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a) $\frac{dy}{dx} = 2\sinh x - y\tanh x$

$\frac{dy}{dx} + y\tanh x = \sinh x$

$P = \tanh x$, $Q = 2\sinh x$

$\int P\,dx = \int \tanh x = \int \frac{\sinh x}{\cosh x}\,dx$

$\cosh x = 4$

$\int \frac{\sinh x}{4} = dx$

$u = \cosh x$ $\quad dx = \frac{du}{\sinh x}$

$du/dx = \sinh x$

$\int \frac{\sinh u}{u} = \frac{du}{\sinh x}$

$\int \frac{1}{u} du = \ln u = \ln \cosh x$

$IF = e^{\int P dx} = e^{\ln \cosh x}$

$IF = \int Q \cdot If\,dx$

Then $IF = \int Q \cdot If\,dx$

$y\cosh x = \int 2\sinh x \cdot \cosh x\,dx$

$2\sin x\cos x = \sin(2x)$

$\therefore 2\sinh x\cosh x = \sin(2x)$

$y\cdot\cosh x = \int \sinh 2x\,dx$

$y\cdot\cosh x = \frac{1}{2}\cosh 2x + c$

$\cosh 2y = \cosh 2x + c$

$y = \frac{\frac{\cosh 2x + c}{2}}{\cosh x}$ $\quad$ Let $2c = A$

$y = \frac{\cosh 2x + A}{\cosh x}$

b) $dy/dx + 2y = e^{2x}$

$P = 2$ $\quad \int P\,dx = 2x$

$Q = e^{3x}$

$IF = e^{\int P dx} = e^{2x}$

$\therefore y \cdot IF = \int Q \cdot f\,dx$

$y \cdot e^{2x} = \int e^{3x} \cdot e^{2x}\,dx$

$y \cdot e^{2x} = \int e^{3x}\,dx$

$y \cdot e^{2x} = \frac{1}{3} e^{3x+c}$

$y = \frac{\frac{1}{2} e^{3x+c}}{e^{2x}}$

c) $2\,dy/dx = x^2 + 2x + 1$

$dy/dx = x + 2 - \frac{1}{x}$

$\int \frac{dy}{dx} = \int x + 2 - \frac{2}{3}\,dx$

$y = \frac{x^2}{2} + 2x - 3\ln x + c$

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

$\frac{dy}{dx} y^{-3} + \frac{y^{-3}}{x} = 1$ $\quad$ — ①

$Z = y^{1-n}$

$n = 3$

$Z = y^{1-3}$, $\quad x = y^{-2}$ $\quad$ — ②

$\frac{dz}{dy} = -2y^{-3}\,dy/dx$ $\quad$ — ③

when multiplying eqn 1 by $1-n$

$-2y^{-3}\frac{dy}{dx} \quad \frac{2y^{-3}}{x} = -2$

and $\frac{dz}{dy} = -2y^{-3}\frac{dy}{dx}$

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Sub eq^n 2 & 3 into 4

$\frac{dz}{dy} - \frac{2z}{x} = -2$

$\therefore P = -2/x, \quad Q = -2$

$\int P\,dx - 2\ln x$

$IF = e^{-3\ln 3x} = -2$

$z \cdot IF = \int Q \cdot IF\,dx$

$z \cdot x^{-2} = \int -2x^{-2}\,dx$

$= -\frac{2x^{-1}}{-1} + c$

$zx^{-2} = 2x^{-1} + c$

$Z = \frac{2x^{-1}}{x^{-2}} + \frac{c}{x^{-2}}$

$Z = 2x + cx^2$

$Z = x(2 + cx)$

$Z = y^{-2}$

$y^{-2} = x(2 + cx)$

$1/y^2 = x(2 + cx)$

$y^2 = \frac{1}{2(2+cx)}$

$\therefore y = \sqrt{\frac{1}{x(2+cx)}}$

$y = \frac{1}{\sqrt{x(2+cx)}}$

e) $x^2 \frac{dy}{dx} = x^2 \sin 3x + 4$

$\frac{dy}{dx} = x\sin 3x + 4$

$\int \frac{dy}{dx} = \int \overset{u}{x}\, \overset{dv}{\sin 3x} + \int 4x^{-2}$

$-\frac{1}{3} [illegible] \int \frac{1}{3}\cos 3x + \frac{4x^{-1}}{-1}$

$= \frac{-x\cos 3x}{3} + \frac{\sin 3x}{9} - 4x^{-1}$

$y = \frac{\sin 3x}{9} - \frac{x\cos 3x}{3} - \frac{4}{x}$

f) $(x^3 + xy^2)\,dy/dx = 2y^3$

$y = vx$

$dy/dx = v + x\,dv/dx$

$v + x\,dv/dx = \frac{2(vx)^3}{x^3 + v^2x^3}$

$v + x\,dv/dx = \frac{x^3(2x^3)}{x^3(1+v^2)}$

$= \frac{2v^3 - v(1+v^2)}{1+v^2} = \frac{2v^3 - v - v^3}{1+v^2}$

$x\,dv = v^3$

$\frac{1+v^3}{v^3 - v}\,dv = 1/x\,dx$

$v(v-1)(v+1) = v^3 - v$

$\frac{1+v^3}{v^3-v} = \frac{A}{v} + \frac{B}{v-1} + \frac{C}{v+1}$

$1+v^2 = A(v-1)(v+1) + B(v)(v+1) + C(v)(v-1), \quad v=1$

$1+1^2 = B(1)(2)$

$2 = B(2)$

$B = 1$

$v = -1$

$1+(-1)^2 = C(-1)(-1-1)$

$2 = 2C, \quad C = 1$

$v = 0$

$1+(0)^2 = A(0-1)(0+1)$

$1 = A(-1)(1)$

$1 = A-1$

$A = -1$