Diploma Programme
Programme du diplôme
Programa del Diploma

Markscheme

November 2023

Mathematics: applications and interpretation

Higher level

Paper 2

16 pages

Instructions to Examiners

Abbreviations

M Marks awarded for attempting to use a correct **Method**.

A Marks awarded for an **Answer** or for **Accuracy**; often dependent on preceding ***M*** marks.

R Marks awarded for clear **Reasoning**.

AG Answer given in the question and so no marks are awarded.

FT Follow through. The practice of awarding marks, despite candidate errors in previous parts, for their correct methods/answers using incorrect results.

Using the markscheme

1 General

Award marks using the annotations as noted in the markscheme eg ***M1***, ***A2***.

2 Method and Answer/Accuracy marks

- Do **not** automatically award full marks for a correct answer; all working **must** be checked, and marks awarded according to the markscheme.
- It is generally not possible to award ***M0*** followed by ***A1***, as ***A*** mark(s) depend on the preceding ***M*** mark(s), if any.
- Where ***M*** and ***A*** marks are noted on the same line, *e.g.* ***M1A1***, this usually means ***M1*** for an **attempt** to use an appropriate method (*e.g.* substitution into a formula) and ***A1*** for using the **correct** values.
- Where there are two or more ***A*** marks on the same line, they may be awarded independently; so if the first value is incorrect, but the next two are correct, award ***A0A1A1***.
- Where the markscheme specifies ***A3***, ***M2*** *etc.*, do **not** split the marks, unless there is a note.
- The response to a "show that" question does not need to restate the ***AG*** line, unless a **Note** makes this explicit in the markscheme.
- Once a correct answer to a question or part question is seen, ignore further working even if this working is incorrect and/or suggests a misunderstanding of the question. This will encourage a uniform approach to marking, with less examiner discretion. Although some candidates may be advantaged for that specific question item, it is likely that these candidates will lose marks elsewhere too.
- An exception to the previous rule is when an incorrect answer from further working is used **in a subsequent part**. For example, when a correct exact value is followed by an incorrect decimal approximation in the first part and this approximation is then used in the second part. In this situation, award ***FT*** marks as appropriate but do not award the final ***A1*** in the first part. Examples:

	Correct answer seen	Further working seen	Any FT issues?	Action
1.	$8\sqrt{2}$	5.65685... *(incorrect decimal value)*	No. Last part in question.	Award ***A1*** for the final mark *(condone the incorrect further working)*
2.	$\frac{35}{72}$	0.468111… (incorrect decimal value)	Yes. Value is used in subsequent parts.	Award ***A0*** for the final mark *(and full **FT** is available in subsequent parts)*

3 Implied marks

Implied marks appear in **brackets e.g. *(M1)***,and can only be awarded if **correct** work is seen or implied by subsequent working/answer.

4 Follow through marks (only applied after an error is made)

Follow through (***FT***) marks are awarded where an incorrect answer from one **part** of a question is used correctly in **subsequent** part(s) (e.g. incorrect value from part (a) used in part (d) or incorrect value from part (c)(i) used in part (c)(ii)). Usually, to award ***FT*** marks, **there must be working present** and not just a final answer based on an incorrect answer to a previous part. However, if all the marks awarded in a subsequent part are for the answer or are implied, then ***FT*** marks should be awarded for *their* correct answer, even when working is not present.

For example: following an incorrect answer to part (a) that is used in subsequent parts, where the markscheme for the subsequent part is ***(M1)A1***, it is possible to award full marks for *their* correct answer, **without working being seen.** For longer questions where all but the answer marks are implied this rule applies but may be overwritten by a **Note** in the Markscheme.

- Within a question part, once an **error** is made, no further ***A*** marks can be awarded for work which uses the error, but ***M*** marks may be awarded if appropriate.
- If the question becomes much simpler because of an error then use discretion to award fewer ***FT*** marks, by reflecting on what each mark is for and how that maps to the simplified version.
- If the error leads to an inappropriate value (*e.g.* probability greater than 1, $\sin\theta = 1.5$, non-integer value where integer required), do not award the mark(s) for the final answer(s).
- The markscheme may use the word “their” in a description, to indicate that candidates may be using an incorrect value.
- If the candidate’s answer to the initial question clearly contradicts information given in the question, it is not appropriate to award any ***FT*** marks in the subsequent parts. This includes when candidates fail to complete a “show that” question correctly, and then in subsequent parts use their incorrect answer rather than the given value.
- Exceptions to these ***FT*** rules will be explicitly noted on the markscheme.
- If a candidate makes an error in one part but gets the correct answer(s) to subsequent part(s), award marks as appropriate, unless the command term was “Hence”.

5 Mis-read

If a candidate incorrectly copies values or information from the question, this is a mis-read (***MR***). A candidate should be penalized only once for a particular misread. Use the ***MR*** stamp to indicate that this has been a misread and do not award the first mark, even if this is an ***M*** mark, but award all others as appropriate.

- If the question becomes much simpler because of the ***MR***, then use discretion to award fewer marks.
- If the ***MR*** leads to an inappropriate value (*e.g.* probability greater than 1, $\sin\theta = 1.5$, non-integer value where integer required), do not award the mark(s) for the final answer(s).
- Miscopying of candidates' own work does **not** constitute a misread, it is an error.
- If a candidate uses a correct answer, to a "show that" question, to a higher degree of accuracy than given in the question, this is NOT a misread and full marks may be scored in the subsequent part.
- ***MR*** can only be applied when work is seen. For calculator questions with no working and incorrect answers, examiners should **not** infer that values were read incorrectly.

6 Alternative methods

Candidates will sometimes use methods other than those in the markscheme. Unless the question specifies a method, other correct methods should be marked in line with the markscheme. If the command term is 'Hence' and not 'Hence or otherwise' then alternative methods are not permitted unless covered by a note in the mark scheme.

- Alternative methods for complete questions are indicated by **METHOD 1**, **METHOD 2**, *etc*.
- Alternative solutions for parts of questions are indicated by **EITHER** . . . **OR**.

7 Alternative forms

Unless the question specifies otherwise, **accept** equivalent forms.

- As this is an international examination, accept all alternative forms of **notation** for example 1.9 and $1{,}9$ or 1000 and $1{,}000$ and 1.000.
- Do not accept final answers written using calculator notation. However, ***M*** marks and intermediate ***A*** marks can be scored, when presented using calculator notation, provided the evidence clearly reflects the demand of the mark.
- In the markscheme, equivalent **numerical** and **algebraic** forms will generally be written in brackets immediately following the answer.
- In the markscheme, some **equivalent** answers will generally appear in brackets. Not all equivalent notations/answers/methods will be presented in the markscheme and examiners are asked to apply appropriate discretion to judge if the candidate work is equivalent.

8 Format and accuracy of answers

If the level of accuracy is specified in the question, a mark will be linked to giving the answer to the required accuracy. If the level of accuracy is not stated in the question, the general rule applies to final answers: *unless otherwise stated in the question all numerical answers must be given exactly or correct to three significant figures*

Where values are used in subsequent parts, the markscheme will generally use the exact value, however candidates may also use the correct answer to a "correct" level of accuracy (e.g 3 sf) in subsequent parts. The markscheme will often explicitly include the subsequent values that come "*from the use of 3 sf values*".

Simplification of final answers: Candidates are advised to give final answers using good mathematical form. In general, for an ***A*** mark to be awarded, arithmetic should be completed, and any values that lead to integers should be simplified; for example, $\sqrt{\frac{25}{4}}$ should be written as $\frac{5}{2}$. An exception to this is simplifying fractions, where lowest form is not required (although the numerator and the denominator must be integers); for example, $\frac{10}{4}$ may be left in this form or written as $\frac{5}{2}$. However, $\frac{10}{5}$ should be written as 2, as it simplifies to an integer.

Algebraic expressions should be simplified by completing any operations such as addition and multiplication, e.g. $4e^{2x} \times e^{3x}$ should be simplified to $4e^{5x}$, and $4e^{2x} \times e^{3x} - e^{4x} \times e^{x}$ should be simplified to $3e^{5x}$. Unless specified in the question, expressions do not need to be factorized, nor do factorized expressions need to be expanded, so $x(x+1)$ and $x^2 + x$ are both acceptable.

Please note: intermediate ***A*** marks do NOT need to be simplified.

9 Calculators

A GDC is required for this paper, but If you see work that suggests a candidate has used any calculator not approved for IB DP examinations (eg CAS enabled devices), please follow the procedures for malpractice.

10. Presentation of candidate work

Crossed out work: If a candidate has drawn a line through work on their examination script, or in some other way crossed out their work, do not award any marks for that work unless an explicit note from the candidate indicates that they would like the work to be marked.

More than one solution: Where a candidate offers two or more different answers to the same question, an examiner should only mark the first response unless the candidate indicates otherwise. If the layout of the responses makes it difficult to judge, examiners should apply appropriate discretion to judge which is "first".

1. (a) 25 (m) ***A1***

[1 mark]

(b) (i) recognition of need to use Pythagoras theorem ***(M1)***

$BF^2 = 20^2 + 25^2$

$(BF =)\ 32.0\ \ (32.0156\ldots,\ \sqrt{1025},\ 5\sqrt{41})$ (m) ***A1***

(ii) correct use of trig ratio for $B\hat{F}M$ ***(M1)***

$(B\hat{F}M =)\ \tan^{-1}\left(\frac{25}{20}\right)$ or equivalent

$(B\hat{F}M =)\ 51.3\ (51.3401...)$ ***A1***

Note: Accept radian answer of $0.896\ \ (0.896055\ldots)$ Accept an answer of 51.4 from use of 3sf answer to part (b)(i) and then either cosine rule or inverse sine.

[4 marks]

(c) attempt to use arc length formula ***(M1)***

(arc length =) $\frac{2\times 51.3401...}{360}\times 2\pi(32.0156\ldots)$ ***(A1)***

(arc length =) $57.4\ \ (57.3755\ldots)$ (m) ***A1***

Note: Accept 57.3 from use of 3 sf. values of their answers from parts (b)(i) and (b)(ii).

[3 marks]

(d) $34.0156\ldots$ (seen anywhere) ***(A1)***

use of area of sector formula ***(M1)***

recognition of subtracting areas of two sectors ***(M1)***

(area =) $\frac{102.680\ldots}{360}\times\pi\left((34.0156\ldots)^2-(32.0156\ldots)^2\right)$

(area =) $118\ (m^2)\ \ (118.335\ldots)$ ***A1***

[4 marks]

(e) multiplying their area from part (d) by 0.12 or 12 ***(M1)***

0.12 (m) seen **OR** $1183350\ (cm^2)$ seen ***(A1)***

$118.335\ldots\times 0.12$ **OR** 1183350×12

$14.2\ \ (14.2002\ldots)\ m^3$ **OR** $14200000\ (14200236)\ cm^3$ ***A1***

[3 marks]

[Total 15 marks]

2. (a) (i) 150 (cm) ***A1***

(ii) attempt to substitute values in the mean formula with at least one mid-interval value multiplied by a corresponding frequency ***(M1)***

(mean $=$) 176 (176.3) (cm) ***A1***

[3 marks]

(b) 183 **OR** 168 seen ***(A1)***

Note: These values may be seen in the working for part (c).

$(\text{IQR} = 183 - 168 =)$ 15 (cm) ***A1***

[2 marks]

(c) (upper bound =) $183 + 1.5 \times 15$ **OR** 205.5 seen ***A1***

$205.5 > 204$ **OR** $204 - 183 < 22.5$ **OR** $204 - 22.5 < 183$) ***R1***

Laszlo's height is not an outlier ***A1***

Note: Do not award ***R0A1***.

[3 marks]

(d) H_0: The heights of the students can be modelled by $N(176, 13.5^2)$

H_1: The heights of the students cannot be modelled by $N(176, 13.5^2)$ ***A1A1***

Note: Award ***A1*** for each correct hypothesis that includes a reference to normal distribution with a mean of 176 and a standard deviation of 13.5 (or variance of 13.5^2). "Correlation", "independence", "association", and "relationship" are incorrect.

Award at most ***A0A1*** for correctly worded hypotheses that include a reference to a normal distribution but omit the distribution's parameters in one or both hypotheses. Award ***A0A1*** for correct hypotheses that are reversed.

[2 marks]

(e) (i) $h \sim \mathrm{N}(176, 13.5^2)$

attempt to find normal probability in either correct range ***(M1)***
$\mathrm{P}(170 \leq h < 180)$ **OR** $\mathrm{P}(h \geq 190)$

recognition of multiplying either of their probabilities by 200 ***(M1)***
$0.288137... \times 200$ **OR** $0.149859... \times 200$

$a = 57.6$ $(57.6274...)$, $b = 30.0$ $(29.9718...)$ ***A1A1***

(ii) $\mathrm{df} = 4$ ***(A1)***

$(p =)$ 0.0166 $(= 0.0166282\ldots)$ ***A1***

comparing their p-value to 0.05 ***R1***
$0.0166 < 0.05$

Note: Accept p value of 0.0165 $(= 0.0164693...)$ from using a and b to 3 sf.

(Reject H_0 There is sufficient evidence to say that) the data has not been drawn from the $(\mathrm{N}(176, 13.5^2))$ distribution. ***A1***

Note: Do not award ***R0A1***.

The conclusion to part (e)(ii) **MUST** follow through from their hypotheses seen in part (d); if hypotheses are incorrect/reversed etc., the answer to part (e)(ii) must reflect this in order for the ***A1*** to be credited.

[8 marks]
[Total 18 marks]

3. (a) (i) attempt to find 15% or 85% of 285000 ***(M1)***
285000×0.85
$242\,250$ (USD) ***A1***

Note: Do not award ***A1*** if answer is not given exact.

(ii) $N = 360$
$I\% = 4$
$PV = (\pm)\,242\,250$
$FV = 0$
$P/Y = 12$
$C/Y = 12$ ***(M1)(A1)***

Note: Award ***M1*** for an attempt to use a financial app in their technology with at least two entries seen, award ***A1*** for all entries correct.

$(PMT =)$ 1156.54 (USD) ***A1***

Note: Do not award final ***A1*** if answer is not given to 2 dp.

[5 marks]

(b) 1156.54×360 ***(M1)***
416354 (USD) ***A1***

Note: Do not award ***A1*** if answer is not given to the nearest dollar, unless already penalized in part (a)(ii).

[2 marks]

(c) $I\% = 4$
$PV = (\pm)\,242\,250$
$PMT = (\mp)1300$
$FV = 0$
$P/Y = 12$
$C/Y = 12$ ***(A1)***

Note: Award ***A1*** for $PMT = (\mp)1300$ seen.

$(N =)\ 292$ ***A1***

[2 marks]

(d) **METHOD 1**
$N = 291$
$I\% = 4$
$PV = (\pm)\,242\,250$
$PMT = (\mp)1300$
$P/Y = 12$
$F/Y = 12$ ***(A1)***

Note: Award ***A1*** for $N = 291$ seen.

$(FV =)\ 871.91\ (871.908\ldots)$ ***A1***

valid attempt to find interest in final month (e.g. $N = 1$ **OR** $PV = 871.91$) ***(M1)***

$N = 1$
$I\% = 4$
$PV = 871.91\ (871.908\ldots)$
$FV = 0$
$P/Y = 12$
$F/Y = 12$

$(PMT =)\ 874.82$ (USD) ***A1***

Note: Do not award ***A1*** if answer is not given correct to 2dp, unless already penalized previously.

METHOD 2

$N = 292$
$I\% = 4$
$PV = (\pm)\,242\,250$
$PMT = (\mp)1300$
$P/Y = 12$
$F/Y = 12$ ***(A1)***

Note: Award ***A1*** for $N = 292$ seen.

$(FV =)\ 425.185\ldots$ ***A1***

$1300 - 425.185...$ ***(A1)***
$(PMT =)\ 874.82$ (USD) ***A1***

Note: Accept 874.81. Do not award ***A1*** if answer is not given correct to 2dp, unless already penalized previously.

[4 marks]

(e) $291 \times 1300 + 874.82$ ***(M1)***

379174.82

attempt to find difference between their value and their part (b) ***(M1)***
$(416354 - 379174.82)$

37179 (USD) ***A1***

Note: Accept 37180 (USD) from using the 2 dp. answer from part (b). Do not penalize for not rounding to nearest dollar if this has already been penalized in part (b).

[3 marks]
[Total 16 marks]

4. (a) (i) $h(0) = 0.00623\ (\text{km})\ (= 0.00622517)$ ***A1***

(ii) this is the height of the nose of the plane (above the runway), when the plane is on the runway ***A1***
[2 marks]

(b) (i) $y = 9.94$ ***A1***

Note: Accept $h = 9.94$.

(ii) **EITHER**
this is the height that the (nose of the) plane approaches (but does not reach) ***A1***
OR
this is the maximum possible height of the (nose of the) plane ***A1***
OR
the (nose of the) plane does not exceed this height ***A1***
[2 marks]

(c) **METHOD 1 (chain rule)**

$h(x) = 10\left(1+150\mathrm{e}^{-0.07x}\right)^{-1} - 0.06$ ***(M1)***

find $h'(x) = -10\left(1+150\mathrm{e}^{-0.07x}\right)^{-2} \times 150\mathrm{e}^{-0.07x} \times -0.07$ ***A1M1A1***

$\left(= \dfrac{105\mathrm{e}^{-0.07x}}{(1+150\mathrm{e}^{-0.07x})^2}\right)$

Note: Award ***A1*** for correct first term $\left(-10\left(1+150\mathrm{e}^{-0.07x}\right)^{-2}\right)$, ***M1*** for attempt to use the chain rule, ***A1*** for correct use of chain rule $\left(\times 150\mathrm{e}^{-0.07x} \times -0.07\right)$. Award at most ***A1M1A0*** if additional terms are seen. The answer is not required to be simplified beyond what is shown in the markscheme.

METHOD 2 (quotient rule)

$$\frac{\left(1+150\,\mathrm{e}^{-0.007x}\right)(0) - 10\left(150\mathrm{e}^{-0.007x} \times -0.007\right)}{\left(1+150\,\mathrm{e}^{-0.007x}\right)^2}$$ ***M1A1***

Note: Award ***M1*** for attempt to use quotient rule, ***A1*** for correct use.

$$= \frac{-10\left(150\mathrm{e}^{-0.007x} \times -0.007\right)}{\left(1+150\,\mathrm{e}^{-0.007x}\right)^2} \quad \left(= \frac{105\mathrm{e}^{-0.07x}}{(1+150\mathrm{e}^{-0.07x})^2}\right)$$ ***A1A1***

Note: Award ***A1*** for correct numerator and ***A1*** for correct denominator.

[4 marks]

(d) evidence of a graph of $h'(x)$ ***(M1)***

maximum at $x = 71.6 \quad (= 71.58051...)$ ***(A1)***

$h'(71.58051...) = 0.175$ ***A1***

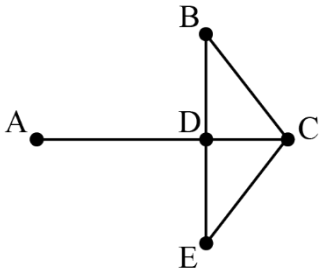
maximum gradient is less than 0.2

and hence the regulation is being followed ***A1***

[4 marks]

[Total 12 marks]

5. (a)



A1

[1 mark]

(b) (i) $\boldsymbol{P} = \begin{pmatrix} 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 & 1 \\ 0 & 0 & 1 & 1 & 0 \end{pmatrix}$ ***(M1)***

$\boldsymbol{P}^3 = \begin{pmatrix} 0 & 1 & 2 & 4 & 1 \\ 1 & 2 & 5 & 6 & 2 \\ 2 & 5 & 4 & 6 & 5 \\ 4 & 6 & 6 & 4 & 6 \\ 1 & 2 & 5 & 6 & 2 \end{pmatrix}$

$a = 6$ ***A1***

(ii) 5 (routes) ***A1***

[3 marks]

(c) A and C identified as start/finish points (in either order) ***(A1)***
for example : A – D – E – C – D – B – C ***A1***

[2 marks]

(d) cost of their Eulerian trail A to C (=180) ***(A1)***
consider edges to get from C to A ***(M1)***

235 (USD) ***A1***

[3 marks]

(e) (i) A to C (or C to A) ***A1***

(ii) best is CBDA
55 (USD) ***A1***
[2 marks]

(f) (i) A – D – C – B – E – A **OR** 50, 45, 30, 120, 60 ***(A1)***
summing their 5 edges ***(M1)***
$50 + 45 + 30 + 120 + 60$
(upper bound =) 305 (km) ***A1***

(ii) attempt to find MST without vertex A ***(M1)***
(MST =) 130 ***(A1)***
$130 + 50 + 60$ ***(M1)***
(lower bound =) 240 (km) ***A1***
[7 marks]
[Total 18 marks]

6. (a) $x = -1 + 2\lambda,\ y = 1 - \lambda$ ***A1***
[1 mark]

(b) $\begin{pmatrix} 1 & 7 \\ 7 & -1 \end{pmatrix}\begin{pmatrix} -1+2\lambda \\ 1-\lambda \end{pmatrix} = \begin{pmatrix} 6-5\lambda \\ -8+15\lambda \end{pmatrix}$ ***(M1)(A1)***

$\boldsymbol{r} = \begin{pmatrix} 6 \\ -8 \end{pmatrix} + \lambda\begin{pmatrix} -5 \\ 15 \end{pmatrix}$ (or equivalent) ***(M1)A1***

Note: Award ***(M1)*** for the correct format of a vector equation of a line, ***A1*** for the line being completely correct.

[4 marks]

(c) (i) $\begin{pmatrix} \cos\left(\frac{\pi}{4}\right) & -\sin\left(\frac{\pi}{4}\right) \\ \sin\left(\frac{\pi}{4}\right) & \cos\left(\frac{\pi}{4}\right) \end{pmatrix}$ **OR** $\begin{pmatrix} 0.707 & -0.707 \\ 0.707 & 0.707 \end{pmatrix}$ **OR** $\begin{pmatrix} \frac{1}{\sqrt{2}} & -\frac{1}{\sqrt{2}} \\ \frac{1}{\sqrt{2}} & \frac{1}{\sqrt{2}} \end{pmatrix}$ ***A1***

(ii) $\begin{pmatrix} 5\sqrt{2} & 0 \\ 0 & 5\sqrt{2} \end{pmatrix}$ ***A1***
[2 marks]

(d) $(\boldsymbol{R} =) \begin{pmatrix} \cos 2\alpha & \sin 2\alpha \\ \sin 2\alpha & -\cos 2\alpha \end{pmatrix}$ ***A1***
[1 mark]

(e) (i) attempt to multiply matrices from part (c) (in any order) ***(M1)***

e.g. $\boldsymbol{X} = \begin{pmatrix} 5\sqrt{2} & 0 \\ 0 & 5\sqrt{2} \end{pmatrix} \begin{pmatrix} \cos\left(\frac{\pi}{4}\right) & -\sin\left(\frac{\pi}{4}\right) \\ \sin\left(\frac{\pi}{4}\right) & \cos\left(\frac{\pi}{4}\right) \end{pmatrix}$

$\boldsymbol{X} = \begin{pmatrix} 5 & -5 \\ 5 & 5 \end{pmatrix}$ ***A1***

(ii) substituting $\boldsymbol{T}$, $\boldsymbol{R}$ and $\boldsymbol{X}$ ***(M1)***

$\begin{pmatrix} 1 & 7 \\ 7 & -1 \end{pmatrix} = \begin{pmatrix} \cos 2\alpha & \sin 2\alpha \\ \sin 2\alpha & -\cos 2\alpha \end{pmatrix} \begin{pmatrix} 5 & -5 \\ 5 & 5 \end{pmatrix}$

multiplying by inverse (in any order) ***(M1)***

$\begin{pmatrix} 1 & 7 \\ 7 & -1 \end{pmatrix} \begin{pmatrix} 5 & -5 \\ 5 & 5 \end{pmatrix}^{-1} = \begin{pmatrix} \cos 2\alpha & \sin 2\alpha \\ \sin 2\alpha & -\cos 2\alpha \end{pmatrix}$

$\begin{pmatrix} \cos 2\alpha & \sin 2\alpha \\ \sin 2\alpha & -\cos 2\alpha \end{pmatrix} = \begin{pmatrix} -\frac{3}{5} & \frac{4}{5} \\ \frac{4}{5} & \frac{3}{5} \end{pmatrix}$ ***A1***

$\cos 2\alpha = -\frac{3}{5}$ **AND** $\sin 2\alpha = \frac{4}{5}$

$\alpha = 1.11 \ \ (= 1.107148...)$ **OR** $63.4^\circ \ \ (63.4349\ldots^\circ)$ ***A1***

[6 marks]

[Total 14 marks]

7. (a) (let X be the random variable the weight of an individual in the city of Melba)

$X \sim \mathrm{N}(72, 10^2)$

recognizing need to find $\mathrm{P}(X > 85)$ (condone "86" for the ***M1***) ***(M1)***

e.g. correct sketch of normal curve **OR** $0.0968 \ \ (= 0.0968005...)$ seen

let Y be the random variable the number of people more than 85 kg

attempt to use a binomial distribution ***(M1)***

$Y \sim \mathrm{B}(10, 0.0968005...)$ ***(A1)***

Note: This ***(A1)*** can be implied by the value $0.988580\ldots$

$\left(\mathrm{P}(Y \geq 4) =\right) \ 0.0114 \ \ (= 0.0114196...)$ ***A1***

[4 marks]

(b) let W be the random variable the total weight of a sample of eight people

$W \sim \mathrm{N}(576, 8\times10^2)$ ***A1A1A1***

Note: Award ***A1*** for normal distribution; ***A1*** correct mean; ***A1*** correct variance or SD (SD = 28.2842…).

[3 marks]

(c) attempt to use inverse normal (or equivalent) ***(M1)***

$\mathrm{P}(W > w) = 0.01$

$(w =)\ 642\ (\mathrm{kg})\ \ (641.799\ldots)$ ***A1***

[2 marks]

(d) (i) *Any two correct assumptions identified,* ***A1A1***

e.g.

That Laetitia's clients are a random sample of the city's population

That people take only one holiday a year

That the choice of individual holidays is independent

That Laetitia is her clients' only agent

Note: Accept "assumes the proportion that takes a holiday abroad is 42%".

(ii) $\mathrm{H}_0 : p = 0.42$ ***A1***

$\mathrm{H}_1 : p < 0.42$ ***A1***

(iii) let Q be the random variable the number who go holiday abroad

$Q \sim \mathrm{B}(200,\ 0.42)$ ***(A1)***

$\left(\mathrm{P}(Q \le 67) =\right)\ 0.00850\ \ (= 0.00849906...)$ ***A1***

$0.00850 < 0.05$ ***R1***

EITHER

there is evidence that Laetitia's claim is reasonable ***A1***

OR

there is insufficient evidence to accept the newspaper's claim ***A1***

Note: Follow through within this part, for correctly comparing and concluding with their **probability**, e.g. it is possible to award ***A0A0R1A1***.
The conclusion to part (e)(iii) MUST follow through from their hypotheses seen in part (e)(ii); if hypotheses are incorrect/reversed etc., the answer to part (e)(iii) must reflect this in order for the ***A1*** to be credited.

[8 marks]

[Total 17 marks]