

## Proofs (Higher)

Please write clearly in block capitals

Forename:

Surname:

### Materials

For this paper you must have:

- mathematical instruments



You must **not** use a calculator.

### Instructions

- Use black ink or black ball-point pen. Draw diagrams in pencil.
- Fill in the boxes at the top of this page.
- Answer all questions.
- You must answer the questions in the spaces provided. Do not write outside the box around each page or on blank pages.
- Do all rough work in this book. Cross through any work you do not want to be marked.

### Information

- The marks for questions are shown in brackets.
- You may ask for graph paper, tracing paper and more answer paper. These must be tagged securely to this answer book.

### Advice

- In all calculations, show clearly how you work out your answer.

**1** Show that the following statements are true: (Level 6)

**1(a)**  $4(2x - 3) - 2(2x + 9) \equiv 4x - 30$

**[2 marks]**

\_\_\_\_\_

\_\_\_\_\_

Answer \_\_\_\_\_

**1(b)**  $(n - 1)^2 - (n - 2)^2 \equiv 2n - 3$

**[2 marks]**

\_\_\_\_\_

\_\_\_\_\_

Answer \_\_\_\_\_

**1(c)**  $(n + 2)^2 - 3(n + 4) \equiv (n + 4)(n - 3) + 4$

**[2 marks]**

\_\_\_\_\_

\_\_\_\_\_

Answer \_\_\_\_\_

**1(d)**  $3(n + 3)(n - 1) - 3(1 - n) \equiv (3n - 3)(n + 4)$

**[2 marks]**

\_\_\_\_\_

\_\_\_\_\_

Answer \_\_\_\_\_

**Turn over for next question**

**2** Show that the following statements are true, (Level 6)

**2(a)**  $(3n + 1)(n + 3) - n(3n + 7) \equiv 3(n + 1)$

**[2 marks]**

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Answer \_\_\_\_\_

**2(b)**  $(n + 3)^2 - (3n + 4) \equiv (n + 1)(n + 2) + 3$

**[2 marks]**

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Answer \_\_\_\_\_

**2(c)**  $(n - 3)^2 - (2n + 1) \equiv (n - 4)^2 - 8$

**[2 marks]**

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Answer \_\_\_\_\_



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**3(a)** Prove the product of two even numbers is always even.

(Level 6)

[2 marks]

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Answer \_\_\_\_\_

**3(b)** Prove that the product of two odd numbers is always odd.

[2 marks]

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Answer \_\_\_\_\_

**3(c)** Prove the product of three consecutive odd numbers is odd.

[3 marks]

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Answer \_\_\_\_\_



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**4(a)** Prove algebraically that the sum of any three odd numbers is odd.

*(Level 6)*

**[2 marks]**

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Answer \_\_\_\_\_

**4(b)** Prove algebraically that the sum of the squares of two odd integers is always even.

**[2 marks]**

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Answer \_\_\_\_\_

**4(c)** Prove that when two consecutive integers are squared, that the difference is equal to the sum of the two consecutive integers.

**[2 marks]**

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Answer \_\_\_\_\_

**Turn over for next question**

**5(a)** Prove that,

(Level 6)

$$(n + 3)^2 + n(3 - n) - 3(n + 4)$$

is a multiple of 3 for all integer values of n.

[2 marks]

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Answer \_\_\_\_\_

**5(b)** Prove algebraically that the sum of two consecutive numbers is odd.

[2 marks]

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Answer \_\_\_\_\_

**5(c)** Prove algebraically that the sum of the squares of two consecutive multiples of 5 is not a multiple of 10.

[2 marks]

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Answer \_\_\_\_\_

Turn over for next question

**6(a)** Show algebraically that the sum of any 3 consecutive even numbers is always a divisible by 6. (Level 7)

**[2 marks]**

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Answer \_\_\_\_\_

**6(b)** Prove algebraically that  $(4n + 2)^2 - (2n + 2)^2$  is a multiple of 4 for all positive integers.

**[2 marks]**

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Answer \_\_\_\_\_

**6(c)** Prove algebraically that  $(2n + 3)^2 - (2n - 3)^2$  is a multiple of 8 for all positive integers of  $n$ .

**[2 marks]**

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Answer \_\_\_\_\_

**Turn over for next question**

**7(a)** If  $2n$  is always even for all positive integer values of  $n$ , prove algebraically that the sum of the squares of any two consecutive even numbers is always a multiple of 4. (Level 7)

**[3 marks]**

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Answer \_\_\_\_\_

**7(b)** Prove algebraically that the difference between the squares of any two consecutive numbers is always an odd number.

**[2 marks]**

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Answer \_\_\_\_\_

**Turn over for next question**



- 8(a)** Tom says that  $7x - (2x + 3)(x + 2)$  is always negative.  
Is he correct? Explain your answer.

(Level 7)

**[3 marks]**


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Answer \_\_\_\_\_

- 8(b)** Change a single number in Tom's statement that would lead to a change in your conclusion.  
Why is this the case?

**[1 mark]**


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Answer \_\_\_\_\_



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Turn over ►

**9(a)** Show that the difference between  $14^{20}$  and  $21^2$  is a multiple of 7.

(Level 8)

**[3 marks]**

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Answer \_\_\_\_\_

**9(b)** Show that  $3^{60} - 25$  is not a prime number.

**[2 marks]**

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Answer \_\_\_\_\_

**Turn over for next question**

10 Part of a 10x10 1-100 number grid is pictured below

(Level 8)

1	2	3	4	5
11	12	13	14	15
21	22	23	24	25
31	32	33	34	35
41	42	43	44	45

A 2x2 square of numbers is selected.

The following operation is performed:

Difference of the leading diagonal  $\times$  Difference of the other diagonal

$$(23 - 12) \times (22 - 13) = 11 \times 9 = 99$$

10(a) Verify that this is also the case for a different 2x2 square of numbers on the grid.

[1 mark]

Answer \_\_\_\_\_

10(b) Prove this result for all possible 2x2 squares on the grid.

[3 marks]

Answer \_\_\_\_\_

End of Questions