H20

問2

(1) ・内部

$$\int H\,dl = \frac{\pi x^2}{\pi a^2} I$$

$$H = \frac{1}{2\pi x} \cdot \frac{x^2}{a^2} I$$

$$= \frac{x}{2\pi a^2} I \quad [A/m]$$

・外部

$$\int H\,dl = I$$

$$H = \frac{I}{2\pi x} \quad [A/m]$$

(2)

$$d\Phi = B \cdot dS$$

$$= \nu H \cdot dx$$

$$= \frac{\nu I}{2\pi a^2} x \cdot dx$$

$$\Phi = \int_0^a \frac{\nu I}{2\pi a^2} x\,dx$$

鎖交回数は全体の $\frac{\pi x^2}{\pi a^2}$ 倍になるので

$$\Phi' = \int_0^a \frac{\nu I}{2\pi a^4} x^3\,dx$$

$$= \frac{\nu I}{8\pi} \quad [Wb]$$

(3)

$$L_i = \frac{\Phi'}{I}$$

$$= \frac{\nu}{8\pi} \quad [H]$$

(4)

$$H = \frac{I}{2\pi x} + \frac{I}{2\pi(d-x)} \quad [A/m]$$

(5)

$$d\Phi = \mu_0 H\,dx$$

$$\Phi = \frac{\mu_0 I}{2\pi} \int_a^{d-a} \left(\frac{1}{x} + \frac{1}{d-x}\right) dx$$

$$= \frac{\mu_0 I}{2\pi} \left[\log \frac{x}{d-x}\right]_a^{d-a}$$

$$= \frac{\mu_0 I}{2\pi} \log \frac{d-a}{a} \cdot \frac{d-a}{a}$$

$$= \frac{\mu_0 I}{2\pi} \log \frac{(d-a)^2}{a^2}$$

$d \gg a$ より $d-a \fallingdotseq d$

$$\Phi = \frac{\mu_0 I}{2\pi} \log \frac{d^2}{a^2} = \frac{\mu_0 I}{\pi} \log \frac{d}{a}$$

$$L_e = \frac{\Phi}{I} = \frac{\mu_0}{\pi} \log \frac{d}{a} \quad [H]$$

(6)

$$L = L_e + 2L_i \quad [H]$$