Mark Scheme (Results)

January 2021

Pearson BTEC Nationals

In Engineering (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:

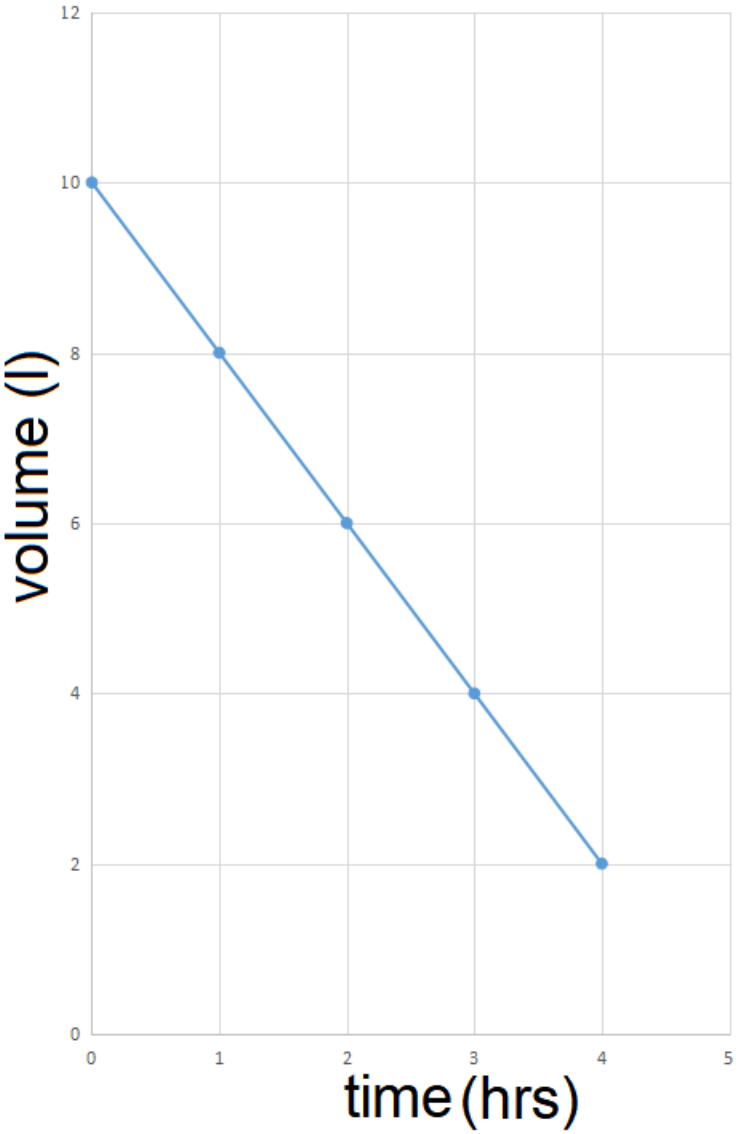
- M marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- A marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- B marks are unconditional accuracy marks (independent of M marks)
- Marks should not be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

BTEC Next Generation Mark Scheme

Engineering Unit 1 - 2101

Question number	Answer	Mark
1	 • Both axes with appropriate labels (e.g. volume or litres and time or hours) (1) • Both axes with appropriate values (1) • Correct 'y intercept' at 10 (1) • Accurate plotting of graph with a gradient of -2 (1)	(4)

Question number	Working	Answer	Notes	Mark
2	(4c-12) -3(6-2c) = c+6 4c-12 -18 + 6c = c+6 9c = 36 c = 36/9 c=4 **Alternative method** 4c - 2n - 3(n - 2c) = c + n 4c - 2n - 3n + 6c = c + n 4c + 6c - c = 2n + 3n + n 9c = 6n 9c = 6 x 6 9c = 36 c = 36/9 c = 4	<u>c = 4</u>	M1 for fully correct substitution of value for *n* M1 for correct expansion of brackets M1 for correct rearranging in terms of *c* A1 for correct answer for *c* (ft) M1 for correct expansion of brackets M1 for correct rearranging of terms M1 for fully correct substitution of value of *n* A1 for correct answer for *c* (ft)	(4)

Question number	Working	Answer	Notes	Mark
3	800mm = 0.8m (or equivalent) Radius of roller = 0.8/2 Radius = 0.4 m Area = $2\pi rh + 2\pi r^2$ Area = $2\pi \times 0.4 \times 1.2 + 2\pi \times 0.4^2$ Area = 4.02 m^2 **Alternative method** Area of top or bottom of cylinder = $(\pi d^2/4)$ = $(\pi \times 0.8^2/4)$ A = 0.5027 Area of top and bottom = 1.005m^2 Area of side = πdh = $\pi \times 0.8 \times 1.2$ = 3.015 m^2 Total area = 1.005+3.015 Total area = 4.02 m^2	Area = 4.02 m^2 Or Area = 4.02×10^6 mm^2 Or Area = 40212 cm^2 Or Area = 4021238 mm^2 Accept answers that are rounded to 4 or 4×10^6	M1 for conversion from mm to m (oe) M1 for conversion of diameter to radius of roller M1 for correct substitution of values A1 for correct answer for total area (ft) M1 for conversion from mm to m (oe) M1 for area of top or bottom M1 for area of curved side A1 for correct answer for total area (ft)	(4)

Question number	Working	Answer	Notes	Mark
4 (a)	$d = \frac{a^9}{a^2}$ $d = a^{(9-2)}$ $d = a^7$	$\underline{d = a^7}$	M1 for applying one relevant law of indices A1 for correct full simplification (ft)	(2)
(b)	$d = 3^7$ $d = 2187$	$\underline{d = 2187}$	A1 for correct answer for d(cao)	(1)

Question number	Working	Answer	Notes	Mark

5	Angle (rad) = $70^{\circ} \times \pi/180$ Angle = 1.222 Radians Area of a sector = $r^2\theta/2$ Area of large sector A = $(90^2 \times 1.222)/2 = 4949.1$ Area of small sector A = $(30^2 \times 1.222)/2 = 549.9$ Area of the component = 4949.1 - 549.9 Area = 4399.2 mm^2 **Alternative method 1** Area of the large circle – the smaller circle $A=\pi(R^2-r^2)$ $A=\pi(90^2-30^2)$ A=25446.9-2827.4 A=22619.5 Area of sector 22619.5*70/360 Area of sector = 4398 mm^2 **Alternative method 2** Angle (rad) = $70^{\circ} \times \pi/180$ Angle = 1.222 Radians Area of sector A = 0.5 x 1.222 x$(90^2 - 30^2)$ A = 4399.2	Area of sector = 4398 mm^2 Or 0.0044 m^2 or 43.98 cm^2 Area = 4399.2 mm^2 Accept answers rounding to 4400 mm^2 (or equivalent)	M1 for correct substitution of values A1 for correct angle in radians (ft) A1 for correct area of the large sector (ft) A1 for correct area of the small sector (ft) A1 for the correct area of the component (ft) M1 for the correct recognition of a large and a small circle M1 for the correct substitution of values (ft) A1 for area of the large circle – a small circle (ft) M1 for the correct substitution of values (ft) A1 for area of the component (ft) M1 for correct substitution of values A1 for correct angle in radians (ft) M1 for setting up the equation for area of the component M1 for correct substitution of values (ft) A1 for area of the component (ft)	**(5)**

Section B

Question number	Answer	Mark
6	B - water	**(1)**

Question number	Answer	Mark
7	C – Uniformly distributed load	**(1)**

Question number	Answer	Mark
8	D - kilogram metre squared	**(1)**

Question number	Working	Answer	Notes	Mark
9 **(a)**	$A_1 = \pi \times 0.25^2$ *or* $A_1 = (\pi \times 0.5^2)/4$ $A_1 = \pi/16$ $A_1 = 0.196\ m^2$	$A_1 = 0.196\ m^2$ Or $A_1 = 196350\ mm^2$ Or $A_1 = 1.96 \times 10^{-3}\ m^2$ Accept $A_1 = 0.2\ m^2$ $A_1 = \pi/16\ m^2$	M1 for correct substitution of values A1 for correct answer for inlet area (ft)	**(2)**
(b)	$A_1V_1 = A_2V_2$ $0.196 \times 2 = A_2 \times 3$ $A_2 = 0.196 \times 2 / 3$ $A_2 = 0.13\ m^2$	$A_2 = 0.13\ m^2$ Or $A_2 = 130900\ mm^2$ Or $A_1 = 1.31 \times 10^{-3}\ m^2$	M1 for correct substitution of values (ft) M1 for rearranging in terms of A_2 A1 for correct answer for A_2 (ft)	**(3)**

Question number	Answer	Mark
10	Award **one** mark for an initial statement and **one** further mark for an expansion, up to a maximum of **two** marks. • To represent forces acting on a body (1) using arrows that reflect the magnitude / direction of each force (1) • Free-body diagrams are used to represent the forces acting on the body (1) which allows the forces to be resolved in to their component parts / the resultant to be determined (1) Accept any other reasonable response	**(2)**

Question number	Working	Answer	Notes	Mark
11 **(a)** **(b)**	VR = driver/driven VR = 10/18 VR = 0.556 Output = input x VR Output = 300 x 0.556 Output = 166.67 revs/min	VR = 0.556 VR = 10/18 or 5/9 Accept 10:18 Output = 166.67 revs/min	M1 for recognition of VR = driver/driven M1 for correct substitution of values A1 for correct answer for VR (cao) M1 for recognising output = input x VR M1 for correct substitution of values (ft) A1 for correct answer for velocity of driven gear (ft)	 **(3)** **(3)**

Question number	Working	Answer	Notes	Mark
12	$\varepsilon = \Delta L/L$ $\varepsilon = 0.03/2.5$ $\varepsilon = 0.012$ $E = \sigma/\varepsilon$ $E = 857/0.012$ $E = 71417$ N/mm^2 or MPa	$E = 71417$ N/mm^2 $E = 0.71417$ MN/mm^2 $E = 71.417$ GN/m^2 $E = 71417$ MN/m^2 $E = 71417$ MPa $E = 71.417$ GPa	M1 for correct substitution of values A1 for correct answer for ε (ft) M1 for correct substitution of values (ft) A1 for correct answer for E (ft) A1 (dep) for correct unit for E	 **(5)**

Question number	Working	Answer	Notes	Mark
13	Work done = energy used WD = KE + PE $Fs = 0.5\ mv_t^2 + mgh$ (v_t is the velocity of the combined hammer and spike after impact) $WD = 800x0.15 = 120$ $PE = (12 + 8) \times 9.81 \times 0.15$ $PE = 29.43\ J$ $120 = 0.5\ (12 + 8)v_t^2 + 29.43$ $120 = 10v_t^2 + 29.43$ $v_t^2 = (120 - 29.43)/10$ $v_t^2 = 9.057$ $v_t = \sqrt{9.057}$ $v_t = 3.009$ m/s **Conservation of momentum** $M_1v_1 + m_2v_2 = m_tv_t$ (v_1 is the velocity of the hammer on impact) $12v_1 + 0 = 3.009 \times 20$ $v_1 = 60.18/12$ $v_1 = 5.015$ m/s	$v_1 = 5.015$ m/s Accept answers rounding to 5	M1 for recognition that WD = KE + PE A1 for correct value for work done A1 for correct value for PE M1 for rearranging in terms of v_t (ft) A1 for correct answer for velocity of combined hammer and spike v_t (ft) M1 for recognising conservation of momentum and momentum = mv M1 for the correct substitution of values (ft) M1 for rearranging in terms of v_1 (ft) A1 for the correct answer for velocity of the hammer v_1 (ft)	**(9)**

	Alternative order of working Velocity of hammer just before collision = (v_1) Velocity of spike before collision = 0 Velocity of hammer and spike just after collision = (v_2) **Conservation of momentum** $12(v_1) = (12+8)(v_2)$ $12(v_1) = 20(v_2)$ $v_1 = 20(v_2)/12$ Work done in driving spike = Force x distance WD = 800x0.15 =120J Energy change = Change in (KE + PE) = $0.5(20)(v_2)^2$ +(20x9.81x0.15) **Conservation of energy** $10(v_2)^2$ +29.43 = 120 $(v_2) = \sqrt{((120-29.43)/10)}$ (v_2) = 3.009 m/s But, 12(v1) = $20(v_2)$ [from above] Therefore, $12v_1 = 20$ x3.009 $v_1 = 20$ x3.009/12 v_1 = 5.02 m/s		M1 for recognising conservation of momentum M1 for recognising momentum = mv M1 for the correct substitution of values (ft) M1 for recognition that WD = KE + PE M1 for correct substitution of values M1 for rearranging in terms of v_2 (ft) A1 for correct answer for velocity of combined hammer and spike v_2 (ft) M1 for rearranging in terms of v_1 (ft) A1 for the correct answer for velocity of the hammer v_1 (ft)	

	Alternative method for Q13 $Fa + Ff = Fg$ $Ma + Ff = mg$ $20a + 800 = 20 \times 9.81$ $a = (196.2 - 800) / 20$ $a = -30.19$ m/s – (ignore the -ve sign) Find the velocity after collision (U) $V^2 = u^2 + 2as$ $0 = u^2 + 2as$ $u = (-2 \times -30.19 \times 0.15)^{1/2}$ $u = (9.057)^{½}$ $u = 3.009$ m/s Conservation of momentum $m_1v_1 = m_2v_2$ $12 \times v_1 = 20 \times 3.009$ $V_1 = 5.015$ m/s		M1 for setting up the equation, rearranging the equation and for correct substitution of values A1 for the deceleration (ft) M1 for correct selection of the equation and substitution of values (ft) M1 for rearranging in terms of u (ft) A1 for the correct value of u (ft) M1 for recognising conservation of momentum and momentum = mv M1 for the correct substitution of values (ft) M1 for the correct rearranging in terms of v_1 (ft) A1 for the correct value of v_1 (ft)	

Section C

Question Number	Answer	Mark
14	B - dielectric	**(1)**

Question Number	Answer	Mark
15	D - zener diode	**(1)**

Question number	Working	Answer	Notes	Mark
16	$P = V^2/R$ $P = 3^2 / 32$ $P = 9/32$ $P = 0.28\,W$	$\underline{P = 0.28\ W}$ $\underline{P = 9/32}$ Accept answers rounding to 0.3 W	M1 for correct substitution of values A1 for the correct answer for P (cao)	**(2)**

Question number	Working	Answer	Notes	Mark
17	$E = V/d$ $E = 12/5$ $E = 2.4\ V/mm$ $E = 2400\ V/m$	$\underline{E = 2.4\ V/mm}$ Or $\underline{E = 2400\ V/m}$ Or $\underline{E = 2.4\ kV/m}$	M1 for correct substitution of values A1 for correct answer for E(ft) A1 (dep) for correct unit	**(3)**

Question Number	Answer	Mark
18	Award **one** mark for an initial statement and **one** further mark for an expansion, up to a maximum of **two** marks. • The output voltage/current/power remains constant / does not fluctuate (1) meaning that prototype circuits will not be damaged (1) • The output voltage/current can be adjusted / set to an exact value (1) meaning that different types of prototype circuit can be tested / reliable test results can be achieved (1) Accept any other reasonable response	**(2)**

Question number	Working	Answer	Notes	Mark
19(a)	$V_{rms} = V_{peak}/\sqrt{2}$ $V_{peak} = V_{rms} \times \sqrt{2}$ $V_{peak} = 230 \times \sqrt{2}$ $V_{peak} = 325.27$ V	$\underline{V_{peak} = 325.27}$ V Accept answers rounding to 325 V	M1 for rearranging in terms of V_{peak} M1 for correct substitution of values (ft) A1 for correct answer for V_{peak}(ft)	**(3)**
(b)	$V_{average} = 2 \times V_{peak}/\pi$ $V_{average} = 2 \times 325.27/\pi$ $V_{average} = 207.1$ V	$\underline{V_{average} = 207.1}$ V Accept answers rounding to 207 V	M1 for correct substitution of values (ft) A1 for correct answer for $V_{average}$ (ft)	**(2)**

Question number	Working	Answer	Notes	Mark
20	$H = NI/l$ $H = (120 \times 1.5)/0.1$ $H = 1800$ A/m $B/H = \mu_0\mu_r$ $B = H\mu_0\mu_r$ $B = 1800 \times 4\pi\times10^{-7} \times 200$ $B = 0.45$ T	<u>B = 0.45 T</u>	M1 for recognition of the need to calculate magnetic field strength (H) M1 for correct substitution of values A1 for correct answer for H (ft) M1 for rearranging in terms of B M1 for correct substitution of values (ft) A1 for correct answer for flux density(ft)	**(6)**

Question number	Working	Answer	Notes	Mark
21	$Z = V/I$ $Z = 60 / 0.160$ $Z = 375\Omega$ $Z = \sqrt{(R^2 + X_C^2)}$ $X_c = \sqrt{(Z^2 - R^2)}$ $X_C = \sqrt{(375^2 - 56^2)}$ $X_C = 370.8\ \Omega$ $X_C = 1/2\pi fC$ $f = 1/X_C 2\pi C$ $f = 1/(370.8 \times 2 \times \pi \times 32 \times 10^{-6})$ $f = 1/0.075$ $f = 13.41$ Hz	f = 13.41 Hz Accept answers rounding to 13.4	M1 for rearranging to make Z the subject M1 for correct substitution of values A1 for correct answer for Z (ft) M1 for recognising the relationship between Z, R and X_C M1 for rearranging in terms of X_C M1 for correct substitution of values (ft) A1 for correct answer for X_C(ft) M1 for rearranging in terms of f M1 for correct substitution of values (ft) A1 for correct answer for f (ft)	**(10)**