|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **1(a)** |  | M1 | 1.1a |
|  | M1  A1 | 1.1b  1.1b |
|  | 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 derivative  M1: Applies the product rule again to find the second derivative  A1: Correct second derivative simplified or un-simplified  M1: 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 factorials  A1: Correct expression | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **2(a)** |  | M1 | 2.1 |
|  | M1  A1 | 2.1  1.1b |
|  | M1 | 2.1 |
|  | A1\* | 1.1b |
|  | **(5)** |  |
| **(b)** |  | M1 | 3.1a |
|  | A1 | 1.1b |
|  | M1 | 1.1b |
|  | A1  A1 | 1.1b  1.1b |
|  | **(5)** |  |
| **(10 marks)** | | | |
| **Notes** | | | |
| (a)  M1: Begins the proof by demonstrating that  M1: Attempts to expand including the binomial coefficients  A1: Correct expansion  M1: 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* only  A1: Correct equation  M1: Solves their equation for cos*θ*  A1: 2 correct solutions  A1: All 3 correct solutions. Ignore extra solutions outside the range but deduct this mark if there are extra answers in range. | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **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 formula  M1: Squares and uses to obtain an expression in an integrable form  A1ft: Correct follow through integration  M1: Correct use of correct limits (e.g. may use 0🡪2π or (0🡪π) etc.)  A1: Correct area enclosed by the curve  M1: Fully correct strategy for obtaining the area to be painted  A1: Correct area | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **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 fractions  M1: Starts the process of differences to identify the relevant fractions at the start and end  A1: Correct fractions that do not cancel  M1: Attempt common denominator  A1: Correct answer  (b)  M1: Uses the answer to part (a) to calculate f(50) – f(9 or 10)  A1: Correct exact answer | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **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 equation  A1: Correct solution  M1: Interprets the initial conditions to find the constant of integration  M1: Uses their solution to the problem to find the velocity after 3 seconds  A1: 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 | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **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* = 2  M1: Makes a statement that assumes the result is true for *n* = *k* and *n* = *k* + 1  M1: Substitutes the assumption statements into the given result  A1: Correct expression that has been processed correctly to be in terms of 3*k* + 1 and 2*k* + 1  A1: Obtains with no errors and all working shown  A1: Correct complete conclusion that may be part of a narrative throughout the proof | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **Question** | **Scheme** | **Marks** | **AOs** |
| **7(a)** | or | M1 | 1.1b |
| Or | M1  A1 | 3.1a  1.1b |
|  | **(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 |  |  |
|  | M1  A1 | 3.1a  1.1b |
|  | M1  A1 | 1.1b  2.5 |
|  | **(4)** |  |
| **(12 marks)** | | | |
| **Notes** | | | |
| (a)  M1: Starts by attempting to find an appropriate scalar product or finding the parametric equation of the perpendicular line  M1: A complete strategy to establish the required distance  A1: Correct exact answer (allow any exact form)  (b)  M1: Attempts both scalar products  A1: Makes a correct deduction  (c)  M1: Calculates the scalar product between the normal vectors  M1: 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 product  A1: Correct direction of required line  M1: Uses their direction and a point on the line to form a vector equation for the line  A1: Correct equation using correct notation | | | |

|  |  |  |  |
| --- | --- | --- | --- |
| **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* correctly  M1: Proceeds to the printed answer by substituting into the second equation  A1\*: Achieves the printed answer with no errors  (b)  M1: Uses the model to form and solve the Auxiliary Equation  A1: Correct roots of the AE  M1: Uses the model to form the Complementary Function  A1: Correct CF  M1: Chooses the correct form of the PI according to the model and uses a complete method to find the PI  A1ft: 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 constants  A1: 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 | | | | |