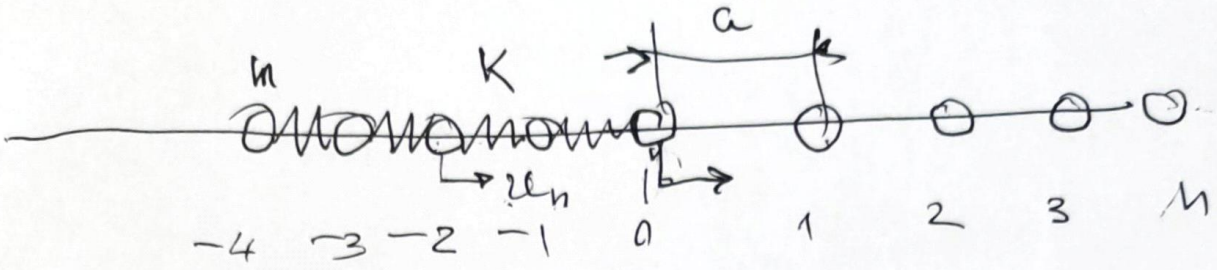
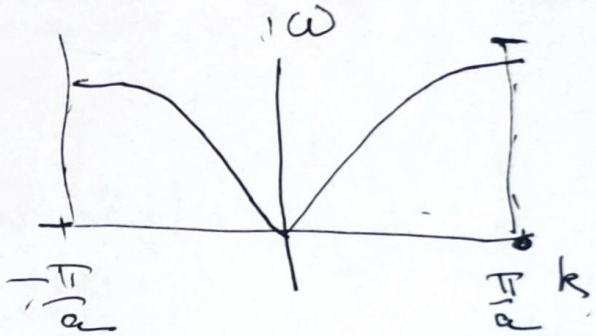


$$m\ddot{u}_n = K[(u_{n-1} - u_n) + (u_{n+1} - u_n)]$$

$$u_n(t) = u_n e^{-i\omega t}$$

$$-\omega^2 u_n = -\frac{K}{m}(2u_n - u_{n+1} - u_{n-1})$$

$$u_n = u(k)\, e^{ikan}$$



$$-\omega^2 u(k) e^{ikan} = -\frac{K}{m}(2e^{ikan} - e^{ika(n+1)} - e^{ika(n-1)})$$

$$u(k)$$

$$-\omega^2 u(k) = -\frac{K}{m}(2 - e^{ika} - e^{-ika}) \cdot u(k)$$

$$= -\frac{2K}{m} u(k) \left[1 - \cos ka\right]$$

$$\omega^2 = \frac{2K}{m}(1 - \cos ka) = \frac{2K}{m} \sin^2 \frac{ka}{2}$$

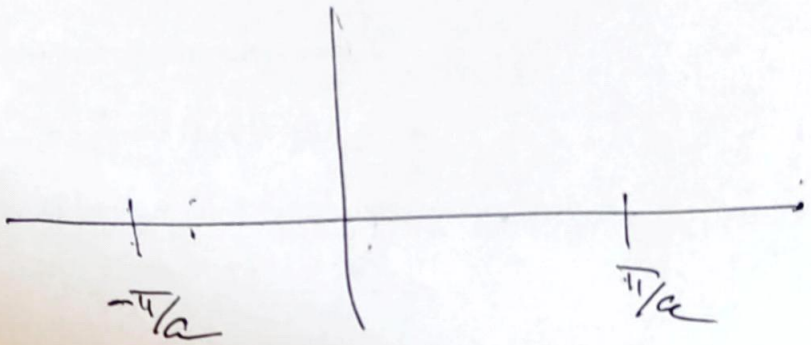
$$\omega = \sqrt{\frac{2K}{m}} \left| \sin \frac{ka}{2} \right|.$$

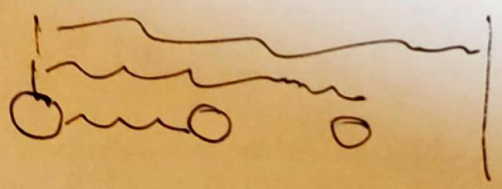
$k = 0$

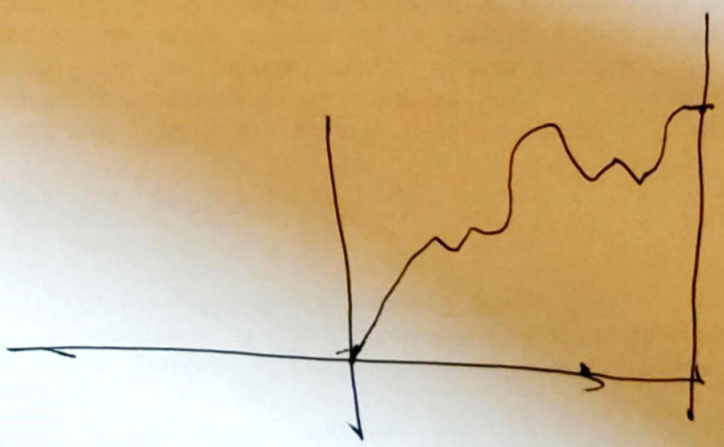
$$u_n = u(k=0) \cdot e^{i0an} = u(k=0)$$

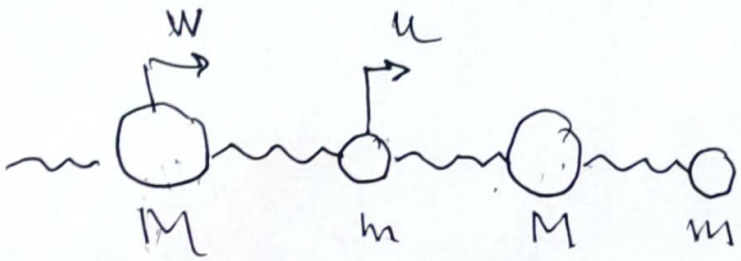
$$k \longrightarrow k + \frac{2\pi}{a}$$

$$e^{ikan} \longrightarrow e^{ikan} \cdot e^{i an \cdot \frac{2\pi}{a}}$$





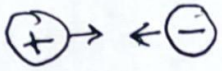




$M\ddot{w}_n =$

$m\ddot{u}_n =$

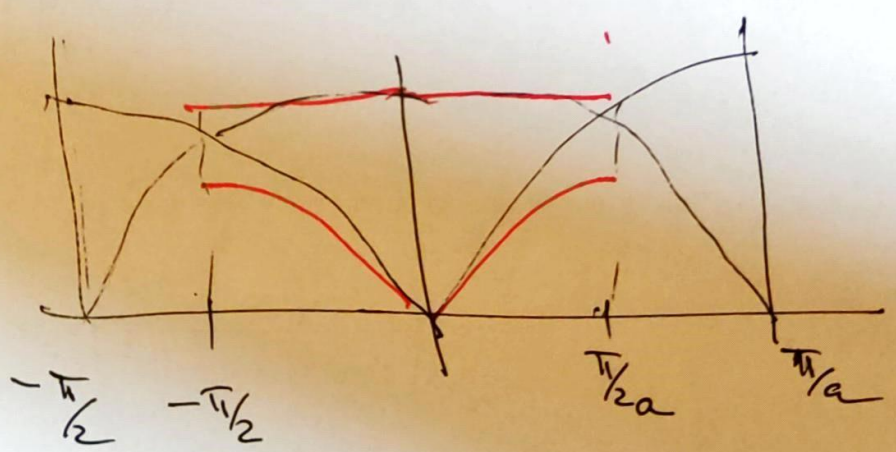
NaCl



$$w_n = w(k)\, e^{i2kan}$$

$$u_n = u(k)\, e^{i2kan}$$

$$\begin{pmatrix} -M\omega^2 w(k) \\ -m\omega^2 u(k) \end{pmatrix} = \begin{pmatrix} \quad K \quad \end{pmatrix} \begin{pmatrix} w(k) \\ u(k) \end{pmatrix}$$



$$\frac{1}{\mu} = \frac{1}{m} + \frac{1}{M}.$$