1) a) $z' = \boxed{\left(\frac{1}{\tan^{-1} t}\right) \cdot \left(\frac{1}{1+t^2}\right)}$

b) $u' = \boxed{2^{\cos v} \cdot \ln 2 \cdot (-\sin v)}$

c) $\ln y = \sqrt{x} \ln x \; ; \; \frac{1}{y} y' = \frac{1}{2\sqrt{x}} \ln x + \frac{\sqrt{x}}{x} = \frac{1}{\sqrt{x}}\left(\frac{\ln x}{2} + 1\right)$

$y' = \boxed{\left(x^{\sqrt{x}}\right)\left(\frac{1}{\sqrt{x}}\right)\left(\frac{\ln x}{2} + 1\right)}$

2) a) $\int \underbrace{x^2 \overset{u}{\ln x} \, dx}_{dv} = (\underset{u}{\ln x})(\underset{v}{\tfrac{x^3}{3}}) - \int \underset{v}{\frac{x^3}{3}} \underbrace{\frac{1}{x} dx}_{du} = \ln x\left(\frac{x^3}{3}\right) - \frac{1}{3}\int x^2 \, dx$

$= \boxed{\frac{x^3}{3} \ln x - \frac{1}{9} x^3 + C}$

$u = \ln x \quad dv = x^2 dx$

$du = \frac{1}{x} dx \quad v = \frac{x^3}{3}$

b) $\int_0^{.5} \frac{\sin^{-1} x}{\sqrt{1-x^2}} dx = \int_0^{\frac{\pi}{6}} u \, du = \frac{u^2}{2}\Big|_0^{\pi/6} = \frac{1}{2}\left(\frac{\pi}{6}\right)^2 = \boxed{\frac{\pi^2}{72}}$

$u = \sin^{-1} x, \; du = \frac{dx}{\sqrt{1-x^2}}$

$x = 0 \quad u = \sin^{-1} 0 = 0$

$x = \frac{1}{2} \quad u = \sin^{-1} \frac{1}{2} = \frac{\pi}{6}$

3) a) $\lim_{x \to 0} \frac{\sin 4x}{\sin 3x} \overset{(LH)}{=} \lim_{x \to 0} \frac{4 \cos 4x}{3 \cos 3x} = \boxed{\frac{4}{3}}$

$\left(\frac{\infty}{\infty}\right)$

b) $\lim_{x \to 0^+} \sqrt{x} \ln x = \lim_{x \to 0^+} \frac{\ln x}{\frac{1}{\sqrt{x}}} \overset{(LH)}{=} \lim_{x \to 0^+} \frac{\frac{1}{x}}{-\frac{1}{2} x^{-3/2}} = \lim_{x \to 0} \left(-\frac{1}{2}\right) \frac{x^{3/2}}{x}$

$(0 \cdot \infty)$

$= -\frac{1}{2} \lim_{x \to 0} \sqrt{x} = \boxed{0}$

c) $\lim_{x \to 0} \frac{e^x - x - 1}{x^2} \overset{(LH)}{=} \lim_{x \to 0} \frac{e^x - 1}{2x} \overset{(LH)}{=} \lim_{x \to 0} \frac{e^x}{2} = \boxed{\frac{1}{2}}$

$\left(\frac{0}{0}\right) \qquad \left(\frac{0}{0}\right)$

4) a)

$$\lim_{x\to 0} \frac{1}{x^3}\int_0^x \sin t^2\,dt = \lim_{x\to 0} \frac{\int_0^x \sin t^2\,dt}{x^3} \overset{(LH)}{=} \lim_{x\to 0} \frac{\sin x^2}{3x^2}$$ let $\underline{u=x^2}$

$\left(\frac{0}{0}\right)$

$$= \frac{1}{3}\lim_{u\to 0}\frac{\sin u}{u} = \boxed{\frac{1}{3}}$$

b) $f'(x) = \dfrac{1}{1+x^2} + \dfrac{1}{1+\left(\frac{1}{x}\right)^2}\left(-\dfrac{1}{x^2}\right) = \dfrac{1}{1+x^2} - \dfrac{1}{x^2+1} = 0$

$\therefore$ $f(x) = C$, constant

when $x=1$, $\tan^{-1} 1 = \pi/4$, $\tan^{-1}\left(\frac{1}{1}\right) = \tan^{-1}(1) = \pi/4$

$\therefore$ $C = f(1) = \tan^{-1}(1) + \tan^{-1}\left(\frac{1}{1}\right) = \frac{\pi}{4} + \frac{\pi}{4} = \boxed{\pi/2}$