 \times 80 \times 10^{-6})/0.0003$ $C = 1.33$ $Q = CV$ $Q = 1.33 \times 60$ $\underline{Q = 80C}$	$\underline{Q = 80C}$ Accept final values that round to whole numbers.	M1 for determining C M1 for process of calculating Q A1 for correct value of Q	**(3)**

Question number	Working	Answer	Notes	Mark
11	$E = v/d$ $E = 20/0.0035$ $\underline{E = 5714\ V/m}$	$\underline{E = 5714\ V/m}$ accept $\underline{5.7\ kV/m}$ Accept values between 5714.0000 and 5714.3000 Accept values between 5.7140 and 5.7143	A1 for correct value of E	**(1)**

Question number	Answer	Mark
12	Award **one** mark for each feature of a waveform, up to a maximum of **4** marks.  • Correct time period T = 1/f (1 cycle = 360 degrees/2 π) **(1)** • Correct amplitude (+/- 3) **(1)** • Correct shape of waveform (sine wave) **(1)** • Labelling voltage axis (volts) **(1)** • Labelling peak voltage/peak to peak voltage **(1)**	**(4)**

Question number	Working	Answer	Notes	Mark
13	$F = q_1q_2/(4\pi\varepsilon_0r^2)$ $q_2 = (F \times 4\pi\varepsilon_0r^2)/ q_1$ $q_2 = 172 \times 4 \times \pi \times 8.85\times10^{-12} \times 1.2^2/0.3$ $= 2.75\times10^{-8} /0.3$ $\underline{q_2 = 9.17 \times 10^{-8}\ C}$	$\underline{q_2 = 9.17 \times 10^{-8}\ C}$ Accept final values that round to whole numbers. Allow follow through for incorrect working at earlier stages	M1 for correct manipulation and population of formula A1 for correct value of q_2	**(2)**

Question number	Working	Answer	Notes	Mark

14	Resistance in top branch = 560+330 = 890 Ω Resistance in lower branch = 1000 + 100 = 1100 Ω Total resistance in parallel branches $R = (R_1R_2)/(R_1 + R_2)$ R = (1100 x 890)/(1100 + 890) R = 492 Ω Total resistance in circuit = 2200 + 492 = 2692 Ω Power = V^2/R P = $12^2/2692$ P = 0.053 W	P = 0.053 W Also accept P = 53 mW Allow follow through for incorrect working at earlier stages	M1 for resistance in top branch M1 for resistance in lower branch M1 for total resistance of the two parallel branches A1 for total resistance A1 for correct value of power	**(5)**

Question Number	**Answer**	**Mark**

15(a)	Award **one** mark for application and **one** additional mark for an appropriate linked expansion. • A diode can be used in a rectifier to convert AC voltages to DC voltages (1) only allowing current flow in the forward direction (1). • A diode can provide reverse current protection (1) which is achieved by the diode being placed in series with the positive side of the supply (1). • Diodes can be used to provide voltage spike suppression (1) by providing a safe route for excess voltages preventing damage to sensitive components (1). • A light emitting diode can be used as an indicator (1) that only lights up as electricity flows in one direction through it (1). Accept any other relevant application with expansion. Do not accept a basic description of the function of a diode on its own e.g. electricity only flows one way.	**(2)**

Question Number	Answer	Mark
15(b)	Award **one** mark for reason and **one** additional mark for appropriate expansion. • Once the breakdown/Zener voltage is passed (1) it allows current to flow in both directions (1). • A constant/consistent DC output voltage can be maintained to the load (1) even if there are variations in the input voltage or changes in the load current (1). • A stabilised/smoothed output voltage can be specified (1) which will be the same as the breakdown voltage of the diode (1). Accept any other relevant phrasing/wording.	**(2)**

Question number	Working	Answer	Notes	Mark
16	Induced EMF (e) = $Blv\sin\theta$ Initial emf	<u>Change in emf = 2.74 V</u>	M1 for determining the initial emf. A1 for initial value	**(5)**

	e_1 = 1.3 x 0.45 x 20 sin 50 e_1 = 8.96 V Final emf e_2 = 1.3 x 0.45 x 20 sin 90 e_2 = 11.7 V Change in emf = $e_2 - e_1$ <u>Change in emf = 2.74 V</u>	Accept final values that round to whole numbers. Allow follow through for rounding variations.	of emf. M1 for process of determining final emf. A1 for value of final emf. A1 for change in emf.	

Question number	Working	Answer	Notes	Mark
17	Impedance of coil Z Z = V/I Z = 120/0.15 Z = 800Ω $Z = \sqrt{(R^2 + X^2)}$ $Z^2 = R^2 + X^2$ $800^2 = 68^2 + X^2$ 640000 - 4624 = X^2 X = √635376 X = 797 Ω $X = 2\pi fL$ L = 797/(2π x 50) <u>L = 2.54 H</u>	<u>Inductance L = 2.54 H</u> Allow follow through for incorrect working at earlier stages Allow follow through for rounding variations.	M1 for determining Z M1 for value of X M1 for determining L A1 for the value of L	**(4)**

Question number	Working	Answer	Notes	Mark
18(a)	Output power = 56.5kW = ωT	<u>1798 rpm</u>	M1 for finding the value of ω A1 for the correct	**(4)**

	$\omega = 56.5x10^3/T$ $\omega = 56.5x10^3/300$ $\omega = 188.3$ rad/s speed= $\omega \times 60 / 2\pi$ speed = $188.3 \times 60 / 2\pi$ = <u>1798 rpm</u>	Allow follow through for rounding variations	value of ω M1 for recognising the relationship between rads and rpm A1 for correct speed in rpm	

Question number	Working	Answer	Notes	Mark
18(b)	Input power: $0.005 \times 46x10^6$ = <u>230 kW</u> Power out from generator Power = IV Power = 80 x 415 = 33.2 kW Overall efficiency = 33.2/230 = <u>0.1443 or 14.43%</u>	<u>0.1443 or 14.43%</u> Accept final values that round to one decimal place. Allow follow through for rounding variations ft	M1 for recognising the need to multiply energy content by mass flow rate A1 for correct value of input power M1 for correct method to calculate power out from generator A1 for the correct value of output power from generator M1 for correct population of the relationship between input and output A1 for correct efficiency value given (ft acceptable)	**(6)**

Question Number	Answer	Mark
18(c)	Award **one** mark for identification of an effect on the efficiency of the system and **one** further mark for justifying for how it affects the efficiency,	

	upto a maximum of **4** marks. • Output power will be increased **(1)** increasing the efficiency of the system **(1)** • Losses due to friction are reduced as the speed of the motor increases (1) the effects of friction are virtually constant and therefore have less impact on efficiency **(1)** • The amount of 'slip' between the stator's magnetic field and the rotor will be increased **(1)** meaning the operation of the generator will become closer to the synchronous speed of the generator **(1)** Accept any other appropriate explanation.	**(4)**

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