your name(s)____

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Physics 851 Quiz #8 - Wednesday, Nov 27th

Consider the one-dimensional situation, with a particle of mass $m = 938.38$ MeV/c^2, in a potential

$$V(x) = \left\{ \begin{array}{rl} \infty, & x < 0 \\ V_0 e^{-x^2/2R^2}, & x > 0 \end{array} \right.$$
$$V_0 = 12\text{ MeV},\ R = 3\text{ fm or 30fm}$$

A particle with energy $E = 15$ MeV is incident on the potential from $x = +\infty$ and reflect backward. The wave function for large x has the form

$$\psi(x) = (e^{2i\delta} e^{ikx} - e^{-ikx})/2$$

1. Write a program that solves for $|\psi(x)|^2$, then plots it for $0 < x < 4R$. Note $\hbar c$=197.326 MeV fm.
2. Using energy conservation, use classical physics to solve for the momentum of the particle as a function of x, $p(x, p_\infty)$, where p_∞ is the asymptotic momentum. On the same graph as above, plot dp/dp_∞ as a function of x.

If you wish you can use the following python code to solve for the wave function,

```
def V(VV0,R,xx):
  return VV0*exp(-0.5*xx*xx/(R*R))

hbarc=197.326
N=2400
m=939.0
V0=12.0
E=15.0
R=float(input("Enter R: "))
Rmax=8*R
x=np.ndarray(shape=(N),dtype=float)
dx=Rmax/N
psi=np.ndarray(shape=(N),dtype=complex)
psisquared=np.ndarray(shape=(N),dtype=float)
ci=complex(0,1.0)
x[N-1]=(N-1)*dx
x[N-2]=(N-2)*dx
k=sqrt(2.0*m*E)/hbarc
psi[N-1]=exp(-ci*k*x[N-1])
psi[N-2]=exp(-ci*k*x[N-2])
for i in range(N-3,-1,-1):
  x[i]=i*dx
  psi[i]=2.0*psi[i+1]-psi[i+2]-2.0*m*dx*dx*(E-V(V0,R,x[i+1]))*psi[i+1]/(hbarc*hbarc)

delta=-(0.5*ci*log(psi[0]/conjugate(psi[0]))).real
print('delta=',delta*180/pi)

for i in range(0,N):
  psi[i]=(-psi[i]+exp(2.0*ci*delta)*conjugate(psi[i]))/(2.0*ci)
  psisquared[i]=(psi[i]*conjugate(psi[i])).real

plt.plot(x,psisquared,linestyle='-',linewidth=2,color='r')
```