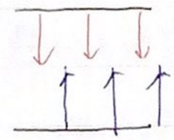
2021 秋 電磁気学



$E = \frac{V}{2d}$

$F = QE = \frac{QV}{2d}$

(1) $C_V = \varepsilon_0 \frac{a^2}{d}$

$U = \frac{1}{2} C_V V^2$

(2) 極板間引力 F を求める.

$U = \frac{\varepsilon_0 a^2 V^2}{2} \frac{1}{d}$

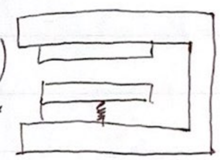
$F = -\frac{\varepsilon_0 a^2 V^2}{2} \frac{1}{d^2}$ （上向き）

② $E = \frac{V}{2d}$ ↓ $F = C_V V \cdot E$

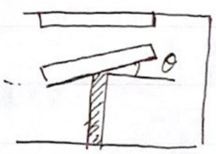
$F = \frac{\partial U}{\partial d}$ （d の向きに注意）

(3) Δd を $\varepsilon_0, a, C_V, C_0$ を用いて表す.

$C_0 = \varepsilon_0 \frac{a^2}{d_0}, \quad C_V = \varepsilon_0 \frac{a^2}{d} \Rightarrow \Delta d = d - d_0 = \varepsilon_0 a^2 \left(\frac{1}{C_V} - \frac{1}{C_0} \right)$



(4) $C_1 = \int_0^{\frac{a}{2}} \varepsilon_0 \frac{a\,dx}{d - \theta x} = -\frac{\varepsilon_0 a}{\theta} \ln \left| 1 - \frac{a\theta}{2d} \right|$ （$a\,dx$ — dS）

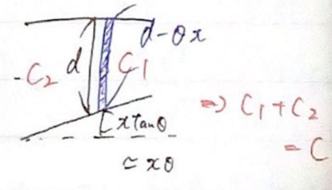


$\theta << \frac{d}{a}$ より $\frac{a\theta}{d} << 1 \Rightarrow \log(1+x) \simeq x - \frac{1}{2}x^2 + \frac{1}{3}x^3 + \cdots$

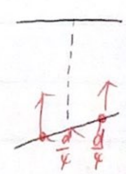
$C_2 = \frac{\varepsilon_0 a}{\theta} \ln \left| 1 + \frac{a\theta}{2d} \right|$

$C = C_1 + C_2 = \left(-\frac{\varepsilon_0 a}{\theta} \right) \cdot \left(-2\frac{a\theta}{2d} - 2\frac{1}{3}\left(\frac{a\theta}{2d}\right)^3 \right)$

$= \varepsilon_0 \frac{a^2}{d} \left(1 + \frac{1}{3} \left(\frac{a\theta}{2d} \right)^2 \right)$



(5) $F = \frac{\partial U}{\partial d} \rightarrow \begin{cases} U_1 = \frac{1}{2} C_1 V^2 \\ U_2 = \frac{1}{2} C_2 V^2 \end{cases}$



$F_1 = U_1' = -\frac{\varepsilon_0 a^2}{2d} \frac{1}{1 - \frac{a\theta}{2d}} \cdot \frac{V^2}{2}$

$F_2 = U_2' = \frac{\varepsilon_0 a^2}{2d} \frac{1}{1 + \frac{a\theta}{2d}} \cdot \frac{V^2}{2}$

$|N| = U_1' \cdot \frac{a}{4} + U_2' \cdot \frac{a}{4} = \frac{\varepsilon_0 a^3}{4d^2 - a^2\theta^2} \cdot \frac{V^2}{2}$

(4) の積分