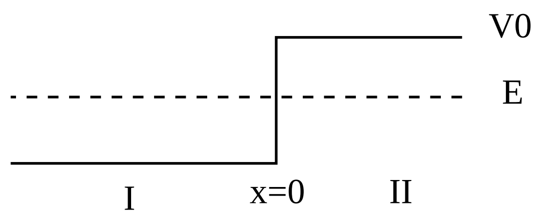
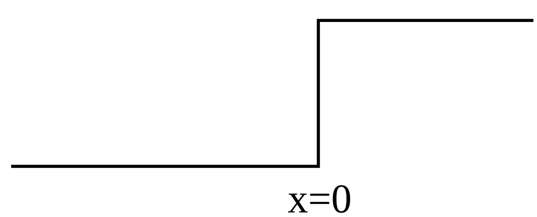
PH320 exam 2: 3/5/08

Do problem 1 and any 2 of the other 4. Problem 1 is worth 50 points. The rest are worth 25 each. No calculators. Closed book, although you may use 2 crib sheets (Letter or A4 size).

1: 50 A particle is incident on the barrier below from the left with energy $E < V_0$.



- Compute and interpret the reflection coefficient.
- In region II the wavefunction decays exponentially with depth. What is the depth of penetration as a function of E? Sketch this penetration (or "skin") depth as a function of E as E approaches V_0 from below.
- Sketch the real part of $\psi(x)$ and $|\psi(x)|^2$ on the following graph:

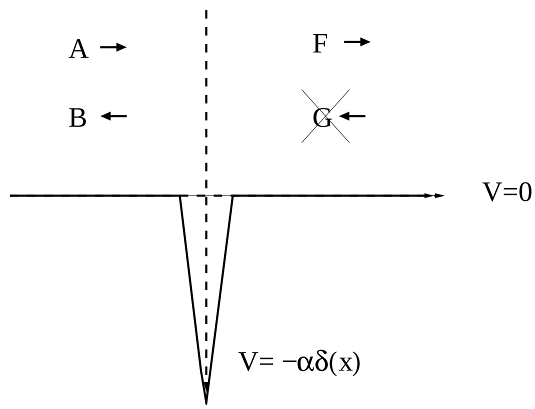


2: 25 It is a theorem that for any dynamical variable Q:

$$\frac{d}{dt}\langle Q\rangle = \frac{i}{\hbar}\langle [H, Q]\rangle + \langle \frac{\partial Q}{\partial t}\rangle$$

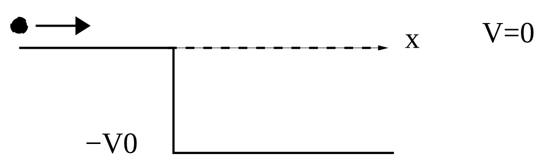
Use this theorem to compute $\frac{d}{dt}\langle x\rangle$. Note that there is rarely an explicit time dependence in Q; in particular $\frac{\partial x}{\partial t} = 0$.

3: 25 For the delta function potential well pictured here we showed in class that $\frac{B}{A} = \frac{i\beta}{1-i\beta}$ and $\frac{F}{A} = \frac{1}{1-i\beta}$ where $\beta = \frac{m\alpha}{\hbar^2 k}$ and $k = \sqrt{2mE}/\hbar$



- Compute the reflection (R) and transmission (T) coefficients as a function of energy (E).
- What are the limiting values of R and T as $E \to \infty$?
- Now let $V(x) = \alpha\delta(x)$. What are T and R in this case?

4: 25 A particle of mass m and energy $E > 0$ approaches an abrupt drop in potential as shown in the figure.



If $E = V_0/3$, what is the probability that the particle will reflect?

5:25

- Prove the folliwing identity for arbitrary operators A, B, C:

$$[AB, C] = A[B, C] + [A, C]B$$

- Show that for any function $f(x)$:

$$[f(x), p] = i\hbar \frac{df}{dx}$$