MN-1
August 2015 QE

1. Consider a two-dimensional sheet of graphene believed to have a $E(\vec{k})$ relationship given by:

$$E(\vec{k}) = \pm\alpha\sqrt{k_x{}^2 + k_y{}^2} \qquad (1)$$

where α is a constant. Consider only one branch of the dispersion relation in (1) described by the positive sign (ignoring the negative sign). You may also ignore the two spins. Obtain expressions (as functions of the energy E) for the

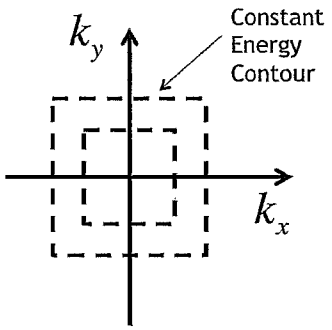
(a) **[20 points]** velocity v(E)

(b) **[20 points]** "mass" m(E) defined as

$$m(E) \equiv \frac{momentum}{velocity} = \frac{\hbar k}{v}$$

(b) **[30 points]** density of states per unit energy per unit area, D(E)

2. [30 points] A two-dimensional material has an $E(\vec{k})$ relationship such that the constant energy contours are in the form of squares as shown.



An electron initially at the origin (in the x-y plane as well as the k_x-k_y plane) is subject to an electric field at 30 degrees to the x-axis as shown.

Sketch the trajectory (based on the semiclassical picture) of the electron in both the x-y plane and in the k_x- k_y plane. Explain your reasoning.