Pearson

Mark Scheme (Results)

Summer 2017

Pearson Edexcel International GCSE
In Further Pure Mathematics (4PM0) Paper 02

edexcel

Edexcel and BTEC Qualifications

Edexcel and BTEC qualifications are awarded by Pearson, the UK's largest awarding body. We provide a wide range of qualifications including academic, vocational, occupational and specific programmes for employers. For further information visit our qualifications websites at www.edexcel.com or www.btec.co.uk. Alternatively, you can get in touch with us using the details on our contact us page at www.edexcel.com/contactus.

Pearson: helping people progress, everywhere

Pearson aspires to be the world's leading learning company. Our aim is to help everyone progress in their lives through education. We believe in every kind of learning, for all kinds of people, wherever they are in the world. We've been involved in education for over 150 years, and by working across 70 countries, in 100 languages, we have built an international reputation for our commitment to high standards and raising achievement through innovation in education. Find out more about how we can help you and your students at: www.pearson.com/uk

Summer 2017
Publications Code 4PM0_02_1706_MS

General Marking Guidance

- All candidates 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 penalised for omissions.
- Examiners should mark according to the mark scheme not according to their perception of where the grade boundaries may lie.
- There is no ceiling on achievement. 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.
- **Types of mark**
  - M marks: method marks
  - A marks: accuracy marks
  - B marks: unconditional accuracy marks (independent of M marks)
- **Abbreviations**
  - cao – correct answer only
  - ft – follow through
  - isw – ignore subsequent working
  - SC - special case
  - oe – or equivalent (and appropriate)
  - dep – dependent
  - indep – independent
  - eeoo – each error or omission
- **No working**

  If no working is shown then correct answers normally score full marks

  If no working is shown then incorrect (even though nearly correct) answers score no marks.
- **With working**

  If there is a wrong answer indicated always check the working in the body of the script and award any marks appropriate from the mark scheme.

  If it is clear from the working that the "correct" answer has been obtained from incorrect working, award 0 marks.

Any case of suspected misread loses two A (or B) marks on that part, but can gain the M marks. Mark all work on follow through but enter A0 (or B0) for the first two A or B marks gained.

If working is crossed out and still legible, then it should be given any appropriate marks, as long as it has not been replaced by alternative work.

If there are multiple attempts shown, then all attempts should be marked and the highest score on a single attempt should be awarded.

- **Follow through marks**

  Follow through marks which involve a single stage calculation can be awarded without working since you can check the answer yourself, but if ambiguous do not award.

  Follow through marks which involve more than one stage of calculation can only be awarded on sight of the relevant working, even if it appears obvious that there is only one way you could get the answer given.

- **Ignoring subsequent work**

  It is appropriate to ignore subsequent work when the additional work does not change the answer in a way that is inappropriate for the question: eg. incorrect cancelling of a fraction that would otherwise be correct.

  It is not appropriate to ignore subsequent work when the additional work essentially shows that the candidate did not understand the demand of the question.

- **Linear equations**

  Full marks can be gained if the solution alone is given, or otherwise unambiguously indicated in working (without contradiction elsewhere). Where the correct solution only is shown substituted, but not identified as the solution, the accuracy mark is lost but any method marks can be awarded.

- **Parts of questions**

  Unless allowed by the mark scheme, the marks allocated to one part of the question CANNOT be awarded in another

General Principles for Further Pure Mathematics Marking

(but note that specific mark schemes may sometimes override these general principles)

Method mark for solving a 3 term quadratic equation:

1. Factorisation:

$(x^2+bx+c)=(x+p)(x+q)$, where $|pq|=|c|$ leading to $x=....$

$(ax^2+bx+c)=(mx+p)(nx+q)$ where $|pq|=|c|$ and $|mn|=|a|$ leading to $x=....$

2. Formula:

Attempt to use the **correct** formula (shown explicitly or implied by working) with values for a, b and c, leading to $x=....$

3. Completing the square:

$x^2+bx+c=0$: $\left(x\pm\frac{b}{2}\right)^2\pm q\pm c=0,\quad q\neq 0$ leading to $x=....$

Method marks for differentiation and integration:

1. Differentiation

Power of at least one term decreased by 1. $(x^n\to x^{n-1})$

2. Integration:

Power of at least one term increased by 1. $(x^n\to x^{n+1})$

Use of a formula:

Generally, the method mark is gained by **either**

quoting a correct formula and attempting to use it, even if there are mistakes in the substitution of values

or, where the formula is not quoted, the method mark can be gained by implication from the substitution of correct values and then proceeding to a solution.

Answers without working:

The rubric states "Without sufficient working, correct answers may be awarded no marks".

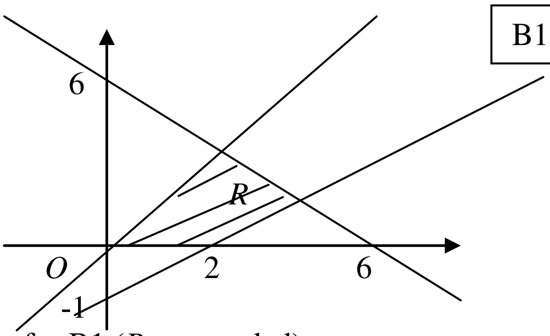
General policy is that if it could be done "in your head" detailed working would not be required.
(Mark schemes may override this eg in a case of "prove or show...."

Exact answers:

When a question demands an exact answer, all the working must also be exact. Once a candidate loses exactness by resorting to decimals the exactness cannot be regained.

Rounding answers (where accuracy is specified in the question)

Penalise only once per question for failing to round as instructed - ie giving more digits in the answers.
Answers with fewer digits are automatically incorrect, but the isw rule may allow the mark to be awarded before the final answer is given.

Question Number	Scheme	Marks
1(a)	 B1 each line correct	B1B1B1 (3)
(b)	Shade in or out for B1 (*R* not needed)	B1ft (1)
(c)	$(y+2x)_{\max} = 10\frac{2}{3}$	B1 (1)
		[5]

(a)
B1 B1 for each line which is correct ie crosses both axes at the correct points.
B1 *x*- axis intercepts are: origin, 6 and 2
B1 Enter B1B1B1, B1B1B0, B1B0B0
(b)
B1ft Correct area shaded. Follow through their 3 lines **provided** area shown is the internal area above the *x*-axis
(c)
B1 Correct answer only (or one correct answer clearly indicated). Allow $10.5 \le x \le 10.8$ (as it can be obtained by calculation or by reading values from the grid)

Question Number	Scheme	Marks
2	$x^2 - 6x + 5 = 11 - x$	M1
	$x^2 - 5x - 6 \ (=0)$ OR $y^2 - 17y + 60 \ (=0)$	A1
	$(x-6)(x+1) \ (=0)$ $(y-12)(y-5) \ (=0)$	dM1
	$x = 6, \ y = 5$	A1
	$x = -1, \ y = 12$	A1 [5]

M1 Obtain an equation in one variable. Must be quadratic but no simplification needed
A1 Correct simplified 3 term quadratic equation, terms in any order
dM1 Solve their quadratic by any valid means (see "General Principles")
A1 Either (*x*, *y*) pair correct **or** both *x* values **or** both *y* values correct
A1 Second pair correct. It must be clear how the values are paired. (Horizontally as shown or vertically is sufficient.)

Question Number	Scheme	Marks
3 (a)	$b^2 - 4ac = p^2 - 36 < 0$ oe	M1A1
	$-6 < p < 6$ or $\lvert p \rvert < 6$	A1 (3)
(b)	$49 - 4q^2 \ge 0$ $-\frac{7}{2} \le q \le \frac{7}{2}$ $\left(\text{or } 3.5, \sqrt{12.25}\right)$ Allow with < or =	M1

Question Number	Scheme	Marks
	$q = \pm 3, \pm 2, \pm 1, 0$	A1A1cso (3) [6]

(a)

M1 Use the discriminant to form an inequality or equation. Can have ($\le, <, =, >, \ge$)

A1 Correct inequality Allow with <0 or ≤ 0. May be implied by the correct answer.

A1 $-6 < p < 6$, $p > -6$ and $p < 6$, $|p| < 6$ score A1 but $p > -6$ or $p < 6$ scores A0

(b)

M1 Use the discriminant to form an **inequality** or equation for q **and** attempt to **solve** it. (Inequality/equation for q^2 and no further work scores M0)
$(x \pm q)(x \pm q) = 0$ so $q = \pm 3.5$ oe scores M0

A1 Any 4 correct values - can come from an equation.

A1cso All 7 correct - must have used an inequality.

4(a)	$a = 6t + 2$	M1A1
	$t = 2 \quad a = 14$ (m/s^2)	A1ft (3)
(b)	$s = t^3 + t^2 + 5t \ (+c)$	M1,A1(**M1 on e-PEN)**
	$s = 51\ (\text{m})$	A1cso (3)[6]

(a)

M1 Differentiate the expression for v. Min one term differentiated (see "General Principles") and none integrated.

A1 Correct differentiation

A1ft Substitute $t = 2$ to obtain the acceleration. Follow through their expression for the accel, provided attempt at differentiation has been made (ie M mark earned).

(b)

M1 Attempt to integrate the expression for v, constant of integration not needed. Min 2 of 3 terms to be integrated and none differentiated.

A1 Correct integration with or without c

(M1 on e-PEN)

A1cso For $s = 51\ (\text{m})$ A constant of integration must have been included and made =0

ALT **(b) By definite integration**:
M1: Integrate min of 2 of 3 terms (ignore limits); A1: Correct integration
A1cso: For $s = 51\ (\text{m})$ by substitution of limits 0 and 3.

NB Parts not labelled: Int and sub $t = 3$, assume (b); Diff and sub $t = 2$, assume (a)

5(a)	$(2x+3)^2 = x^2 + (4x-5)^2 - 2x(4x-5)\cos 60°$	M1A1
	$4x^2 + 12x + 9 = x^2 + 16x^2 - 40x + 25 - 4x^2 + 5x$	

Question Number	Scheme	Marks
	$9x^2-47x+16\ \ (=0)$ oe	A1
	$x=\dfrac{47\pm\sqrt{47^2-4\times9\times16}}{18}\ \ (=4.8561...,\ 0.36608...)$	dM1
	$BC=4x-5>0\ \ \therefore x=4.86$	A1 (5)
(b)	$AB=4.8561,\ BC=4\times4.856-5\ \ (=14.42)$	
	Area $=\dfrac{1}{2}\times4.8561\times(4\times4.856-5)\sin60°$	M1A1ft
	$=30.33...=30.3\ (\text{cm}^2)$	A1 (3) [8]

(a)

M1 Use the cosine rule in ΔABC to form a quadratic equation in x

A1 Correct, unsimplified, equation

A1 Correct **simplified** equation, terms in any order. (3TQ; $\cos60°=\dfrac{1}{2}$ used.)

dM1 Solve their 3TQ by any valid means. Accept the solution of an incorrect equation by formula **only** if the substitution is shown or the formula quoted. (Calculator solutions accepted **only** if the final answer is correct, but not necessarily rounded.)

A1 Use the expression for BC in terms of x to identify the correct value of x. Award if 2 values for x are shown, followed by a clearly identified final single value. Must be 3 significant figures.

(b)

M1 For using any complete method for finding the area of the triangle, including using their value of x to find the lengths of the sides needed.

A1ft Correct numbers used, follow through their value of x.

A1cao Correct area, no ft. Must be 3 significant figures unless penalised in (a)
Use of 4.86 will lose the final A mark for premature approximation as it leads to 30.4.

ALT **For (b)**
Use any other **complete** method to find the area. Must attempt to find all the necessary terms using their value of x

Eg: Heron's formula: Area $=\sqrt{s(s-a)(s-b)(s-c)}$ where $s=\dfrac{1}{2}(a+b+c)$

Or $\dfrac{1}{2}\times\text{base}\times\text{height}$

M1 method correct and complete; A1ft A1 as main scheme

6 (a)	$p^6+6p^5(qx)+\dfrac{6\times5}{2!}p^4(qx)^2+\dfrac{6\times5\times4}{3!}p^3(qx)^3+\dfrac{6\times5\times4\times3}{4!}p^2(qx)^4$	M1
	$=p^6+6p^5qx+15p^4q^2x^2+20p^3q^3x^3+15p^2q^4x^4...$	A1A1 (3)
(b)	$4\times15p^2q^4=9\times15p^4q^2$	M1

Question Number	Scheme	Marks
	$4q^2 = 9p^2$ oe	A1
	$(p+q)^6 = 15625 \quad (p+q=5)$	M1 (NB A1 on e-PEN)
	$4(5-p)^2 = 9p^2$	
	$10-2p = \pm 3p$	M1
	$p=2\ q=3$ or $p=-10\ q=15$	A1A1 (6) [9]

(a)M1 Apply the binomial expansion to $(p+qx)^6$ or $p^6\left(1+\frac{qx}{p}\right)^6$ or use Pascal's triangle. Must start $p^6+...$ and have qx (or appropriate power of this) in at least one term or start $p^6(1+...)$ and have $\frac{qx}{p}$ (or appropriate power of this) in at least one term. Can have 3!, 4! or 6, 24 (but not 3, 4)

If $\begin{pmatrix} a \\ b \end{pmatrix}$ or C_b^a seen, no marks until coefficients as shown are seen (or final expansion is correct).

A1 Any 3 terms correct.(p^6 can be one of these.)
Allow with $(qx)^2$ etc provided the numerical part has been simplified.

A1 All 5 terms correct. Brackets expanded for this mark.

(b)

M1 Equate 4 times their coeff of x^4 to 9 times their coeff of x^2. Allow if powers of x included or x = 1 substituted in each term. Award on basis of **their coefficients** even if no powers of p included.

A1 Simplified equation as shown. No x seen now. This mark can be gained if x = 1 has been substituted. (Not follow through.) Coefficients can be a multiple of those shown.

M1 (A1 on e-PEN) Obtain a second equation connecting p and q by substituting $x=1$ in f(x). Award for $(p+\text{ their } q)^6 = 15625$ or sub $x=1,\ q=\frac{3}{2}p$ in their expansion

M1 Eliminate either p or q between their 2 equations and obtain a linear equation in one variable.

A1 One pair of values for p and q correct (NB must have previous M mark)

A1 Second pair correct. Pairing must be clear.

NB: If inequality signs used (due to $(p+q)>0$) treat as = but deduct the final A mark if earned.

7(a)	Surface area $= 2(5x^2+hx+5xh) = 480$	M1
	$480 = 12hx + 10x^2$ oe	A1

Question Number	Scheme	Marks
	$V = 5x^2h = 5x^2 \times \dfrac{480-10x^2}{12x}$	dM1
	$V = 200x - \dfrac{25}{6}x^3$ *	A1cso (4)
(b)	$\dfrac{dV}{dx} = 200 - \dfrac{25}{2}x^2$	M1
	$\dfrac{dV}{dx} = 0 \quad x = 4 \quad (x > 0)$	dM1A1
	$V = 200 \times 4 - \dfrac{25}{6} \times 4^3 = 533\frac{1}{3}$ (accept 533 or $\dfrac{1600}{3}$)	dM1A1cao (5) [9]

(a)

M1 Attempt to obtain a **dimensionally correct** expression for the surface area in terms of x and h and equate to 480

A1 Correct equation, as shown or equivalent.

dM1 Use the volume and eliminate h from the expression

A1cso Obtain the given expression for V in terms of x from correct working

(b)

M1 Differentiate the expression for V. $200x \to 200$ or $\dfrac{25x^3}{6} \to kx^2$ must be seen with no integration.

dM1 Equate their derivative to 0 and solve for x

A1 Correct value of x. Must be positive, negative value need not be shown but if seen ignore it.

dM1 Substitute their **positive** value of x in the expression for V and obtain a numerical value for V. Depends on both M marks above.

A1cao For the correct value of V. Can be exact or at least 3 sig figs.

NB If 2 values of x are both **given** and **used**, the correct final answer must be clearly identified or both A marks are lost.

8(a)	$(\alpha+\beta)^2 = p^2 \quad \alpha\beta = +7$	B1

Question Number	Scheme	Marks
(i)	$\alpha^2+\beta^2=(\alpha+\beta)^2-2\alpha\beta,\ =p^2-14$	M1,A1
(ii)	$\alpha^2\beta^2=49$	B1ft (4)
(b)	$7(p^2-14)=5\times 49$	
	$p^2=49 \quad p=\pm 7$	M1A1 (2)
(c)	$\frac{2p}{\alpha^2}+\frac{2p}{\beta^2}=\frac{2p(\alpha^2+\beta^2)}{\alpha^2\beta^2}=\frac{2p(p^2-14)}{49}=\frac{14\times 35}{49}=10$	M1A1
	$\frac{2p}{a^2}\times\frac{2p}{\beta^2}=\frac{4p^2}{\alpha^2\beta^2}=\frac{4\times 49}{49}=4$	B1
	$x^2-10x+4=0$	M1A1 (5) [11]

(a)

B1 Correct product of the roots (can be implied by use of $2\alpha\beta=14$) and $(\alpha+\beta)^2=p^2$ seen somewhere. (Ignore $\alpha+\beta=p$)

(i)M1 Correct algebraic expression ready for the required substitution.

A1 Correct expression. (p^2-14)

(ii)B1ft Correct numerical value, follow through their product of the roots.

(b)

M1 Substitute their answers from (a) in the given equation and solve for *p*.

A1 Correct values for *p* - both required.

(c)

M1 Add the roots of the new equation to obtain a single fraction (denominator to be $\alpha^2\beta^2$ and substitute their positive value of *p* and values of $(\alpha+\beta)^2$ and $\alpha^2\beta^2$ to obtain a numerical value of this sum.

A1 Correct value of this sum

B1 Correct value of the product of the roots

M1 Use equation x^2- sum of roots $\times x+$ product of roots $(=0)$ with their sum and product (numerical values needed) and with or without "= 0"

A1 Completely correct equation as shown or equivalent to the one shown.

9 (a)	$x^3-4x^2-4x+16=(x-2)(x-a)(x-b)$	

Question Number	Scheme	Marks
	$=(x-2)\left(x^2-(a+b)x+ab\right)$	
	$x^3-2x^2-(a+b)x^2+2(a+b)x+abx-2ab$	M1
	$-ab=8,\ -(a+b)-2=-4 \quad a=-2,\ b=4$	M1A1A1 (4)
	ALT: $(x-2)\left(x^2-2x-8\right),=(x-2)(x-4)(x+2)$ M1, M1 $a=-2,\ b=4$ A1A1 corr answers	
(b)	$D:(0,16)$	B1
	$\frac{\mathrm{d}y}{\mathrm{d}x}=3x^2-8x-4$	M1
	At D grad = -4	A1
	$y-16=-4x$ oe	dM1A1 (5)
(c)	$y=0 \Rightarrow x=4$ or $x=4 \Rightarrow y=0$ ($\therefore$ passes through B)	B1 (1)
(d)	Area = $\int_0^4\left(16-4x-\left(x^3-4x^2-4x+16\right)\right)\mathrm{d}x$	M1
	$=\left[\frac{4}{3}x^3-\frac{1}{4}x^4\right]_0^4$	dM1A1
	$=\frac{4}{3}\times4^3-\frac{1}{4}\times4^4\ (-0)$	dM1
	$=21\frac{1}{3}$ (21.3 or better) or $\frac{64}{3}$	A1 (5) [15]

(a)

M1 Write the cubic as a product of 3 linear brackets and multiply out these 3 brackets. One bracket must be $(x\pm2)$

Question Number	Scheme	Marks
M1	Extract 2 equations in a and b and solve them	
A1A1	Correct values for a and b. Coordinates of the points accepted. Award A1A1, A1A0 or A0A0	
ALT 1	**M1** Divide given cubic by $(x \pm 2)$ **M1** Factorise the quadratic obtained. **A1A1** Correct values of a and b deduced from the resulting brackets. Coordinates of the points accepted. No errors in the working for A1A1 Division by $x+2$ can score M1M1	
ALT 2	Factorise the given cubic **M1**: $(x^2-4)(x-4)\ (=0)$ **M1** $(x-2)(x+2)(x-4)\ (=0)$ **A1A1** Correct values for *a, b* A1A1 Coordinates of the points accepted.	
ALT 3	Remainder/factor theorem: **M1** try $x = \pm$ any factor of 16 **M1** Try more factors of 16 until 2 factors found giving no remainder. **A1A1** correct values of *a*, *b* Coordinates of the points accepted.	
OR	**No working shown** and correct answers stated, 4/4	
(b)		
B1	Correct y coordinate for D.	
M1	Differentiate the given equation for C. Minimum 2 terms differentiated and no integration.	
A1	Substitute $x=0$ to obtain the correct gradient at D	
dM1	Use any complete method to obtain an equation of l using their gradient and y coordinate. If $y = mx + c$ used there must be an attempt to find the value of c. Depends on M mark above.	
A1	Correct equation in any form.	
(c)B1	Substitute $y = 0$ or $x = 4$ into the correct equation of l to show l passes through (4, 0) This correct equation need not have been awarded all the marks in (b) (No conclusion need be given here.)	
(d)		
M1	Use Area = $\int_0^4 (\text{line} - \text{curve})\,dx$ - either way round - or use the **difference** of 2 separate integrals, both with limits 0 and 4.	
dM1	Integrate their single function or both integrals. Depends on the first M mark	
A1	Correct integration for their method.	
dM1	Substitute the correct limits (0 and 4) in their integrated expression(s) and obtain a value for the area. Depends on the both M marks	
A1	Correct area, exact or min 3 significant figures. Must be positive.	
ALT	By splitting the area:	
M1	Reqd area = area $\Delta OBD - \int_0^2 (x^3-4x^2-4x+16)\,dx - \int_2^4 (x^3-4x^2-4x+16)\,dx$.	
dM1	Triangle area by formula or integration of equation of l and curve equation integrated	
A1	Correct integration (and area of triangle = 32 if by formula)	
dM1	Substitute the limits into their integrated expressions and obtain a value for the area. Depends on both M marks.	
A1	Correct area, exact or min 3 significant figures. Must be positive.	
10 (a)	$AC = \sqrt{8^2+3^2} = \sqrt{73}$	M1A1
	$\tan 45° = \dfrac{CH}{AC}$, $CH = \sqrt{73} = 8.54$ cm	M1A1 (4)

Question Number	Scheme	Marks
(b)	$\sin 45°$ or $\cos 45° = \dfrac{CH}{AH}$ or $\dfrac{AC}{AH}$ or Pythagoras	M1
	$AH = \sqrt{73} \times \sqrt{2}$, $= 12.1$ cm	A1ft, A1 (3)
(c)	$FN^2 = FH^2 + \left(\dfrac{1}{2}CH\right)^2$	M1
	$= 73 + \dfrac{73}{4}$, $FN = \sqrt{91.25} = 9.55\,\text{cm}$	A1ft, A1 (3)
(d)	$\tan GFB = \dfrac{GB}{FG} = \dfrac{\sqrt{73}}{3}$	M1A1ft
	$\angle GFB = 70.7°$	A1 (3)
(e)	$\sin FNG = \dfrac{FG}{FN} = \dfrac{3}{\sqrt{91.25}}$	M1A1ft
	$\angle FNG = 18.3°$	A1 (3) [16]

NB Penalise failure to round as instructed once for lengths ((a), (b) and (c)) **and** once for angles ((d) and (e)) Use of exact answers for lengths is also only penalised once.

(a)

M1 Use Pythagoras, with a + sign to obtain the length of AC

A1 Correct length AC, seen here or later (or implied by a correct final answer).

M1 Use $\tan 45° = \dfrac{CH}{AC}$ (fraction either way up)

A1 Correct length of CH. Must be 3 significant figures

(b)M1 Use $\sin 45°$ or $\cos 45° = \dfrac{CH}{AH}$ or $\dfrac{AC}{AH}$ or Pythagoras with a + sign (or any other **complete** method)

A1ft $AH =$ their $CH \times \sqrt{2}$ or equivalent. (May be implied by a correct final answer.)

A1 Correct length AH. Must be 3 significant figures unless already penalised in (a).

(c)

M1 Use Pythagoras with a + sign in ΔFHC

A1ft Correct numbers, follow through their AC and CH.

A1 Correct length FN. Must be 3 significant figures unless already penalised above.

(d)

M1 Use any complete method for finding $\angle GFB$ or $\angle HEC$

A1ft Correct numbers used in their method, follow through any previously found lengths used.

A1 Correct answer. Must be in degrees and correct to 1 decimal place. (70.6° from using $CH = 8.54$ scores M1A1A0)

(e)M1 Use any **complete** method for obtaining $\angle FNG$, eg trig as shown, or Pythagoras and cosine rule. (Cosine rule needs $NG = \sqrt{329}/4$)

A1ft Correct numbers in their choice of method, follow through lengths found previously.

A1 Correct answer. Must be in degrees and correct to 1 decimal place unless penalised in (d).

11 (a)	$\log pq^4 - \log pq^2 = \log\left(\dfrac{pq^4}{pq^2}\right) = \log q^2$ or $2\log q$	M1

Question Number	Scheme	Marks
	$\log pq^6 - \log pq^4 = \log\left(\frac{pq^6}{pq^4}\right) = \log q^2$ or $2\log q$	A1
	$\therefore \log pq^4 - \log pq^2 = \log pq^6 - \log pq^4$ *	A1cso (3)
	ALT: $\log pq^4 - \log pq^2 = \log p + 4\log q - \log p - 2\log q = 2\log q$ etc	
(b)	$d = \log q^2$ or $2\log q$	B1
	$a = \log pq^2 - \log q^2, = \log p$	M1,A1 (3)
(c)	$S_n = \frac{n}{2}\left(2a + (n-1)d\right) = \frac{n}{2}\left(2\log p + (n-1)\log q^2\right)$	M1A1
	$= n\log\left(pq^{(n-1)}\right)$	M1A1cso (4) [10]

(a)M1 Apply log theory to either side of the equation to obtain a single log.

Statements such as $\log pq^4 = 4\log pq$ and $\log\frac{pq^4}{pq^2} = \log pq^2$ score M0 if they appear in both or M1A0 if only in one.

A1 Apply log theory to the other side of the equation to obtain a single log. Both applications must be correct.

A1cso Conclusion given. Can quote the given result, use # or say eg "(hence) shown" "so same" or "qed"

ALT

M1 $\log pq^4 - \log pq^2 = \log\left(\frac{pq^4}{pq^2} \times \frac{q^2}{q^2}\right) = \log\left(\frac{pq^6}{pq^4}\right) = \log pq^6 - \log pq^4$

A1A1 Work shown correct - includes the conclusion due to layout. Incorrect work gets A0A0

(b)

B1 Correct common difference in either form shown. May be implied by subsequent working.

M1 Subtract their common difference from the second term or twice their common difference from the third term.

A1 Correct first term. Correct answer w/o working scores 3/3

(c)

M1 Use the (correct) formula for the sum of the first *n* terms with their *a* and *d*

A1 Correct *a* and *d* in the formula (**no ft**)

M1 Use log theory to combine the logs in their sum.

A1cso Correct final answer, must be as shown.

NB If *s* is used instead of *n*, all but final A mark is available. If *s* is replaced with *n* at end, all marks available.

Pearson Education Limited. Registered company number 872828
with its registered office at 80 Strand, London, WC2R 0RL, United Kingdom