Question 1

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

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$$xy = \int x\ln x\,dx = \frac{x^2}{2}\ln x - \int \frac{x^2}{2}\frac{1}{x}\,dx$$

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$y=1$ at $x=1$

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$$y=1 \text{ at } x=1 \qquad \Longrightarrow \; c=\frac{5}{4} \qquad \Longrightarrow \; y=\frac{x}{2}\ln x-\frac{x}{4}+\frac{5}{4x}$$

Question 3

$$\frac{dT}{dt} = -k\left(T - \sin t\right)$$

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$$\Longrightarrow \qquad e^{kt}T = k\int e^{kt}\sin t\,dt$$

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$$\implies \qquad e^{kt}T = k\int e^{kt}\sin t\,dt = kI_1 + c$$

Question 3

$$I_1 = \int e^{kt} \sin t \, dt$$

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$$I_2 = \int e^{kt} \cos t \, dt$$

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$$I_2 = \int e^{kt} \cos t \, dt = \frac{e^{kt}}{k} \cos t + \frac{1}{k} \int e^{kt} \sin t \, dt$$

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$$\begin{aligned} I_2 = \int e^{kt} \cos t \, dt &= \frac{e^{kt}}{k} \cos t + \frac{1}{k} \int e^{kt} \sin t \, dt \\ &= \frac{e^{kt} \cos t}{k} + \frac{1}{k} I_1 \end{aligned}$$

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$$I_1 = \frac{e^{kt}}{k} \sin t - \frac{1}{k} \left(\frac{e^{kt} \cos t}{k} + \frac{1}{k} I_1 \right)$$

$$\left(1 + \frac{1}{k^2} \right) I_1 = \frac{1}{k^2} \left(k e^{kt} \sin t - e^{kt} \cos t \right)$$

Question 3

$$I_1 = \int e^{kt}\sin t\,dt = \frac{e^{kt}}{k}\sin t - \frac{1}{k}\int e^{kt}\cos t\,dt = \frac{e^{kt}}{k}\sin t - \frac{1}{k}I_2$$

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$$\left(1+\frac{1}{k^2}\right)I_1 = \frac{1}{k^2}\left(ke^{kt}\sin t - e^{kt}\cos t\right)$$

$$\Longrightarrow \qquad I_1 = \frac{1}{1+k^2}\left(ke^{kt}\sin t - e^{kt}\cos t\right)$$

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$$e^{kt}T = kI_1 + c = \frac{k}{1+k^2}\left(ke^{kt}\sin t - e^{kt}\cos t\right) + c$$

$$\implies \qquad T = ce^{-kt} + \frac{k}{1+k^2}\left(k\sin t - \cos t\right)$$

Question 4

$$(s-t)(s+t-u)$$

Question 4

$$(s - t)(s + t - u) = s^2 - su - t^2 + tu$$

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Take

$$s = \frac{dy}{dx} \qquad u = x \qquad t = y$$

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$$\frac{dy}{dx} - y = 0$$

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$$\frac{dy}{dx} + y - x = 0$$

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$$\frac{dy}{dx} - y = 0 \qquad \Longrightarrow \qquad y = Ae^x$$

$$\frac{dy}{dx} + y - x = 0 \qquad \Longrightarrow \qquad \frac{dy}{dx} + y = x$$

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$$\frac{d}{dx}\left(ye^x\right) = e^x \frac{dy}{dx} + e^x y = xe^x$$

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$$ye^x = \int xe^x\,dx$$

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$$ye^x = \int xe^x\,dx = xe^x - \int e^x\,dx$$

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$$ye^x = \int xe^x\,dx = xe^x - \int e^x\,dx = xe^x - e^x + B$$

$$y = x - 1 + Be^{-x}$$