Consider a two-dimensional sheet of graphene (a material currently being investigated for possible device applications) 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 $\alpha$ 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.

**1. [35 points]** Derive an expression for the density of available states per unit energy per unit area, D(E). Your answer should be in terms of the energy E and $\alpha$.

**2. [35 points]** Derive an expression relating the equilibrium density of electrons per unit area to the Fermi level at zero temperature. Your answer should be in terms of the Fermi energy $E_f$ and $\alpha$.

**3. [30 points]** An electron initially having x=0, $k_x$=0, y=0 and $k_y$=0 is subject to an electric field in the negative x-direction. Sketch the trajectories x(t), $k_x$(t) and the x-directed velocity $v_x(t)$ of the electron based on the semiclassical picture. Explain your reasoning.