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| **Question** | **Scheme** | **Marks** | **AOs** |
| **1(a)** |  | M1 | 1.1a |
|  | M1A1 | 1.1b1.1b |
|  | M1 | 3.1a |
|  | A1 | 2.1 |
|  | **(5)** |  |
| **(b)** |  | M1 | 1.1b |
|  | M1 | 1.1b |
|  | A1 | 2.2a |
|  | **(3)** |  |
| **(8 marks)** |
| **Notes** |
| (a)M1: Realises the need to use the product rule and attempts the first derivativeM1: Applies the product rule again to find the second derivativeA1: Correct second derivative simplified or un-simplifiedM1: Uses their derivatives in order to obtain values for *p* and *q*A1: Completes the proof and obtains the correct values of *p* and *q*(b)M1: Attempts all 5 derivatives at *x* = 0 using the result from part (a)M1: Uses the correct Maclaurin series including the factorialsA1: Correct expression |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **2(a)** |  | M1 | 2.1 |
|  | M1A1 | 2.11.1b |
|  | M1 | 2.1 |
|  | A1\* | 1.1b |
|  | **(5)** |  |
| **(b)** |  | M1 | 3.1a |
|  | A1 | 1.1b |
|  | M1 | 1.1b |
|  | A1A1 | 1.1b1.1b |
|  | **(5)** |  |
| **(10 marks)** |
| **Notes** |
| (a)M1: Begins the proof by demonstrating that M1: Attempts to expand including the binomial coefficientsA1: Correct expansionM1: Uses  to obtain an expression in terms of and A1\*: Concludes the argument by equating the two expressions leading to the printed answer with no errors(b)M1: Makes the connection with part (a) and reaches an equation in cos*θ* onlyA1: Correct equationM1: Solves their equation for cos*θ*A1: 2 correct solutionsA1: All 3 correct solutions. Ignore extra solutions outside the range but deduct this mark if there are extra answers in range. |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **3** | Area enclosed by curve =  | M1 | 3.1a |
|  | M1 | 2.1 |
|  | A1ft | 1.1b |
| Area enclosed by curve =  | M1 | 3.1a |
|  | A1 | 1.1b |
| Total shaded area == 314.15… – 180.24… + 78.53… | M1 | 3.1a |
|  | A1 | 3.2a |
|  | **(7)** |  |
| **(7 marks)** |
| **Notes** |
| M1: A correct strategy identified for finding the area enclosed by the polar curve using a correct formulaM1: Squares and uses to obtain an expression in an integrable formA1ft: Correct follow through integrationM1: Correct use of correct limits (e.g. may use 0🡪2π or (0🡪π) etc.)A1: Correct area enclosed by the curveM1: Fully correct strategy for obtaining the area to be paintedA1: Correct area |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **4(a)** |  | M1 | 3.1a |
|  | M1 | 2.1 |
|  | A1 | 1.1b |
|  | M1 | 1.1b |
|  | A1 | 2.2a |
|  | **(5)** |  |
| **(b)** |  | M1 | 1.1b |
|  | A1 | 1.1b |
|  | **(2)** |  |
| **(7 marks)** |
| **Notes** |
| (a)M1: A complete strategy to find *A* and *B* e.g. partial fractionsM1: Starts the process of differences to identify the relevant fractions at the start and endA1: Correct fractions that do not cancelM1: Attempt common denominatorA1: Correct answer(b)M1: Uses the answer to part (a) to calculate f(50) – f(9 or 10)A1: Correct exact answer |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **5(a)** |  | M1 | 1.1b |
|  | M1 | 3.1b |
|  | A1 | 1.1b |
|  | M1 | 3.4 |
|  | M1 | 3.4 |
|  | A1 | 1.1b |
|  | **(6)** |  |
| **(b)** | For large values of *t*, the velocity increases | B1 | 1.1b |
|  | **(1)** |  |
| **(c)** | E.g.* The raindrop may hit an obstacle as it falls
* The raindrop is unlikely to be at rest initially
* The raindrop may be affected by the wind as it falls
* The raindrop will eventually hit the ground
 | B1 | 3.5b |
|  | **(1)** |  |
| **(8 marks)** |
| **Notes** |
| (a)M1: Divides through by (*t* + 4)M1: Uses the model to find the integrating factor and attempts the solution of the differential equationA1: Correct solutionM1: Interprets the initial conditions to find the constant of integrationM1: Uses their solution to the problem to find the velocity after 3 secondsA1: Correct value(b)B1: Makes a sensible comment regarding the motion of the raindrop e.g. as *t* increases so does *v*(c)B1: States a limitation of the model – see scheme for examples |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **6** | When *n* = 1, When *n* = 2, So the result is true for *n* = 1 and *n* = 2 | B1 | 2.2a |
| Assume true for *n* = *k* and *n* = *k* + 1 so and  | M1 | 2.4 |
|  | M1 | 1.1b |
|  | A1 | 1.1b |
|  | A1 | 2.1 |
| If the statement is true for *n* = *k* and *n* = *k* + 1then it has been shown true for *n* = *k* + 2 and as it is true for *n* = 1 and *n* = 2, the statement is true for all positive integers *n*. | A1 | 2.4 |
|  | **(6)** |  |
| **(6 marks)** |
| **Notes** |
| B1: Shows the statement is true for *n* = 1 and *n* = 2M1: Makes a statement that assumes the result is true for *n* = *k* and *n* = *k* + 1M1: Substitutes the assumption statements into the given resultA1: Correct expression that has been processed correctly to be in terms of 3*k* + 1 and 2*k* + 1A1: Obtains with no errors and all working shownA1: Correct complete conclusion that may be part of a narrative throughout the proof |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **7(a)** | or  | M1 | 1.1b |
| Or | M1A1 | 3.1a1.1b |
|  | **(3)** |  |
| **(b)** |  | M1 | 1.1b |
| As 4**i** + **j** – 7**k** is perpendicular to both direction vectors of *Π*2 then it must be perpendicular to *Π*2 | A1 | 2.2a |
|  | **(2)** |  |
| **(c)** |  | M1 | 1.1b |
|  | M1 | 2.1 |
|  | A1 | 1.1b |
|  | **(3)** |  |
| **(d)** | 4*x* + *y* – 7*z* = 0 and 2*x* – 3*y* + 4*z* = –8 |  |  |
|  | M1A1 | 3.1a1.1b |
|  | M1A1 | 1.1b2.5 |
|  | **(4)** |  |
| **(12 marks)** |
| **Notes** |
| (a)M1: Starts by attempting to find an appropriate scalar product or finding the parametric equation of the perpendicular lineM1: A complete strategy to establish the required distanceA1: Correct exact answer (allow any exact form)(b)M1: Attempts both scalar productsA1: Makes a correct deduction(c)M1: Calculates the scalar product between the normal vectorsM1: Applies the scalar product formula with their – 23 to find a value for cos*θ*A1: Correct answer(d)M1: Attempts to find the direction e.g. by finding 2 points on the line or uses vector productA1: Correct direction of required lineM1: Uses their direction and a point on the line to form a vector equation for the lineA1: Correct equation using correct notation |

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| **Question** | **Scheme** | **Marks** | **AOs** |
| **8(a)** |  | B1 | 2.1 |
|  | M1 | 2.1 |
|  | A1\* | 1.1b |
|  | **(3)** |  |
| **(b)** |  | M1 | 3.4 |
|  | A1 | 1.1b |
|  | M1 | 3.4 |
|  | A1 | 1.1b |
| PI: Try  | M1 | 3.4 |
|  | A1ft | 1.1b |
|  | **(6)** |  |
| **(c)** |  | M1 | 3.4 |
|  | A1 | 1.1b |
|  | **(2)** |  |
| **(d)** | (NB ) | M1 | 3.3 |
|  | A1 | 1.1b |
|  | M1 | 3.1b |
|  | M1 | 1.1b |
| = 5.39 minutes | A1 | 3.2a |
|  | **(5)** |  |
| **(e)** | E.g.* The model suggests that, in the long term, the amount of antibiotic in the blood (and/or the body tissue) will remain constant and this is unlikely
 | B1 | 3.5a |
|  | **(1)** |  |
| **(17 marks)** |
| **Notes** |
| (a)B1: Differentiates the first equation with respect to *t* correctlyM1: Proceeds to the printed answer by substituting into the second equationA1\*: Achieves the printed answer with no errors(b)M1: Uses the model to form and solve the Auxiliary EquationA1: Correct roots of the AEM1: Uses the model to form the Complementary FunctionA1: Correct CFM1: Chooses the correct form of the PI according to the model and uses a complete method to find the PIA1ft: Combines their CF and PI to give *x* in terms of *t*(c)M1: Uses the model and their answer to part (b) to give *y* in terms of *t*A1: Correct equation(d)M1: Realises the need to use the initial conditions to establish the values of their constantsA1: Correct particular solutions for *x* and *y* M1: Differentiates both expressions, sets them equal and proceeds to reach an equation of the form M1: Correct use of logarithms to reach *t* = …A1: Correct value(e)B1: Suggests a suitable evaluation of the model |