$$f(x) = \frac{x^2 \ln x}{e^x \sin x}$$

$$f'(x) = \frac{e^x \sin x \frac{d}{dx}(x^2 \ln x) - x^2 \ln x \frac{d}{dx}(e^x \sin x)}{(e^x \sin x)^2}$$

$$= \frac{e^x \sin x \left(x^2 \frac{d}{dx}(\ln x) + \ln x \frac{d}{dx}(x^2)\right) - x^2 \ln x \left(e^x \frac{d}{dx}(\sin x) + \sin x \frac{d}{dx}(e^x)\right)}{e^{2x} \sin^2 x}$$

$$= \frac{e^x \sin x \left(x^2 \frac{1}{x} + \ln x \; 2x\right) - x^2 \ln x \left(e^x \cos x + \sin x \, e^x\right)}{e^{2x} \sin^2 x}$$

$$= \frac{e^x \left[x \sin x + 2x \ln x \sin x - x^2 \ln x \cos x - x^2 \ln x \sin x\right]}{e^{2x} \sin^2 x}$$

$$f'(x) = \frac{x \sin x (1 + 2\ln x) - x^2 \ln x (\cos x + \sin x)}{e^x \sin^2 x}$$

$$f''(x) = \frac{e^x \sin^2 x \frac{d}{dx}\left[x \sin x (1+2\ln x) - x^2 \ln x (\cos x + \sin x)\right] - \qquad \frac{d}{dx}(e^x \sin^2 x)}{(e^x \sin^2 x)^2}$$

Logarithmic differentiation:

$$\boxed{y = x^{2x}} \qquad \boxed{y = x^2} \rightarrow \frac{dy}{dx} = 2x$$

Power rule

$$y = x^{2x}$$

Taking logarithm on both sides to find

$$\ln y = \ln x^{2x} = 2x \ln x$$

$$\frac{d}{dx}(\ln y) = \frac{d}{dx}(2x \ln x)$$

$$\Rightarrow \frac{1}{y} \frac{dy}{dx} = 2x \frac{d}{dx}(\ln x) + \ln x \frac{d}{dx}(2x)$$

$$\Rightarrow \frac{dy}{dx} = y\left[2x \frac{1}{x} + \ln x \; 2\right]$$

$$\Rightarrow \frac{dy}{dx} = x^{2x}\left[2 + 2\ln x\right]$$