Mark Scheme (Results)

January 2020

Pearson BTEC Level 3

Engineering

Unit 1: Engineering Principles (31706H)

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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:

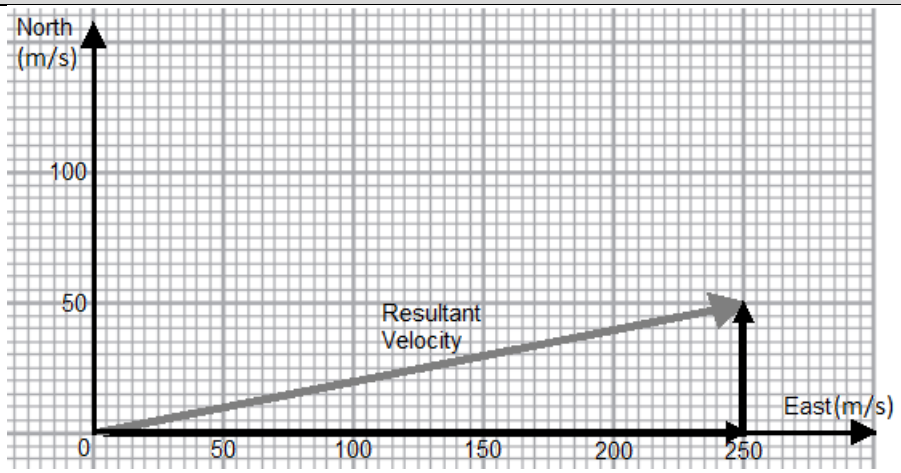
- M marks: method marks are awarded for 'knowing a method and attempting to apply it', unless otherwise indicated.
- A marks: Accuracy marks can only be awarded if the relevant method (M) marks have been earned.
- B marks are unconditional accuracy marks (independent of M marks)
- Marks should not be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

Question number	Answer	Mark
1	 • Both axes/vector with appropriate values to the same scale (1) • Both axes/vector with appropriate labels (1) • The East **and** North vector plotted accurately to scale (ft) (1) • Accurate plotting of the resultant velocity (ft) (1)	**(4)**

Question number	Working	Answer	Notes	Mark
2	$V = (\pi r^2 h)/3$ $r = 0.8/2$ $r = 0.4$ $V = (\pi 0.4^2 \times 1.2)/3$ $V = 0.201\ m^3$	$\underline{V = 0.201\ m^3}$ Or $\underline{V = 201061 cm^3}$ Or $\underline{V = 201 \times 10^6 mm^3}$ Accept answers rounding to $0.2\ m^3$	M1 for conversion of diameter to radius M1 for correct substitution of values (ft) A1 for correct answer for V (ft)	**(3)**

Question number	Working	Answer	Notes	Mark
3	Tanθ = opp/adj Tan 22 = opp/2100 Opp = 2100 x tan22 Opp = 848.5 m **Alternative approach 1** $\frac{c}{\sin C} = \frac{a}{\sin A}$ $\frac{2100}{\sin 68} = \frac{a}{\sin 22}$ $a = \frac{2100 \times \sin 22}{\sin 68}$ **a = 848.5** **Alternative approach 2** Cos = adj/hyp AB = 2100/cos22 AB = 2265 $AB^2 = 2100^2 + opp^2$ $opp = \sqrt{2265^2 - 2100^2}$ Opp = 848.6 m	<u>height = 848.5 m</u> <u>Accept answers in a range 848 to 849</u>	M1 for stating the Tan function correctly M1 for correct substitution of values M1 for rearranging in terms of 'opp' (ft) A1 for correct answer for opposite side (ft) A1 for calculating the missing angle (68) M1 for correct substitution of values M1 for rearranging in terms of 'a' (ft) A1 for correct answer for a (ft) M1 for rearranging in terms of AB A1 for correct answer for AB (ft) M1 for rearranging in terms of 'opp' (ft) A1 for correct answer for opposite side (ft)	**(4)**

	Alternative approach 3 sin = opp/hyp AB = 2100/sin68 AB = 2265 $AB^2 = 2100^2 + opp^2$ $opp = \sqrt{2265^2 - 2100^2}$ Opp = 848.6 m **Do not accept graphical solutions**		M1 for rearranging in terms of AB A1 for correct answer for AB (ft) M1 for rearranging in terms of 'opp' (ft) A1 for correct answer for opposite side (ft)	

Question number	Working	Answer	Notes	Mark
4	Eqn 1 12a + 3b = 16 Eqn 2 4a + 15b = 24 **Method 1** Multiply eqn 2 by 3 12a + 45b = 72 (eqn 3) Subtract eqn 1 from eqn 3 42b = 56 b = 1.333 Sub into eqn 1 12a + 3x1.3333 = 16 12a + 4 = 16 12a = 12 a = 1	a = 1 b = 1.333 Accept a = 1 b = 1.3 Or a = 1 b = 4/3 Or b = 1 1/3	M1 for multiplying the equation 2 by 3 o.e M1 for subtraction eqn 1 from eqn 3 (o.e) A1 for correct answer for first variable (ft) A1 for correct answer for second variable (ft)	**(4)**

	Method 2 Multiply eqn 1 by 5 60a + 15b = 80 (eqn 3) Subtract eqn 2 from eqn 3 56a = 56 a = 1 Sub into eqn 2 4x1 + 15b = 24 4 + 15b = 24 15b = 20 b = 1.3333			

Question number	**Working**	**Answer**	**Notes**	**Mark**
5(a)	$P=P_0e^{\frac{h}{k}}$ $e^{\frac{h}{k}}=\frac{P}{P_0}$ $\frac{h}{k}=\ln(\frac{P}{P_0})$ $h=k\ln(\frac{P}{P_0})$	$h=k\ln(\frac{P}{P_0})$ Accept $h=k(\ln P-\ln P_0)$	M1 for rearranging in terms of 'e' M1 for application of 'ln' on both sides(ft) M1 for recognition that lne = 1 A1 for rearranging in terms of h (ft)	**(4)**
5(b)	h = -8150 x ln(70000/100000) h = -8150 x ln(0.7) h = 2906.9	<u>h = 2906.9</u> Accept h = 2907 as an answer	A1 for correct answer for h (ft) (cao)	**(1)**

Section B

Question number	Answer	Mark
6	A - Archimedes' principle	**(1)**

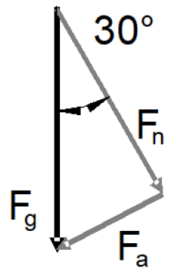
Question number	Answer	Mark
7	D – Newtons per metre squared	**(1)**

Question number	Working	Answer	Notes	Mark
8 (a)	$v = u + at$ $v = 0 + 3 \times 8$ $v = 24$ m/s	<u>$v = 24$ m/s</u>	M1 for correct substitution of values A1 for correct answer for v (cao)	
(b)	$v^2 = u^2 + 2as$ $s = (v^2 - u^2)/2a$ $s = (0 - 24^2)/(2 \times -4)$ $s = -576/-8$ $s = 72$ m	<u>$s = 72$ m</u> <u>$s = 0.072$km</u>	M1 for rearranging in terms of s M1 for correct substitution of values (ft) A1 for correct answer for s (ft) A1 (dep) for the correct unit	
	Alternative method 1: $t = (v-u)/a$ $t = (0-24)/-4$ $t = 6$ $s = ut + at^2/2$ $s = 24x6 + (-4x6^2)/2$ $s = 144 - 72$ $s = 72$m		M1 for correct answer for t M1 for correct substitution of values (ft) A1 for correct answer for s (ft) A1 (dep) for the correct unit	
	Alternative method 2: $t = (v-u)/a$ $t = (0-24)/-4$ $t = 6$ $s = (u+v)t/2$ $s = (24+0)x6/2$ $s = 144/2$ $s = 72$m		M1 for correct answer for t M1 for correct substitution of values (ft) A1 for correct answer for s (ft) A1 (dep) for the correct unit	**(4)**

(3)

Question number	Working	Answer	Notes	Mark
9(a)	ω = RPM x (2π/60) ω = 120 x (2π/60) ω = 240π/60 ω = 4π or ω = 12.5664 rad/s **Accept** ω = 12.57 rad/s **Alternative method 1** 120 RPM is equivalent to 2 RPS 2π rads = 1 rev ω = 4π rads/s **Alternative method 2** Time period is the time taken for one complete cycle = 60/120 = 0.5 Frequency (f) = 1/time period f= 1/0.5 f= 2 ω = 2πf ω = 2π x 2 ω = 4π rads/s	<u>ω = 12.57 rad/s</u> <u>ω = 4π</u> Accept answers rounding to 12.6 rads/s	M1 for recognising ω = RPM x (2π/60) M1 for correct substitution of values (ft) A1 for correct answer for ω (ft) M1 for converting RPM into RPS M1 for converting revolutions into radians (ft) A1 for correct answer for ω (ft) A1 for calculating frequency M1 for correct substitution of values (ft) A1 for correct answer for ω (ft)	
(b)	$a = \omega^2 r$ 280mm = 0.28 m $a = 12.5664^2 \times 0.28$ $a = 44.216$ m/s^2	<u>$a = 44.216$ m/s^2</u> Accept answers rounding to 44 m/s^2	M1 for conversion of mm to m M1 for correct substitution of values (ft) A1 for correct answer for a (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. ● A system of forces that do not act on the same point (1) which in turn produces a moment/couple (1) ● Forces are all acting on the same plane (1) but they do not all pass through the same point (1) ● Two or more forces acting in different directions (1) that do not pass through a common point (1) Accept any other reasonable response.	**(2)**

Question number	Working	Answer	Notes	Mark
11	 **Alternative method 1** $F_a = F_g \sin\theta$ $\theta = 30°$ $F_a = 75\sin30$ $F_a = 37.5$ N **Alternative method 2** $F_a = F_g \cos\theta$ $\theta = 60°$ $F_a = 75\cos60$ $F_a = 37.5$ N	$\underline{F_a = 37.5\text{ N}}$	M1 for recognising the force due to gravity can be resolved into two components (may be implied) (could be a sketch of the forces) M1 for setting up $F_a = F_g \sin\theta$ M1 for recognising $\theta = 30$ M1 for correct substitution of values (ft) A1 for correct answer for F_a (ft) M1 for recognising the force due to gravity can be resolved into two components (may be implied) (could be a sketch of the forces) M1 for setting up $F_a = F_g \cos\theta$ M1 for recognising $\theta = 60$ M1 for correct substitution of values (ft) A1 for correct answer for F_a (ft)	**(5)**

Question number	Working	Answer	Notes	Mark
12	Conversion of 50mm to 0.05 m $A_1 = (0.05^2\pi/4)$ $A_1 = 1.96x10^{-3}\ m^2$ Volumetric flow rate (Q) is constant, therefore $Q = 1.96x10^{-3} \times 2$ $Q = 3.93x10^{-3}\ m^3/s$ Time to fill = volume/flow rate Time = $18/3.93x10^{-3}$ Time = 4580 seconds <u>The alternative solution uses the velocity at the outlet.</u> $A_2 = (0.03^2\pi/4)$ $A_2 = 0.71x10^{-3}\ m^2$ $A_1V_1 = A_2V_2$ $1.96\ x10^{-3} \times 2 = 0.71x10^{-3} \times V_2$ $V_2 = (1.96\ x10^{-3} \times 2)/0.71x10^{-3}$ $V_2 = 5.55m/s$ $Q = A_2V_2$ $Q = 0.71x10^{-3} \times 5.55$ $Q = 3.93x10^{-3}\ m^3/s$	<u>Time = 4580 seconds</u> Accept answers in a range of 4500 to 4600 – allowing for rounding	M1 for conversion of mm to m M1 for correct substitution of values A1 for correct answer for A_1 (ft) M1 for recognising flow rate Q = A x v M1 for correct substitution of values (ft) A1 for correct answer for flow rate (ft) M1 for recognising time to fill = volume/volumetric flow rate M1 for correct substitution of values (ft) A1 for correct answer for time (ft) M1conversion of mm to m A1 for correct answer for A_2 (ft) A1 for correct answer for V_2 (ft) M1 for recognising flow rate Q = A x v M1 for correct substitution of values (ft) A1 for correct answer for flow rate (ft)	**(9)**

	Time to fill = volume/flow rate Time = $18/3.93x10^{-3}$ Time = 4580 seconds		M1 for recognising time to fill = volume/volumetric flow rate M1 for correct substitution of values (ft) A1 for correct answer for time (ft)	

Section C

Question Number	Answer	Mark
13	D - watt	**(1)**

Question Number	Answer	Mark
14	C – permittivity	**(1)**

Question Number	Answer	Mark
15	Award **one** mark for an appropriate use. ● Adjust/change level of light sources (1) ● Adjust/change volume (1) ● Adjust/change motor speeds (1) ● Adjust/change power supply output voltage (1) ● Adjust/change frequencies in a low/high-pass filter (1) Accept any other reasonable responses.	**(1)**

Question number	Working	Answer	Notes	Mark
16	$1/C_t = 1/C_1 + 1/C_2$ $1/C_t = 1/12 + 1/18$ $1/C_t = 0.13888$ $C_t = 1/0.13888$ $C_t = 7.2$ F	$\underline{C_t = 7.2 \text{ F}}$ Accept answers in a range of 7.1 to 7.3 - allowing for rounding variations	M1 for correct substitution of values M1 for rearranging in terms of C_t (ft) A1 for the correct answer for C_t (ft)	**(3)**

Question number	Working	Answer	Notes	Mark
17(a) **(b)**	$I = q/t$ $I = 36/24$ $I = 1.5$ A $V = IR$ $R = V/I$ $R = 12/1.5$ $R = 8\ \Omega$	$\underline{I = 1.5\ A}$ $\underline{R = 8\ \Omega}$	M1 for correct substitution of values A1 for correct answer for current (ft) M1 for rearranging in terms of R M1 for correct substitution of values (ft) A1 for correct answer for resistance (ft)	**(2)** **(3)**

Question number	Working	Answer	Notes	Mark
18	$E = Blv$ $L = 250mm = 0.25$ m $E = 2.2 \times 0.25 \times 8$ $E = 4.4$ V	$\underline{E = 4.4\ V}$	M1 for conversion of mm to m M1 for correct substitution of values (ft) A1 for correct answer for E (cao) A1 (dep) for correct unit	**(4)**

Question number	Working	Answer	Notes	Mark
19	$V_{rms} = V_{peak}/\sqrt{2}$ $V_{rms} = 34/\sqrt{2}$ $V_{rms} = 24V$ $V_p/N_p = V_s/N_s$ $N_s = V_s \times N_p/V_p$ $N_s = 24 \times 750 / 110$ $N_s = 163.63$ $N_s = 164$ turns	<u>164 turns</u>	M1 for recognition of the relationship between peak voltage and RMS voltage. M1 for correct substitution of values A1 for correct answer for V_{rms} (ft) M1 for rearranging in terms of N_s M1 for correct substitution of values (ft) A1 for correct answer for number of turns (ft)	**(6)**

Question number	Working	Answer	Notes	Mark
20	$Z = V/I$ $Z = 230/0.125$ $Z = 1840\ \Omega$ $Z = \sqrt{(X_L^2 + R^2)}$ $Z^2 = X_L^2 + R^2$ $X_L^2 = Z^2 - R^2$ $X_L^2 = 1840^2 - 560^2$ $X_L^2 = 3072000$ $X_L = 1752\ \Omega$	<u>L = 5.58 H</u> Accept answers rounding to 5.6 H	M1 for rearranging in terms of Z and/or correct substitution of values A1 for correct answer for Z (ft) M1 for recognising the relationship between impedance, reactance and resistance M1 rearranging in terms of X_L^2 M1 for correct substitution of values (ft) A1 for correct answer for X_L (ft)	**(9)**

	$X_L = 2\pi fL$ $L = X_L/2\pi f$ $L = 1752/2\pi \times 50$ $L = 5.58$ H		M1 for rearranging in terms of L M1 for correct substitution of values (ft) A1 for correct answer for inductance (ft)	

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