

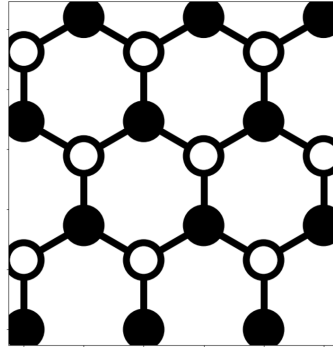
Solid state physics 2019 Minitest 3

29 March 2019

Good luck!

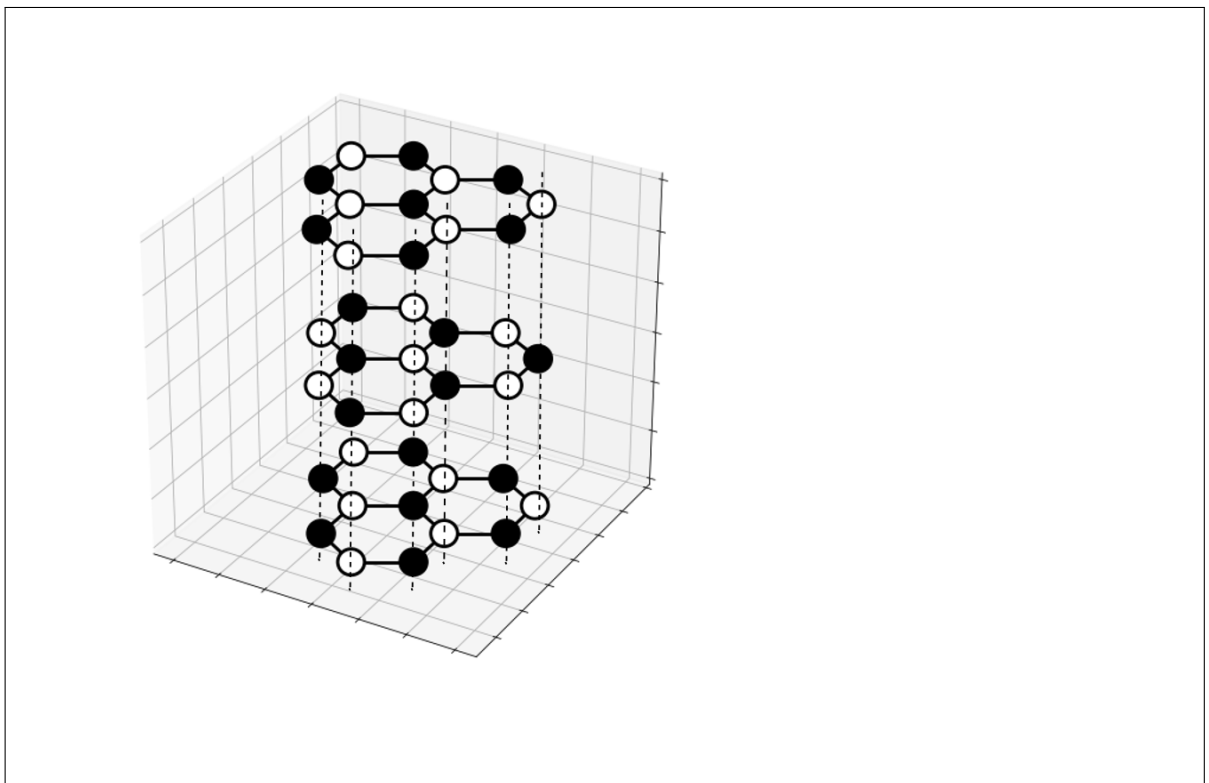
- You may not use textbooks, notes, or calculators.
- When plotting, label the axes and mark the important values.
- If you need extra answer space: ask for an extra exam copy, fill in your name and continue writing the solution.

1. (50 points) Consider hexagonal boron nitride - a crystal that consists of atomic layers that have a honeycomb crystal structure, with half the atoms being boron (B, filled circles) and half nitrogen (N, empty circles) shown here:



The layers are stacked such that on top of each boron atom there is a nitrogen atom in the next layer and vice versa, as shown in the plot below. The distance between neighboring B and N atoms within each layer is a , the distance between the layers is h .

- (a) (10 points) Draw the primitive lattice vectors, and a primitive unit cell of hexagonal boron nitride in the plot below. Does this unit cell stay primitive if we make all atoms the same? Explain your answer.



(b) (10 points) Write down the lattice vectors in Cartesian coordinates. Write down the basis.

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(c) (10 points) Compute the reciprocal lattice vectors.

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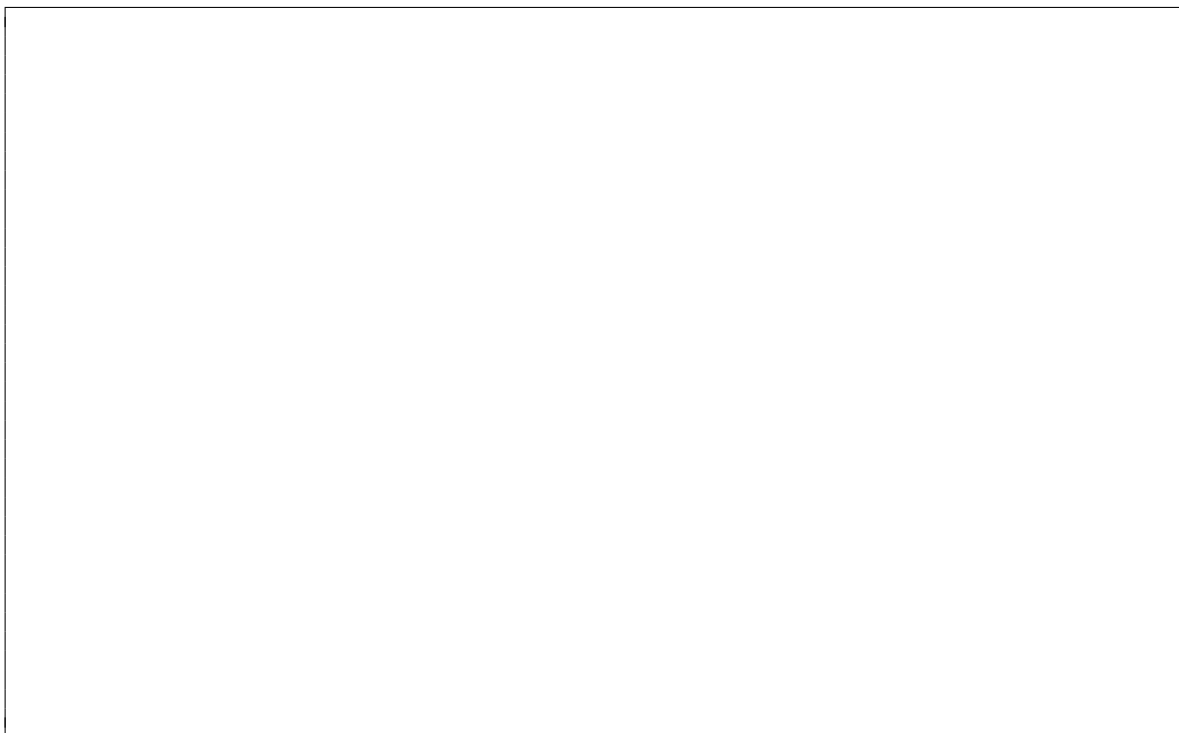
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2. (50 points) Consider 1D electrons in a potential

$$V(x) = \sum_{n=-\infty}^{\infty} [A\delta(x - 2na) + B\delta(x - (2n + 1)a)].$$

Here $\delta(x)$ is the Dirac delta-function.

(a) (10 points) Sketch the nearly free electron model band structure for this potential (you do not have to compute the sizes of the gaps between different bands). Use the *reduced* Brillouin zone scheme.



(b) (10 points) Compute the size of the gap between the first and the second band, and the gap between second and the third band.

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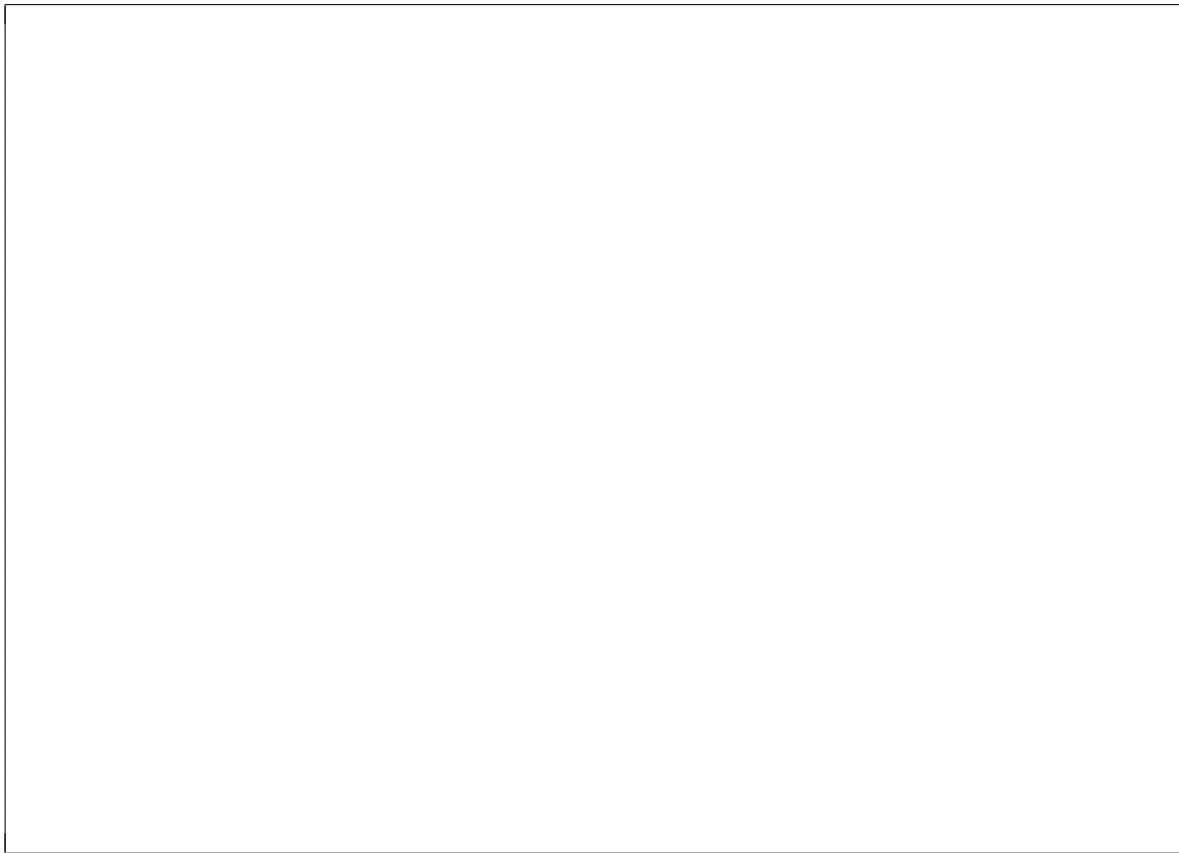
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(c) (10 points) Sketch the band structure in the case $A = B$. How is it related to the case $A \neq B$?



(d) (10 points) Sketch the band structure for $A = -B$. Which band gaps are equal to 0?

