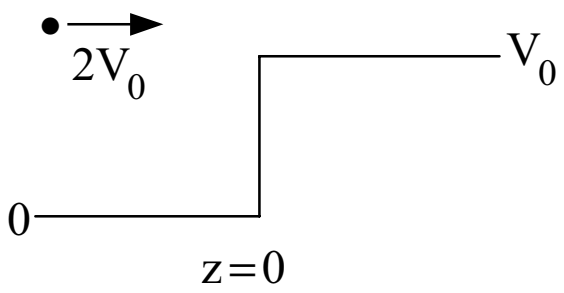
# Test 2 (2000.4.26)

## Prob.1 (40)

Electron waves can partially reflected and transmitted at a potential discontinuity just like EM waves at a refractive index discontinuity. With this in mind, answer the following questions.

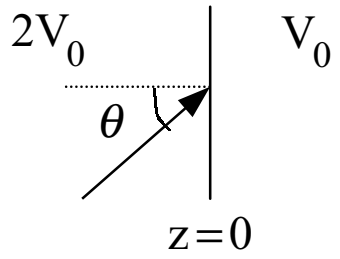
(a) (10) An electron with mass m and kinetic energy $2V_0$ is incident upon a potential barrier as shown below. To the left of the barrier($z<0$), the potential is $V_0$. Write down the electron wave solution in each region. Make sure you specify k in each region.

(b) (10) Using the boundary conditions at $z=0$, determine the numerical value for the coefficient of the reflected wave assuming the coefficient of the incident wave is 1.




(c) (10) If 100 electrons are incident at the potential interface described above, what is the expected number of electrons reflected at the interface.

(d) (10) Now the electron wave is obliquely (with an angle) incident to the interface as shown below. Determine the critical angle for the total internal reflection above which the electron wave gets all reflected. (Hint: Remember conditions for the total internal reflection of EM waves)




## Prob. 2 (20)

The dispersion relationship (w-k relationship) is one of the most important characteristic of any waves.

(a) (5) What is the dispersion relationship for EM waves in vacuum?

(b) (5) Determine the group velocity for a free-particle wave with mass m from its w-k relation ship.

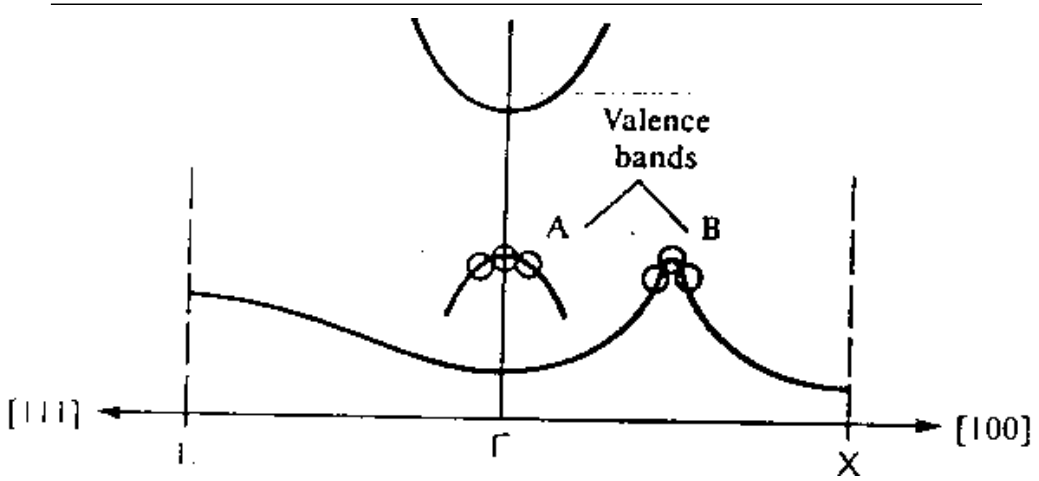
(c) (10) For any waves, there exists a unique relation between the dispersion relationship and the governing differential wave equations. For a wave X that has the dispersion relationship $w = ck + ak^2$, where a and c are constants, what is the governing differential wave equation for this wave?

## Prob.3 (20)

A certain hypothetical material is characterized by the E-K plot shown below.

(a) (10) Which holes, band A or band B holes, have greater [100] direction effective mass?

(b) (10) Sketch the expected form of the valence band constant energy surfaces.




## Prob. 4 (20)

Answer the following questions by comparing two semiconductor materials whose E-K plots shown below.

(a) (5) If photodetectors are made out of two materials, which one can detect longer wavelength light, I or II? Explain why very briefly.

(b) (5) Which material has more direction-dependent electron mobility, I or II? Explain why very briefly.

(c) (5) If currents are injected into two materials, which one can produce more light, I or II? Explain why very briefly.

(d) (5) Which material has larger periodicity of potential well, I or II? Explain why very briefly.