I (a) 単振動

(b), (c) 減衰振動

(d) 強制振動

(1) (a) $\frac{1}{2}m\omega^2x^2$

(d) $\frac{1}{2}m\omega^2x^2 + \frac{m\omega^2}{4A^2}x^4$

(2) (a) $x(t) = A\sin\omega t$

(b) $\ddot{x} = -\omega^2 x - \omega\dot{x}$

$x = Ae^{\omega' t}$ とおくと

$$A(\omega'^2 + \omega\omega' + \omega^2)e^{\omega' t} = 0$$

$$\omega' = \frac{-\omega \pm \sqrt{\omega^2 - 4\omega^2}}{2} = \frac{-1 \pm \sqrt{3}i}{2}\omega$$

$$\therefore x = Ae^{\frac{-1+\sqrt{3}i}{2}\omega t} + Be^{\frac{-1-\sqrt{3}i}{2}\omega t}$$

$$x(0) = A + B = 0$$

$$\therefore x = A' e^{-\frac{1}{2}\omega t}\sin\frac{\sqrt{3}}{2}\omega t$$

$$x'(t) = A'e^{-\frac{1}{2}\omega t}\left(-\frac{1}{2}\omega\sin\sqrt{3}\omega t + \frac{\sqrt{3}}{2}\omega\cos\frac{\sqrt{3}}{2}\omega t\right)$$

$$x'(0) = \frac{\sqrt{3}}{2}\omega A' = A\omega$$

$$\therefore x(t) = \frac{2A}{\sqrt{3}}e^{\frac{1}{2}\omega t}\sin\frac{\sqrt{3}}{2}\omega t$$

(c) $x = Ae^{\omega' t}$ とおくと

$$A(\omega'^2 + 2\omega\omega' + \omega^2)e^{\omega' t} = 0$$

$$\omega' = -\omega$$

$$\therefore x(t) = Ae^{-\omega t} + Bte^{-\omega t}$$

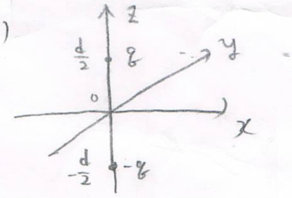
$$x(0) = 0 \rightarrow A = 0$$

$$x'(t) = (B - B\omega t)e^{-\omega t}$$

$$x'(0) = B = A\omega$$

$$\therefore x(t) = A\omega t e^{-\omega t}$$

II (3)



$$E_z(0,0,z) = \frac{1}{4\pi\varepsilon_0}\left(\frac{q}{(z-\frac{d}{2})^2} + \frac{-q}{(z+\frac{d}{2})^2}\right)$$

$$= \frac{q}{4\pi\varepsilon_0}\frac{1}{z^2}\left\{\left(1-\frac{d}{2z}\right)^{-2} - \left(1+\frac{d}{2z}\right)^{-2}\right\}$$

$$\simeq \frac{q}{4\pi\varepsilon_0}\frac{1}{z^2}\left(1+\frac{d}{z} - 1 + \frac{d}{z}\right)$$

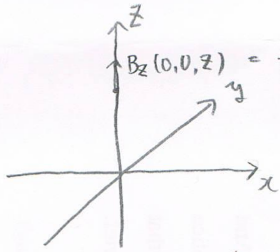
$$= \frac{qd}{2\pi\varepsilon_0}\frac{1}{z^3} = \frac{\alpha}{z^3}$$

$$\therefore \alpha = \frac{qd}{2\pi\varepsilon_0}$$

$qd \rightarrow m$, $\frac{1}{\varepsilon_0} \rightarrow \mu_0$

$$\gamma = \frac{m\mu_0}{2\pi}$$

(4)



$$B_z(0,0,z) = \frac{\mu_0 j}{2\pi}\cdot\frac{\pi a^2}{(z^2+a^2)^{\frac{3}{2}}}$$

$$B_z = \frac{\mu_0 j}{2\pi}\frac{\pi a^2}{z^3}\left(1+\frac{a^2}{z^2}\right)^{-\frac{3}{2}}$$

$$\simeq \frac{\mu_0 j}{2\pi}\frac{\pi a^2}{z^3}\left(1 - \frac{3a^2}{2z^2}\right) \qquad z \gg a$$

$$\simeq \frac{\mu_0 j}{2\pi}\frac{\pi a^2}{z^3}$$

$$= \frac{m\mu_0}{2\pi}\frac{1}{z^3} \qquad \therefore m = \pi a^2 j$$