技術系問題演習講座
記述　電磁気学（工学基礎）

2019年　労基B　記述　No.4

I (1) E ($F = qE$) ⇒ (+の電荷の) 力

E_x,

$$E_x = -k_0 \frac{2q}{(a+b)^2} + k_0 \frac{q}{b^2}$$

$$= \frac{k_0 q(a^2+2ab-b^2)}{b^2(a+b)^2}$$

$$E_y = 0$$

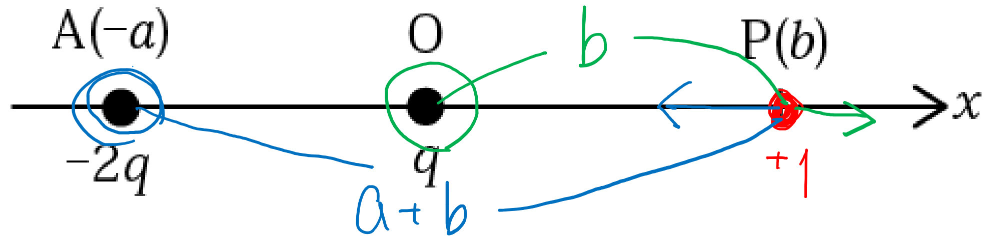
(2) V ($U = qV$) ⇒ エネルギー

$$V = k_0 \frac{(-2q)}{a+b} + k_0 \frac{q}{b}$$

$$= \frac{k_0 q(a-b)}{b(a+b)} \quad //$$

クーロンの法則

$$E = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r^2}, \quad V = \frac{1}{4\pi\varepsilon_0} \cdot \frac{q}{r}$$



(3)

$$E_A = k_0 \frac{2q}{a^2 + c^2}$$

$$E_x = -E_A \cos\theta$$

$$= -k_0 \frac{2q}{a^2+c^2} \times \frac{a}{\sqrt{a^2+c^2}}$$

$$= \frac{-2k_0 q a}{(a^2+c^2)^{\frac{3}{2}}} \quad //$$

$$E_y = -E_A \sin\theta + k_0 \frac{q}{c^2}$$

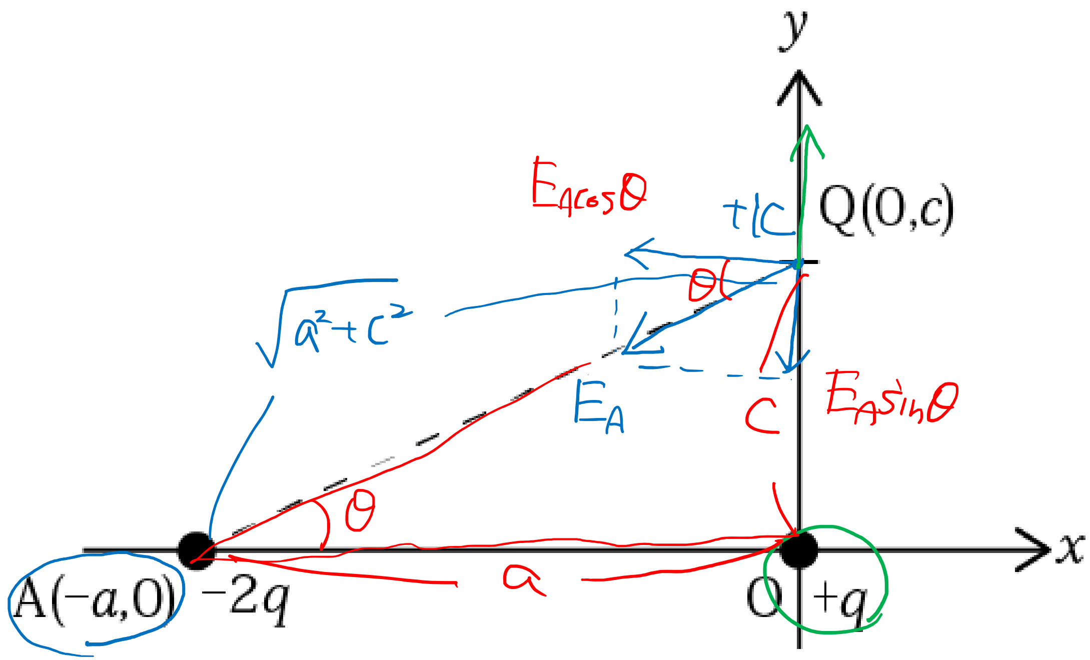
$$= -\frac{2k_0 q c}{(a^2+c^2)^{\frac{3}{2}}} + \frac{k_0 q}{c^2}$$

$$= k_0 q \left\{ -\frac{2c}{(a^2+c^2)^{\frac{3}{2}}} + \frac{1}{c^2} \right\} \quad //$$

(4)

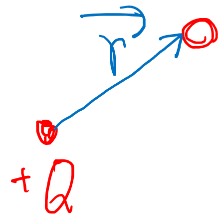
$$V = k_0 \frac{-2q}{\sqrt{a^2+c^2}} + k_0 \frac{q}{c}$$

$$= k_0 q \left(-\frac{2}{\sqrt{a^2+c^2}} + \frac{1}{c} \right) \quad //$$

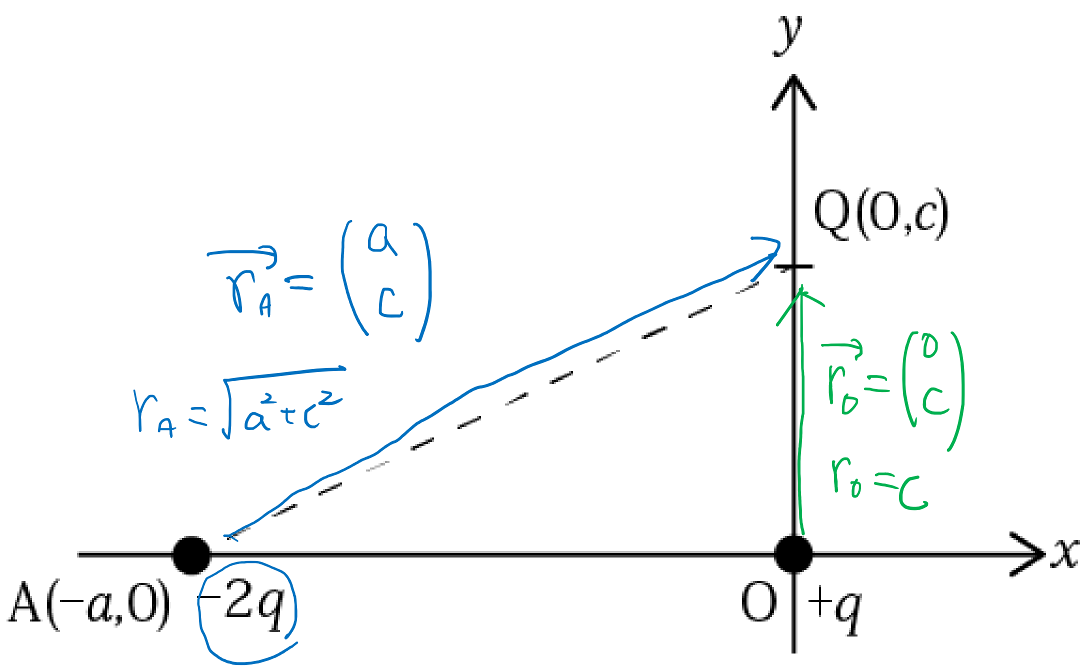


公式

$$\vec{E} = \frac{1}{4\pi\epsilon_0}\frac{Q}{r^3}\vec{r}$$



$$\vec{E} = k_0 \frac{-2q}{(a^2+c^2)^{\frac{3}{2}}} \begin{pmatrix} a \\ c \end{pmatrix} + k_0 \frac{q}{c^3} \begin{pmatrix} 0 \\ c \end{pmatrix}$$

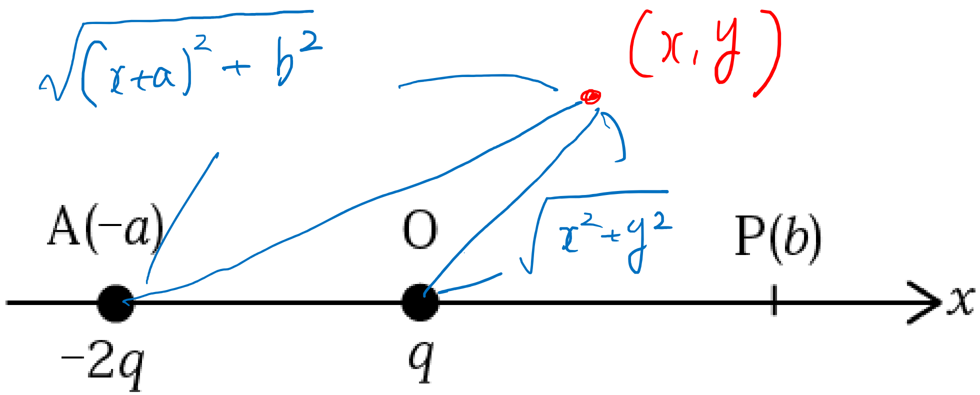


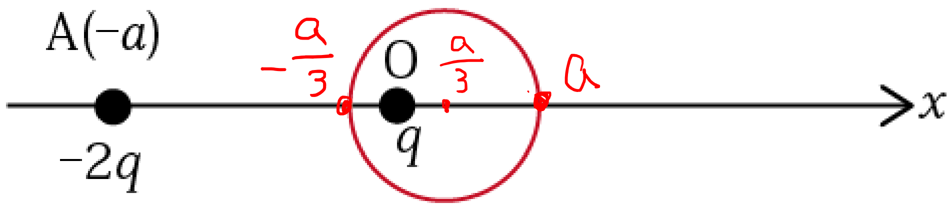
(5)

$$V = k_0 \frac{-2q}{\sqrt{(x+a)^2 + b^2}} + k_0 \frac{q}{\sqrt{x^2+y^2}} = 0$$

$$4(x^2+y^2) = (x+a)^2 + b^2$$

$$\rightarrow \left(x - \frac{a}{3}\right)^2 + y^2 = \left(\frac{2}{3}a\right)^2 \quad //$$



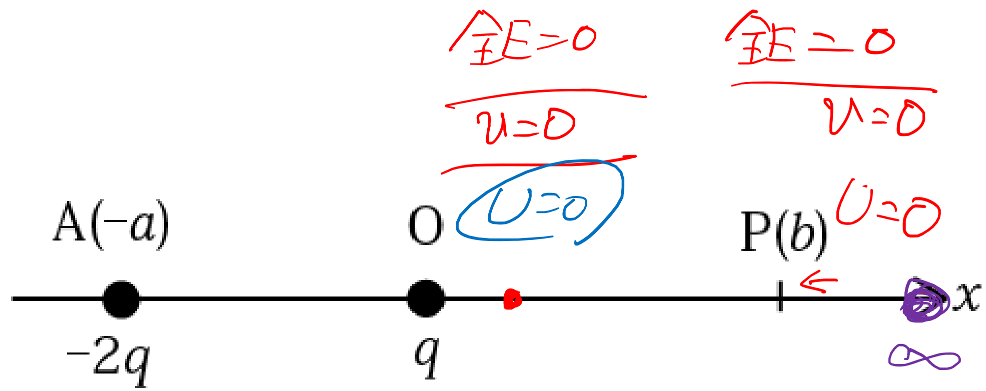


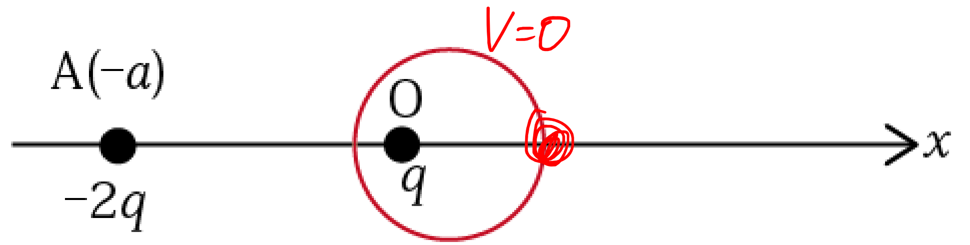
(6)(i) $V=0$のところまで近付く

よって(5)より

$x=a$ //

$V=\frac{1}{4\pi\varepsilon_0}\cdot\frac{q}{r}$ → $U=qV$





(6)(ii) 求める位置を x とする.

全E = 0 なので.

$$全E = qV + \frac{1}{2}mv^2$$

qV → min

$\frac{1}{2}mv^2$ → max

よってVがmin.とであればよい.

$$V = -k_0\frac{2q}{x+a} + k_0\frac{q}{x} = k_0q\left(-\frac{2}{x+a} + \frac{1}{x}\right)$$

$$V'(x) = k_0q\left(\frac{2}{(x+a)^2} - \frac{1}{x^2}\right) = 0$$

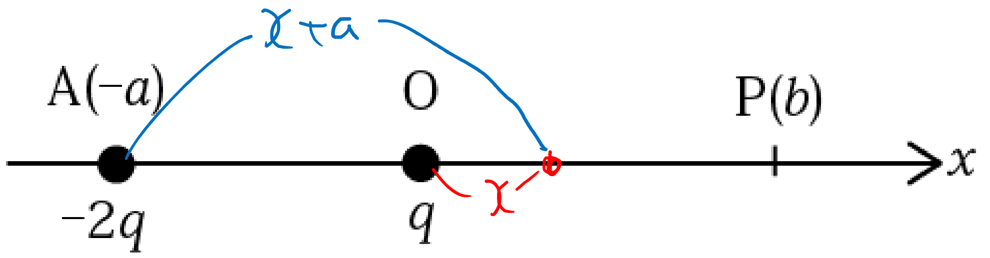
$$2x^2 = (x+a)^2$$

$$\pm\sqrt{2}x = x + a$$

$$(\sqrt{2}-1)x = a$$

$$x = \frac{a}{\sqrt{2}-1} = (\sqrt{2}+1)a$$

(別) E=0としてもよい



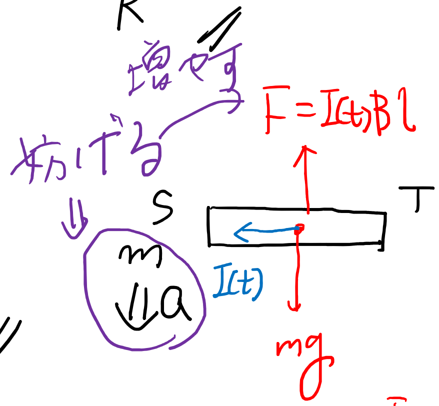
II

(1) フレミングの左手より

向き：上向き

大きさ　$F = IBl = \dfrac{VBl}{R}$ //

(2) 運動方程式

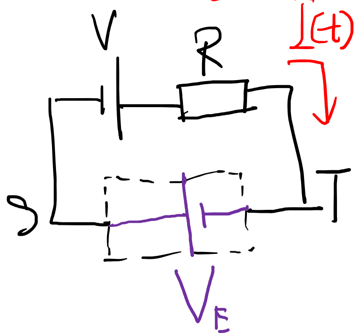


$ma(t) = mg - I(t)Bl$ //

キルヒホッフ

$V + V_E = RI$

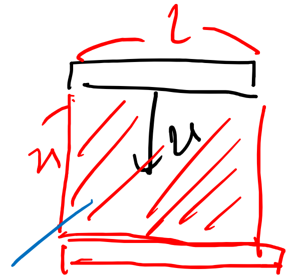
ファラデー



$\Phi = BS$

$V_E = \dfrac{d\Phi}{dt} = B\dfrac{dS}{dt}$　面積速度

1sの通過面積



$V_E = Bul$

$\dfrac{dS}{dt} = ul$

$\therefore\ V + Bl\,u(t) = RI(t)$ //

(3) 速度一定：$a = 0$

(2)より

$mg = IBl$

キルヒホッフ

$V + vBl = RI$

$V + vBl = \dfrac{mgR}{Bl}$

$\therefore\ v = \dfrac{mgR}{(Bl)^2} - \dfrac{V}{Bl}$ //

(4)

$W = V \times I$

$= \dfrac{mgV}{Bl}$ //

$Q = I^2 R$

$= \left(\dfrac{mg}{Bl}\right)^2 R$ //

$U = mgv = \left(\dfrac{mg}{Bl}\right)^2 R - \dfrac{mgV}{Bl}$

よって

$U = Q - W$

$\Rightarrow\ Q = U + W$