**Level 3 Condensed Matter Physics- Part I**
**Weekly problem 2**

(1) Define the term *group velocity* for nearly-free electrons in a metal. Explain how a nearly-free electron can have a velocity which changes with increasing wavevector $k$. Draw a sketch of a typical energy – wavevector $E(k)$ relationship for a nearly-free conduction electron in a metal across the first Brillouin zone. Use your diagram to show where the group velocity of electrons is zero and where it is a maximum. **[4 marks]**

(2) A metal has an energy – wavevector $E(k)$ relationship given by: $E(k) = C(k^2 - Dk^4)$ where $C$ and $D$ are constants. From this obtain an expression for the group velocity of an electron, $v_g$. From what you know about the behavior of $v_g$ across the Brillouin zone, determine the value of $D$. **[3 marks]**

(3) For the above metal the effective mass at the first Brillouin zone boundary ($k = \pi/a$) is -0.5 times the effective mass at the centre of the Brillouin zone ($k = 0$), where $a$ is the lattice spacing. Find the values for the effective masses at $k = 0$ and at $k = {}^{\pi}/_{a}$ in terms of the constant $C$.
**[3 marks]**