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17/ENG04/026
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1) $y = e^{x^2+x}$

$y' = (2x+1)e^{x^2+x}$

$y'' = 2e^{x^2+x} + (2x+1)(2x+1)e^{x^2+x}$

$y''' = 2e^{x^2+x} + (2x+1)^2 e^{x^2+x}$

$y'(2x+1) + 2y$

$= (2x+1)e^{x^2+x} \cdot (2x+1) + 2(e^{x^2+x})$

$= (2x+1)^2 e^{x^2+x} + 2e^{x^2+x}$

but $y'' = 2e^{x^2+x} + (2x+1)^2 \cdot e^{x^2+x}$

$y'' = y'(2x+1) + 2y$

part A;

$A = y''$, $A' = y'''$, $A^n = y^{2+n}$

part B;

$B = y'(2x+1)$

$u = y'$, $u^n = y^{n+1}$

$v = 2x+1$, $v' = 2$, $v'' = 0$

$B = (y^{n+1})(2x+1) + n(y^n)(2) + 0$

$B^n = (2x+1)y^{n+1} + 2ny^n$

part C;

$C = 2y$

$C^n = 2y^n$

$A^n + B^n + C^n$

$y^{n+2} = (2x+1)y^{n+1} + 2ny^n + 2y^n$

$y^{n+2} = (2x+1)y^{n+1} + 2y^n(n+1)$

$y^{n+2} = (2x+1)y^{n+1} + 2(n+1)y^n.$

2) $y = x^3 e^{4x}$

Let $u = e^{4x}$, $u' = 4e^{4x}$, $u'' = 16e^{4x}$, $u^n = 4^n e^{4x}$

Let $v = x^3$, $v' = 3x^2$, $v'' = 6x$, $v''' = 6$, $v'''' = 0$

Using Leibniz theorem;

$$y^n = 4^n e^{4x} \cdot x^3 + n \cdot 4^{n-1} e^{4x} \cdot 3x^2 + \frac{n(n-1)}{2!} 4^{n-2} e^{4x} \cdot 6x + \frac{n(n-1)(n-2)}{3!} \cdot 4^{n-3} e^{4x} \cdot 6 + 0$$

$$y^n = 4^n e^{4x} \cdot x^3 + 3x^2 n \cdot 4^{n-1} e^{4x} + 3n(n-1) \cdot 4^{n-2} e^{4x} x + n(n-1)(n-2) 4^{n-3} e^{4x}$$

$$\therefore y^5 = 4^5 e^{4x} \cdot x^3 + 3x^2(5) \cdot 4^4 e^{4x} + 3(5)(4) \cdot 4^3 e^{4x} \cdot x + n(n-1)(n-2) \cdot 4^{n-3} e^{4x}$$

$$y^5 = 1024 e^{4x} \cdot x^3 + 3840 e^{4x} \cdot x^2 + 3840 e^{4x} \cdot x + 960 e^{4x}$$

$$y^5 = 64 e^{4x}(16x^3 + 60x^2 + 60x + 15)$$

ii) $x^2 \frac{d^2y}{dx^2} + x \frac{dy}{dx} + y = 0$

for Part A;

$A = x^2 y''$

$u = y''$, $u^n = y^{n+2}$

$v = x^2$, $v' = 2x$, $v'' = 2$, $v''' = 0$

$$A^n = (y^{n+2}) x^2 + n(y^{n+1}) 2x + \frac{n(n-1)}{2} \cdot (y^n) 2 + 0$$

$$\cancel{A^n = x^2 y^{(n+2)} + 2xny^{(n+1)}}$$

$$A^n = x^2 y^{(n+2)} + 2xny^{(n+1)} + n(n-1) y^n$$

for Part B;

$B = xy'$

$u = y'$, $u^n = y^{n+1}$

$v = x$, $v' = 1$, $v'' = 0$

$$B^n = (y^{n+1}) \cdot x + n(y^n) 1 + 0$$

$$= xy^{n+1} + ny^n$$

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for Part c

$c = y$

$c^n = y^n$

$A^n + B^n + C^n = 0$

$= x^2 y^{(n+2)} + 2xn y^{(n+1)} + (n^2 - n) y^n + x y^{n+1} + n y^n + y^n = 0$

$= x^2 y^{(n+2)} + (2n+1) x y^{n+1} + (n^2+1) y^n = 0$