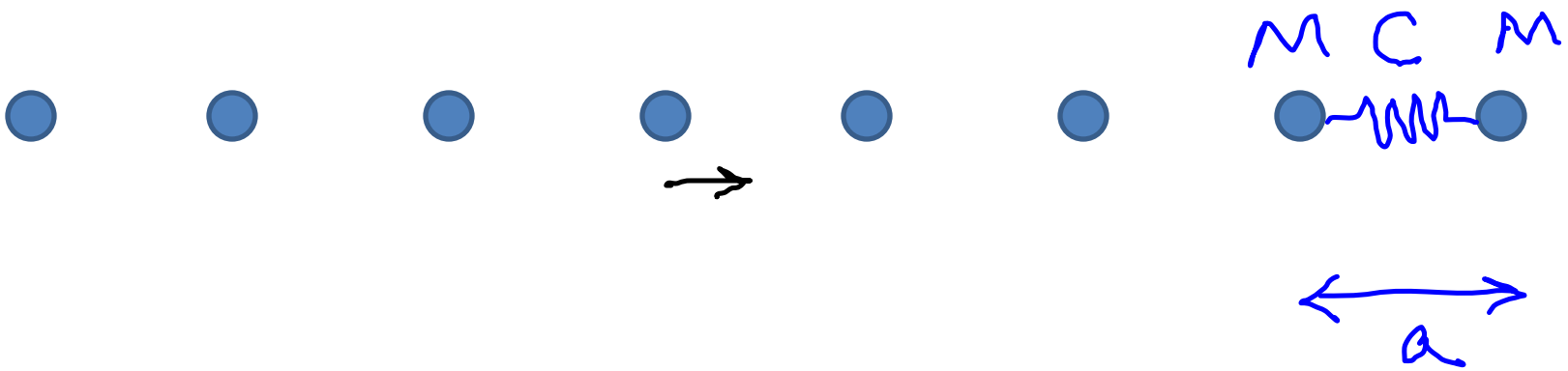
To err is human; to double-check, super-smart human.

The following diagram shows a few atoms in a very long 1 dimensional crystal. Each circle represents an atom of mass M and each neighboring pair of atoms are connected by a spring of spring constant C.

Indicate with an arrow underneath $each$ atom (an example is already given under one of the atoms) for the $k \to 0$ mode for $\omega_k = \sqrt{\frac{4C}{M}} \left|\sin\frac{ka}{2}\right|$ and explain why this solution of ω_k makes sense when $k \to 0$.



Challenge: why is $k = \frac{2\pi}{a}$ equivalent to $k = 0$? And, any $k = \frac{2\pi n}{a}$?

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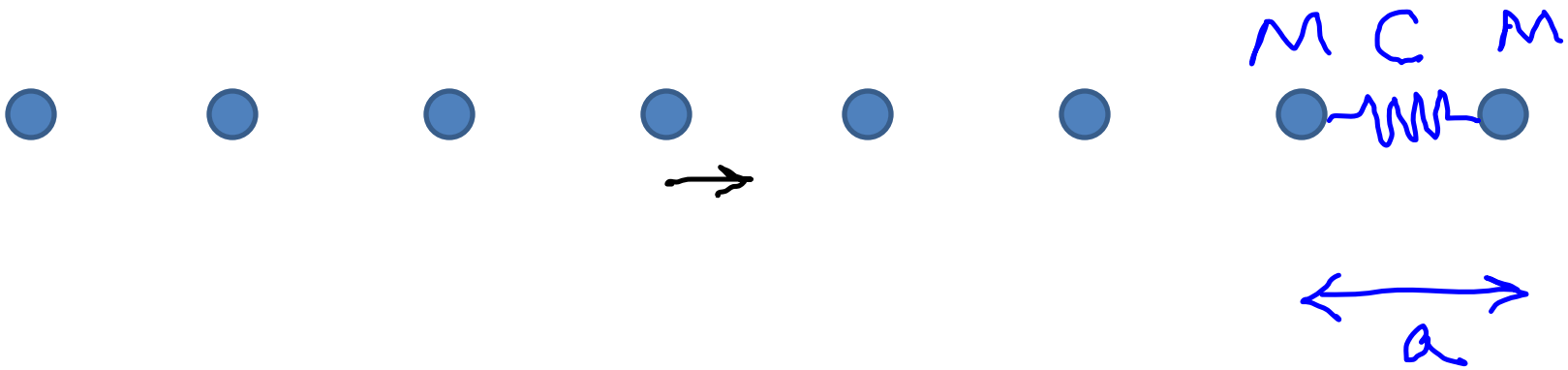
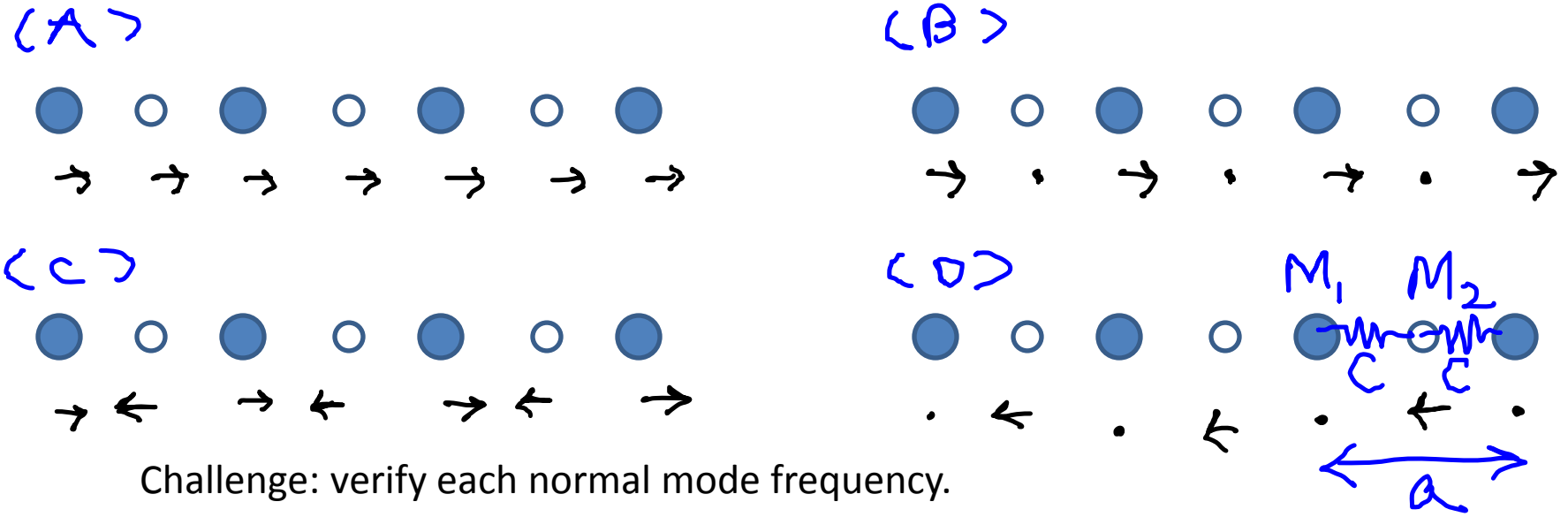


Challenge: why is $k = \frac{\pi}{a}$ equivalent to $k = -\frac{\pi}{a}$? And, any $k = \frac{\pi}{a} + \frac{2\pi n}{a}$?

Di-atomic 1-D crystal

Consider a di-atomic 1-D crystal, with the basis consisting of two different masses M_1 and M_2, but with all bonds characterized by the same spring constant C. In this crystal, some phonon modes include (1) a zero frequency mode at $k = 0$, (2) a mode with $\omega = \sqrt{2C\left(\frac{1}{M_1} + \frac{1}{M_2}\right)}$ at $k = 0$, (3) a mode with $\omega = \sqrt{\frac{2C}{M_1}}$ at $k = \frac{\pi}{a}$ and (4) a mode with $\omega = \sqrt{\frac{2C}{M_2}}$ at $k = \frac{\pi}{a}$. Indicate which of these four modes each of the following four diagrams correspond to.



Challenge: verify each normal mode frequency.