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MARKING SCHEME

LEAVING CERTIFICATE EXAMINATION 2006

MATHEMATICS – ORDINARY LEVEL – PAPER 1

GENERAL GUIDELINES FOR EXAMINERS – PAPER 1

1. Penalties of three types are applied to candidates' work as follows:
 - Blunders - mathematical errors/omissions (-3)
 - Slips - numerical errors (-1)
 - Misreadings (provided task is not oversimplified) (-1).

Frequently occurring errors to which these penalties must be applied are listed in the scheme. They are labelled: B1, B2, B3,..., S1, S2,..., M1, M2,...etc. These lists are not exhaustive.

2. When awarding attempt marks, e.g. Att(3), note that
 - any *correct, relevant* step in a part of a question merits at least the attempt mark for that part
 - if deductions result in a mark which is lower than the attempt mark, then the attempt mark must be awarded
 - a mark between zero and the attempt mark is never awarded.
3. Worthless work is awarded zero marks. Some examples of such work are listed in the scheme and they are labelled as W1, W2,...etc.
4. The phrase "hit or miss" means that partial marks are not awarded – the candidate receives all of the relevant marks or none.
5. The phrase "and stops" means that no more work is shown by the candidate.
6. Special notes relating to the marking of a particular part of a question are indicated by an asterisk. These notes immediately follow the box containing the relevant solution.
7. The sample solutions for each question are not intended to be exhaustive lists – there may be other correct solutions. Any examiner unsure of the validity of the approach adopted by a particular candidate to a particular question should contact his/her advising examiner.
8. Unless otherwise indicated in the scheme, accept the best of two or more attempts – even when attempts have been cancelled.
9. The *same* error in the *same* section of a question is penalised *once* only.
10. Particular cases, verifications and answers derived from diagrams (unless requested) qualify for attempt marks at most.
11. A serious blunder, omission or misreading results in the attempt mark at most.
12. Do not penalise the use of a comma for a decimal point, e.g. €5.50 may be written as €5,50.

APPLYING THE GUIDELINES

Examples of the different types of error:

Blunders (i.e. mathematical errors) (-3)

- Algebraic errors : $8x + 9x = 17x^2$ or $5p \times 4p = 20p$ or $(-3)^2 = 6$
- Sign error $-3(-4) = -12$
- Fraction error (incorrect fraction, inversion etc); apply once.
- Cross-multiplication error
- Operation chosen is incorrect. (e.g, multiplication instead of division)
- Transposition error :eg $-2x - k + 3 \Rightarrow -2x = 3 + k$ or $-3x = 6 \Rightarrow x = 2$ or $4x = 12 \Rightarrow x = 8$ each time.
- Distribution error (once per term, unless directed otherwise) eg $3(2x + 4) = 6x + 4$ or $\frac{1}{2}(3 - x) = 5 \Rightarrow 6 - x = 5$
- Expanding brackets incorrectly: apply once unless directed otherwise, eg $(2x - 3)(x + 4) = 8x^2 - 12$
- Omission, if not oversimplified.
- Index error, each time unless directed otherwise
- Factorisation: error in one or both factors of a quadratic: apply once $2x^2 - 2x - 3 = (2x - 1)(x + 3)$
- Root errors from candidate's factors: error in one or both roots: apply once.
- Error in formulae: eg $T_n = 2a + (n - 1)d$
- central sign error in uv or u/v formulae
- omission of $\div v^2$ or division not done in u/v formula (apply once)
- Vice-versa substitution in uv or u/v formulae (apply once)

Slips (-1)

- Numerical slips: $4 + 7 = 10$ or $3 \times 6 = 24$ but $5 + 3 = 15$ is a blunder.
- An omitted round-off or incorrect round off to a required degree of accuracy, or an early round off is penalised as a slip each time,
- However an early round-off which has the effect of simplifying the work is at least a blunder
- Omission of units of measurement or giving the incorrect units of measurement in an answer is treated as a slip, once per section (a), (b) and (c) of each question.

Misreadings (-1)

- Writing 2436 for 2346 will not alter the nature of the question so MR(-1)
However, writing 5000 for 5026 will simplify the work and is penalised as at least a blunder.

Note: Correct relevant formula *isolated* and stops: if formula is *not* in Tables, award attempt mark.

QUESTION 1

Part (a)	10 marks	Att 3
Part (b)	25 marks	Att 8
Part (c)	15 marks	Att 5

*No penalty for omitting € symbol, but if answer given in cent, then must include c, otherwise S-1.

Part (a)	10 marks	Att 3
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(a) €320 is $\frac{4}{9}$ of a prize fund. Find the total prize fund.

(a)	10 marks	Att 3
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$\frac{1}{9} = \frac{320}{4} \quad \dots 3m$ $= 80 \quad \dots 7m$ $\frac{2880}{4} \text{ or } 80 \times 9 \quad \dots 7m$ $\left[\frac{9}{9} = \frac{320 \times 9}{4} \right] = \text{€}720 \quad \dots 10m$	<p>or</p> $\frac{1}{9} = \frac{320}{4} \quad \dots 3m$ $\frac{5}{9} = \frac{320 \times 5}{4} \quad \dots 7m$ $= 400 \quad \dots 7m$ $320 + 400 = \text{€}720 \quad \dots 10m$	
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*Correct answer without work: full marks.

*400 without work, award 7marks.

Blunders (-3)

B1 An incorrect numerator, eg 320×4 and continues.

B2 An incorrect denominator, eg $320/9$ and continues.

Note: $\frac{320 \times 4}{9} = 142.(222\dots)$ is $1 \times B$ (inversion); (if then not calculated: $2 \times B = 4m$).

B3 Gets 2880 ($=320 \times 9$) and stops (1 step missing).

B4 Incorrect or no simplification, or simplification not possible.

Slips (-1)

S1 A numerical slip.

Attempts (3 marks)

A1 Mentions 9 times and stops or 5 times and stops.

A2 Mentions $\frac{1}{4}$ or $\div 4$ and stops.

A3 Mentions $5/9$ or gets $5/9$ of 320 or 177.77 with work.

Worthless (0)

W1 Mentions $1/9$ and stops.

W2 Incorrect answer with no work (other than 400).

Aoife pays a fixed monthly charge of €15 for her mobile phone. This charge includes 100 free text messages and 50 minutes free call time each month. Further call time costs 28 cent per minute and additional text messages cost 11 cent each.

In one month Aoife sends 140 text messages and her call time is 2 hours.

- (i) Find the total cost of her fixed charge, text messages and call time.
- (ii) VAT is added to this cost at the rate of 21%.
Find the amount paid, including VAT.

(b)(i)

15 marks

Att 5

140-100 = 40 (first subtr.)	.....5m	} interchangeable
120-50 = 70 (2 nd one)	.....9m	
40×11c = €4.40 (first mult.)	.....12m	} interchangeable
and 70×28c = €19.60 (2 nd mult.)	.....14m	
Total = €4.40 + €19.60 + €15 = €39.00	.....15m	

*Correct answer without work: Att5.

Blunders (-3)

- B1 40×28 and/or 70×11 and continues.
- B2 Incorrect use or no use of either the free calls or free texts (once only).
Note: 140×11 and 120×28 and continues correctly is B2 (12m).
- B3 Using 1hr = 100mins and continues (4.40+42.00+15.00 ⇒ €61.40).

Slips (-1)

- S1 Each numerical slip.
- S2 Incorrect or no total.

Attempts (5 marks)

- A1 Mentions 40 only or the 70 only and stops.
- A2 Mentions 120 and no other relevant work.
- A3 Mentions multiplying by 11 and/or by 28 and stops.
- A4 Some relevant use of the 15 (addition only).

Worthless (0)

- W1 Mentions 150 and stops.

(b)(ii)

10 marks

Att 3

$100\%+21\% = 121\%$	.....3m	or	$21\% \text{ of } \text{€}39$	.....3m
$\frac{39 \times 121}{100}$	..... 7m		$= \text{€}8.19$	.....7m
$= \text{€}47.19$	.....10m		$\text{€}39 + \text{€}8.19$	.....9 m
			$= \text{€}47.19$	.....10m

*Correct answer without work: full marks.

*Accept candidate's answer from part (b)(i).

*€8.19 with no work: 7m.

Case: *without work*

4719c ... 10m

4719 9m

€4719 7m

Blunders (-3)

B1 Uses 100/121 (getting 32.23) or similar.

B2 Subtracts the 21% (or 8.19) instead of adding (getting 30.81).

B3 Decimal error in calculations.

Attempts (3 marks)

A1 Mentions 121% or 21/100 or 121 only and stops.

A2 Some relevant use of the 39 (or candidate answer from (b)(i)). eg 39×21 only.

A3 Mentions 100 or 100% and stops.

Part (c)

15 (10, 5) marks

Att (3, 2)

(c) The standard rate of income tax is 20% and the higher rate is 42%.
 Colm has weekly tax credits of €50 and a standard-rate cut-off point of €240
 Until recently, Colm had a gross weekly income of €900.

(i) Calculate the tax Colm paid each week.

(ii) After getting a pay rise, Colm's weekly after-tax income increased by €20.30.
 Calculate the increase in Colm's gross weekly income.

(c)(i)

10 marks

Att 3

$900-240 = 660$3 m	} interchangeable
$240 \times 0.2 = \text{€}48$	.....4 m
$660 \times 0.42 = \text{€}277.20$	.....7 m
$48 + 277 = \text{€}325.20$		
$325.20 - 50 = \text{€}275.20$10 m	

* Correct answer without work: Att3.

Blunders (-3)

B1 No subtraction, ie $900 \times 42\%$ used with the $240 \times 20\%$ and continues.

B2 Decimal error in calculations.

B3 20% of an incorrect figure.

B4 Incorrect or no use of tax credit.

B5 Tax rates interchanged, ie $240 \times 42\%$ with $660 \times 20\%$ (once) and continues.
 (ie getting 100.80 and 132.00 respectively \Rightarrow Gross 232.80 \Rightarrow Nett €182.80).

Slips (-1)

S1 Each numerical slip.

Attempts (3 marks)

- A1 Mention of 660 and no other relevant work.
A2 Some relevant tax calculation and stops.
A3 Two tax costs appearing which are then added and stops.
A4 Some relevant use of the tax credits ie by subtracting.

(c)(ii)

5 marks

Att 2

$100 - 42 = 58$	.....2m
$58\% = 20.30$	
Increase = $\frac{20.30 \times 100}{58}$	
= €35	.....5m

* Correct answer without work: Att2.

* Accept 935 for full marks (includes the increase)with work; otherwise Att2.

Blunders (-3)

- B1 $\frac{20.30 \times 100}{42} = 48.333$ calculated out.
B2 Uses 20% \Rightarrow 80% getting $\frac{20.30 \times 100}{80} = 25.375$.
B3 Decimal error in calculations.

Slips (-1)

- S1 Each numerical slip.
S2 Decimal part of an incorrect answer omitted e.g. 48.33 written as 48.

Attempts (2 marks)

- A1 58% appearing.
A2 Gets 42% of 20.30 (8.526) and stops.
A3 Some relevant subtraction from 100 indicated.e.g. $100 - 20$.
A4 Gets 900 – answer (i) with or without adding 20.30.

Worthless (0)

- W1 Mentions 42/100 or 20/100 and stops.

QUESTION 2

Part (a)	15 marks	Att 5
Part (b)	20 marks	Att 7
Part (c)	15 marks	Att 5

Part (a) **15 marks** **Att 5**

(a) Simplify $3(2x + 4) - 5(x + 1)$.

(a) **15 marks** **Att 5**

$$\begin{aligned}6x + 12 - 5x - 5 &= 12m \\= x + 7 &= 15m\end{aligned}$$

* Ignore extra work after $x + 7$.

Blunders (-3)

- B1 Distribution error to max $2 \times B$.
- B2 Algebraic errors.
- B3 $3(2x + 4) = 5(x + 1)$ and continues.

Attempts (5 marks)

- A1 Any correct multiplication or addition

Part (b) **20 (5, 15) marks** **Att (2, 5)**

Let $f(x) = 2x^3 + ax^2 + bx + 14$.

(i) Express $f(2)$ in terms of a and b .

(ii) If $f(2) = 0$ and $f(-1) = 0$, find the value of a and the value of b .

(b)(i) **5 marks** **Att 2**

$$\begin{aligned}f(2) &= 2(2)^3 + a(2)^2 + b(2) + 14 \quad [5m] \\&= 16 + 4a + 2b + 14 \quad \text{or} \quad 4a + 2b + 30 \quad [5m]\end{aligned}$$

* Errors, if any, in simplifying $f(2)$ are applied in (ii).

* Accept correct long division (Remainder = $4a + 2b + 30$) or synthetic division. Otherwise apply slips and blunders.

Blunders (-3)

- B1 Substitutes $x = -2$

Attempts (2 marks)

- A1 Replaces a and/or b by ± 2 .
- A2 Attempt at division by $x \pm 2$.
- A3 Any correct substitution.

b(ii)**15 marks****att 5**

$$f(-1) : 2(-1)^3 + a(-1)^2 + b(-1) + 14 \dots 5m$$

$$2(-1)^3 + a(-1)^2 + b(-1) + 14 = 0 \dots 6m$$

$$f(2) : 2(2)^3 + a(2)^2 + b(2) + 14 = 0 \dots 9m$$

} interchangeable

$$\left. \begin{array}{l} a - b = -12 \\ 2a + b = -15 \end{array} \right\} \dots 12m$$

$$3a = -27 \Rightarrow a = -9; b = 3 \dots 15m$$

*Blunders (-3)*B1 Mathematical error in simplifying $f(2) = 0$.B2 Error in substitution $f(-1)$.B3 Error in simplifying $f(-1) = 0$.

B4 Mathematical error in solving simultaneous equations (once).

Slips (-1)

S1 Numerical errors.

*Attempts (5 marks)*A1 Any correct simplification of $f(2)$ or $f(-1)$ and stops.A2 Any correct substitution of $f(-1)$ and stops.A3 Replaces a and/or b by ± 1 or ± 2 .

Part (c)**15 (10, 5) marks****Att (3, 2)**

- (c) (i) Find the smallest natural number k such that
 $2x + 4(x+3) + 7(2x+4) < 20(x+k)$.
- (ii) The lengths of the sides of a triangle are
 $4\sqrt{x}$, $(x-4)$ and $(x+4)$ where $x > 4$.
 Prove that the triangle is right-angled.

(c)(i)**10 marks****Att 3**

$$2x + 4x + 12 + 14x + 28 < 20x + 20k \quad \dots 4m$$

$$\Rightarrow 20x + 40 < 20x + 20k \quad \text{or} \quad \Rightarrow 20k > 40 \quad \dots 7m$$

$$\Rightarrow k > 2 \quad \dots 9m$$

$$\Rightarrow k = 3 \quad \dots 10m$$

Blunders (-3)

- B1 Distribution error to max $2 \times B$.
 B2 Transposition error(s).
 B3 Algebraic errors.
 B4 Error in direction of inequality.

Slips (-1)

- S1 Finishes at $k > 2$.
 S2 Numerical errors.

Misreadings (-1)

- M1 Uses ' \leq ' (Answer $k = 2$).

Attempts (3 marks)

- A1 Any correct step in multiplication/transposition/simplification.

(c)(ii)**5 marks****Att 2**

$$(4\sqrt{x})^2 = 16x \quad \text{and} \quad (x-4)^2 = x^2 - 8x + 16 \quad \text{and} \quad (x+4)^2 = x^2 + 8x + 16 \quad [4m]$$

$$\text{Pythagoras: } 16x + x^2 - 8x + 16 = x^2 + 8x + 16 \quad [5m]$$


Blunders (-3)

- B1 Error in squaring.

Slips(-1)

- S1 Hypotenuse incorrectly or not identified or no correct conclusion.

Attempts (2 marks)

- A1 Any mention of Pythagoras' Theorem or draws  with some relevant labelling of side(s).
 A3 Substitutes a value > 4 for x and continues.
 A3 Effort at squaring any term.

Worthless (0marks)

- W1 States slope formula.
 W2 States 90° and stops.
 W3 Adds 2 (or 3) sides.

QUESTION 3

Part (a)	15 marks	Att 5
Part (b)	20 marks	Att 7
Part (c)	15 marks	Att 5

Part (a)	15 marks	Att 5
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(a) Find the value of $\frac{ab-c}{2}$, when $a = 3$, $b = \frac{2}{3}$ and $c = 1$.

(a)	15 marks	Att 5
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$$\frac{3\left(\frac{2}{3}\right)-1}{2} \dots\dots[9m] \dots\dots = \frac{2-1}{2} \dots\dots[12m] \dots\dots = \frac{1}{2} \dots\dots[15m]$$

*Correct answer with no work for full marks.

Blunders (-3)

B1 Mathematical error each time to max 2×B.

Slips (-1)

S1 Numerical slips.

Misreadings (-1)

M1 Incorrect substitution for a , b , c (once only) and continues (work must be shown).

Attempts (5 marks)

A1 Some correct substitution and stops.

Worthless (0 marks)

W1 Incorrect answer with no work.

Part (b)	20 marks	Att 7
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(b) Solve for x and y

$$x - 2y = 10$$

$$x^2 + y^2 = 20$$

(b)	20 marks	Att 7
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$x = 2y + 10$7m
$\Rightarrow (2y + 10)^2 + y^2 = 20$...8m
$\Rightarrow 5y^2 + 40y + 80 = 0$ or $y^2 + 8y + 16 = 0$11m
$\Rightarrow (y + 4)^2 = 0$...14m
$\Rightarrow y = -4$...17m
$x = [2(-4) + 10] = 2$...20m

*Apply similar structure if y isolated first.

* Set of coordinates found by trial and error, or without work:

(2, -4) verified in both equations, 20 marks; if not verified in both, Att 7.

Incorrect answer: no marks, whether tried to verify or not.

*No additional marks from the point where the equation becomes linear. But see A3 below.

*No penalty for excess answer (Use of quadratic to find 2nd variable).

Blunders (-3)

- B1 Distribution error.
- B2 Sign error, each time.
- B3 Quadratic formula error (in formula, substitution or simplification). Each time to a maximum of 2 blunders (equivalent to two steps).
- B4 Incorrect factors. Apply once.
- B5 Incorrect root(s) from candidate's factor(s). Apply once.
- B6 Fails to find value of second variable.
- B7 Finds x but substitutes back into y (or vice versa).
- B8 Transposition errors (Each time.)

Attempts (7 marks)

- A1 Effort at isolating x or y e.g. $2y = x - 10$ and stops.
- A2 Correct quadratic formula and stops.
- A3 An effort to find the *second* variable, having found the first variable with work of no value.

Worthless (0)

- W1 Incorrect values without work.
- W2 Invented values substituted, and continues, e.g. $y = 0 \Rightarrow x = 10$ or some such.
- W3 $x - 2y = 10 \Rightarrow x^2 + 4y^2$ and continues. But see A3.

Part (c)

15 (10, 5) marks

Att (3, 2)

(c) Solve for x

$$x = \frac{3 + 2x}{x - 2}, \quad x \neq 2$$

and give your solutions in the form $a \pm \sqrt{b}$, where $a, b \in \mathbf{N}$.

Write one of your solutions correct to two decimal places. Using this value, show that the difference in the values of the left hand side and the right hand side of the given equation is less than 0.1

(c)[(i)]

10 marks

Att3

$$x = \frac{3 + 2x}{x - 2} \Rightarrow x(x - 2) = 3 + 2x \quad [3m] \Rightarrow x^2 - 4x - 3 = 0. \quad [4m]$$

$$\Rightarrow x = \frac{4 \pm \sqrt{16 + 12}}{2} = \frac{4 \pm \sqrt{28}}{2} \quad [7m] = 2 \pm \sqrt{7}. \quad [10m]$$

*No additional marks from the point where the equation becomes linear.

Blunders (-3)

- B1 Quadratic formula error (in formula, substitution or simplification). Each time to a maximum of 2 blunders.
- B2 Transposition errors (each time).
- B3 Answer not written in surd form.

Attempts (3 marks)

- A1 Correct quadratic formula and stops.
- A2 Some correct attempt at eliminating fraction (even if incomplete or only partially correct).

Worthless (0 marks)

- W1 Unsuccessful trial and error approach.

(c)[(ii)]

5 marks

Att 2

$2 + \sqrt{7} = 2 + 2.645 = 4.65$ .....2 marks....	$2 - \sqrt{7} = 2 - 2.645 = -0.65$
$\text{RHS} = \frac{3 + 2(4.65)}{4.65 - 2} = 4.64$ .....4 marks.....	$\text{RHS} = \frac{3 + 2(-0.65)}{-0.65 - 2} = -0.64$
$|\text{LHS} - \text{RHS}| =$ $|4.65 - 4.64| = 0.01$ [< 0.1] .....5 marks....	$|\text{LHS} - \text{RHS}| =$ $|-0.65 - (-0.64)| = 0.01$ [< 0.1]

*Accept candidate's answer from(i)

Blunders (-3)

- B1 $\sqrt{7} = 3.5$.
- B2 Mathematical error.
- B3 Substitution into equations $x(x - 2) = 3 + 2x$ or $x^2 - 4x - 3 = 0$ and finishes.

Slips (-1)

- S1 $\sqrt{7}$ incorrectly rounded or not rounded.

Attempts (2 marks)

- A1 Some effort at expressing x as decimal.
- A2 Some effort at substitution using answers from (i).

Worthless (0marks)

- W1 Substitution of (incorrect) value(s) other than from (i).

QUESTION 4

Part (a)	10 marks	Att 3
Part (b)	20 marks	Att 6
Part (c)	20 marks	Att 6

Part (a)	10 marks	Att 3
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Let $u = 3 - 6i$ where $i^2 = -1$.
Calculate $|u + 2i|$.

(a)	10 marks	Att 3
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$ 3 - 6i + 2i $ 3m
$= 3 - 4i $ 4m
$=\sqrt{(3)^2 + (-4)^2}$ or $\sqrt{9+16}$ 7m
$=\sqrt{25}$ or 5	...10m

- * No penalty for substituting 4 for -4 in mod formula.
- * Accept distance formula applied to (0, 0) and (3, -4).

Blunders (-3)

- B1 Mathematical errors.
- B2 Error in modulus formula.
- B3 Incorrect substitution into formula e.g. $(-4i)^2$.
- B4 No $\sqrt{\quad}$ used.
- B5 Finds $|u| + |2i|$.

Attempts (3 marks)

- A1 Substitutes for u and stops.
- A2 $\sqrt{a^2 + b^2}$ or distance formula correct and stops.
- A3 $\sqrt{a^2 - b^2}$, distance formula with 1 error, or $a^2 + b^2$ with some correct substitution and stops.

Worthless (0 marks)

- W1 Incorrect formula (other than A3) with/without substitution.

Part (b)	20 (10, 10) marks	Att (3, 3)
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- (i) Solve $z^2 - 4z + 29 = 0$.
Write your answers in the form $x + yi$ where $x, y \in \mathbf{R}$.
- (ii) Write in its simplest form $i(i^4 + i^5 + i^6)$.

(b)(i)

10 marks

Att 3

$z = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a} \quad \dots 3m \dots$	$(x + iy) + (x - iy) = 4$ <p>and/or</p> $(x + iy)(x - iy) = 29$
$= \frac{4 \pm \sqrt{(-4)^2 - 4(1)(29)}}{2(1)} \quad \dots 7m \dots$	$\Leftrightarrow 2x = 4 \Rightarrow x = 2$
<p>or</p> $= \frac{4 \pm \sqrt{-100}}{2} \quad \dots 7m \dots$	$x^2 + y^2 = 29$
$= \frac{4 \pm 10i}{2} \quad \text{or} \quad 2 \pm 5i \quad \dots 10m \dots$	$(2)^2 + y^2 = 29$ $y = \pm 5$

*Correct answers by trial and error must be verified to get full marks otherwise Att 3.

Blunders (-3)

B1 Error in quadratic formula (formula/substitution) to max 2×B.

B2 Errors in simplification.

Attempts (3 marks)

A1 Effort at factorising e.g. $(z + \dots)(z - \dots)$.

A2 Effort at trial and error.

(b)(ii)

10 marks

Att 3

$i(i^4 + i^5 + i^6)$ $= i(1 + i - 1)$ $= i(i) = i^2$ $= -1. \quad [10m]$	or	$i(i^4 + i^5 + i^6)$ $= i^5 + i^6 + i^7$ $= i - 1 - i$ $= -1 \quad [10m]$
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*Correct answer without work: Att 3.

*Care needed in distinguishing i and 1.

10 marks: Fully correct with work.

7 marks : (a) If a non trivial power of i is evaluated correctly (i.e. other than i or i^2)
Examples $i^6 = 1$; $i^3 = -i$ etc.

and

(b) $i \times$ (quantity with i) is correctly multiplied.
Examples: $i(i^4) = i^5$; $i(i) = i^2$; $i(i^{15}) = i^{16}$ (but e.g. $i(3) = 3i$ is not sufficient).

3 marks: One of the elements (a) or (b) above only

Attempts (3 marks)

A1 Any correct work with relevant indices e.g. $i^2 = -1$, $i^4 = i.i.i.i$ (but $i(i^{15})$ and stops W)

Worthless (0 marks)

W1 $1(4+5+6) = 15$ or such.

(i) Express $\frac{3-2i}{1-4i}$ in the form $x + yi$.

(ii) Hence, or otherwise, find the values of the real numbers p and q such that

$$p + 2qi = \frac{17(3-2i)}{1-4i}.$$

(c)(i)

10 marks

Att 3

(I)	3m...	(II)	$\frac{3-2i}{1-4i} = x + yi$
$\frac{3-2i}{1-4i} \times \frac{1+4i}{1+4i}$	...3m...	$\Rightarrow 3-2i = (1-4i)(x+yi)$	
$3-2i+12i-8i^2$ <u>or</u> $1-16i^2$	...4m..	$x-4xi+yi-4yi^2$ or $x+4y+(-4x+y)i$ (RHS)	
$= 3-2i+12i-8i^2$ <u>and</u> $1-16i^2$	...7m...		
$= \frac{3-2i+12i-8i^2}{1-16i^2}$	...7m	$x+4y = 3$	$-4x+y = -2$
$= \frac{11+10i}{17}$ or $\frac{11}{17} + \frac{10i}{17}$	...10m	$x = \frac{11}{17}$	$y = \frac{10}{17}$

Blunders (-3)

B1 Incorrect conjugate.

B2 $i^2 \neq -1$. Once only if consistent.

B3 Each omitted or incorrect term when multiplying out. max of 2 (1 on num., 1 on denom.).

B4 Real and imaginary parts mixed up, e.g. when adding.

B5 Inverts in the last step.

Attempts (3 marks)

A1 Correct conjugate and stops.

A2 Any correct relevant multiplication indicated.

(c)(ii)

10 marks

Att 3

$p + 2qi = 17\left(\frac{11}{17} + \frac{10i}{17}\right)$ [3m]	$= 11 + 10i$ [4m]
$\Rightarrow p = 11$ and/or $2q = 10$ [7m]	$\Rightarrow p = 11$ and $q = 5$ [10m]

*Accept candidate's $x + iy$ from (i) unless oversimplified.

*Correct p and q found without work: if both verified, 10m, otherwise Att 3.

* If $(p+2qi)(1-4i) = 17(3-2i)$ used, mark as in part (i) (II)

Blunders (-3)

B1 $i^2 \neq -1$, once if consistent.

B2 Sign errors, each time.

B3 Real and imaginary parts confused, e.g. real \neq real, imaginary \neq imaginary.

Attempts (3 marks)

A1 Some correct multiplication of brackets.

QUESTION 5

Part (a)	10 marks	Att 3
Part (b)	20 marks	Att 7
Part (c)	20 marks	Att 7

Part (a) **10 marks** **Att 3**

The first term of an arithmetic sequence is 17 and the common difference is -8 .
Find, in terms of n , an expression for T_n , the n th term.

(a) **10 marks** **Att 3**

$a = 17$ or $d = -8$ or $T_n = a + (n-1)d$ [3m]
 $a = 17$ or $d = -8$ **with** $T_n = a + (n-1)d$ [4m]
 all 3 written [7m]
 $= 17 + (n-1)(-8)$ or $= 25 - 8n$. [10m].

- * Accept correct answer without work.
- * Ignore notation.

Blunders(-3)

- B1 Incorrect a .
- B2 Incorrect d but a and d interchanged $1 \times B$.
- B3 Error in formula (not more than 1 error, otherwise attempt at best).
- B4 Finds S_n of AP instead of T_n .

Attempts (3marks)

- A1 GP formula with any correct substitution.
- A2 S_n of AP formula written.
- A3 $T_1 = a$.

Case:
 17, 9, 4 m
 17, 25, 3m
 $a = 17$ 3m
 17 on its own 0 m

Worthless(0marks)

- W1 17 and /or -8 written.
- W2 GP formula(e) and stops.

(b) **20 (5, 5, 10) marks** **Att (2, 2, 3)**

The n th term of a geometric series is $T_n = 4\left(\frac{1}{2}\right)^n$.

- (i)** Find a , the first term.
- (ii)** Find r , the common ratio.
- (iii)** Write $4 - S_{10}$ in the form $\frac{1}{2^k}$, $k \in \mathbf{N}$, where S_{10} is the sum of the first ten terms.

(b)(i) **5 marks** **Att 2**

$$T_1 = a = 4\left(\frac{1}{2}\right)^1 \quad [2m] \quad = 2 \quad [5m]$$

- * Accept correct answer with no work.
- * Award 5 marks for ans = 2 even if $(4 \times \frac{1}{2})^1$ written.

Blunders (-3)

B1 Incorrect value of n used.

Attempts (2 marks)

A1 States $n = 1$ and stops.

A2 Writes T_1 and stops.

A3 Writes T_n for GP (ar^{n-1}).

A4 Formula for S_n of GP written correctly.

A5 $4 \div \frac{1}{2}$.

A6 T_n of AP with some correct substitution.

Worthless (0marks)

W1 $4 \pm \frac{1}{2}$

W2 T_n or S_n of AP and stops.

(b)(ii)

5 marks

Att 2

$$T_2 = 4\left(\frac{1}{2}\right)^2 = \left[4\left(\frac{1}{4}\right)\right] = 1 \quad [2m] \Rightarrow r = \frac{T_2}{T_1} = \frac{1}{2} \quad [5m] \quad (\text{or by inspection, or any } T_n \div T_{n-1})$$

* Accept correct answer with no work.

* Accept value of a from (i).

Blunders (-3)

B1 Mathematical errors

Attempts (2 marks)

A1 T_1 or $a = 2$

A2 Formula for T_n of GP written and stops.

A3 Formula for T_n of AP with some correct substitution

Worthless (0marks)

W1 T_n or S_n of AP and stops.

(b)(iii)

10 marks

Att 3

$$(I) \quad S_n = \frac{a(1-r^n)}{1-r} [3m] \quad S_{10} = \frac{2\left(1-\left(\frac{1}{2}\right)^{10}\right)}{1-\frac{1}{2}} \quad \text{or} \quad 4-4\left(\frac{1}{2}\right)^{10} \quad \text{or} \quad 3\frac{255}{256} [7m]$$

$$\Rightarrow 4-S_{10} = 4-4+4\left(\frac{1}{2}\right)^{10} = \frac{4}{2^{10}} = \frac{1}{2^8} [10m]$$

$$(II) \quad 2+1+\frac{1}{2}+\frac{1}{4}+\frac{1}{8}+\frac{1}{16}+\frac{1}{32}+\frac{1}{64}+\frac{1}{128}+\frac{1}{256} [7m] \Rightarrow 4-(2+1+\dots\dots\dots) = \frac{1}{2^{256}}$$

$$= \frac{1}{2^8} [10m]$$

* Accept a and r values from (i) and (ii) if not oversimplified.

* Accept $S_n = \frac{a(r^n-1)}{r-1}$ form of formula.

Blunders (-3)

- B1 Error in formula (not more than 1 error, otherwise attempt at best).
- B2 Error in substitution (once if consistent).
- B3 Mathematical error in calculation to max B×2.
- B4 Each term missing in (II).
- B5 Extra term(s) included in addition in last step in (II).

Slips (-1)

- S1 Gives answer as 2^{-8} or $1/256$ or 0.003906....
- S2 Numerical errors.

Attempts (3 marks)

- A1 Attempt at adding terms.
- A2 Writes out at least 2 correct terms.
- A3 Formula for S_n of AP with some correct substitution.

(c) **20 (10, 5, 5)** **Att (3, 2, 2)**

The first three terms of an arithmetic sequence are

$$h + 3, \quad 5h - 2, \quad 6h - 13$$

where h is a real number.

- (i) Find the value of h .
- (ii) Hence, write down the value of each of the first three terms.
- (iii) Find the value of the eleventh term.

(c)(i) **10 marks** **Att 3**

$$5h - 2 - (h + 3) = 6h - 13 - (5h - 2) \quad [3m]$$

$$\Rightarrow 5h - 2 - h - 3 = 6h - 13 - 5h + 2 \quad \Rightarrow 3h = -6 \quad [7m] \quad \Rightarrow h = -2 \quad [10m]$$

* Accept correct answer without work or by T + E.

Blunders (-3)

- B1 Mathematical errors.

Attempts (3 marks)

- A1 $T_3 - T_2 = T_2 - T_1$ or similar and stops.
- A2 a or $T_1 = h + 3$ and/or $T_2 = 5h - 2$ and/or $T_3 = 6h - 13$.
- A3 Effort at T+E.
- A4 $a, a + d,$ and/or $a + 2d$ written, or T_n formula written.

Worthless (0 marks)

- W1 $\frac{T_2}{T_1} = \frac{T_3}{T_2}$ or similar, and stops, but see A2.

(c)(ii)

5 marks

Att 2

$$h + 3 = -2 + 3 = 1$$

$$5h - 2 = 5(-2) - 2 = -12$$

$$6h - 13 = 6(-2) - 13 = -25$$

- * Accept h from part (i).
- * Accept correct answers with no work.

Blunders (-3)

- B1 One term omitted.
- B2 Sign error.

Slips (-1)

- S1 Arithmetic error.

Attempts (2 marks)

- A1 T_n of AP and stops.
- A2 One term only calculated.
- A3 Some relevant substitution.
- A4 Two correct answers (with/without 3rd incorrect answer) with no work.

Worthless(0marks)

- W1 Incorrect answers, or only 1 correct answer, with no work.

(c)(iii)

5 marks

Att 2

$$d = T_2 - T_1 = -12 - 1 = -13 \text{ [2m]}$$

$$T_{11} = a + 10d = 1 + 10(-13) \text{ [still 2m]} = 1 - 130 = -129 \text{ [5m]}$$

or

$$\text{List: } 1, -12, -25, \dots, -129 \text{ [5m]}$$

- * Accept terms from (ii).

Blunders (-3)

- B1 Error in formula (not more than 1 error, otherwise attempt at best).
- B2 Error in substitution.
- B3 Mathematical error in calculation.
- B4 $n = 11 \pm 1$ in listing method.

Slips (-1)

- S1 Arithmetic errors.

Attempts (2 marks)

- A1 Finds T_4 .
- A2 Formula for T_n written.
- A3 S_n formula with some correct substitution.

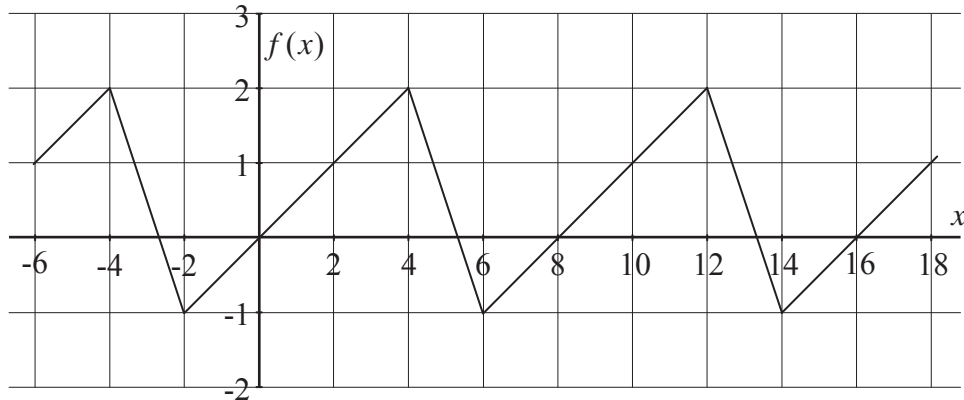
QUESTION 6

Part (a)	15 marks	Att 6
Part (b)	20 marks	Att 7
Part (c)	15 marks	Att 6

Part (a) **Att (2, 2, 2)**

15 (5, 5, 5) marks

- (a) $f : x \rightarrow f(x)$ is a periodic function defined for $x \in \mathbf{R}$.
The period is as indicated in the diagram



- (i) Write down the period and range of the function.
(ii) Find $f(44)$.

(a)(i) **Att (2, 2)**

10 (5, 5) marks

Period = 8, Range = [-1, 2]

- * Accept correct answers without work for all (a).
- * Accept -2, 6 or 6,-2 or equivalent for period.
- * Accept [2, -1] for range.

Blunders (-3)

- B1 One incorrect element in period (provided 2 elements given).
- B2 One incorrect element in range.

Slips (-1)

- S1 Answers unlabelled in wrong order, or incorrectly labelled.

Attempts (2 marks)

- A1 Some idea of periodicity e.g. 'pattern repeats 3 times'.
- A2 Range given as 3.

(a) (ii) **Att 2**

5 marks

$f(44) = f(4) = 2$

- * Accept correct answer without work
- * Accept candidate's value for period from (i) or correct period.

Blunders (-3)

- B1 Uses incorrect period.
- B2 Incorrect reading using correct period.

Slips (-1)

- S1 Numerical slip (if work shown).

Attempts (2 marks)

A1 Shows some understanding of periodicity e.g. $f(0) = f(8)$ (in this part).

A2 Any incorrect answer in range $[-1, 2]$ with/without work.

Worthless (0 marks)

W1 Incorrect answer outside range $[-1, 2]$ without work.

Part (b)

20 (10, 5, 5) marks

Att (3, 2, 2)

The temperature, C , in degrees Celsius, of a liquid in an insulated container is related to time t , in hours, by

$$C = 86 - 6t.$$

(i) Draw the straight line graph of this relation, putting t on the horizontal axis, for $0 \leq t \leq 8$.

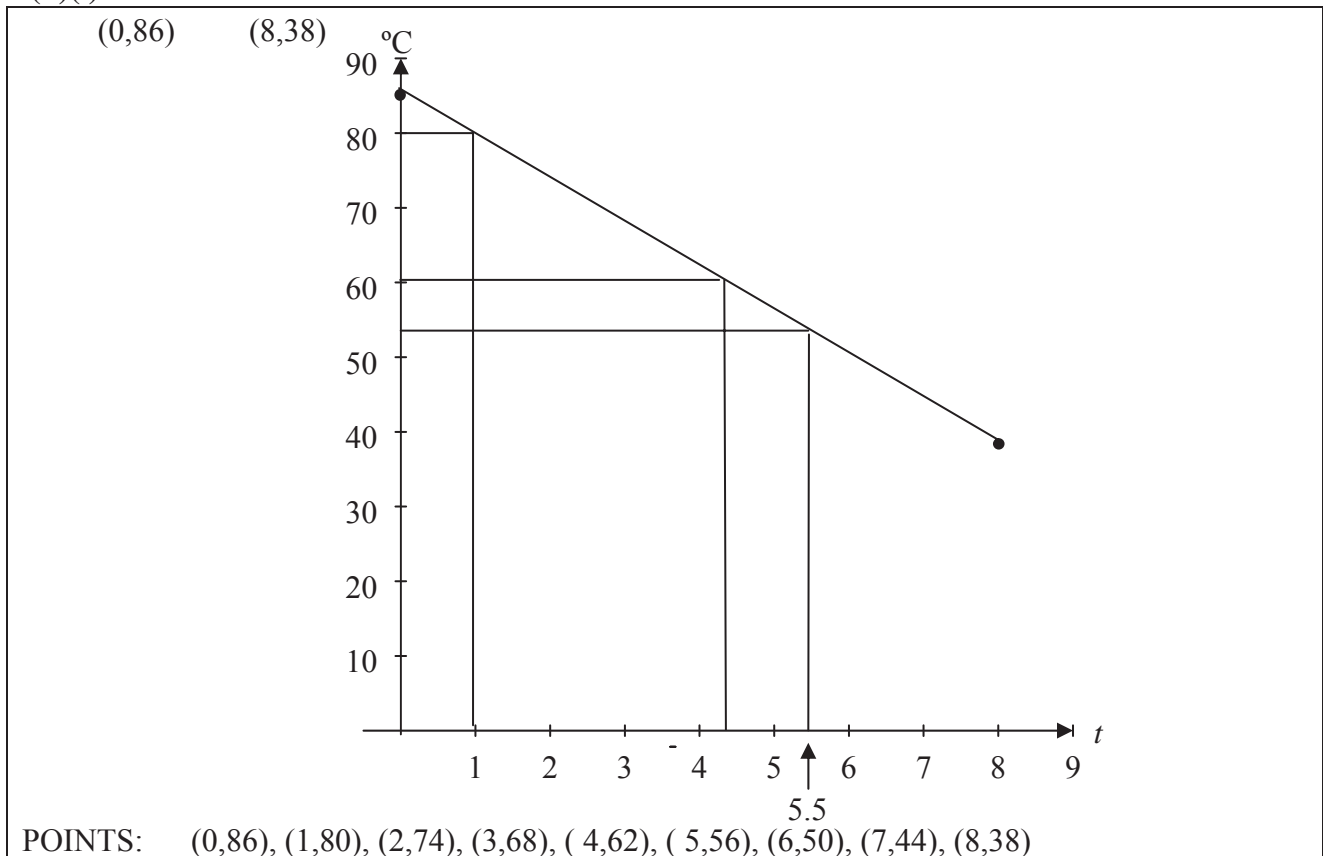
(ii) Use your graph to estimate the temperature when $t = 5.5$ hours.

(iii) Use your graph to estimate the time it takes for the temperature to fall from 80 degrees to 60 degrees.

(b)(i)

10 marks

Att3



* 2 points only needed to draw graph but graph must pass through (0, 86) and (8, 38).

* Do not penalise if graph extends beyond given domain.

* Range need only be $[f(0), f(8)]$[38, 86].

Blunders (-3)

B1 Points plotted but not joined.

B2 Scale error (once only).

Slips (-1)

S1 Each point calculated incorrectly to max -2.

Case:

Any 1 correct point plotted correctly and stops: 4 marks

No point from candidate's table plotted correctly, or no correct point plotted. Att 3

- S2 Each point plotted incorrectly to max -2.
 S3 Each end point $t = 0$, $t = 8$ omitted (i.e. full domain not used).

Misreadings (-1)

- M1 Axes reversed.

Attempts (3 marks)

- A1 Draws scaled axes and stops.
 A2 One or more points correctly calculated but not plotted – Table but no graph.

(b)(ii)

5 marks

Att 2

53°

- * Accept candidate's graph from (i).
- * Allow tolerance of $\pm 2^\circ$.
- * Units: S(-1) once if unit omitted/incorrect in either of parts (ii) or (iii). Deduct at first non-zero or non attempt mark section, where applicable.

Blunders (-3)

- B1 Value of C calculated (53°).

Attempts (2 marks)

- A1 $t = 5.5$ marked and stops.
 A2 Answer read from wrong axis.

(b)(iii)

5 marks

Att 2

$4.3 - 1 = 3.3$ hours

- * Use candidate's graph.
- * Allow tolerance of ± 0.2 hours.

Blunders (-3)

- B1 Calculates answer.
 B2 Subtraction not done.
 B3 Times indicated on graph.

Slips (-1)

- S1 Numerical error.

Attempts (2 marks)

- A1 80 and/or 60 indicated on graph and stops.

Part (c)**15 (5, 5, 5) marks****Att 6(2, 2, 2)**Let $f(x) = 3 + 8x - 2x^2$, $x \in \mathbf{R}$.

- (i) Find the co-ordinates of the point at which the curve $y = f(x)$ cuts the y -axis.
(ii) Find the value of x for which $f(x)$ is a maximum.
(iii) For what range of values of x is $f'(x) > 4$?

(c)(i)**5 marks****Att 2** $f(0) = 3$. or $(0, 3)$.

- * Accept solution from table or graph for parts (i) and (ii) if accurate and specific.
* Accept correct answer without work.

Blunders (-3)

B1 Mathematical errors in calculation.

Slips (-1)

S1 Numerical slips.

S2 x -ordinate missing i.e. answer = 3 without work.S3 $(3, 0)$ without work.*Attempts (2 marks)*A1 Some *correct* substitution of $x = 0$ and stops.A2 $f(x) = 0$ and continues.*Worthless (0 marks)*

W1 Uses derivative.

(c)(ii)**5 marks****Att 2** $f'(x) = 8 - 4x$ [2m] $\Rightarrow 8 - 4x = 0$ [2m] $\Rightarrow 4x = 8 \Rightarrow x = 2$. [5m]**Table:** Possible Domain $(0, 3)$ $(1, 9)$ $(2, 11)$, $(3, 9)$ $(4, 3)$

- * Correct answer without work Att 2m

Blunders (-3)

B1 Differentiation errors, once per term.

B2 Transposition errors.

*Slips (-1)*S1 If using table/graph, value of $f(x)$ given.*Attempts (2 marks)*A1 Any mention of $f'(x)$ or similar, or any term differentiated correctly.

(c)(iii)

5 marks

Att 2

$8 - 4x > 4$ [2m] $\Rightarrow -4x > -4$ [2m] $\Rightarrow x < 1$ [5m]
--

* Accept candidate's value of $f'(x)$ from (ii).

Blunders (-3)

B1 Transposition errors.

B2 Error in handling inequality.

B3 $f'(x) = 4$ and continues ie inequality ignored.

Slips (-1)

S1 $x \in \mathbf{N}$ i.e. $x = 0$ (ignore if $x < 1$ written).

Attempts (2 marks)

A1 Value of $f'(x)$ stated or found again in this part.

Worthless (0 marks)

W1 $f(x) > 4$ whether solved or not.

QUESTION 7

Part (a)	10 marks	Att 3
Part (b)	20 marks	Att 6
Part (c)	20 marks	Att 7

Part (a) **10 marks** **Att 3**

(a) Differentiate $5x^3 - 4x + 7$ with respect to x .

(a) **10 marks** **Att3**

$$\left[\frac{dy}{dx} \right] = 15x^2 - 4$$

*Correct answer without work or notation: full marks, 10m.

*If done from first principles, ignore errors in procedure – just mark the answer.

*Only one term correctly differentiated, award 4 marks.

Blunders (-3)

B1 Differentiation error, once per term.

Attempts (3 marks)

A1 Unsuccessful effort at first principles, e.g. $y + \Delta y$ on L.H.S., or x replaced by $x + \Delta x$ on R.H.S., ‘limit’ mentioned, $\Delta x \rightarrow 0$, $f(x+h)$, etc.

A2 Writes down the notation ‘ dy/dx ’ or ‘ $f'(x)$ ’ and stops.

Worthless (0)

W1 No term differentiated correctly, but check attempts first.

Part (b) **20 (10, 10) marks** **Att 6**

(b) (i) Differentiate $\frac{x^2 - 1}{x + 1}$ with respect to x and write your answer in its simplest form.

(ii) Given that $y = (5 - x^2)^3$, find $\frac{dy}{dx}$ when $x = 2$.

(b)(i) **10 marks** **Att 3**

<p>(I)</p> $\frac{(x+1)2x - (x^2 - 1)1}{(x+1)^2} \quad 7 \text{ m}$ $= \frac{2x^2 + 2x - x^2 + 1}{(x+1)^2}$ $= \frac{x^2 + 2x + 1}{(x+1)^2} \quad 9 \text{ m}$ $= 1 \quad 10 \text{ m}$	<p>(II)</p> $\frac{(x+1)(x-1)}{x+1}$ $= x-1 \quad 3 \text{ m}$ $\Rightarrow \frac{dy}{dx} = 1 \quad 10 \text{ m}$
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- * Apply penalties as in guidelines.
- * No penalty for omission of brackets if multiplication implied. (Decide by later work).
- * If $u.v$ used (even if u/v identified initially) i.e. $(x^2 - 1)(x + 1) \dots$ and continues: Att3.
- * No marks for writing down u/v or $u.v$ formula from Tables, and stopping.
- * Penalties for simplification part to max -3.

Blunders (-3)

B1 Differentiation errors, once per term.

Attempts (3 marks)

A1 u and/or v correctly identified and stops.

A2 Any correct differentiation.

A3 $x^2 - 1$ factorised correctly and stops.

(b)(ii)

10 marks

Att 3

<p>(I)</p> $\frac{dy}{dx} = 3(5 - x^2)^2(-2x) \quad 7 \text{ marks}$ $= 3(5 - 4)^2(-4)$ $= -12 \quad 10 \text{ marks}$	<p>(II)</p> $y = 125 - 75x^2 + 15x^4 - x^6$ $\frac{dy}{dx} = -150x + 60x^3 - 6x^5$ $= -150(2) + 60(2)^3 - 6(2)^5$ $= -12$	<p>(III)</p> $u = 5 - x^2$ $\frac{dy}{dx} = 3u^2(-2x) \quad 7 \text{ marks}$ $= 3(5 - 4)^2(-4)$ $= -12 \quad 10 \text{ marks}$
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- * Treat $3(5-x^2)^2$ and $(-2x)$ as separate parts.
- * No penalty for omission of brackets if multiplication implied.
- * If differentiation correct accept -12 without work.

Blunders (-3)

B1 Differentiation errors, once per term.

B2 (II) Errors in expanding brackets to max $2 \times B$.

<u>Case:</u>	
$\frac{dy}{dx} = 3(5-(2)^2)^2(-2(2))$	7m
$= -12$	10m

Attempts (3 marks)

A1 If cube ignored...-2x even if finished correctlyoversimplification.

A2 $u = 5 - x^2$ and stops.

A3 Some correct element of chain rule eg index = 2 or coefficient = 3.

A4 At least 1 correct term multiplied out.(II).

A5 Any correct differentiation.

Worthless (0marks)

W1 Substitutes $x = 2$ into $f(x)$ and stops.

W2 uv or u/v written and stops.

Part (c)

20 (10, 5, 5) marks

Att (3, 2, 2)

A missile is fired straight up in the air. The height, h metres, of the missile above the firing position is given by

$$h = t(200 - 5t)$$

where t is the time in seconds from the instant the missile was fired.

- (i) Find the speed of the missile after 10 seconds.
- (ii) Find the acceleration of the missile.
- (iii) One second before reaching its greatest possible height, the missile strikes a target. Find the height of the target.

(c)(i)

10 marks

Att 3

$$h = 200t - 5t^2 \text{ [3m]} \Rightarrow \frac{dh}{dt} = 200 - 10t \text{ [7m]} = 200 - 10(10) = 100 \text{m/s [10m]}$$

- * Correct answer without work Att 3.
- * No retrospective marking.
- * No penalty for incorrect notation.
- * If the parts of (c) are unlabelled, and the context doesn't identify which part is which, assume the questions were answered in sequence from (c)(i) to (c)(iii).
- * Units: S(-1) once if unit omitted/incorrect in any of parts (i) (ii) or (iii). Deduct at first non-zero or non attempt mark section, where applicable.

Blunders (-3)

- B1 Differentiation errors, once per term.
- B2 Incorrect or no value for t substituted into dh/dt equation.

Slips (-1)

- S1 Numerical slips.

Attempts (3 marks)

- A1 dh/dt or dy/dx or $f'(x)$ mentioned.
- A2 $\frac{d^2h}{dt^2} = -10$ (candidate may rectify error in this part).

Worthless (0 marks)

- W1 $t = 10$ substituted into h equation.
- W2 Incorrect answer without work.
- W3 States speed = d^2h/dt^2 and stops.
- W4 Effort to use Speed = Distance \div Time.

(c)(ii)

5 marks

Att 2

$$\frac{d^2h}{dt^2} = -10 \text{ m/s}^2$$

- * Accept correct answer without work.
- * Accept $v = u + at$ or equivalent with correct values for u , v and corresponding t calculated and used.
- * Accept use of dh/dt from (i) provided expression contains 't'. Otherwise Att at most.

Blunders (-3)

B1 Differentiation errors, once per term.

Attempts (2 marks)

A1 $\frac{d^2h}{dt^2}$ or $\frac{dv}{dt}$ or similar written.

A2 Finds or attempts to find dh/dt in this part.

Worthless (0 marks)

W1 Incorrect answer without work.

(c)(iii)

5 marks

Att 2

$$\frac{dh}{dt} = 200 - 10t \quad [2m] \quad 200 - 10t = 0 \quad [2m] \quad \Rightarrow 10t = 200 \Rightarrow t = 20 \quad [2m]$$

$$\text{At } t = 19, h = 200(19) - 5(19)^2 = 3800 - 1805 = 1995m \quad [5m]$$

- * Accept use of dh/dt from (i) provided expression contains 't'. Otherwise Att at most.
- * Ignores 'maximum height' element: Att2 at best
- * Correct answer without work: Att2

Blunders (-3)

B1 Differentiation errors, once per term.

B2 Mathematical errors.

B3 Incorrect equation substituted.

Slips (-1)

S1 Numerical slips.

S2 Ignores '1 second before' and continues.

Attempts (2 marks)

A1 Mentions dh/dt or similar or attempts to differentiate (even partially correctly).

A2 Makes some use of $h = t(200 - 5t)$.

Worthless (0 marks)

W1 Incorrect answer without work.

